INTERNATIONAL ENERGY AGENCY

Creating Markets for Energy Technologies

OECD

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The International Energy Agency (IEA) is an autonomous body which was established in November 1974 within the framework of the Organisation for Economic Co-operation and Development (OECD) to implement an international energy programme.

It carries out a comprehensive programme of energy co-operation among twenty-six* of the OECD's thirty Member countries. The basic aims of the IEA are:

- to maintain and improve systems for coping with oil supply disruptions;
- to promote rational energy policies in a global context through co-operative relations with non-member countries, industry and international organisations;
- to operate a permanent information system on the international oil market;
- to improve the world's energy supply and demand structure by developing alternative energy sources and increasing the efficiency of energy use;
- to assist in the integration of environmental and energy policies.

** IEA Member countries: Australia, Austria, Belgium, Canada, the Czech Republic, Denmark, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Japan, the Republic of Korea, Luxembourg, the Netherlands, New Zealand, Norway, Portugal, Spain, Sweden, Switzerland, Turkey, the United Kingdom, the United States. The European Commission also takes part in the work of the IEA.*

ORGANISATION FOR ECONOMIC CO-OPERATION AND DEVELOPMENT

Pursuant to Article 1 of the Convention signed in Paris on 14th December 1960, and which came into force on 30th September 1961, the Organisation for Economic Co-operation and Development (OECD) shall promote policies designed:

- to achieve the highest sustainable economic growth and employment and a rising standard of living in Member countries, while maintaining financial stability, and thus to contribute to the development of the world economy;
- to contribute to sound economic expansion in Member as well as non-member countries in the process of economic development; and
- to contribute to the expansion of world trade on a multilateral, non-discriminatory basis in accordance with international obligations.

The original Member countries of the OECD are Austria, Belgium, Canada, Denmark, France, Germany, Greece, Iceland, Ireland, Italy, Luxembourg, the Netherlands, Norway, Portugal, Spain, Sweden, Switzerland, Turkey, the United Kingdom and the United States. The following countries became Members subsequently through accession at the dates indicated hereafter: Japan (28th April 1964), Finland (28th January 1969), Australia (7th June 1971), New Zealand (29th May 1973), Mexico (18th May 1994), the Czech Republic (21st December 1995), Hungary (7th May 1996), Poland (22nd November 1996), the Republic of Korea (12th December 1996) and Slovakia (28th September 2000). The Commission of the European Communities takes part in the work of the OECD (Article 13 of the OECD Convention).

FOREWORD

Expanding markets for clean and efficient energy technologies is an effective policy pathway towards reducing greenhouse gas emissions and increasing energy security. But many promising technologies face cost hurdles or other obstacles to commercial deployment. Creating markets for the new technologies requires new initiatives.

At their 1999 meeting, IEA Energy Ministers "emphasised the need to mobilise public and private resources to deploy environmentally sound technologies globally". IEA's Committee on Energy Research and Technology subsequently initiated a project on lessons learned and best practices in technology deployment policies. A project group was set up by the IEA Secretariat to conduct the analysis. IEA governments and other partners provided case studies on successful deployment programmes. This book presents the findings of the project.

The context for the programmes varies from country to country. To generalise lessons learned, the cases are therefore analysed from three different perspectives. The Research, Development and Deployment perspective focuses on learning processes and learning investments to reduce cost and reach large-scale markets. The Market Barrier perspective applies economic analysis in order to understand the mechanisms impeding deployment of new technologies. The Market Transformation perspective considers the network of market actors and practical techniques to stimulate technological change. The key message is that the design and implementation of successful deployment programmes demands vision from all three perspectives.

Following their analysis, the project group at the IEA Secretariat arranged a workshop around the three perspectives in November 2001. Authors of case studies were joined by researchers and industry representatives. The participants confirmed and enlarged on the three-perspective framework. The project group's analysis and the workshop papers are the basis for this book.

Robert Priddle
Executive Director

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At the November 2001 workshop "Technologies Require Markets", Mel Kliman, Peter Lund and Leo Schrattenholzer analysed the case studies, each from one of the three perspectives. Their reports contributed to the chapters describing the perspectives. Other contributors to the workshop were: Lars Bergman, Graham Campbell, Ken Friedman, Jim Hansen, Phil Harrington, Winfrid Hoffman, Marc Ledbetter, Bengt-Åke Lundvall, Simon Minett, Francois Moisan, Hans Nilsson, Clas-Otto Wene.

Mel Kliman has acted as external editor-in-chief for this book, pulling the different pieces together into a narrative. The IEA Secretariat thanks the Norwegian Government for its financial support for the work on this publication.

The project group leading the work at the IEA Secretariat consisted of Maria Virdis (until September 2000), Clas-Otto Wene (since October 2000) and Hans Nilsson (since December 2000). Maria Virdis defined and collected the case studies. Hans Nilsson and Clas-Otto Wene developed the three-perspective framework, conducted the November 2001 workshop and provided analysis for this book.

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Leo Schrattenholzer, "Analysing the Case Studies from the Perspective of the R&D and Deployment Model", paper presented to IEA Workshop, *Technologies Require Markets: Best Practices and Lessons Learned in Energy Technology Deployment Policies*, Paris 28-29 November 2001.

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EXECUTIVE SUMMARY: CREATING MARKETS FOR ENERGY TECHNOLOGIES

The development of markets for cleaner and more efficient energy technologies is at the centre of efforts in industrial societies to achieve a better fit between economic growth and environmental protection, and to deliver lasting energy security. Clean energy technologies will be the building blocks of a transformed energy system – a key component of the more sustainable economy we are seeking in the 21st century – but only if they can be made to perform at a level and a cost that society deems acceptable.

The technological and market developments required to transform the energy system will be conceived and implemented largely in the private sector. But success in this endeavour will not be determined exclusively by market forces. Governments that value the wider benefits of cleaner and more efficient energy technologies will work in partnership with market actors to ensure there are real opportunities for technologies to make the difficult transition from laboratory to market. This book is about the design and implementation of policies and programmes for that purpose.

Governments are motivated to assist not only because they have a responsibility for the pursuit of long-term societal goals and stewardship of the planet, but also because they understand that their policy settings help to determine whether markets develop and operate efficiently. Policymakers must therefore understand the markets concerned and they must have a highly developed capacity to mount effective programmes. In both cases experience is the best teacher.

For that reason IEA Member countries have come together to share their national experiences in technology deployment policy. The IEA

has collected 22 studies of successful market development programmes. These case studies provide a wealth of information on the variety of programmes undertaken and the evolution of ideas in this policy area. Most importantly they inform us of the benefits of experience on the path to success in facilitating technology market development.

Because the value of the kind of information contained in the case studies resides fundamentally in the details, it was necessary to develop a methodology that would help us to understand and synthesise the lessons they carry and convey them to a wider policy audience. The case studies were examined from three perspectives on deployment policymaking that have taken shape over the last quarter century:

- the ***Research, Development and Deployment Perspective***, which focuses on the innovation process, industry strategies and the learning that is associated with new technologies;
- the ***Market Barriers Perspective***, which characterises the adoption of a new technology as a market process, focuses on decisions made by investors and consumers, and applies the analytical tools of the economist;
- the ***Market Transformation Perspective***, which considers the distribution chain from producer to user, focuses on the role of the actors in this chain in developing markets for new energy technologies, and applies the tools of the management sciences.

In part the three perspectives are different vocabularies for discussing the same phenomena. Yet they are complementary – each adds something that the others lack. The strength of the R&D+Deployment perspective is its vision of the future. It focuses on the technology itself, its costs and performance, and the process of market entry through niche markets. Through the application of economic analysis, the market barrier perspective improves our understanding of barriers that impede the application of cleaner and more efficient energy technologies and provides a disciplined approach for making decisions about policy interventions. The market transformation perspective

encourages sensitivity to the practical aspects of crafting policies that take account of the complex nature of actual markets and produce the desired results.

A key message developed in this book is that policy initiatives designed to facilitate the adoption of cleaner energy technologies are unlikely to succeed unless policy designers pay attention to each of these three perspectives. It is necessary to:

- invest in niche markets and learning in order to improve technology cost and performance;
- remove or reduce barriers to market development that are based on instances of market failure;
- use market transformation techniques that address stakeholders' concerns in adopting new technologies and help to overcome market inertia that can unduly prolong the use of less effective technologies.

Around this central theme, a close reading of the IEA case studies revealed more detailed messages about the nature of successful policy-making. Some key points are:

- Deployment policy and programmes are critical for the rapid development of cleaner, more sustainable energy technologies and markets. While technology and market development is driven by the private sector, government has a key role to play in sending clear signals to the market about the public good outcomes it wishes to achieve.

- Programmes to assist in building new markets and transforming existing markets must engage stakeholders. Policy designers must understand the interests of those involved in the market concerned and there must be clear and continuous two-way communication between policy designers and all stakeholders. This calls for the assignment of adequate priorities and resources for this function by governments wishing to develop successful deployment initiatives.

- Programmes must dare to set targets that take account of learning effects; i.e., go beyond what stakeholders focused on the here-and-now may consider possible.
- The measures that make up a programme must be coherent and harmonised both among themselves and with policies for industrial development, environmental control, taxation and other areas of government activity.
- Programmes should stimulate learning investments from private sources and contain procedures for phasing out eventual government subsidies as technology improves and is picked up by the market.
- There is great potential for saving energy hidden in small-scale purchases, and therefore the gathering and focusing of purchasing power is important.
- Most consumers have little interest in energy issues *per se*, but would gladly respond to energy efficiency measures or use renewable fuels as part of a package with features they do care about.

In the end it is the combined effect of technology potential and customer acceptance that makes an impact on the market and hence on energy systems. Developing a deeper understanding of both, including how they are influenced by the actions of government, is an essential ingredient of effective deployment policy.

CHAPTER 1: IN SEARCH OF A COMPREHENSIVE APPROACH TO MARKET DEVELOPMENT POLICY

Technology and Economic Change

Technological change has become a part of normal life in modern industrial societies and this state of continuous flux is recognised as a primary source of economic growth. Markets for familiar goods and services are transformed to accommodate new ways of doing things; markets for entirely new products seem to take root overnight. In some periods of modern history a great number of small and large changes over an extended period have been instigated by a specific technological development and their collective effect has been a dramatic transformation in the way things are done. The exploitation of the railway, the automobile, jet travel and now the computer are classic examples. One can easily imagine that we are now in the early stages of another such transformation, in this case towards energy systems that will be environmentally benign and deliver long-term energy security and stability.

If that hypothesis holds, this next episode of dramatic change will be distinguished by some new features. The big changes of the 19th and 20th centuries were driven by the promise of dazzling new opportunities. In contrast, the transformation of our energy systems is now being driven by the need to avoid the negative side-effects of economic activity. While the beginnings of change came in the 1970s and were motivated by the threat that energy scarcity would interfere with our high standard of living, the motivation for change is now dominated by concern for the environment.

That difference presents a new kind of challenge. Governments played important roles in all of the earlier dramatic changes in our economies

referred to above, including an important involvement in the processes of research, development and the deployment of new technologies. But in those situations, once the promise of the new technologies became evident, it was not necessary for governments to motivate a reluctant private sector into getting involved. This time it is and this challenge will be made more difficult by the current political ethos, which favours minimal interference by governments in the operation of markets.

Fortunately, in regard to finding and implementing technological solutions to problems, there is a long history of cooperation between government and the private sector. The development and deployment of modern transportation technology, the computer, and the current communication revolution based on the internet and the wireless telephone have all been in part dependent on government policy and on cooperation between R&D entities in the public and private sectors. Likewise the energy system can be transformed through a continuation of that spirit of cooperation. The private sector is empowered with the know-how and capacity for innovation needed to deliver the results; governments bear the responsibility to express the collective will in regard to the need for change and to convey it in the form of effective policies.

In such a world the question of how governments design and manage their energy policies is fundamental. This book is about one aspect of the much larger challenge discussed above: how to approach the design and implementation of government policies to facilitate the development of markets for the energy technologies that will be the building blocks of a transformed energy system.

Understanding Market Development Policy

In this sort of policy environment it is more important than ever for governments to recognise the part they must play in getting better energy technologies into the marketplace competently and with a light touch. Policy-makers must understand the markets concerned and they

must have a highly developed capacity to mount effective programmes. In regard to both objectives, experience is the best teacher.

In fact, a large body of this kind of experience has been built up in IEA countries over the last quarter century. Since the energy crises of the 1970s governments have been active, to varying degrees, in running programmes to encourage the development and adoption of cleaner and more efficient energy technologies. There is much to be gained by reflecting on what can be learned from such experience. To this end, the IEA invited Member countries to prepare case studies on successful market development policies so that national experience could be shared. Government officials in 10 IEA countries responded to the invitation with a total of 20 case studies; the European Commission and an international cooperative research programme each provided an additional study. The whole set of 22 case studies was discussed in depth at a workshop in November 2001, entitled *Technologies Require Markets: Best Practices and Lessons Learned in Energy Technology Deployment Policies*. Analysis of the case studies by IEA staff members and independent consultants, as well as the open discussion of workshop participants, form the basis of this book.[1]

Information exchanges of this sort clearly benefit those who participate in them. It is always stimulating for policy practitioners to see how other people in other situations are coping with the range of problems that have been occupying them. However, attempting an overall analysis that is transferable across countries is a much larger challenge.

A case study describes a single instance of a broader phenomenon. If it is well done, it can enhance our understanding of it by helping us to think about it in detail and take account of what actually happens when ideas are put into practice. It can be especially rich when it has been written by people directly involved in the experience reported upon. At the same time, the picture conveyed by a case study depends

1. The case studies are summarised briefly in Chapter 2 and short descriptions of the results of the projects reported on are provided in an Annex at the end of this book. The CD-ROM attached to this book contains the full text of the Case Studies and Summaries of Case-Study Findings.

strongly on its context. The details of the design of a policy and its effects depend on the traditions, culture, politics and economic structure that prevail in the country where it is applied. National energy supply systems differ greatly – they are the result in each country of a long development process conditioned by natural resource endowments and institutional constraints that guide resource exploitation and technology choices. Consumer behaviour and patterns of energy demand are social and commercial constructs that depend on economic structure, tradition and cultural values. Furthermore, a case study may reflect the particular perspective of the person who has written it. For this book, the reports were typically prepared by people involved in technology deployment programme management. These are the people who are likely to have the best grasp of the overall story to be told, but they tell it from a particular vantage point, which may not adequately account for the experiences of other groups involved, such as industrial participants and the public.

To respond to the challenge of interpreting information that is so dependent on context and the vantage points of individual authors, it was necessary to apply a methodology based on two principles: extensive comparisons across case studies dealing with similar phenomena and the conscious application of an analytical framework. This analytical approach is referred to as '*triangulation*', because it involves looking at the set of case studies from three different perspectives (Nilsson and Wene, 2002). The objective was to see whether this sort of analysis would lead to a more comprehensive understanding of the experiences reported on in the case studies, and one that would help to distinguish the generic and transferable lessons from the specific aspects of different national experiences.

Three Perspectives

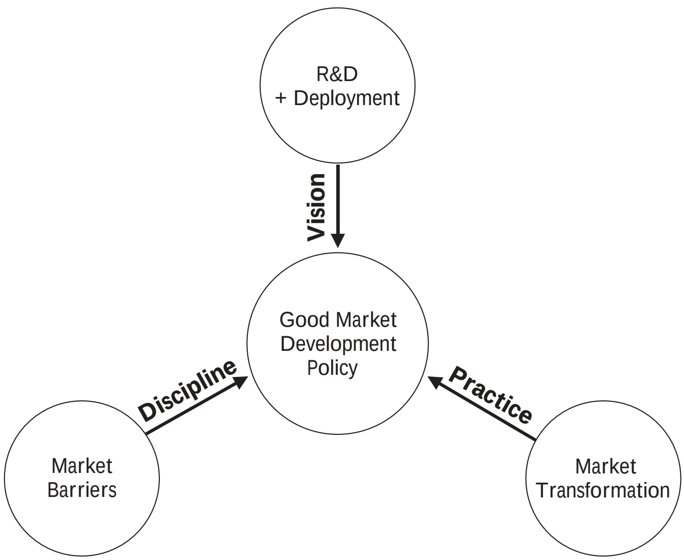
The three perspectives used to analyse the case studies are based on three aspects of technology market development policy that can be easily discerned, though they also overlap considerably.

- The *research, development and deployment perspective* focuses on the nature of innovation, industry strategies and the learning process associated with new technologies. At the centre of this perspective is a well-recognised phenomenon that has an important role in both technology development and policy-making. Private industry R&D stimulated by investments in a new technology, and the 'learning-by-doing' that comes with its use, improve technical performance and reduce cost. Governments can play a valuable role in this process with policies and programmes that support initial deployment of new technologies. That insight, combined with the mind set of people involved in R&D and technology deployment, gives this perspective an orientation towards the future, one in which learning and adaptation to better technologies are a normal part of the process of societal change.
- The m*arket barriers perspective* characterises the adoption of a new technology as a market process and focuses on the frameworks within which decisions are made by investors and consumers. Anything that slows the rate at which the market for a technology expands can be referred to as a market barrier. The emphasis in this perspective is on understanding such barriers and in what circumstances there might be a legitimate role for governments to play in reducing them. In this case the mind-set of the economist is evident. Economic analysis and the discipline it promotes is central to the barriers perspective.
- The m*arket transformation perspective* focuses on what needs to be done in practical terms to build markets for new energy technologies. It is concerned with the behaviour and roles of market actors, how their attitudes guide decisions and how these attitudes can be influenced. It is about the craft of market development programmes and the experience of implementing them.

The strength of the research, development and deployment perspective is its vision of the future; the market transformation perspective encourages sensitivity to the practical aspects of crafting policies to get results; and the market barrier perspective leads to policies that work

efficiently and generate net value. A key message developed in this book is that a combination of the three perspectives is needed to make good policy that helps to facilitate the adoption of new energy technologies.

Figure 1.1. Putting Together an Overall Perspective on Technology Market Development



What is to Come

A brief survey of the IEA case studies is presented in Chapter 2. It indicates the range of policies and programmes covered by them and conveys an 'aerial view' of their character and the broad issues raised by them.

Chapters 3, 4 and 5 deal in turn with the three perspectives defined above. Each chapter contains a discussion of how that perspective approaches the policy aspects of facilitating the adoption of new energy technologies. It should be noted at the outset that this is not a 'How to...' book, in the sense of providing recipes for constructing

policies consistent with each perspective. That would be a much larger project. It is rather intended to convey the essential ideas of each approach, illustrate them with reference to the case studies that are the information source for the book, and discuss the importance of applying all three sets of ideas in a comprehensive approach to the making of policy.

Chapter 6 is a discussion of some analytical tools used in market development policy and the difficulties involved in evaluating its impacts. Chapter 7 conveys the results of our attempts to understand the case studies in a framework based on a synthesis of all three policy perspectives and Chapter 8 presents our conclusions in summary form.

CHAPTER 2: AN OVERVIEW OF THE CASE STUDIES

Actions by government in support of market development for new energy technologies come in many shapes and sizes. Some are big, some small. Some focus on very specific technologies, some are concerned with a broad range. An action might be directed to a narrow market niche, an industry, a collection of markets that make up a broad sector of the economy, or even to all energy users. Some policy measures focus on final consumers; some of them target decision makers in service industries and some are directed to suppliers of technology. The case studies collected for this work cover all of these variations and more.

The purpose of this chapter is to convey a broad sense of the policies and programmes reported on in the case studies, with he objective of setting the stage for a more analytical discussion of market development policy in the chapters that follow. We do that by way of a series of thumbnail sketches of the individual case studies. Additional material and analytical commentary on the studies is brought into Chapters 3-5 to illustrate various aspects of the three policy perspectives discussed in this book.

Most readers will simply want to browse through the short sketches set out below to get an idea of the variety of deployment measures that have proven to be successful in IEA countries. The case study reports can be consulted, however, on the attached CD-ROM in the file named 'Case Studies'. Besides the full text of the case study reports, the CD contains a file called 'Summaries of Case-Study Findings' which for each case study presents an overview of targeted technologies, policy mechanisms, relations to the three perspectives and actors involved in the deployment programme. Also included on the CD are papers presented at the '*Technologies*

Require Markets' Workshop by three rapporteurs, each of whom discussed the case studies from the vantage point of one of the three perspectives described in Chapters 3-5 (Kliman, 2001; Lund, 2001; Schrattenholzer, 2001). At various points throughout this book, material has been drawn from these three papers.

To make browsing easier the case study descriptions are organised into groups, as follows:

Collecting the Case Studies

The IEA's Committee on Energy Research and Technology got this exercise in information exchange underway by inviting its members to report on successful policy efforts in their respective countries. Short descriptions of projects were submitted, from which 22 were chosen as subjects for the case studies. The government officials who prepared the reports in each participating country worked independently, but organised their material according to a template provided by a project group set up by the IEA Secretariat. They reported under five main headings: Policy Objectives, Design and Development, Actors and Participants, Monitoring and Evaluation, and Program Results. The objective was to share their experience of making and implementing policy in a practical context. Due to the broad variation in the types of policies that could be considered, the case study template was made open and flexible rather than highly detailed and constraining. Not surprisingly the focus and the analytical depth of the stories submitted by the national authors vary considerably across the 22 reports, with differing emphases on the various possible issues that could be treated – economic, organisational, administrative, communication, management and so on.

Table 2.1 shows the countries that submitted case studies, the names of the programmes reported on and their start dates. Some programmes were started recently. Of the older ones, many continue to operate, either because they involve programmed stages that are still in progress or because they are open-ended. In many instances current versions of these programmes have been built on the experience of earlier versions.

- End-use technologies ready for use;
  - Energy Efficiency Best Practice,
  - Technology Procurement,
  - Other Building Sector Programmes;
- Renewable Energy Technologies;
- Fossil-based Technologies;
- Technology Transfer.

Table 2.1: Deployment Policy Case Studies

Country	CS No.	Case Study Title	Start Year
Austria	1	The deployment of biomass district heating	80
	2	Thermoprofit: Reducing energy consumption in buildings	99
Canada	3	Renewable energy deployment initiative in space and water heating/cooling	98
Denmark	4	Labelling for small buildings to save energy and water	82
Finland	5	Diesel engines for combined-cycle power generation	95
Germany	6	Solarbau: Energy efficiency and solar energy in the commercial building sector	95
	7	Wind power for grid connection – the 250 MW wind programme	89
Japan	8	Photovoltaic power generation – from R&D to deployment	93
Netherlands	9	Deployment of high efficiency heat recovery for domestic ventilation	95
	10	Photovoltaic covenant	97
	11	Deployment of renewable energy in a liberalised energy market by fiscal instruments	96
Sweden	12	Market transformation: lighting	91
	13	Market transformation: heat pumps	93
	14	Environmentally-adapted energy systems in Baltic Sea region	92
United Kingdom	15	Energy efficiency best practice	89
United States	16	Unconventional natural gas exploration and production	78
	17	Sub-compact fluorescent lamps	98
	18	Clean coal technology demonstration	85
	19	Industrial assessment centres	76
	20	Motor challenge and BestPractices programs	92
European Union	21	Energy + refrigerator/freezer procurement	99
International	22	IEA/SolarPACES START Missions	97

End-use Technologies Ready for Use

The state of development of a technology affects the kind of policies used to build a market for it. Some market development issues need to be dealt with long before a technology is ready for mass adoption and the measures taken will vary accordingly. At the mature end of the development spectrum, one finds a range of end-use technologies that are either entirely ready for wide adoption (e.g., various forms of building insulation) or require small steps toward further development to be more widely marketable. The most obvious examples in the latter category are technologies that are well developed in a generic sense but require adaptations for particular uses or particular market segments (e.g., compact fluorescent lamps and vacuum-panel insulation for electrical appliances). Also at this end of the spectrum are cases in which systems analysis shows that well proven technologies can be applied in new ways (e.g., new ways of using electric motors).

Energy Efficiency Best Practice

Consistent with a central theme in this book – that technological change involves an ever-present learning process – information dissemination programmes have an important role in building markets for new technologies. In several countries governments have developed 'best-practice' programmes as efficient vehicles for conveying information. Typically such programmes are carried out for sponsoring governments by subsidiary agencies or private corporations, which develop specialised expertise on reaching the buyers of a wide range of energy technologies at key decision points.

The United Kingdom's ***Energy Efficiency Best Practice Programme*** (CS15) is a pioneer in this area. In operation since 1989 and highly developed, it is notable for being very market-oriented and having a business-style approach to management. Its focus is on saving energy in industry, buildings and the business use of transport.

The objective is straight-forward: help organisations to cut energy bills by 10-20 percent. Do it by providing the independent advice and assistance needed to persuade them to use cost-effective technologies and management techniques. While much information is conveyed in response to individual queries, the core output is a portfolio of descriptive and prescriptive publications ranging from detailed technical reports to simple leaflets. For every £1 of expenditure, the programme must provide a benefit of at least £5/year of energy savings. By 1999 the Energy Efficiency Best Practice Programme had stimulated energy savings in excess of £650 million/year, equivalent to over 4 million tonnes/year of carbon savings.

The American *BestPractices Programme* is an amalgamation of several energy efficiency activities of the Office of Industrial Technologies in the US Department of Energy. Case Study 20 focuses primarily on one component of it, the ***Motor Challenge Programme***, which promotes energy efficiency in motor systems. The American programme is more decentralised than the UK approach. It centres on partnerships with key industrial trade associations, which leverage the funding provided by USDOE. Two main policy mechanisms are used: the development of information and decision-making tools; and the development of strategic partnership networks with industrial trade associations and industrial supply companies. The first category includes training programmes, which so far have been received by more than 7 000 people.

At the centre of the Motor Challenge Programme are two ideas: the harnessing of business motivations of energy end-users, manufacturers and vendors to disseminate technical information and promote energy efficiency; and the promotion of a systems approach to managing motor systems. Industrial engineers have long known that the careful matching of the elements of an industrial plant (in the case of motor systems – motors, controls, couplings and process machinery) to the work to be performed yields far more savings than upgrading just the individual components. A market assessment carried out under the programme found that over 71 percent of total potential savings came from systems-level measures, such as improving the configuration and

control schemes in pump, fan and compressor systems. An independent estimate of this one component of the US BestPractices programme found that it is a cost-effective way of saving almost 25 million US$ of energy annually.

A second case study from the US on a *BestPractices* activity reports on the ***Industrial Assessment Center Programme*** (CS19). It focuses on education and demonstrates again how creative partnering can be used to leverage government-funded programmes. In this case the key partners are universities – the programme trains engineering students in energy efficiency for small- and medium-sized manufacturing plants. The students, led by their teachers, perform energy audits and industrial assessments, following these up with recommendations to the manufacturers involved. Essentially this is an information dissemination programme, but with an interesting potential for long-lasting and continuing effects. Young engineers are being motivated in regard to energy efficiency; and there is every reason to expect that they will continue to apply their knowledge throughout their careers. Even without this long-term effect, which would be difficult to monitor, an evaluation of the programme by the Oak Ridge National Laboratory concludes that in 1999 its energy assessments resulted in a benefit/cost ratio of 4.9 for the first year after the assessment. The true ratio will be much higher because energy savings will continue to accrue in the future.

Technology Procurement

Competitive procurement processes can be used to encourage equipment suppliers to develop and market specific types of energy technologies according to a set of specifications defined in a policy package. Suppliers are typically rewarded with assured sales. This is a useful approach when technologies are close to being ready for the market but require additional development with a particular eye on what potential buyers are looking for. At the same time, the specification list can include measures intended to establish marketing procedures suited to the equipment involved. A procurement programme is an economical tool because by engaging equipment suppliers it combines the pursuit of

technical and market development objectives in one policy and it leaves most of the detailed decisions on how to achieve goals in the hands of the suppliers. An important step in launching a procurement programme is consultation with all stakeholders in the market. The needs of potential buyers have to be identified and understood in depth and the scope for supplier-response to these needs explored. The case studies indicate that this consultation stage needs to be extensive and the whole programme needs to be highly organised.

Procurement programmes in Sweden are the subjects of two case studies. Swedish efforts in this area go back to the early 1990s and became well known in policy circles. Case Study 12, entitled ***Market Transformation: Lighting***, reports on a programme carried out in 1991-92 to build a market for high-frequency electronic ballasts, which can result in electricity savings of 20-25 percent. The ballasts can be marketed as part of a package of improved product characteristics that will be attractive to consumers; for instance, by combining them with new luminaire designs and effective control, they bring improved light quality and better lighting control. A buyers group was formed in Sweden and guaranteed a direct purchase of 26 000 ballasts, with an option on a further 26 000. Sales of high-frequency lighting in Sweden prior to 1992 amounted to about 5 000 units. A programme to demonstrate high-frequency lighting to potential buyers was undertaken concurrently with the procurement project. The market grew rapidly following the programme; about 60-70 percent of luminaire sales in Sweden are now of the high-frequency variety.

Case Study 13, ***Market Transformation: Heat Pumps***, reports on a two-year procurement programme started near the end of 1993 to encourage the development of reliable, cheaper and improved heat pumps for detached houses. The purchaser group, which consisted of a variety of potential buyers, including some from other Nordic countries, guaranteed the purchase of at least 2 000 units of the winning models. At the time this was about the level of a year's sales of residential heat pumps in Sweden. The procurement was combined with other activities supporting the market penetration of the winning

models. This included a subsidy for the first trial batch, positive labelling, education for professionals and information dissemination to suppliers and the public. New heat pumps resulting from the programme have been marketed since the end of 1995. Sales by the end of 1996 were estimated to be between 4 000-5 000 units.

An American case study on procurement, ***Sub-Compact Fluorescent Lamps*** (CS17), provides interesting detail on the role of stakeholder consultation. In early 1998 the US Department of Energy set out to develop the market for a new generation of smaller, brighter and less expensive CFLs – a sub-compact lamp. A multi-stage consultation was organised with representatives of the initial target market and a comprehensive list of related stake-holder groups. This included building owners and operators, housing trade associations, lighting suppliers, energy efficiency specialists and retailers. The consultation process identified several market barriers, which were then used to define a procurement programme. The key barriers to be responded to by participating manufacturers were lamp size and price, but other more subtle barriers were taken on as well.[2] The initial sales goal of one million lamps was exceeded by more than 50 percent and five manufacturers commercialised new products; as a result of the programme, 16 new lamp models have been introduced into the US market at reasonable prices. This programme departed from the usual practice of procurement programmes intended to build markets for new technologies in an interesting way, in that it did not guarantee purchases of newly-developed products in advance.

Finally, efforts are underway to use the procurement technique in an international cooperative framework, as described in Case Study 21 on the European Union's ***Energy+ Refrigerator/Freezer Procurement*** programme.[3] A pilot project started in 1999 has pursued increased

2. These are discussed in Chapter 6.

3. The EU programme is not the only attempt to use this tool in an international framework. It has also been attempted in two of the IEA's international cooperative R&D programmes – the Demand-Side Management Programme (see http://dsm.iea.org/NewDSM/Work/Tasks/3/task3.asp) and the Solar Heating and Cooling Progamme (see http://www.iea-shc.org/ and go to Task 24 under the 'Research Tasks' link).

market penetration for highly efficient refrigerator-freezers. Ten European countries were involved. This is an ambitious effort in light of the need to take account of national particularities in project design. The 10 countries are different not only in terms of climate and culture, but also in terms of the structure of markets and frameworks of governance. The Energy+ programme has therefore had to take a more fluid approach to designing procurement policies; it does not involve the tight link between product specifications and winners of a design competition that characterise the typical national procurement competition. At one level, the programme can be viewed as a focused approach to facilitating communication between end-users, policy stakeholders and appliance manufacturers. The features that consumers want can be effectively made known to manufacturers, who will be encouraged to supply new products on a larger scale. Approximately 100 organisations, representing more than 15 000 retail outlets and the management of more than one million dwellings, joined the initial project.

Other Building Sector Programmes

While several of the programmes discussed above relate to energy use in buildings, there are other programmes included in the case studies that are more specifically focused on buildings as energy-using systems. The building and construction sector presents a great challenge to the designers of technology deployment policies because it is highly fragmented. A large array of different market players influence technology and design decisions, each type working in its own accepted niche with long-established operating procedures that are subject to much inertia. In such a setting it is not effective to encourage greater energy efficiency by having a separate market development programme for each building-related technology. It is better to approach the market on its own interrelated terms, pinpoint the key decision makers in different parts of the system and find ways to encourage them to make better energy choices. Several case studies illustrate how policy designers have been effective in doing this.

Energy service companies were developed in the early stages of energy conservation programmes in part to deal with the market fragmentation problem in the building sector. In effect, a new market took form to provide information gathering and analytical services for energy users. Case Study 2, ***Thermoprofit – Reducing Energy Consumption in Buildings***, describes a project to improve the dissemination and effective application of energy efficiency information, in large part by improving the performance of energy service companies. It involves the use of third party financing, energy performance contracting and quality labelling. The programme originated in the Austrian city of Graz, though it operates at a regional level and has the potential of developing multi-regional networks.

The Danish programme on ***Labelling for Small Buildings to Save Energy and Water*** (CS4) provides for energy audits and 'energy labels' in the housing sector. The seller of a house must have an audit performed by an approved consultant before a sale takes place. As discussed further in Chapter 4, in addition to the direct effects on the houses audited, this sort of programme helps to make energy efficiency considerations a normal part of housing market transactions. The case study reports that more than 10 percent of all single-family houses in Denmark had an energy label after the scheme was in effect for $3\frac{1}{2}$ years.

The Dutch programme to encourage the ***Deployment of High Efficiency Heat Recovery for Domestic Ventilation*** (CS9) involves three types of activities: improved information dissemination, improvements in equipment and the inclusion of mechanical ventilation with heat recovery in building standards. The last measure works through an energy performance standard that must be satisfied by new buildings in the Netherlands. The installation of a high-efficiency ventilation system with heat recovery is one option that can be included among the list of things that a builder does in order to satisfy the standard. Such ventilation systems were included in less than 1 percent of new houses in the Netherlands in 1995; in 1999 they were included in 10 percent of them and the upward trend was expected to continue.

Renewable Energy Technologies

Some technologies based on renewable energy sources also relate to the building sector in ways similar to the end-use technologies discussed above; others are more closely associated with developments in the electricity supply sector. A German project straddles both categories. Demonstrating that buildings could be optimised in relation to the use of solar energy was the guiding objective in Germany's ***Solarbau: Energy Efficiency and Solar Energy in the Commercial Building Sector*** (CS6). It consists of up to 25 demonstration projects involving non-residential buildings, geographically distributed over all regions of Germany. Started in 1995, the programme is expected to last for 10 years with a budget of approximately 5 million euros. The idea is to integrate passive and active solar design with advanced heating, ventilation and air-conditioning (HVAC) techniques and innovative thermal insulation. This will involve the development of components, planning tools and an evaluation and information program called *SolarBau: MONITOR*.

A Canadian programme, the ***Renewable Energy Deployment Initiative*** (CS3) is intended to stimulate demand for renewable energy systems in the heating and cooling of space and water. It consists of two policy mechanisms: financial incentives and targeted market development initiatives. The latter involves the development of partnerships with stakeholders, strategy development, market assessments and implementation activities. So far, market development strategies have been prepared for ground-source heat pumps, solar water- and air-heating systems and biomass combustion systems, all three for industrial, commercial and institutional buildings. A fourth strategy, for residential swimming pools, was in preparation when the case study was submitted.

The Japanese programme to develop photovoltaic power takes its place among the most ambitious of those covered by the IEA case studies. Case Study 8, ***Photovoltaic Power Generation – from R&D to Deployment***, describes an effort that has been very large and broad-

ranging in its activities, while at the same time being focused on specific targets. Its origins trace back to 1974, when Japan reacted quickly after the 1973 oil crisis to begin expanding its energy options. The current version of the programme involves an overall target, set in 1998, of having 5 000 MW of installed photovoltaic (PV) capacity by 2010. The case study notes the possibility that residential PV-systems will one day become conventional. Over 10 000 residential units have been installed annually. Approximately 200 MW were in place by the end of FY1999.

Both R&D activities and programmes more directly focused on developing markets are included in the programme. The R&D targets are guided by an understanding of the learning-by-doing process (more on this in Chapter 3) and also involve specific technology-development objectives: new technologies for the practical application of PV power generation systems; a low-energy-consumption manufacturing process for solar grade silicon; a practical technology for making high-efficiency multicrystalline silicon solar cells; and advanced manufacturing technologies for PV power generation systems. The deployment programme seeks in general to develop PV-markets and also to demonstrate the endurance of PV-systems. Activities include field tests, subsidies for residential PV use and support of new businesses involving PV power.

The market for PV power is also being developed in the Netherlands. Case Study 10 reports on the ***Photovoltaic Covenant***, a voluntary programme backed up with funding for subsidies and R&D; this includes resources from the private sector. The Covenant has resulted in a network of active participants: energy distribution companies, PV manufacturers, stakeholders in the building sector, R&D institutions and government agencies. The initial Covenant was started for three years in 1997. Government funding for R&D is in the area of solar cells, components for grid-connection applications, autonomous PV systems and pilot projects in buildings. On deployment, the programme had a target of 7.7 MW of grid-connected PV in the built environment in the year 2000. That target was reached; at the time the case study was

prepared discussion was underway on a target of 250 MW by 2007 for a second Covenant.

The Netherlands has also mounted a broadly-based programme in support of the ***Deployment of Renewable Energy in a Liberalised Energy Market by Fiscal Instruments*** (CS11). This programme is different from many of the others discussed here in that it operates on an economy-wide basis, backing up more focused deployment programmes, but is also capable of producing additional results independently of them. It is an important part of the Dutch government's effort to achieve its goal of having 10 percent of all energy used coming from renewable sources by 2020. The share at the time the report was prepared was 1.2 percent.

Some elements of the Dutch fiscal programme were introduced over the past decade, including a tax on the use of electricity and natural gas, voluntary agreements with players in the energy sector and industry in general (including the PV Covenant, discussed above) and various subsidies for new initiatives (e.g., tax credits, favourable interest rates and accelerated depreciation). Two important components were added in 2001. One is the availability of 'green electricity' in a fully liberalised electricity market. Consumers pay an additional tariff when they buy it, but in return are exempted from paying the energy tax; 3.5 percent of households have responded to this offer. The second is a legally-based system, as distinct from the voluntary system that preceded it, of tradable certificates in the electricity distribution industry in support of targets for energy produced from renewable sources.

German support for the development of renewable-sourced electric power has also been broad, though wind power was the main focus in the programme described in Case Study 7, ***Wind Power for Grid Connection – the 250 MW Wind Programme***. In addition to direct subsidies, electricity producers benefited under the programme from a system of compensation for the higher costs of using renewables; this was defined by the Electricity Feed Law (EFL) of 1991. This legislation has been replaced by the Renewable Energy Law (REL) of 2000, which is designed

to expand the effect of the EFL to reach a broader range of renewables and also to make adjustments that respond to the current stage of liberalisation of electricity markets in Europe. The 250 MW Wind Programme was focused strongly on the demonstration of technologies to deal with technical barriers and includes an ambitious data collection activity on the technical and operating performance of wind turbines. Investment targets have been achieved at much higher levels than originally expected and a substantial equipment manufacturing industry that competes internationally has been developed due to the combined effects of the 250 MW Wind Programme and the EFL/REL. The contracting phase of the programme was completed at the end of 1995; the closing date for the whole programme is scheduled for 2006.

A long-standing renewable energy programme in Austria was motivated in part by the objective of supporting agriculture. A significant amount of the financial resources for the ***Deployment of Biomass District Heating*** (CS1) has come from the federal agriculture ministry. Started in 1980, more than 500 district heating plants that use wood chips, industrial wood waste or straw as fuel were established by 1999. Plants operate at levels between a few hundred kW and 10 MW; about two-thirds have power less than 1500 kW. Subsidies provided for agricultural co-operatives usually included a soft loan and a direct subsidy, with net-cash-value amounting to about 50 percent of the total investment-costs of the project. Commercial operators of district heating plants were eligible for a 30 percent subsidy from the environment ministry. Indirect financial support was available from a 50 percent reduction in the value-added tax on wood. Surveys have shown that customer support for these plants was strongly influenced by the environmental benefits involved and by a desire to support local agriculture and self-sufficiency.

Fossil-based Technologies

The case studies convey the impression that making progress on fossil fuel technologies has called for work on fundamentally new concepts.

In some respects the challenges in this area have had more to do with classic industrial R&D, rather than with developing markets for technologies that are close to being ready for the final buyer. Energy resource exploitation and conversion, rather than end-use services, are the focus of attention. Three programmes were reported on: two from the United States that provided support for a range of technologies and one narrowly-focused programme from Finland on the development of a new type of diesel engine. While all three are about R&D programmes, they illustrate that innovation is not a linear process – effective support at the R&D stage must take account of market needs to be satisfied in later stages.

Case Study 16 is on an American programme for ***Unconventional Natural Gas Exploration and Production***, which was first started in 1978 when the "gloomy, almost crisis-like outlook for the future of domestic natural gas in the late 1970s set in motion a set of national-level initiatives for adding new gas supplies." The programme was a combination of support for R&D and direct price and tax incentives for exploration and drilling. This included tax credits and the deregulation of well-head prices for natural gas from selected sources during the period when gas prices were in general regulated. Production of unconventional gas responded strongly to these incentives. In 1998 it accounted for 4,500 Bcf of supply, up from 1,500 Bcf when the programme started. Proved reserves of unconventional gas are 52 Tcf, up from less than 20 Tcf. At the end of this case study the authors set out an interesting list of 'lessons learned' from USDOE's experience with R&D policy in relation to the exploiting unconventional gas.

The US ***Clean Coal Technology Demonstration*** programme (CS18) is a huge R&D effort based on government-industry partnerships, so far funded by more than $5.6 billion of investment shared by the federal and state governments and industrial corporations. The programme is an example of the technology procurement approach discussed above, but in this case focused more strongly at the R&D level and carried out on a much larger scale than the examples in the end-use area. Starting in 1985, it has been implemented by way of five competitive bidding

solicitations. It "is a partnership in which the federal government sets performance objectives, founded on national environmental concerns, and asks industry to respond with technical solutions." Several successful technologies that went through CCT demonstrations are noted in the case study; some of these are still pre-competitive, some have had national and international sales volumes of several billion dollars. The case study illustrates how success in deployment programmes depends strongly on learning from early experiences and on the early involvement of key stakeholders, in this case major corporations in the coal and electricity sectors.

Case study 5, ***Diesel Engines for Combined-cycle Power Generation***, was built around the decision of a Finnish company specialising in diesel engines for marine use to pursue the development of a diesel concept that would be suitable for electric power plants. The requirement was thus to have an engine that can compete with gas turbines as prime movers in either single-cycle or combined-cycle power plants. A major technical barrier that has had to be dealt with is the recovery of waste heat, which leaves traditional diesel engines in ways that cannot be easily recovered for the secondary generation of power. The programme is currently in the demonstration stage with a 38 MW pilot plant. For large power plants, fuel efficiencies of 55 percent and above are expected.

Technology Transfer

National experience with market development policy can be applied to transferring knowledge across economies and some IEA countries have undertaken programmes of this kind. Two of them are reported on in the case studies. Case Study 14 from Sweden, ***Environmentally-Adapted Energy Systems in the Baltic Sea Region***, reports on an effort to assist the Baltic states in making their energy systems more efficient and environmentally benign. Its main focus has been on converting heat production plants to the use of biofuels, reducing heat losses in

district heating systems and improving energy efficiency in buildings. In form it is an assisted-loan programme. Much attention is paid to designing projects so that the loans granted will be self-liquidating. This has meant choosing projects that will be economically beneficial but have been held back due to classic market barriers (e.g., lack of knowledge and technical expertise, insufficient sources of finance, etc.). A substantial learning experience has occurred, since the local management of many small projects often had no experience of the discipline of loan management, nor of other aspects of contracting in a market environment. While project contractors in the early stages of the programme were typically Swedish, with the experience gained from the programme, companies in the Baltic states are now becoming prime contractors.

Case Study 22, ***IEA/SolarPACES START Missions***, was prepared by an IEA cooperative R&D programme, *SolarPACES*, which stands for Solar Power and Chemical Energy Systems. *START* stands for *Solar Thermal Analysis, Review and Training*. Under the programme, an international team of experts visits a host country that has favourable solar conditions with a view to identifying promising opportunities for solar thermal power generation and assisting local personnel in the exploitation of these opportunities. Activities include technology analysis, assisting in the definition of feasibility studies, the search for financing and other developmental issues. START missions carried out in Egypt, Jordan, Brazil and Mexico are described in the case study report. The first START mission, to Egypt, has contributed to tangible results. It served as an information base and a source of independent expert evaluation for Egypt's subsequent successful application to the World Bank's Global Environment Facility for support of the construction of a 130 MW hybrid thermal electricity plant.

CHAPTER 3: A RESEARCH, DEVELOPMENT AND DEPLOYMENT PERSPECTIVE

The process by which a technology is taken from the stage of exploring a new application of scientific and engineering ideas, through the development of new equipment, and on to the market is long and complex. It is cyclical rather than linear, though it is often described as if it were linear. Decisions made throughout the process influence the likelihood that a technology will be accepted in the market. In the latter stages, when a technology is being readied for the market and used in actual market settings, the two-way feedbacks between market experience and further technical development are especially important. Market prospects are the most vital stimulant of industry R&D and the deployment of technologies is a key source of information on them. Researchers and developers understand that market development and technology development go hand in hand and this explains why they are interested in deployment issues. Because it captures this organic connection, we have labelled the first of the three perspectives we discuss in this book the *research, development and deployment perspective* – the 'R&D+Deployment perspective' in short form.

The Double Effect of Market Deployment

Investment in cleaner energy technologies in competitive markets has two positive effects. First there is the direct impact on the production and use of energy, which makes the energy system more efficient and cleaner. This is typically the effect directly targeted by governments. The deployment of new technologies also leads market actors to learn how to produce and use them more cheaply and more effectively. It is the combination of the *physical effect* and the *learning effect* that creates the real impact of energy technology deployment programmes.

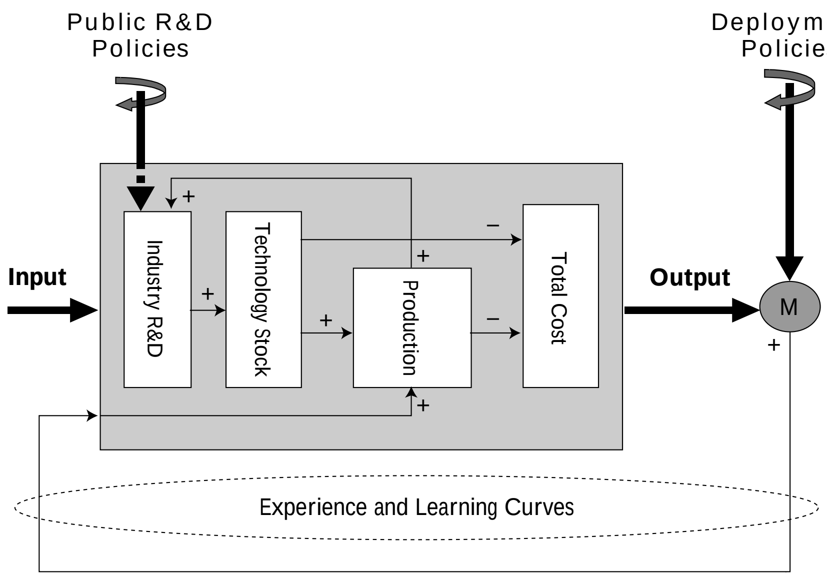
The case studies that provide the source material for this book illustrate these two effects and their roles as guiding principles for the design of successful deployment programmes.

The immediate physical effect may be reduced energy use for the same service, less emissions, higher comfort or reliability, and revenues for the investor. The achievement of these sorts of beneficial effects is usually the primary rationale for government-run technology deployment programmes and growth in sales and market penetration therefore become key indicators of successful deployment programmes. However, in many instances that view is too narrow; it neglects the importance of the link between deployment programmes and private sector decisions to invest in the market learning process. Decision makers in industry may judge the initial costs of market learning for a given technology to be too high and involve too much risk. Though scarce public resources are not sufficient by themselves to bring a new technology through even the early parts of that process, effective government-supported deployment programmes can play a crucial role in encouraging private investment and activating learning processes among market participants.

The rationale for this argument is depicted in Figure 3.1, which summarises how public sector and industry R&D interact to produce a 'virtuous cycle' in which government support encourages corporations to try out new technologies in genuine market settings (Watanabe, 1995 & 1999; Wene, 1999; OECD/IEA, 2000). The two vertical arrows represent the encouragement for industry R&D and production with a new technology brought about by government policies. Expanded output and sales stimulate the 'plus' cycle in the diagram: industry R&D increases further, which enhances the technology stock, which in turn further stimulates production. The production increases also stimulate the learning process and the 'minus' cycle in the diagram, resulting in reductions in the cost of production. This further stimulates sales and the cycle reinforces itself. The figure also indicates the role of experience and learning curves, which will be discussed later in this chapter. They provide a quantitative measure of market learning

and the efficiency of the feed-back from market experience ("M") to production and industry R&D, which leads to cost reductions and improved technology (Wene, 1999; OECD/IEA, 2000).

Figure 3.1. Influences on the Learning System from Public Policies



Source: OECD/IEA (2000), p. 29.

Through this process the learning effect manifests itself in succeeding generations of the technology, with associated reductions in product prices, better technical performance and improved or innovative methods of marketing and application. The technology may become attractive to additional suppliers and products produced with it will account for larger and larger segments of the market, thereby increasing the physical effects of deployment. For new technologies, improvements in cost and technical performance from one generation to the next may be substantial; in mature technologies learning usually manifests itself in better marketing and new applications of more energy-efficient and cleaner variants of the technology.

In the context of this book it is important to emphasise that while public sector R&D is important, it cannot directly bring about the cost reductions that will make the new technology competitive in the market place. "The outstanding feature of this internal learning process is that there is no virtuous cycle and no substantial cost reductions without market interactions" (OECD/IEA, 2000, p.30). Thus to provide a pay-off, the results of public R&D have to enter into the internal industry R&D process. This constitutes a powerful argument in favour of government support for technology deployment – if government is supporting research, it should also be supporting deployment.

From Public R&D to Market Learning

"I don't see how this can work." The Treasury man was sounding more than a little sceptical and was making Anna, who would lead the new programme if it got approved, apprehensive. "I agree," he continued, "that a big pilot project would improve efficiency and do a lot for getting us off the hook on CO_2 reductions. But to me the project itself looks like pie in the sky. Getting that amount of market push would take big money from the taxpayers. The subsidies would go on forever. You said yourself that this technology still doesn't compete on cost and I don't see anybody beating a path to the developer's door to buy the thing."

Anna's boss looked at the three other people around the table and stepped in – more quickly than he should have – to wind up the discussion. "Obviously the people at the lab are going to have to work more on how to get the new technology into operation. I'll suggest to my Director-General that he go to the R&D budget committee with a proposal for another stage of development work."

Anna shook her head. "No. Government R&D money has brought the technology this far but it can only do so much. At some point there has to be industry involvement. They have to get some experience from

actually using the technology and they have to try out a little corner of the market. Then they'll be able to get the product design right, costs will fall, and they'll get some feel about how to approach customers when they do a large-scale launch." She looked across the table at the industry consultant. "I think you people in the industry understand how market learning reduces cost and helps to line up market players who can make the thing work. You are the people who can use a project like this one to set the stage for big market acceptance."

The industry consultant took a deep breath. He knew she was expecting him to turn the argument. How to sum up 200 years of industry experience with developing and selling new technology? Should he start with the reflections of the old clock-makers from 1866, airplane development since 1936, or maybe get more abstract and talk about the rich literature on organisational learning from the management science people? No. Not that way. Short-and-sweet is better. "Yes, it's true," he started, "market experience does reduce cost and improve performance, not only in the equipment, but also in lining up the whole distribution chain ... the wholesalers and retailers, and the service people. In fact, my company clients view such learning as a key strategic factor when they launch new products. We know that we have to price below cost for a while, but as we get experience, cost drops below price and the cash starts flowing in. And we've found that your market facilitation programmes make a big difference. Your consumer information efforts give us legitimacy with the customers; and it's great to get the product standards and energy efficiency labelling edited so that the retailers aren't afraid that they're doing something wrong. All that kind of stuff makes a big difference. Working together like that, it should be possible to phase out the subsidies right on schedule."

The man from the Treasury hesitated. Industry arguments carried weight at the Treasury. He glanced at his watch – still an hour before lunch. "OK", he said, "let's go over the highlights of the new deployment programme one more time."

Two Types of Learning

It is useful to distinguish between the different aspects of learning that a deployment programme may trigger.

Technology learning refers to the progressive reduction in costs and prices and the improvement in performance shown by all technologies as they are adopted through market processes (OECD/IEA, 2000). Most programmes that aim to reduce cost and technical barriers in the way of greater use of a technology focus on technology learning. Initial adoption of the technology in niche markets, and the prospects of larger markets in future, stimulate additional R&D by industry. At the same time, learning-by-doing and scale economies as more output is produced lead to product refinement, lower costs and larger market opportunities. Subsidies to increase market volume stimulate technology learning and technology procurement programmes, labelling and standards may also target technology learning.

There are also other types of barriers that may hinder market expansion for those technologies that are already technically mature and cost-efficient – barriers related to information flows, standards, transaction costs, financing and the organisation of markets (OECD/IEA, 1997a and 1997b). *Institutional* or *organisational learning* refers to an increase in an organisation's capability for effective action (Espejo *et al*, 1996). Applying that idea in this context, market deployment leads to organisational learning for the company developing and promoting a technology, as it learns how to overcome those barriers that are not directly related to the cost or performance of the technology itself. At the same time, the other market players (consumers, intermediaries, governments) also have the opportunity for organisational learning, but in this case the organisation being referred to is the market itself. As a new technology is deployed, the potential returns from a technology and the need to adapt to its characteristics can lead to changes in the behaviour of market actors, which in turn can affect market outcomes and the structure of markets. Examples of policies and programmes that may stimulate this type of learning are

information dissemination, labelling schemes and governmental actions that bring about changes in the organisation of markets for new technologies or services related to them.

The 22 case studies deal with a broad spectrum of technologies, organisations and policies. All of them point to the importance of learning processes. How deployment programmes can stimulate and improve organisational and technology learning in efficient ways is therefore a major theme in this book. We turn our attention now to the issues and challenges involved in doing that.

Creating Conditions for Organisational Learning

The reform of energy supply systems currently underway in many IEA countries and the increasing importance of new customer supply technologies demonstrate the necessity of organisational learning in the energy system.

Historically, increasing demands for energy in industrial societies have been satisfied by the development and growth of centralised energy supply systems. Over the last century, this system learned to evolve and adapt to major shifts in the fossil fuel structure, new technologies for extracting coal, oil and gas, and new centralised technologies for generating electricity (such as nuclear reactors and natural gas combined cycle turbines). Deployment programmes in these supply-side areas have typically targeted technology learning, leaving the responsibility for organisational learning to the market actors. However, the restructuring of energy supply markets on competition policy grounds has challenged the traditional division between the supply system and its customers. In addition, it has been driven by technology developments, such as modular technologies for electricity production. For instance, micro-turbines, fuel cells, photovoltaic systems and other renewable technologies can be installed and owned by the traditional customers of electricity systems; this supports a trend towards decentralised power production. This is imposing new

learning demands on both energy suppliers and their customers, as can be witnessed, for example, in the ongoing upheaval in the electricity markets of many IEA countries.

The case studies include classic examples of supply-side programmes focused on technology learning; e.g., CS16 on the exploitation of unconventional gas and CS18 on the demonstration of clean coal technologies, both from the United States. The Finnish study on diesel engines for combined cycle power generation (CS5) reflects the traditional emphasis on technology learning, but also points to the increasing involvement of energy users. Overall, however, there is a striking indication in the case studies of the new importance given to organisational learning. More than two-thirds of them deal with markets for end-use energy technologies or for decentralised energy production. All of these studies address organisational learning, though some more explicitly than others. Examples that treat organisational learning issues in direct discussion are the Austrian studies on Biomass District Heating (CS1) and the Thermoprofit programme (CS2), the Danish labelling scheme for buildings (CS4), the PV Covenant in The Netherlands (CS9), the Swedish effort to transform the heat pump market (CS13), the United Kingdom's Best Practices Programme (CS15) and the American programme of Industrial Assessment Centers (CS19).

Thus a first broad inference from the case studies is that governments in IEA countries appear to recognise, at least implicitly, the need to focus on organisational learning in deployment policies. This can be understood in light of the potential for improved energy efficiency through the use of new end-use technologies (many of which are well developed and ready for widespread use), the promise of modular and decentralised supply technologies and the widespread interest in regulatory reform. Transforming energy systems and markets to facilitate these changes may require major changes in the way market actors do their business, changes in the relations among them, and in some cases the emergence of new types of actors. Technology learning remains important because sustainable markets for new technologies

ultimately depend on cost reductions. But issues such as the need for information dissemination, market restructuring and changes in consumer behaviour – which are hugely complex – are also important and they call for a new emphasis on organisational learning.

Some case studies illustrate policy tools that can stimulate technology and organisational learning simultaneously. Technology procurement programmes provide excellent examples of this possibility (as illustrated by Case Studies 12, 13, 17 and 21) because they bring together technology developers, customers and intermediaries in the chain of supply. This provides for 'concentrated learning' by all parties – producers use the customer feedback to tailor and refine the product; customers learn how the product can create value and opportunities for them; and intermediaries learn about both the product's advantages and the customer's needs, and therefore how to market and support the technology effectively.

Two additional observations relevant to organisational learning emerge from the case studies. The first observation refers to *stakeholders*. The roles of all of the stakeholders in a technology market development programme must first be analysed and understood. Representatives of relevant groups generally need to be actively engaged in the programme, in some cases even in the design phase. As a programme evolves, relations to other stakeholders may be revealed and these new stakeholders should then be brought into the programme. The Austrian Biomass-District Heating (CS1) and the Danish Labelling Scheme for Buildings (CS4) provide clear illustrations of how the success of a programme depends on stakeholder identification and engagement. They also illustrate the need to revise programmes as new organisational issues emerge.

The second observation refers to the need for *relearning*. Involving the end user in the technology deployment and development process and changing the traditional boundaries between supply and demand require major changes, not just in routines and procedures familiar to market actors, but also in the models and concepts that underpin decisions. Basic ideas on 'How we do business around here' may have

to be re-evaluated, for example in the shift from centralised to decentralised power generation. Where a cleaner energy technology brings with it these sorts of 'paradigm shifts', changes in other policy domains may be necessary, notably taxes, labelling, product standards and, in the case of distributed generation, electricity market rules. However, the case studies also indicate that it is not sufficient only to change these broader policy settings; more directly targeted measures may also be necessary, such as targeted information programmes, employee training and focused technology procurement programmes.[4]

Relearning usually requires changing some fundamental processes. The literature on organisational learning makes the distinction between *single- and double-loop learning*, as depicted in Figure 3.2 below. Single-loop learning focuses on 'How to do things better'. For instance, it could involve observing the effect of putting a product on the market and then correcting production processes and routines in order to fulfil business goals. However, in a learning organisation, sensitivity to new phenomena in the market will activate a second learning loop in which the organisation's goals and the way it does business are questioned. Instead of asking 'How to do things right?' they will ask 'How to do the right things?'. Relearning is part of a double-loop process because the activities in the second loop must build on what is observed through the first loop.[5]

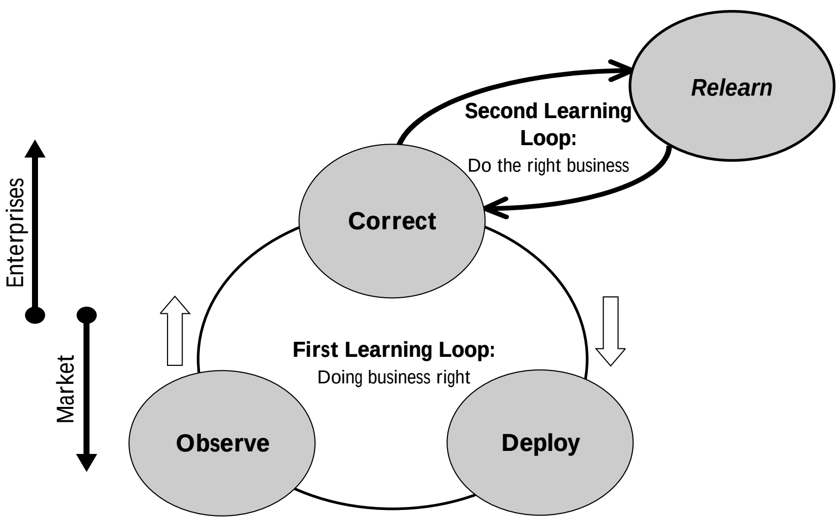
Relearning in this double-loop sense highlights two issues involved in deployment programmes. First, a successful deployment programme is likely to have the effect of stimulating relearning, since the product itself is likely to evolve in response to feedback from the market. Such relearning cannot be taken for granted, however, and may need to be facilitated by the deployment programme. For instance, using the scheme in Figure 3.2, a procurement programme could directly

4. CS1 and CS4 can again be invoked as examples of targeted measures, as can the procurement case studies: 12, 13, 17 and 22.

5. See Espejo *et al* (1996) and Morgan (1986). The latter finds that an efficient first learning loop may actually hinder relearning: "... it is interesting to note that highly sophisticated single-loop learning systems may actually serve to keep the organization on the wrong course, since people are unable or not prepared to challenge underlying assumptions." (p. 90)

influence the 'Deploy' activity[6] (by providing a market pull). Changes in standards and labelling requirements could affect the 'Observe' activity[7] (by influencing the choices of customers), and fiscal measures could affect the 'Correct' activity[8] (by influencing financing decisions and profitability thresholds). The challenge for the programme designer is to find the mix of policies and measures that prompts the enterprise and the market to reconsider their habitual ways of doing business, in order that the benefits of the new technology can be expressed and valued.

Figure 3.2. Double-loop Learning – An Adaptation and Modification of a Model in Morgan (1986)



6. The procurement programmes in Case Studies 12, 13, 17 and 22 focus on the market deployment activity. The Motor Challenge and BestPractices programme, CS20, also focuses on the 'Deploy' activity and explicitly recognises "the challenge of changing ingrained business and engineering practices among end-users and vendors without the use of grants, rebates or other direct financial incentives."

7. One of the speakers from industry at the '*Technologies Require Markets*' workshop provided an illustration of how a company's awareness of change that will come about as a result of a deployment programme prompted relearning. The European Union's labelling scheme for cold appliances made the leading firm in that industry change its business strategy. It stranded investments on a product about to be launched in order to free up resources to develop a new product with a higher efficiency. This product was launched one year later.

8. E.g., as in the Dutch programme for renewable energy in CS11.

The second issue highlighted is that several different market actors may have to go through a process of relearning in order for the new technology to be fully accepted. For instance, changes may have to occur in a multi-stage distribution chain or new relations may have to be developed between independent entities that interact through the market.[9]

The need not only to stimulate, but also to align the relearning process among different organisations, presents a great challenge for the designers of a deployment programme. Obviously it is desirable to rely where feasible on the ability for self-organisation inherent in a well functioning market. This can occur in a situation in which market conditions favour a desired transformation and the deployment programme is needed only to act as a catalyst. Where aligning the relearning process is necessary, interaction with and among existing or would-be market actors has to be a part of the deployment programme. Such interactions can take many forms. The programme may use or foster 'champions' among market actors, who could then act as agents of change.[10] It may help to develop new frameworks for communication between stakeholders, either through direct contact or by way of market devices (e.g., competitive bidding for a guaranteed sale).[11]

The framework for thinking about organisational learning comes from the literature on management science. Though the ideas can appear rather abstract at a general level, the organisational learning concept can have a practical impact because it draws attention to the need for management systems that are open to change and the need for entrepreneurs and policy-makers to view innovation as a continuing process. Of course, the practical details ultimately have to be faced if deployment programmes are to encourage organisational learning. This requires attention to the details of how markets operate and how buyers make decisions. These kinds of issues are discussed further in the chapters on market barriers and market transformation. In

9. E.g., CS12 and CS13 stress the importance of involving retailers, installation and maintenance firms.

10. Case studies 1, 6 and 19 provide examples of such strategies.

11. CS10 provides an example of the establishment of a new forum for market actors. CS13 involves competitive bidding.

combination with those two perspectives, the organisational learning model contributes to the effective design of deployment policy.

Providing Opportunities for Technology Learning

There is overwhelming empirical evidence that deploying new technologies in competitive markets leads to *technology learning*, in which the cost of using a new technology falls and its technical performance improves as sales and operational experience accumulate. Experience and learning curves, which summarise the paths of falling technology costs and improving technical performance respectively, provide a robust and simple tool for analysing technology learning.[12] Viewed from the R&D+Deployment perspective, the curves provide a method to set targets and monitor programmes; this includes a way of estimating programme costs and providing a guide to phasing out programmes as technologies mature and no longer require the support of deployment measures (OECD/IEA, 2000, pp. 45-74).

The shape of the curves indicates that improvements follow a simple power law. This implies that relative improvements in price and technical performance remain the same over each doubling of cumulative sales or operational experience. As an example, Figure 3.3 shows that the prices of photovoltaic modules declined by about 20 percent as each doubling of sales occurred during the period between 1968 and 1998 (Harmon, 2001). Thus the *learning rate* for PV-modules on the world market is 20 percent.[13]

The case studies provide several examples of how deployment programmes have led to technology learning. During Japan's

12. For more detailed discussions, see Boston Consulting Group (1968); Abell and Hammond, (1979); and OECD/IEA (2000).

13. The experience curve is described by the following expression:
Price at year t = $P_0 * X^{-E}$,
where P_0 is a constant and X is cumulative sales. E is a (positive) experience parameter and the learning rate = $(1 - 2^{-E}) * 100$. Experience curves refer to prices; learning curves refer to technical performance.

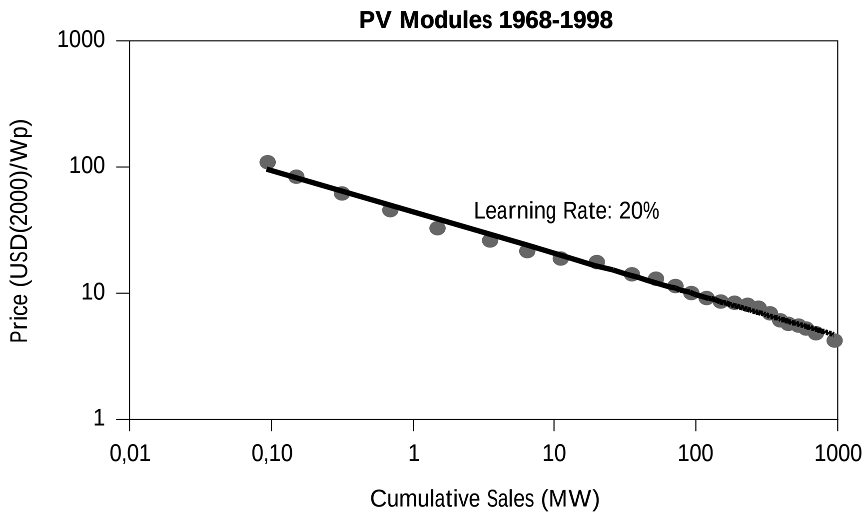
programme for residential PV-systems, costs have been reduced from 30 US$/Wp to 7 US$/Wp;[14] in the case of wind turbines in Germany costs have been reduced by 50 percent.[15] Prices of electronic ballasts were reduced by 30 percent during the Swedish market transformation programme on lighting.[16] The observed learning rates are consistent with measurements from other sources, indicating 18-20 percent for PV-systems, but more modest values of 4-12 percent for wind turbines (Neij, 1999, Durstewitz and Hoppe-Kilpper, 1999) and ballasts (Iwafune, 2000). The tripling of markets for heat pumps in Sweden (CS13) also indicates technology learning, but data are insufficient to draw conclusions about the learning rate (Schrattenholzer, 2001).

The evidence from experience curves draws attention to the need to provide *learning opportunities* for new technologies in markets for energy services. That typically means that a supplier of energy services will have to incur costs that are greater than those incurred when incumbent technologies are used. Figure 3.4 illustrates the point with the experience curve for photovoltaic modules. For photovolvaic systems to compete against currently used technologies in central power stations, the cost of modules has to be brought down to 0.5 US$/$W_p$, indicated by the horizontal line marked 'Price competition with incumbent technology' in the diagram. The experience curve represents the price necessary for a producer of PV modules to cover the cost of production; however, in markets dominated by the incumbent technologies the producer will not obtain this price. Thus the shaded triangle represents the extra cost, *learning investments*, that will have to be covered from other sources if the market for PV-electricity is to expand and the cost of production with PV is to fall to the level of the current market price – the break-even point in the diagram.

Figure 3.4 indicates that a very large amount of learning investment will be needed to bring this technology to the break-even point based

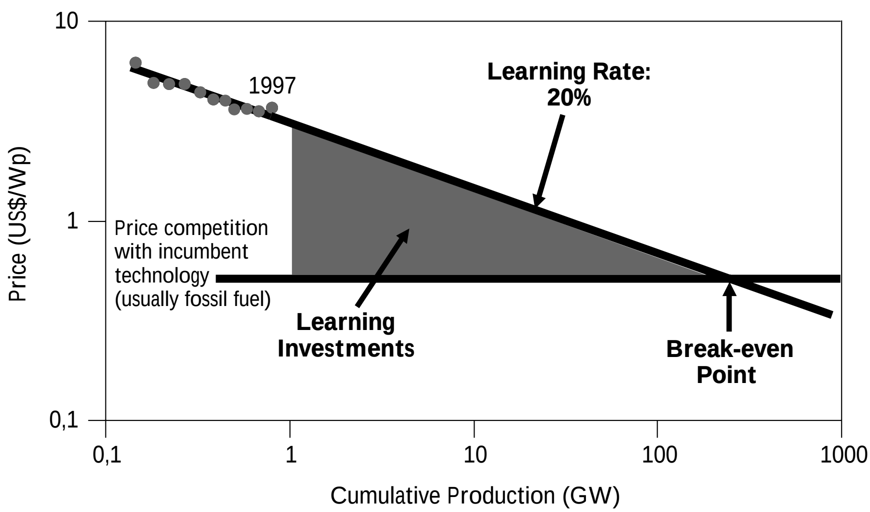
14. CS8. See also OECD/IEA(2000), pp. 64-74.
15. CS7. See also OECD/IEA (2000), pp. 52-64.
16. CS12. See also Schrattenholzer (2001).

Figure 3.3. Thirty Years of Technology Learning



Source: Adapted from Harmon (2001).

Figure 3.4. Making Photovoltaics Break Even



Source: OECD/IEA(2000).

on the fossil fuel technologies presently used to produce electricity from central power stations.[17] Estimates range between 50 to 100 billion US dollars. At current growth rates, 25 years of investment in learning will be required to reach the break-even point.

While some other technologies can be pushed to the break-even point for less than the amount needed for PV, it is clear that large sums of money are needed to finance learning investments. Will they come from investors in the private sector or government? The answer is both. The important point here is to be aware of the issues involved in efforts by government to activate private funding of learning investments and shorten the time horizon within which a technology will be considered a commercial endeavour. In the following section we will discuss how niche markets attract private investors and provide stepping stones to large-volume commercial markets, but first it is useful to consider some general implications of technology learning for the relations between deployment activities in the public and private sectors.

As a matter of course, the private sector finances investment in some new technologies that have not yet reached the break-even point (for example, through venture capital). This can be understood in the terms of Figure 3.4 by recognising the implications of the experience curve continuing to the right of the break-even point. The expectation is that the cost of using a new technology will fall below the current market price. Since incumbent technologies may still account for the larger market share, they will determine the market price for the energy service produced and the new technology will begin earning net profit

17. Figure 3.4 can be used to provide a more precise definition of learning investments for the case of an emerging new electric technology without fuel cost, such as PV. The specific learning investment, LI, per kW of capacity is

LI = P(new) – [8760*r*p(market) – O&M]/annuity,

P(new) is the price per kW for the emerging new technology at the time of investment and p(market) is the price per kWh of electricity from the currently cost-efficient (fossil fuel) technology. r is the load factor and O&M are the operation and maintenance costs at the break-even point for power plants with the new technology. The second term is the break-even price. More detailed calculations of learning investments therefore require databases with time series not only of technology prices and installations, but also of market prices and interest rates. Compare the assumption of a constant break-even price made in the figure with the curve for fossil fuel technologies in OECD/IEA(2000), Fig. 1.5, p. 21. (See also the following footnote.)

that recovers the learning investments.[18] However, existing firms tend to prefer incumbent technologies. Even if they are aware of opportunities for technology learning, they will often be cautious about investing in them and possibly for good reasons from their viewpoint. They may view the learning rate and the associated time path of learning benefits as too uncertain; and any given company may face the risk that some or all of the benefits of its learning investments can end up being captured by its competitors. Thus, if they make learning investments independently at all, they are likely to choose technologies that have already progressed substantially down the learning curve (though exceptions to this are plausible, such as in cases where new technologies have been developed through in-house R&D).

Government deployment programmes that provide assistance or incentives for private investment can thus make a crucial difference for major new technologies in the energy sector. Furthermore, the tendency towards inertia on the part of market actors creates a classic case for action from government – an instance of what economists refer to as positive externalities. If private investors are not forthcoming to undertake learning investments in a technology that is judged to be market-ready, society will benefit if government (which may have a different risk profile and lower costs of capital) puts resources into encouraging and facilitating the investment in technology learning. For practical reasons governments are not in the habit of responding to this argument for just any technology, but in the case of new energy technologies that help to achieve the governmental goals of improving energy security and reducing greenhouse gas emissions, the case for action becomes very strong.

18. This point is made more complex when one recognises that incumbent technologies may still be benefiting from market learning. That is, the price line for the incumbent technology should perhaps be sloping downward; it has been made a horizontal line in Figure 3.4 merely for the sake of simplicity. However, accounting for this point does not change the general thrust of the argument. Some important incumbent technologies are old enough to make the assumption of a zero-learning effect reasonable. Where this is not the case there is still no problem with the argument because the logic of the experience curve implies that added sales reduce cost faster for the new technologies than for the old ones. Consider for instance two technologies with the same learning rates of 20%, but with cumulative sales of 100 MW and 100 GW respectively. For 20% reduction in price, the first technology requires 100 MW added sales, but the second requires 100 GW.

This argument of course raises complex questions about 'picking winners' and about how much cost governments should incur when it is not clear how large the future benefits will be and to whom they will accrue. This is a large subject and an exploration of it is beyond the scope of this book. As already noted, the case study project was focused on the design and implementation of successful deployment programmes and was not intended to cover the process leading to decisions to establish programmes in the first place. However, it is worth noting here that empirically-observed learning effects are helpful when benefit-cost analysis is used to establish whether there is a rationale for a specific deployment programme. Some benefit-cost analyses neglect dynamic effects of this sort, in which case these analyses will be biased towards locking in existing technologies and their variants.[19] As well, changes in a technology and organisational learning effects can bring about changes in the nature of an energy service, which means that price and cost observations for the new form of the service may not be directly comparable to prices and costs of the old form of the service. This can lead to inaccurate conclusions about the relative efficiencies of new and old technologies and could affect benefit-cost calculations.[20] Qualitative changes of this sort are also of interest because they can provide the basis for 'niche markets', as discussed in the next section.

Strategic Niche Market Management

Specific characteristics of new technologies can add value that makes potential buyers with special needs ready to pay extra for energy services produced with them instead of with incumbent technologies. Examples of characteristics that may provide the basis for a niche market are low emissions, modularity and compatibility of a new power

19. See OECD/IEA (2000) pp. 84-91 for a discussion on how technology learning may create alternative technology paths.

20. The role of benefit-cost analysis is discussed further in the next chapter.

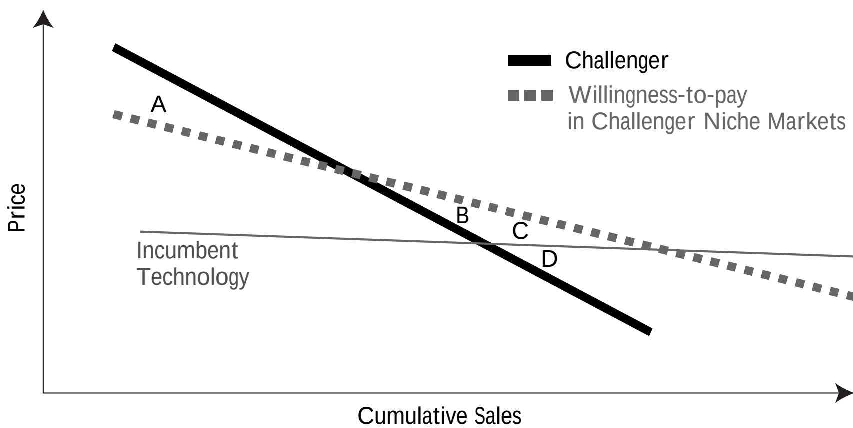
source with electricity load patterns on the grid. The niche markets may be small relative to the total potential for a technology, but they can be important from the viewpoint of providing learning opportunities. Making use of them in deployment programmes can help both to shorten the time before a new technology will be viewed as a viable commercial endeavour and provide a source of business funding for learning investments. Market leaders often use a niche market in developing a 'challenger' to an existing technology, viewing it as a stepping stone towards a mass market.

Figure 3.5 illustrates how a niche market can lead to earlier commercialisation of a technology and that the bill for learning investments can be split between public and private sources. Consider the following scenario. In the situation marked by 'A', the cost of the challenger-technology is still higher than the willingness to pay in the niche market. A subsidy can provide the difference between the actual cost and the price in the niche market. As demand at the upper end of the niche market is satisfied, the price on the niche market is reduced, but learning has also reduced the cost of providing the product. In situation 'B', cost is below the willingness-to-pay in the niche market and no public money is needed to finance learning investments, though it may still be necessary to assist with indirect support (e.g., labelling schemes and other information devices). In situations 'C' and 'D', the market leader may be in the enviable position of being able both to brand his products for a niche market that is very profitable (C) and to let one of his lesser brands feature a low-price version of the product that competes with the incumbent technology (D).

Creating and exploiting niche markets is an efficient strategy for a deployment programme, both to provide learning investments from private sources and to stimulate organisational learning among market actors. The 'Los Angeles initiative' to promote electric vehicles is viewed as a good example of strategic niche market management (Kemp, 1997). Labelling schemes can create niche markets which can be used by brand names to provide learning investments from the

consumer in order to develop their new products.[21] The case studies contain several examples of how niche markets are used to set in motion interactive learning processes and technology development. For instance, organisational learning by way of niche markets is discussed in CS1 on the Austrian programme for biomass in district heating and in CS3 on the Canadian Renewable Energy Development Initiative. Japan's programme on Photovoltaic Power Generation (CS8) provides an excellent example of how niche markets are used to share learning investments between public and private sources.[22] The Dutch PV programme (CS10) shows how niche markets can be systematically used to aid technology learning.[23]

Figure 3.5: Interplay Between Niche Markets and the Experience Curve for a Technology Challenging the Incumbent Technology in the Market



Currently one can find large potentials for energy efficiency improvements hidden in situations in which energy use appears unimportant to the

21. For instance, the European Union labelling scheme for cold appliances created a niche market for highly energy-efficient refrigerators. This market was exploited by the market leader (see also footnote 7). As a result, technology learning has made this originally very expensive technology available on the mass market.

22. See also Chapter 6, Figure 6.2 and OECD/IEA (2000), pp. 64-74.

23. Niche markets are discussed further in Chapter 5 and in the papers presented by the three Rapporteurs to the '*Technologies Require Markets*' Workshop.

individual decision maker, though it aggregates into a large amount of energy used by all consumers taken together (e.g., energy used for standby power in computers and other electronic appliances). From the energy technology perspective, the mass markets in such cases appear highly fragmented and the need for joint relearning among market actors is correspondingly large. The strong need for organisational learning and experimentation favours a niche market approach for deployment programmes in such instances. A good example is lighting, where energy savings come in very small packages which have to be bundled together to make a difference from a policy viewpoint. The two case studies on lighting, CS12 and CS17, indicate the need to start in small niches and ensure feedback for learning both to market actors and to the deployment programmes involved.

CHAPTER 4: A MARKET BARRIERS PERSPECTIVE

Introduction

To say that something should be done to encourage the adoption of new energy technologies is the same as saying that markets for them should be developed and encouraged to grow. When radically new technologies are involved, this will require developing market infrastructure and networks from the ground up. In other cases, involving less radical change through adaptation and improvement of existing technologies and system reorganisation, the transformation of well-established existing markets may be required. Similarly markets for energy services have to be transformed to account for changes in the character of services due to the use of new technologies. In regard to both the technologies themselves and the energy services produced with them, a wide spectrum of market types is involved. For example, regarding size, markets might be small in terms of the numbers of buyers and sellers (e.g., markets for new electricity generation technologies), though very large in terms of the amount of spending that flows through them. Or they might be enormous in terms of the numbers of buyers involved because a small new technology is sold directly to final consumers (e.g., markets for energy-efficient light bulbs).

Inertia is likely to be found in well-established markets based on conventional energy technologies that have been around for many decades. For a variety of reasons – such as ingrained consumer attitudes combined with the large expense involved in trying to change them or the advantages that existing sellers have if their technologies are based on costly capital infrastructure that has been paid for in the past – the market system may be sluggish when it comes to welcoming new products. In the 1980s and 90s, many proponents of energy conservation and diversification believed that normal market processes were far too slow at bringing about the widespread use of new energy technologies

that were urgently needed to enhance energy security and the environment. They suggested that this was due to various barriers in the way of the rapid market penetration of technologies that were obviously superior in their view and they advocated government action to reduce or eliminate them. Some economists responded to these arguments and a debate ensued. The economists did not dispute the existence of obstacles in the way of new technologies, but did disagree with the advocates of government action over the appropriate role of government in mitigating the barriers.[24]

Out of this debate came what we are calling the market barriers perspective, a view that focuses on the desirability of facilitating the adoption of cleaner and more efficient energy technologies, but by way of policies consistent with the underlying objectives and constraints of a market system. The objective of promoting energy conservation is still there, but subject to the constraint that the policy measures used to pursue that goal are economically efficient.[25] Put another way, it is the perspective that results when the barriers that tend to slow the rate of adoption of new technologies are identified and subjected to analysis within the framework of neoclassical economics.[26]

Market Barriers and Economic Analysis

The various market barriers that are viewed as important are by this time well known. Table 4.1 provides a summary list, along with some typical measures that are taken to alleviate the barriers. Note that a

24. See, for example, Sutherland (1991).

25. Economic efficiency is a rigorously defined concept that is the theoretical basis of most prescriptions offered by economists in regard to market-related issues. In a typical formal definition, an allocation of resources is said to be efficient if any reallocation would either leave everyone in the economy equally well off or would make someone worse off. The usefulness of such a definition resides in the way it throws light on situations in which resource allocation is *inefficient* and on the market conditions that are likely to be efficient, or inefficient as the case may be. How these ideas are worked out in detail can be found in any standard textbook on microeconomic theory or the theory of welfare economics.

26. Some portions of this chapter are taken from Kliman (2001), a paper on the market barriers perspective prepared for the "*Technologies Require Markets*" Workshop.

Table 4.1. Types of Market Barriers and Measures that can Alleviate them

<table>
<tr><th>Barrier</th><th>Key Characteristics</th><th>Typical Measures</th></tr>
<tr><td>Uncompetitive market price</td><td>Scale economies and learning benefits have not yet been realised</td><td>• Learning investments
• Additional technical development</td></tr>
<tr><td>Price distortion</td><td>Costs associated with incumbent technologies may not be included in their prices; incumbent technologies may be subsidised</td><td>• Regulation to internalise 'externalities' or remove subsidies
• Special offsetting taxes or levies
• Removal of subsidies</td></tr>
<tr><td>Information</td><td>Availability and nature of a product must be understood at the time of investment</td><td rowspan="2">• Standardisation
• Labelling
• Reliable independent information sources
• Convenient & transparent calculation methods for decision making</td></tr>
<tr><td>Transactions costs</td><td>Costs of administering a decision to purchase and use equipment (overlaps with "Information" above)</td></tr>
<tr><td>Buyer's risk</td><td>• Perception of risk may differ from actual risk (e.g., 'pay-back gap')
• Difficulty in forecasting over an appropriate time period</td><td>• Demonstration
• Routines to make life-cycle cost calculations easy</td></tr>
<tr><td>Finance</td><td>• Initial cost may be high threshold
• Imperfections in market access to funds</td><td>• Third party financing options
• Special funding
• Adjust financial structure</td></tr>
<tr><td>Inefficient market organisation in relation to new technologies</td><td>• Incentives inappropriately split – owner/designer/user not the same.
• Traditional business boundaries may be inappropriate
• Established companies may have market power to guard their positions</td><td>• Restructure markets
• Market liberalisation could force market participants to find new solutions</td></tr>
<tr><td>Excessive/ inefficient regulation</td><td>Regulation based on industry tradition laid down in standards and codes not in pace with development</td><td>• Regulatory reform
• Performance based regulation</td></tr>
<tr><td>Capital Stock Turnover Rates</td><td>Sunk costs, tax rules that require long depreciation & inertia</td><td>• Adjust tax rules
• Capital subsidies</td></tr>
<tr><td>Technology-specific barriers</td><td>Often related to existing infrastructures in regard to hardware and the institutional skill to handle it</td><td>• Focus on system aspects in use of technology
• Connect measures to other important business issues (productivity, environment)</td></tr>
</table>

Source: IEA (1997a).

list of this sort is not comprehensive and is not meant to suggest that the individual barriers are tight categories. The barriers overlap and there is interaction between them and their effects on decisions to invest in new technologies.[27]

According to the principles of market economics, government should intervene in the economy only in a situation in which the market fails to allocate resources efficiently and where the intervention will improve net social welfare. In the 'strong' form of this view, barriers in the way of the adoption of new technologies should be dealt with by government action only if they involve *market failure*. In those cases, government should intervene to correct the market failure (again, subject to the intervention increasing net social welfare). Once this has been done, according to the market barriers perspective, government should leave decisions on the purchase of new technologies to the private sector.

Thus one has to consider to what extent the barriers identified involve market failure and whether there are any qualifications to the market failure argument. There are three levels to this consideration.

Market Failure in Relation to Typical Market Barriers

Some of the market barriers shown in Table 4.1 – such as the cost of collecting information and administering market transactions, the risk of product failure, the high cost of finance for small borrowers, and others included in the table – are normal and inherent aspects of the operation of most markets and they should be allowed to influence decisions in energy markets just as they influence decisions in all other markets. That is, these barriers do not usually satisfy the market failure criterion because they involve necessary costs that have to be covered for all goods and services; the existence of the barriers themselves does not provide a reason for favouring new energy technologies, which

27. A fuller discussion than is possible here is necessary to understand them in depth. See, for instance, Hirst & Brown (1990), OECD/IEA (1997a), Ch. 1, and Reddy (1991).

should have to compete for investment dollars with everything else of value if resources are to be allocated efficiently. However, that is only a first step in making a judgement. Blanket judgements on these matters are inadequate because in specific markets these barriers may have characteristics that do cause market failure. A better understanding of the nature of market failure is necessary to explore this argument. While a thorough primer on the subject is not possible here, it is useful to sketch the general lines of argument.

Most instances of market failure involve *externalities,* which occur in a market transaction if any of the costs or benefits involved in it are not accounted for in the price paid for the product that is exchanged. If there are costs that are external to the market (i.e., the buyer does not pay some of the costs incurred in producing the product), a negative externality occurs. If there are external benefits, a positive externality occurs.

An example of a classic market barrier that can involve market failure is the cost and inconvenience to consumers of finding and analysing information about energy-saving equipment. Consumers require small amounts of technical knowledge to become aware that a useful new energy-efficient product is available and to evaluate the claims of competing brands. Given the administrative costs involved in large numbers of small market transactions, it is hard to imagine that such an information service would be offered exclusively by private firms through individual market transactions. Neither would potential suppliers of such information be very interested in such a market because they would know that the consumer who buys such information could so easily pass it on to others. Thus too little of this kind of information service would be provided relative to the benefit of it to consumers. These factors rationalise the involvement of government agencies in disseminating information on energy efficiency.

Certain aspects of a market's structure may lead to inefficiency. For instance, a firm with monopoly power may be able to fend off competition from a new technology. In some countries or local

markets, suppliers of financial services may not face much competition and this can result in unnecessarily high interest costs for financing purchases of energy-saving equipment.

One can see that government action is likely to be warranted in the case of some market barriers and not in others. In some situations dealing with barriers in a pragmatic way can be a matter of making sure that normal aspects of market infrastructure (e.g., consumer-protection laws, laws of contract) are working well in markets for energy technologies.

Second-best Solutions to Market Failure

There is also a more general argument that favours some level of support for new energy technologies that reduce air pollutants and carbon emissions. The logic of the market failure argument calls for the internalisation of market externalities. For instance, higher taxes on fossil fuels to internalise the external costs of consuming them would encourage the use of better energy technologies. But it is quite unrealistic to expect governments to do this in relation to all externalities. Governments demand a high level of certainty about the results of such expensive policies before instituting them and it is very difficult to convince them of the benefits of internalisation, which will materialise gradually and in complex ways. This is especially so when the damages of externalities are not well understood (as in the case of climate change).

In such a situation other measures are legitimised. An alternative way to achieve some of the same effects is to have government support markets that would grow if the internalisation of externalities were to be achieved. Economists refer to this as a "second-best argument," meaning that certain interventions in the market may be desirable when the first-best solution of depending on efficient markets is not attainable.

This argument should itself be kept in perspective. It does not imply a *carte blanche* for government action in favour of technology market

development. If one pursues the implications of the argument, the problems associated with 'picking winners' have again to be dealt with and, even when there is a consensus about some technologies being winners, the question of how much government resources should be applied to reducing market barriers must be decided. Addressing that question calls for the use of benefit-cost accounting in evaluating proposed market development programmes, a subject discussed further below.

Market Barriers in a Dynamic Setting

For purposes of theorising, economists usually formulate the market barriers and market failure argument in a static framework. That is, to simplify the analysis of normal behavioural and structural issues of the kind we have been discussing, they hypothesise that certain things that may be in motion over longer periods are for the moment held constant. This includes technological change and the preferences of consumers for goods and services. Here we need to discuss both of these things. We should be focusing attention on *dynamic* issues as well as *static* ones.

A particularly relevant dynamic issue is the 'infant-industry argument'. It can be viewed as an earlier version of the market barriers argument that came out of the literature on international trade: a new industry (or market) needs protection from its competitors in other countries because it needs time to get on its feet. This view earned itself a bad name in some circles because, in practical terms, once an industry had protection from international competitors it worked hard at keeping it, and was often successful. The result was a long period of protectionism and the inefficiency that results from it.

Fortunately the institutional framework for government involvement in developing markets for new energy technologies is quite different from that which led to protecting domestic industries from foreign competition by way of legislated tariffs. Most funding for market development programmes is not open-ended; it comes directly from

government budgets and involves year-to-year approvals and auditing procedures. Programmes in support of specific technologies also tend to have various forms of 'sunset clauses', so that direct support for "infant technologies" will be eliminated when a market takes off or when the infant technology has had enough time to take off but demonstrates that it is not economically viable. There is evidence of this way of thinking in the IEA case studies.[28]

The infant-industry argument is important in this discussion because it indicates the potential for substantial positive externalities. A firm that invests in a learning investment produces knowledge that can potentially be used by other firms in the same industry or, depending on the nature of the new knowledge, in other contexts. Whether the knowledge constitutes an external benefit depends on the ability of the firm to claim proprietorship of it. It is not an externality if patents and other forms of protection allow the firm either to keep the knowledge for its own use or sell it at a market-determined value. If it cannot do either of these, the firm will tend to under-invest in learning investments. Such under-investment is another instance of market failure – the existence of an expected positive externality is another strong case for government support of learning investments.

Another dynamic issue that warrants attention is the influence that market activity has on consumer preferences and behaviour. The market model of economic theory pictures an efficient interaction between many competitive suppliers who cannot individually influence the operation of the market and many consumers, each of whom has a well-defined and constant set of tastes. This is often far from reality. For example, the idea that the sport-utility-vehicle arrived on the scene as a result of the automobile companies responding to independently determined demands for them is hardly credible. Energy markets are very often interactions in which the choices available to consumers and

28. See, for instance, the US study on unconventional natural gas exploration and development (CS16) and the Canadian case study on space and water heating and cooling (CS3). For further discussion of the infant industry argument as it relates to the case studies, see Kliman (2001), sec. 4.4.

the preferences they have in regard to these choices are very much influenced by product differentiation strategies and other marketing activities of suppliers. When this occurs, especially in combination with the external effects of energy production and use, there is a strong case for governments to be involved in helping to build workably competitive markets for new energy technologies; and especially a strong case for governments to disseminate information on the implications of consumer decisions for energy consumption.

Applying Economic Analysis

The above discussion indicates that the market barriers perspective has come to be interpreted as being about economic efficiency. Governments should undertake programmes that reduce market barriers to the economically efficient adoption of new energy technologies. Achieving this goal requires policy designers to apply the tools of economic analysis in a practical setting. In addition to the abstractions discussed above, the messy details of actual markets, technologies, consumer behaviour and other complex phenomena have to be dealt with. One would hope that the IEA case studies could provide some insight from practical experience on whether and how this is done.

The issue is whether the policy successes claimed by the drafters of the case studies make good sense in market terms. For instance, have policy measures been designed in ways that make use of market processes and thereby in a competitive environment lead to results that are cost-efficient? Does it appear that units of a new technology are being sold because policy measures have overcome market barriers, as distinct from sales merely being 'purchased' by way of generous subsidies to buyers? Does it appear that policy measures will lead to the evolution of sustainable unsubsidised markets? Is there evidence that the relevant market information possessed by buyers and sellers is being enhanced by the policy measures? Where the infant-industry argument is motivating a policy measure, will it be phased out in timely fashion?

With some exceptions, these specific questions are not addressed directly in the case studies; the template was not designed to produce data that feed directly into the economist's analytical models. However, the studies do contain material that provides relevant insights and the overall impression given is that those responsible for designing technology market development programmes in IEA countries have paid a lot of attention to these kinds of questions. There are various sorts of evidence of this in the case studies: the use of performance objectives in order to leave more finely-tuned choices about technologies and how to market them to sellers and buyers; the attention given to the subtleties of market organisation and infrastructure that must be developed or adapted and to linkages between markets for related products; sensitivity to the view that information processes often involve public goods; the use of pricing to achieve policy objectives; and the use of benefit-cost techniques and other forms of audit in the operation of policy-related programmes. These observations of course apply to varying extents among the cases reported on. There is also a sense that policy design has been affected by when and where a policy was instituted. Later policies have benefited from the experience of earlier attempts at similar measures and national differences in political culture appear to play a role. But overall a market-oriented perspective is reflected in many of the case studies, as illustrated by the following observations.

Performance Objectives

One indication that policy designers understand the advantages of performance objectives as a policy tool is their use of the procurement model. It offers a classic framework for using competitive market behaviour to hasten the development and adoption of better technologies. The policy makers write a list of specific objectives for the technology concerned; the objectives may be both technical, in order to better adapt a technology to particular market needs, and commercial, in the sense of putting in place a suitable approach to marketing the technology. The specification list is then put out in a

competitive bidding process to equipment suppliers. The American report on expanding the market for compact fluorescent lamps (CS17), and the Swedish reports on high-frequency electronic ballasts (CS12) and heat pumps (CS13) indicate that procurement programmes can be highly successful. They also suggest that operating a successful procurement policy requires a lot of careful organisation.

Several other case studies contain illustrations of the use of performance objectives, including the Austrian Thermoprofit programme (CS2), the Dutch programme on domestic ventilation (CS9) and the American programme for unconventional natural gas exploitation (CS16). The Austrian programme involves energy performance contracting by building owners. The Dutch ventilation effort fits into a large framework defined by an Energy Performance Standard introduced in 1995. In the American case study on natural gas the authors note that, among the various lessons they learned from this policy experience, "Special purpose 'performance based' rather than broadly structured or 'input based' economic incentives are a key to success."

The desirable effects of performance objectives can be enhanced with the help of specially-designed market mechanisms. The Dutch policy on encouraging renewable sources of energy includes a tradable certificates scheme for the production of electricity from renewables. It started on a voluntary basis in 1998 and involved a set of targets for each distribution company for the amount of electricity they distributed derived from renewable sources. The producer of each unit of 10 000 kWh of electricity generated from renewables and delivered to the grid received a 'Greenlabel' certificate in addition to the electricity price. Distribution companies that did not distribute enough eligible electricity were able to meet their targets by purchasing these Greenlabel certificates from the generating companies. This leads to more competition in the supply of renewable-based electricity, favours the lower-cost suppliers and distributes the burden of subsidies for renewables more fairly. Operation of the policy has resulted in a new market for bio-energy. In 2001 the voluntary Greenlabel system was

replaced by a similar certificate system established on a legal basis and the marketing of green energy to final consumers in a liberalised market has been introduced.

Market Infrastructure

To function effectively markets must operate within a framework that is suited to the types of goods or services being traded so that it can effectively facilitate exchanges between sellers and buyers. Many of the requirements are obvious, some are quite subtle. A variety of things are involved; e.g., networks with suppliers of intermediate goods and services, the boundaries between producers of different components of a good or aspects of an associated service (i.e., the extent to which production and distribution processes are vertically and horizontally integrated), appropriate contracts and other legal arrangements, information channels, accepted standards and taxonomies. Arrangements of these sorts develop and evolve over time; in established industries traditional ways of doing things become engrained.

All of this has important implications for market development programmes. A new technology may require new kinds of arrangements and the market may have to be built from the ground up. Alternatively the technology may become one product option in an established market, but choosing it may require new ways of doing things and it may be difficult to entice market actors to adjust to its presence. Vested interests in the old way of doing things can be an important factor.

There is much evidence that programme designers are sensitive to these structural needs. Some of the case studies focus on classic aspects of establishing better markets; for instance, by establishing lasting systems of dependable information for buyers. An example is the Danish labelling programme for buildings (CS4). The seller of a building must have an energy audit performed by an approved consultant before the sale takes place. This results in an 'Energy Label' for the building, which provides information on energy and water consumption compared to other buildings with similar use, and

an 'Energy Plan', which documents the labelling information and sets out proposals for improvements in the building. The seller can make improvements before sale in the hope of getting a better price. In cases where that does not happen, the programme provides buyers with information on what needs to be done and a potential source of funds for doing it (the saving due to a lower building price). The overall effect is to make it more likely that market prices will reflect differences in energy efficiency.

The building sector is an especially good example of the need to pay attention to the nature of market structure. As noted in Chapter 2, it is very fragmented and this is in part the *raison d'être* for energy service companies, which provide specialised information gathering and analytical services for energy users. But the effective operation of the energy service market has itself been a challenge. The Thermoprofit programme (CS2), which originated in the Austrian city of Graz, was in part intended to improve the performance of energy service companies, while at the same time contributing to the overall effectiveness of information dissemination in the building sector. In various ways the Austrian case study reflects a sensitivity to the complexity of market processes and the need to find entry points for policy within existing market structures. It has taken existing energy service companies as a starting point and built them into a network. This facilitates information transfer, the availability of financial options, bidding procedures to assure cost controls, monitoring of results and certification. The inclusion of a quality label in the programme recognises the need to deal with market risk for building owners and introduces a potential for internal growth momentum, in the sense that more building owners and building-service consumers will become aware of the advantages of the programme as future transactions in building markets take place.

Programme Efficiency and Success

There is evidence in the case studies that much attention is now paid to designing programmes so that they will be cost efficient and monitoring them to ascertain whether cost targets and programme

objectives are being fulfilled. This is reflected in the structure and organisation of programmes and in the use of *benefit-cost analysis* (BCA) of various sorts in managing programmes.

In regard to programme structure, one important decision concerns the boundaries of different programmes; i.e., the grouping of various market development activities into coherent and efficient programmes. This will be affected by the nature of the product markets being targeted, the technologies involved and the specific nature of programme objectives. We have already seen examples of how the nature of the target markets can influence programme organisation. The fragmented character of building markets has led programme designers to group together promotional and market enhancement activities associated with a range of building technologies and in some cases to base programme mechanisms on performance objectives. In other situations it can make sense to structure programmes around specific functional and process objectives. When certain activities – such as information dissemination and education – are being done in high volumes, it makes sense to set up specialised units that perform these functions for a range of technologies and markets. Three case studies indicate that this kind of specialisation can be carried far and can be very effective: the UK's Energy Efficiency Best Practice Programme (CS15) and two case studies from the US – the Motor Challenge and Best Practices Programme (CS20) and the Industrial Assessment Centers Programme (CS19).

The report on the UK's Best Practice Programme also draws attention to the use of benefit-cost techniques in programme management. It notes that the activities it needs to do to persuade target organisations to use cost-effective technologies and management techniques must provide a benefit of at least £5 per year in energy saving for every £1 of programme cost. It also reports independent estimates in 1999 of total energy savings in excess of £650 million per year and the expectation that the current target of £800 million will be achieved. Another case study that reflects the application of BCA is the already-cited US programme on natural gas exploration (CS16). The programme

was run for the US Department of Energy by the Gas Research Institute, which was required by the Federal Energy Regulatory Commission to apply its benefit-cost techniques as a part of programme management.

BCA is part of this discussion because it is the economist's standard tool for evaluating government programmes in relation to efficiency in resource use, which is the central objective underlying the market barriers perspective. In this view, decisions on setting up programmes in the first place should be subject to a benefit-cost calculation and BCA should be used as a tool in the operation of programmes (e.g., to evaluate applications for grants in support of technology development or marketing). And if BCA has been used in this way, one might expect the approach to be used to report on the success of programmes completed or in operation. In some of the case studies this use of benefit-cost ratios to measure success is mentioned, but more often the reports refer primarily to physical measures as defined by programme objectives when discussing success (e.g., numbers of units of a new technology installed, numbers of energy audits undertaken, etc.). In general one can guess from reading the case studies that attempts at comprehensive BCAs have not been made in very many cases. Its use as a decision-making tool in the operation of programmes is probably more frequent, but in most of the reports there is not enough information provided to allow a judgement on how thorough the BCA calculations were.

In this regard it should be acknowledged that thoroughness in BCA can be very difficult because of the data requirements involved and that there are problems involved in its use in the present context. For instance, for a programme to reduce greenhouse gas emissions a classic BCA would include the assignment of monetary values for the benefits of emission reductions. Given the present state of knowledge, there would be a large element of arbitrariness in assigning such values. At the same time, one can be pragmatic about such limitations by taking as a starting point that the government has decided to pursue emission reductions and focus on the cost side of the calculation. That is, one can use physical measures defined by programme objectives to represent the benefit side and still be thorough about the calculation

on the cost side. It remains necessary to base decisions on the size and other aspects of programmes on coherent procedures of some kind. The BCA framework provides a systematic and transparent approach for doing that. It is possible to use it in a pragmatic way that sensibly recognises the limitations of the overall analytical model.

It is also useful to draw attention to the scope for more use of econometric techniques. This can be useful as an aid in setting programme parameters (e.g., the size of subsidies), as part of more thorough BCA, or simply to understand how effective programmes have been. For instance, a key issue is how to unravel the effects of market development actions from market growth that would likely have taken place anyway. When levels of adoption of a technology have increased during a period in which a market development policy has been in effect, it cannot be automatically concluded that these increases are attributable to the policy. This is often implicitly acknowledged by the presentation of various forms of supporting evidence. However, that evidence is often anecdotal and can be difficult to evaluate. Though econometric techniques themselves involve complex interpretation, they have the advantage of being based on a systematic analysis of statistical data.

There is no mention of econometric investigations in regard to any of the programmes reported on in the case studies. In one respect this is not surprising, since they require large amounts of data that can be costly to collect. Thus their use is a matter of background research and special studies. There is a need to do more of it – in some situations econometric analysis can provide answers to exactly the kinds of questions that policy designers need to know.[29]

29. A recent study provides an excellent illustration of what can be done with econometric techniques. In his study of the "Green Lights" programme of the US Environmental Protection Agency, Horowitz (2001) not only shows that this effort in support of the diffusion of fluorescent lighting ballasts was a very effective policy, he was also able to compare its effects with more piecemeal demand side rebate programmes. He finds that "... it is far more cost-effective to attempt to transform a national market through long-term coordinated coast-to-coast efforts that permit market preferences to evolve and mature, than it is to temporarily manipulate local markets through piecemeal programs that are highly variable from place to place and from year to year. In short, persistent efforts to educate producers and consumers and inform them of energy efficiency benefits appear to be more capable of building sustainable sales volume and market share than the alternative of financial subsidies." (p.121)

Where to from here?

To summarise the above discussion, according to the market barriers perspective, government should do something about barriers when they involve market failure and beyond that leave technology deployment to the market. 'Doing something' involves internalising externalities by adjusting market prices or by making changes in the organisation and structure of markets, including the background framework within which they operate.

The standard way of adjusting market prices to internalise a negative externality is to levy taxes that will force sellers and buyers of products to take account of costs that are external to the market. In the case of positive externalities, such as those that flow from learning investments, the pricing approach to internalising them calls for subsidies. The classic price-adjustment approach to internalising externalities is a powerful tool in some situations and impractical in others. The question of whether and how it should be pushed further in the context of energy use is important, though a subject that is beyond the scope of this book.

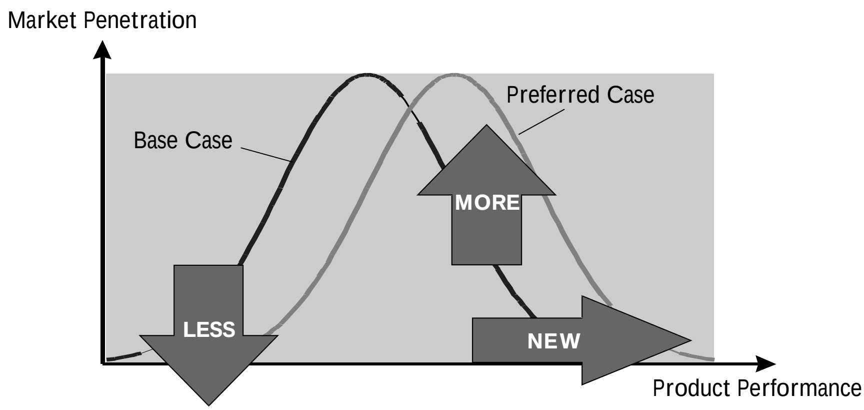
Much of what we refer to as deployment or market development policies falls into the category of adjusting market structure so that markets will operate well in relation to new technologies. Economic analysis is very helpful in identifying in fundamental terms the aspects of market structure that need attention, but provides only part of the framework and analysis needed for designing and implementing policy approaches to improving it. The practical side of the effort requires a much more eclectic approach. That comes with the market transformation perspective, discussed in the next chapter.

CHAPTER 5: A MARKET TRANSFORMATION PERSPECTIVE

What is Market Transformation?

The term *market transformation* has a particular meaning in the context of energy policy; it refers to a significant or even radical change in the distribution of products in a given market, in which the most efficient products substantially displace the least efficient ones. A *market transformation programme* refers to actions taken by government (or sometimes by some other entity acting in the public interest) to facilitate the market transformation process. In effect, the long-term objective of most such initiatives is to make an energy efficient technology or product-type the preferred 'norm' in a market place, whereas a more typical efficiency-performance distribution of the various product brands available in a market is represented by a normal curve with a lower mean performance, as illustrated in Figure 5.1.

Figure 5.1: Effect of Market Transformation on Product Performance



Source: Nilsson (1996)

As the use of the word 'transformation' suggests, the objective of a market transformation programme is to make changes that are both substantial and sustainable. An isolated instance in which a government supports the introduction of a new energy technology does not constitute a market transformation programme. Market transformation is about engineering substantial change in the market for a particular class of products: changes in the behaviour of consumers so that they choose to buy more efficient goods or services; changes in the behaviour of producers, so that they bring to the market only efficient (or at least more efficient) models; changes in the behaviour of wholesalers and retailers in regard to what they make available to final buyers; and changes in the capabilities of suppliers in related markets to provide whatever ancillary goods and services are needed (e.g., suppliers of equipment parts and other intermediate goods, installers, repair companies). When the process is completed, a successful market transformation programme will have had a lasting and significant effect.

An identifiable set of ideas about market transformation has taken shape over the last decade or so among people who have been involved in designing and implementing energy efficiency programmes. This includes contributions from people who have worked in demand-side management (DSM) programmes operated by electrical utilities.[30] As experience with the design of energy conservation programmes accumulated, practitioners began to see the need to make the results of their efforts more durable. To do this it was necessary to expand the horizons of their work, which tended to focus too narrowly on the energy end-use decisions of final consumers. Better results can be obtained by approaching the conservation issue in a broader context that takes account of both demand and supply in markets for the end-use equipment purchased by consumers. The idea took hold that those markets could be changed in ways that would lead consumers to more

30. Discussion of the development of ideas on market transformation can be found in Blumstein *et al* (1998) and other references listed there. Kunkle & Lutzenhiser (1998) report on case studies of market transformation as it evolved from its roots in the context of DSM.

often buy better end-use technologies, for example by working with equipment manufacturers to encourage them to market more energy-efficient products, establishing labelling schemes and taking other initiatives that affect the range of choices available to buyers as well as their knowledge base. By working on both sides of the market the potential for saving energy would be larger and the results more durable. These ideas spread and evolved and in the early 1990s a market transformation perspective began to emerge as a coherent framework for the thinking of those responsible for energy efficiency programmes.[31]

In this book the idea of a market transformation perspective is further expanded. In addition to its being a body of common understanding among those who work on energy efficiency policy and programmes, we see the market transformation perspective as fitting into a larger picture of what can be done by governments to help build markets for new energy technologies. In Chapters 3 and 4 we have shown how the R&D+Deployment and the market barriers perspectives are useful. In both cases, however, these perspectives draw limits around themselves. The R&D+Deployment perspective deals primarily with the implications of learning and the interactions between R&D and market development, particularly for the cost and performance of new technologies. The market barriers perspective identifies obstacles in the way of new technologies and suggests ways to deal with them that conform to the constraints of market economics, but does not deal in depth with how to implement change. Economic analysis is rich in insights about problems in existing markets, but does not say very much about the steps needed to tease new markets out of the entrepreneurial mechanism that creates them. In contrast, the emerging market transformation perspective focuses on the outcome to be achieved and then runs the logic back through all the factors that would be necessary to attain that outcome: improving technology cost

31. Of course, progress on the transformation of some markets for end-use equipment was made before the 1990s. For discussions of early efforts at market transformation, see Geller & Nadel (1994) and Tatutani (1995).

and performance and removing barriers, but also actively creating the conditions that facilitate the rapid market uptake of new more efficient products.

In a nutshell, the idea at the centre of the market transformation perspective is that people involved in technology deployment policy should think about what is needed to encourage the adoption of new products in the same way that private-sector suppliers think about it. That is, they have to understand in depth what makes the market for a new product take off, and then use that understanding to identify aspects of market structure and behaviour that affect product acceptance and also happen to be determined or affected by government actions. The idea is to apply the kind of expertise used by business to develop markets in pursuing the objectives of government policy in the energy sector. Unlike a business, however, the designer of a market transformation strategy is consciously pursuing a public policy objective; and therefore needs to exercise great care not to usurp the proper role of the market in 'picking winners' (and losers). They also must understand that market transformation actions involve risks; for instance, badly designed efforts could diminish choice and competition in the market, possibly leading to increased costs and a reduction in net welfare.

It is useful at the outset to recognise that there is a kind of tension between the market barrier perspective and the market transformation perspective. As we have seen in Chapter 4, the market barriers perspective has been formulated within the framework of neoclassical economics, which involves a strong focus on delineating the roles of government and decision makers in the private sector. Government has an important role, but the underlying value being promoted is that it should be kept to a minimum. This seems at odds with the very definition of the market transformation perspective, which assumes that governments should intervene to make markets work better. It is our contention – and both the IEA case studies and the background ideas discussed further in this chapter bear that out – that the two perspectives have to a great extent come to terms with each other and

that the tension between them is quite healthy.[32] Market transformation programmes involve governments in influencing market decisions, but an important aspect of the market transformation perspective has come to be an emphasis on designing that influence so as to interfere with normal market processes as little as possible. The objective is to affect private energy-related decisions by reducing market barriers, changing incentive structures, providing public information, and encouraging competition in the aspects of products that determine energy efficiency and emissions. Good market transformation programmes are about raising the profile of energy variables in market activities and making once-only adjustments to the background infrastructure in which markets operate; and doing that in ways that are consistent with a public-good approach to policy making in a dynamic economy. It is not about regulatory tribunals, price controls and other forms of intervention that have been overly used and therefore discredited.

Doing Market Transformation

Developing effective market transformation policies is straight forward in principle, but far from easy in practice. The straight forward principle is first to develop an understanding of the buyer-relevant characteristics (both positive and negative) of the technologies being promoted and the workings of the markets that will potentially be transformed; and then to identify strategies that would help to boost the positive attributes (including high energy efficiency) and overcome the negative ones (e.g., high purchase costs, a lack of a proven track

32. This does not mean that the two perspectives are based on exactly the same assumptions – they are not. One illustration of differing assumptions is evident in the importance of the objective of changing consumer behaviour in the market transformation perspective. The market barriers perspective is closely linked to economic theory. The economist's analytical model normally takes consumer preferences as given, which does not encourage focusing on them as a primary target of policy. Thus the market transformation perspective should not be looked on as being only about implementing policies consistent with market barriers perspective; it reflects some differences in thinking.

record, etc.). The practice is far from easy because products and markets differ in ways that might be well understood by suppliers but will not be easily grasped by policy practitioners who arrive on the scene with quite different backgrounds. Furthermore, as noted above, care must be taken not to interfere with the normally efficient aspects of market-based resource allocation.

In large part this challenge is dealt with through diligent and open-minded interaction with people involved in the target markets and by an openness to a variety of expertise. Market transformation practitioners need to be wide-ranging and eclectic in regard to the bodies of knowledge they draw upon. A variety of disciplines are relevant, such as marketing, economics, psychology, management science and engineering; and experience in the target market is obviously a big plus when it comes to qualifying for a job on a market transformation project.

It is not realistic here to try to set out a recipe for doing effective market transformation at a general level. At the same time, it is useful to outline broadly the steps involved and to see how market transformation ideas enter the IEA case studies. All of the case studies involve some aspects of the market transformation approach, but to varying degrees. Table 5.1 puts the 22 cases into three categories.[33] Category 1 programmes (with a single + in the right-hand column of Table 5.1) have been primarily fashioned according to either the R&D+Deployment perspective or the market barriers perspective, but still have some elements of market transformation in them.[34] Programmes reported on in Category 2 (++) include several market transformation features; and Category 3 cases (+++) report on typical market transformation programmes. The assignment of cases to these categories admittedly involves some subjective judgement.

33. This section, and several other parts of this chapter, draw on the "Technologies Require Markets" Workshop paper by Lund (2001).

34. To illustrate how a project can be guided by R&D thinking or a focus on economic incentives but still have some market transformation elements, one can consider the development of photovoltaic power generation in Japan (CS8) and the Netherlands (CS10). Developing networks of communication and alliances with market actors figured importantly in both projects – a central feature of the market transformation approach.

The starting point for the development of market transformation programmes is to identify the technologies and the markets to be worked upon. Central to this is an evaluation of the potential for increasing societal welfare through government action. In the present context this means exploiting a potential for improving energy efficiency in a way that generates net benefit but would not be brought about by normal market processes, at least not as quickly.

Such unexploited potential may exist for various reasons. For instance, the technology to improve the energy efficiency of a given type of household appliance might be available but not yet incorporated to a significant degree into widely marketed models. Suppliers in that market might find their current range of models to be quite profitable; they might be aware of the possibility of improving energy efficiency without adding greatly to their production costs, but may not view its incorporation into their products as a high-priority option in their overall marketing strategies. This might involve a belief that consumers are more likely to focus on initial purchase costs and non-energy aspects of performance than to take account of energy costs over the product's life cycle. Indeed energy might contribute a relatively small portion to total life-cycle costs. In such a situation, a range of market transformation actions can be effective in tilting supplier strategies towards introducing the new technology. In a market with several suppliers it can be possible to do this by taking action that will focus competition on energy efficiency; for instance, with a combination of actions that reinforce each other, such as by working with suppliers through a procurement programme while at the same time enhancing the likelihood that buyers will pay attention to the energy-using characteristics of the appliance by way of an energy labelling system combined with advertising and sales training programmes. In other types of markets it may be necessary to intervene more aggressively to set the transformation in motion; for instance, by amending mandatory product standards.

In practice the market transformation practitioner has to deal with many complications because target markets can be very complex. Many energy services can be provided in more than one way and

markets interact with each other and often disaggregate into systems of sub-markets. Thus even the initial step of specifying the market to be worked on has to be understood as an open process with feedback loops – all of the areas to be worked on may not become clear until after the work has begun.

Table 5.1. IEA Case Studies Categorised According to the Extent Market Transformation Tools were Used

Country	CS No	Case Study Title	Policies & Measures	MT
Austria	1	Deployment of biomass district heating	Niche management, subsidies and soft loans from national and state governments to agricultural cooperatives and biomass users	++
	2	Thermoprofit: Reducing energy consumption in buildings	Energy performance contracting, 3rd-party financing, information programme directed to enhancing performance of energy service companies, quality labelling	++
Canada	3	Renewable energy deployment initiative in space and water heating/cooling	Market assessments & strategy development, partnerships with industry associations, financial incentives	++
Denmark	4	Energy labelling for small buildings to save energy and water	Supply information to real estate markets by way of required energy audit prior to sale, labelling	++
Finland	5	Diesel engines for combined-cycle power generation	R&D, demonstration, Funding programme in partnership with industry	+
Germany	6	Solarbau: Energy efficiency and solar energy in the commercial building sector	R&D funding combined with demonstration programme	+
	7	Wind power for grid connection – the 250 MW wind programme	Experimental and operating-data-collection programme involving various types of subsidies, price incentives & feed-in compensation	++
Japan	8	Photovoltaic power generation – from R&D to deployment	Large government-industry partnership combining R&D, demonstration, standards, information dissemination, etc.	+

Table 5.1. IEA Case Studies Categorised According to the Extent Market Transformation Tools were Used *(continued)*

Country	CS No	Case Study Title	Policies & Measures	MT
Netherlands	9	Deployment of high efficiency heat recovery for domestic ventilation	Information, promotion & regulation programme, incentives; links to operation of overall energy performance standards in new buildings	+++
	10	Photovoltaic covenant	R&D, demonstration, information, through voluntary agreements, subsidies	+
	11	Deployment of renewable energy in a liberalised energy market by fiscal instruments	Differential taxes on conventional & renewable sources; 'green electricity' incentives; tradable-certificate scheme for electricity production	+
Sweden	12	Market transformation: lighting	Procurement, demonstration, information	+++
	13	Market transformation: heat pumps	Procurement with design/ development competition, information dissemination	+++
	14	Environmentally-adapted energy systems in Baltic Sea region	Loan-guarantees, technical assistance to reduce emissions	+
United Kingdom	15	Energy efficiency best practice	Information dissemination, technical assistance, targeted advice, management consulting, etc	++
United States	16	Unconventional natural gas exploration and production	R&D, price & tax incentives, market reforms	++
	17	Sub-compact fluorescent lamps	Procurement, design/development comp., information, consultation with stakeholders	+++
	18	Clean coal technology demonstration	R&D, demonstration, procurement model with design/development competition	++
	19	Industrial assessment centres	Information, auditing, partners with universities	++
	20	Motor challenge and BestPractices programs	Information and decision-making tools, energy assessments, training, strategic partnerships with industry	++
European Union	21	Energy + procurement	Refrigerator/freezer multi-country procurement	+++
International	22	IEA/SolarPACES START Missions	Information, technology transfer	+

Once the scope of the exercise has been established in terms of the technical performance variables to be promoted and the products that are involved, the markets to be worked on are examined closely to identify all of the important decision makers according to the different roles they play. Table 5.2 illustrates that the number of different market players can be large and varied. While some of the roles played by market actors overlap and many actors have multiple roles, the table indicates that consulting with stakeholders, and involving some of them in the transformation process in other ways, is a large job. It is nevertheless a centrepiece of most market transformation programmes. The chances of having a performance enhancement or a new product accepted can be greatly increased through the involvement of important market players, especially when the changes are technically complex and currently accepted products are well established.

Working with stakeholders can be done by tapping into existing networks, such as trade associations and consumer groups, or by building new networks of contacts. For instance, in technology procurement programmes developing cooperative networks among buyer-groups is important. Industry associations may develop their own networks to work together on building the foundations for the offering of a new product.

Broad strategic choices are necessary early in the development of a market transformation programme. For instance, an emerging technology may be technically superior but still not price-competitive. Will the focus in such a case be on cost reduction or on competing through product differentiation? Or both in parallel? Technologies may not yet be well suited to satisfy the whole range of user needs. Will an effort be made to transform a large market or will the programme be limited to a market niche? In general, working in market niches offers less risk and they can be the starting points for larger efforts in the future.

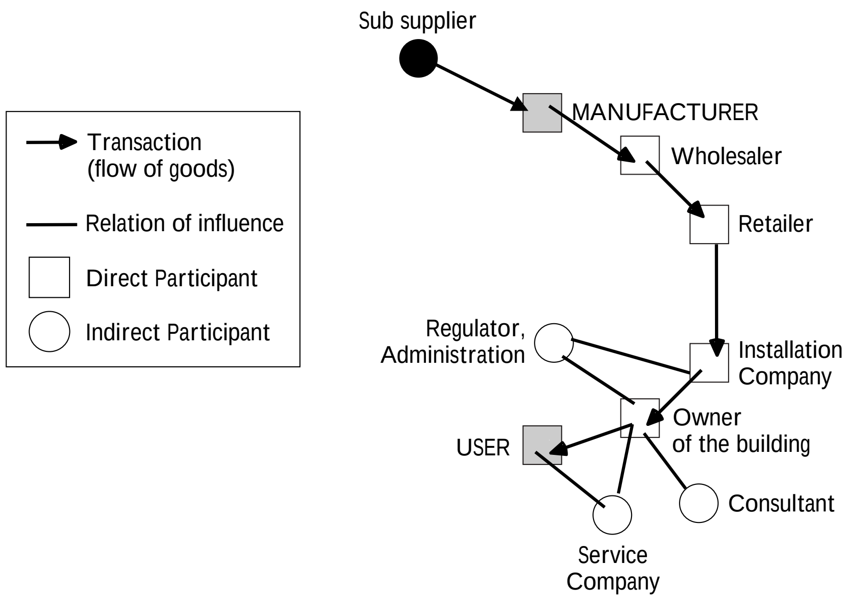
In addition to dealing with these kinds of generic aspects of a market transformation programme, various broadly-defined models can be used

Table 5.2. Types of Market Actors Involved in Case Study Projects

Typical Role	Market Actor
Buyer	Facility operators
Buyer & seller	Distributors, wholesalers, retailers, purchasers, contractors, service companies, utilities, energy distributors
Development	Planners, architects
Development – manufacturing	Manufacturing companies, parts suppliers
Financing	Funding brokers & other financial institutions
Information dissemination	Energy agencies, mass media companies & agencies, individual investors
Policy & funding	Government agencies, other public institutions
Policy – formulation & decisions	Politicians, regulatory agencies & other public authorities
Represent special interests	Trade associations, consumer associations, other NGOs
Basic research	Universities
Research & development	Research institutes, corporate research labs
Seller	Equipment installers, energy distributors
Special tasks (e.g., policy analysis)	Consultants
Technology user	Homeowners, consumers, customers, end-users

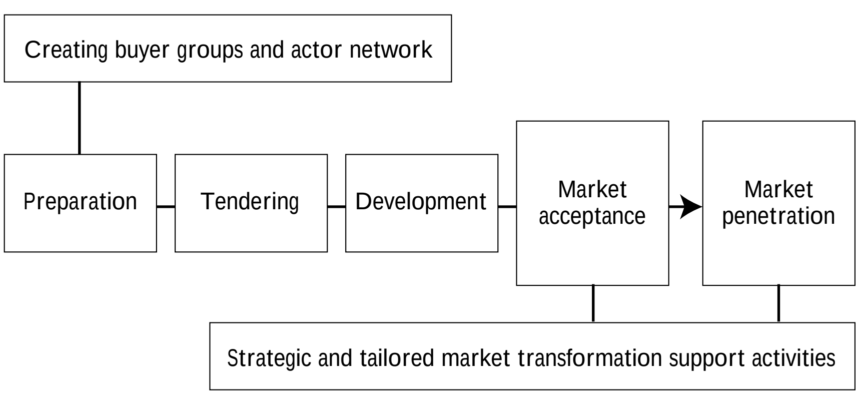
Source: Lund (2001)

Figure 5.2. Developing Networks for Market Transformation



Source: Nilsson (1996).

Figure 5.3. Technology Procurement Process



Source: Lund (2001).

as the basis for developing a detailed plan. Three are briefly described here.

Procurement Actions

Procurement processes are a natural vehicle for encouraging technology market development – they offer an entry point for influencing industry decisions in a framework that governments know well. The case studies on procurement programmes have been cited in both of the two preceding chapters: in regard to the R&D+Deployment perspective to illustrate how policy can be used to encourage technology and organisational learning; and in regard to the market barriers perspective to show how market-linked tools can help to assure that policy objectives are achieved in efficient ways that leave technical decisions and resource allocation to the private sector. In the market transformation perspective, a procurement specification list provides a useful pathway for programme designers to get into the details of market operations.

Technology procurement can be viewed as a tool that can influence the whole chain of innovation and commercialisation. This requires multi-stage procurement programmes, as illustrated in Figure 5.3.

One strength of the procurement model is that it allows policy designers to deal with a thorny problem in end-use energy efficiency policy. How do you entice consumers to buy energy-efficient equipment when the cost of energy is only a small component of its total cost and the consumer is much more interested in characteristics of the equipment other than its energy efficiency? The answer is to entice equipment producers to embed energy-efficient technologies in products designed with other characteristics that consumers think are important. This is not high-level R&D, but it is an important bit of common sense. In the new products that resulted from the procurement programmes in the case studies, equipment suppliers were able to make improvements quite easily. However, prior to being nudged by the procurement programmes, they had little incentive to develop improved versions of their products that would substitute for

existing versions that were already profitable. Procurement programmes arouse a latent potential and encourage new thinking that results in both technical and commercial development. This is illustrated by the US programme on sub-compact fluorescent lighting (CS17), which was a matter of developing bulbs that fit into a larger range of typical lighting fixtures, and the Swedish programme for high-frequency ballasts (CS12), which led to equipment with better lighting quality and increased productivity.

There is great potential for variety in the design of procurement programmes. One way to see that is by considering the spectrum of choices available along several dimensions that are involved in designing them.

- *Components vs systems:* The target technology may vary from specific components of a technical system to a whole system or facility. A single component may be a generic technology and widely applicable, whereas a system may have local features. A system may involve more flexibility and leave room for different approaches, whereas a component-approach is often tied to a certain technology. Risk and complexity increase when going from a single component to a system.

- *National vs international programmes:* Procurement programmes are usually arranged nationally but made open to competition from international manufacturers through national regulation and trade agreements. International procurement processes increase the purchasing power of buyer groups and more strict criteria can be applied.

- *Single-stage vs multi-stage programmes:* Most programmes are single projects based on one product specification. An interesting innovation would be to introduce a multi-stage process that builds on the strengths of a particular procurement approach. Some examples: the first stage might be national and the second stage international in order to multiply the effects of the programme and its appeal to suppliers; the first stage might involve a system component and the

second the whole system; or the first stage might focus on working with manufacturers and the second with consumers.

- *Externally-led vs self-organised programmes:* Technology procurement must be highly organised and carefully managed to be successful, which means that leadership is important. But some versions of the procurement model can take shape spontaneously. For example, it could arise when an established network of buyers comes to a voluntary consensus that a tendering procedure would benefit all members of the group. The Internet is a tool that might be effectively used to collect buyers and build purchasing power.
- *Technology-focused vs ordinary procurement programmes:* The typical market transformation procurement programme has involved a strong focus on the technical characteristics of a relatively new product that requires some development to respond better to competition from established products. In an ordinary procurement programme, the focus may be on creating more purchasing power to reduce the price of better-than-average products.

Finally, it makes sense for a focused procurement programme to be associated with other market transformation actions that affect the market concerned. For instance, new information dissemination programmes and an energy labelling system might be timed to interact with the results of a procurement effort. Similarly the development of buyer-groups might be timed contingently to follow the successful completion of the technical development aspect of the procurement arrangement. This kind of staged approach relates to the subject of the next sub-section.

Strategic Niche Management

As noted in Chapter 3, a technology niche market is one that offers sellers some limited level of protection against competition from existing products and therefore provides some room for experimentation, trial and error, and product modifications. At the same time the new technology is embedded in a wider market. This provides the

opportunity for a different kind of market transformation strategy. Though the market transformation initiatives that are well known in policy circles have focused on facilitating the market penetration of proven products, the model can also be applied to facilitating the transformation of an initial niche platform into a major market. The underlying argument here is based on the idea that niche markets help to set important processes of change in motion: interactive learning, institutional adaptation, networking and technical development efforts that are necessary for the wider implementation of a niche technology.[35] Thus a market transformation programme could accelerate this process by focusing on aspects of change that depend on government actions (such as adjustments to standards and codes, public information, etc.) and providing leadership in bringing users, suppliers and other market actors together in an interactive learning process. This sort of approach to market transformation programmes involves more risk, but could be important in areas that require difficult changes in market infrastructure.

When trying to create the market niche in which such a strategy may be applied, it would be important to require a good fit between the technology being launched and the expectations of the market. This requires close consideration of market characteristics by the market transformation practitioner in ways that parallel the approach of the firms launching the new product. For instance, it is important to choose a niche that takes full advantage of the merits of the new technology, to concentrate initially on a limited number of applications and work first in small geographical areas. Working with forms of the technology that have the potential for scale economies increases the chances of success and it is helpful to focus on customers and users who are demanding and likely to lead the market in adopting new products.

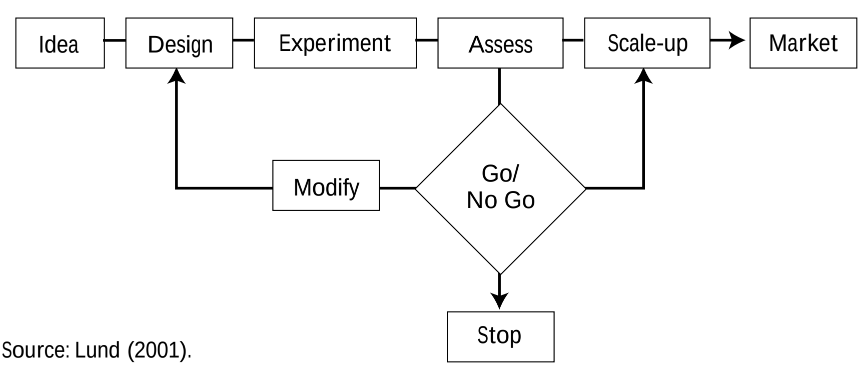
The experimentation phase of the niche strategy is very important, as it may determine the form of the more mature technology that will be the basis of a move to a larger market. It can be accomplished through the

35. For a fuller discussion of this strategy, see (Kemp, 1998).

series of steps outlined in Figure 5.4. Several iterations of this sort – and even several niche markets – may be necessary before a new technology is fully embedded in a market and the key actors are prepared to scale-up to a larger market. Part of the early planning in a market transformation programme should be consideration of what to do if the niche is successful. For example, scaling up sales levels will involve larger financial commitments and early attention should be paid to this need.

By chance the best examples of the application of strategic niche management in the case studies are found in renewables programmes, rather than in the types of end-use markets in which market transformation programmes have more typically been applied. The Austrian Biomass District Heating case (CS1) is one example; it also demonstrates the possibility for market transformation programmes to be initiated by people outside centralised government energy agencies. Its development started in the early 1980s as a bottom-up local activity and government support came later. Small local biomass district heating systems provided the market niche and the key actors were local promoters who both used and developed the systems. More than 500 plants have been installed. The Canadian Renewable Energy Deployment Initiative (CS3) is another example of a programme that focuses on promising niche markets and applications, though it is at a much earlier stage than the Austrian programme.

Figure 5.4. Bringing New Technologies into the Market through a Controlled Experimentation Process



Source: Lund (2001).

Business Concept Innovation

An innovative business strategy may also provide a framework for market transformation policies of a different kind. In some parts of the energy sector traditional business models have involved little emphasis on innovation as a tool for creating competitive advantage; this can also be said about some other sectors of the economy in which large amounts of energy are consumed; e.g., the construction sector. An example in the energy sector is the traditional electric or natural gas utility, which in the past focused strongly on its core business. Regulatory regimes created a static environment that was not conducive to innovations in the products and services put on the market by these companies. Regulatory reform has changed that. In a more competitive environment, companies find that they have to pay attention not only to production efficiency and cost, but also to the specific needs of their target customer groups and to the more subtle characteristics of how they deliver their services. Thus an electricity company may find that it can attract end-use customers by offering a variety of services. E.g., household consumers may respond to the offer of maintenance services, information technology devices that improve household management or reduce energy costs, and 'green energy' packages. Industrial customers respond to time-of-use pricing, energy performance contracting or options to be involved in distributed generation facilities.

This suggests that there are situations in which market transformation techniques can be fit into or coordinated with regulatory reform. While the reform may be primarily motivated by other objectives, opportunities to achieve technology deployment objectives by encouraging new business concepts may take shape as part of the process of competitive change that is set in motion. Moreover one of the case studies indicates that the scope for government-industry cooperation on business concept development is not limited to areas of regulatory reform. CS5 reports on a Finnish project on the use of diesel engines for combined-cycle power generation. It involved support for the development of compact and modular combined heat and power

systems by a major diesel equipment producer. Leading users and several providers of finance joined together to undertake a full-scale demonstration project. New ways of providing competitive energy solutions and total energy service concepts were developed. These have proven successful and have led to increased sales.

Facing the Challenge

Practitioners of market transformation policy clearly face a challenging task. They are expected to find ways to facilitate and hasten the incorporation of new energy technologies into industrial and commercial activities at a time when there is much suspicion about efforts by government to influence the economy. As a result they must treat their job as a matter of fine tuning. Ironically this can be viewed as a desirable state of affairs from the viewpoint of good public policy. The practical side of dealing with market barriers and supporting the emergence of markets for new technologies should not become another round of experiments in economic planning. At the same time, there is a necessary and legitimate role for government in building new markets because all markets work within a legal and institutional framework that is in part determined by government action and because there are important public-good effects associated with the increased use of cleaner and more efficient energy technologies.

In this light a clear guideline for the application of market transformation programmes can be proposed. When approaching markets in which there is an unexploited potential for net benefit to society through the expanded use of better energy technologies, the focus should be very specifically on ways to make the desirable energy-related attributes of the products involved more attractive to the suppliers and buyers of energy-related products and services, while at the same time disturbing normal market processes as little as possible. If this is done right, the forces of market competition will complete the job. It may appear as if market transformation practitioners are

thereby being asked to walk an unrealistically narrow path. Happily there is evidence from a number of successful market transformation programmes that it is possible to find that path.

The idea of a market transformation perspective – one of the building blocks in the overall argument of this book – is in the early stages of its development relative to the other two perspectives we have discussed. It is a compendium of ideas that have taken shape out of the experience of policy practitioners and it is still evolving. It is nevertheless an important part of our discussion because it is about the details of getting the job of deployment policy done. There exist many opportunities to release the potential for cleaner and more efficient energy use. At a time when slowing or reversing the trend of energy consumption and emissions is a high-priority goal for government, the use of market transformation programmes to help release that potential can enhance societal welfare. The market transformation perspective and the craft that is necessary to mount successful market transformation programmes have been developing in response to this need.

CHAPTER 6: TOOLS FOR POLICY DESIGN

Whatever perspective may be motivating a market development programme, careful analysis is needed for designing it, obtaining funds for it, implementing it, managing it and understanding how well it has worked. In this chapter we survey some of the analytical issues associated with undertaking deployment policy. The first section describes some useful analytical tools and comments on them. The second section is a discussion of the challenges involved in evaluating programme impacts. Throughout the chapter we draw on ideas from the three policy perspectives as they are relevant.[36]

Analytical Tools

In this section three methods are discussed briefly: the use of a life-cycle framework in making decisions regarding energy efficiency, the use of experience curves to make rough estimates of subsidies needed to support learning investments, and the use of diffusion curves in developing market strategies. The intention is to illustrate the scope and need for using formal tools in a practical context.

Before proceeding to that, it should be acknowledged that some of the most important analytical requirements are not provided by formal analysis; and that this is confirmed by many observations in the IEA case studies. Sometimes there is no substitute for having a market situation analysed by people with appropriate experience and training

36. The theoretical frameworks associated with the three models determine to a large part their analytical approaches. The market barriers perspective is connected to a well-defined body of theoretical economic analysis. Besides the large literature on experience and learning curves, the R&D+Deployment perspective relies on methods developed in systems analysis and in research on innovation systems. The market transformation perspective relies on knowledge within management sciences and innovation theory, but being the most practice-oriented of the three perspectives, also pragmatically experiments with tools from other disciplines.

who have developed a keen eye for the practical side of their work. The most direct way to focus on marketing strategies for a new end-use technology may be to have a team of marketing specialists and applied psychologists look closely at the current market for the energy service involved. How the structure and organisation of an existing energy service market may impede the penetration of a new product might be most easily understood by a team made up of sales personnel from relevant firms assisted by an applied economist.

The case studies provide illustrations of the importance of drawing on established expertise and practical experience. For instance, the American procurement programme for sub-compact fluorescent lamps (CS17) shows how a market transformation team, in consultation with market stakeholders, was able to come up with practical solutions for some of the classic market barriers. To deal with product risk, the programme required manufacturers to offer an unconditional one-year warranty. It also dealt with the classic problem of building owners making key decisions affecting lighting, but typically not having to pay its operating cost and therefore undervaluing energy efficiency. Common-area outdoor lighting, for which building owners often pay the operating costs, was made part of the product specification for the sub-compact fluorescent lamps (sub-CFL); this enhanced the likelihood that building owners would be interested in the product.

At the same time, those who work on market transformation would undoubtedly agree that analytical tools of the sort discussed below are useful in their work.

Life-cycle Cost and Yield Calculations

Many energy consumers – especially householders, who use small amounts of energy – under-invest in energy efficiency because they are not aware of relevant opportunities or judge them to be too insignificant. When they make purchase decisions they often use simplified rules-of-thumb, which can be biased against rational decisions.

Table 6.1. Increases in Yields on an Investment for Years of Useful Life Longer than the Payback Time Required

		Useful Life of Equipment (Years)							
		3	4	5	6	7	10	12	15
Payback time required (years)	2	37%	79%	120%	159%	196%	300%	361%	444%
	3	–	14%	40%	65%	88%	154%	194%	247%
	4		–	0%	18%	35%	82%	111%	149%
	5			–	–	3%	40%	61%	91%
	6					–	12%	29%	53%
	8	Unprofitable						–	7%

Calculated under the assumption that the purchaser requires 15% return of capital and that inflation is 2%.

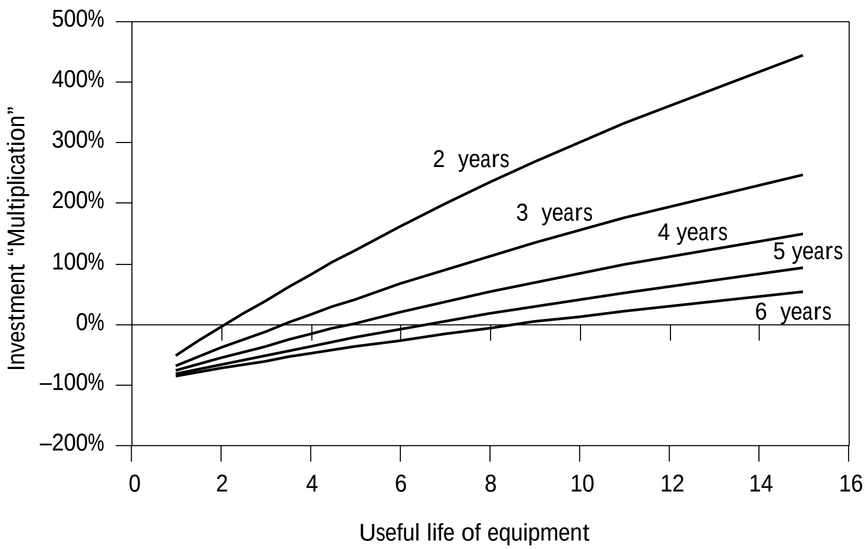
A classic example is the comparison of initial equipment costs when choosing from among alternative technologies, rather than full life-cycle costs. Another is the use of a short payback period as a purchase criterion, instead of calculating the expected net yield on a piece of equipment and comparing it to the opportunity cost of funds used for the expenditure. Manuals and textbook treatments of these kinds of calculations are easily accessible, as are illustrative analyses involving actual equipment.[37]

The effect of using inaccurate numbers and overly simple decision rules can be large. Table 6.1 illustrates the effect of using a payback period that is shorter than the useful life of a piece of equipment. For instance, in the illustration, if a consumer rejected a piece of equipment because it would not pay back its purchase price in two years when the

37. See, for instance, USDOE (2001).

equipment would in fact last for five years, the return on the investment foregone would be 120 percent higher than the two-year return. Figure 6.1 summarises the effect in a graph.

Figure 6.1. 'Multiplication' of yield on an investment that would have been rejected by the application of low pay back times but has long useful life times



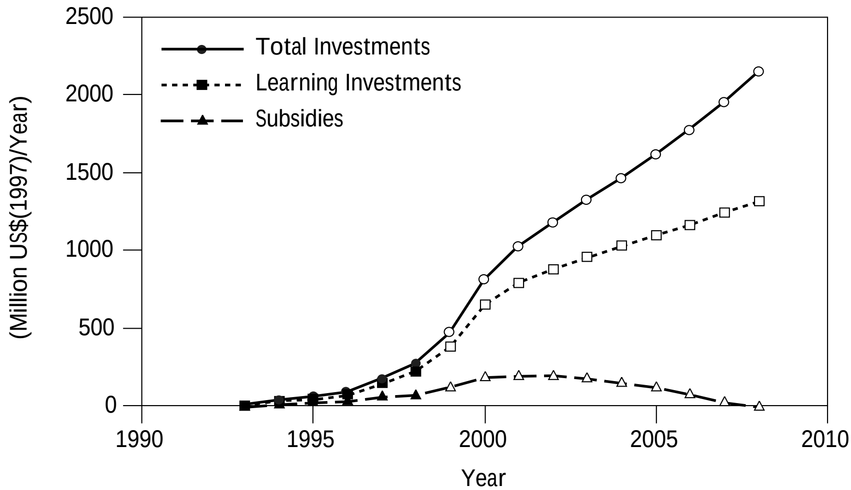
Experience Curves

Experience curves can be used to make rough estimates of subsidies needed to support learning investments on the way towards the take-off of a technology in commercial markets. Figure 6.2 shows the results of a simulation analysis based on Japan's market development programme for residential photovoltaic (PV) systems.[38] The investment curves in the graph are based on assumptions regarding the programme, the markets involved and the learning rates for PV modules expected. The points up to the year 1998 are based on

38. For a detailed description of the programme, see IEA (2000), 64-74.

observed data; the points after that are the result of a simulation exercise (using Japanese budget forecasts for 1999 and 2000).

Figure 6.2. Investments and Subsidies in PV-Roof Programme



Source: OECD/IEA(2000)

When this niche market programme was started in 1993, the costs of residential PV systems were considerably higher than the buyers' willingness-to-pay and sizeable subsidies were required for the first units (consistent with the illustration set out in Chapter 3, Figure 3.5). As cumulative sales rise, the unit cost falls and subsidies for each unit can be reduced. However, in this simulation, volume grows faster than unit subsidies decrease and the total cost for the programme increases. As the programme expands, the initial 70 percent growth rate decreases and beyond 2002 cost reductions overcome sales growth. Prospective market investigations and extrapolation of the observed niche market curve are consistent with the experience curve for this PV-system reaching the point at which a niche market would be viable at around a system cost of 3 US$/Wp. The technology would then have reached the point at which the government's contribution to learning investments can end. With the assumptions used for Figure 6.2, this

would happen in 2007. At that time, the government programme would have initiated a market with an annual sales volume of 2 billion US$. That market would involve additional learning investments that could provide the basis for a continued ride down the experience curve.

In sum, this example illustrates how experience curves can be used to estimate the need for subsidies, the scenario for reducing them and finally phasing them out.

Using the Diffusion Model

The idea that the adoption of successful new products by buyers throughout an economy grows according to an S-shaped curve has long been used in the study of innovation.[39] It is a useful tool for the analysis of market transformation programmes. For instance, it can be used to build a structured view of consumer attitudes that is helpful in developing marketing strategies and in understanding deployment policy. This is illustrated in Figure 6.3.

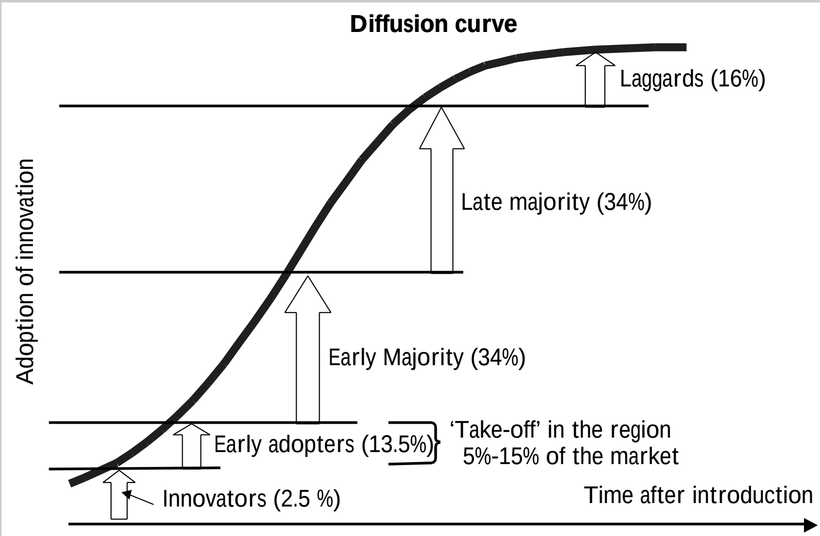
This structure could be mapped onto the niche market curve discussed in the preceding section. The 'Innovators' would then correspond to the first part of the niche market curve, where the buyer has a large willingness to pay for the new technology. An interesting illustration of the use of diffusion curves for analysing deployment programmes is found in Lund (2001, Sec. 6), where it is applied to Case Study 12, the Swedish programme on electronic ballasts.

Success has Many Faces

The aim of deployment programmes is naturally to bring about a lasting impact on the market for some sort of equipment. How to measure that impact and how to evaluate whether a programme can be viewed as successful is a multi-layered complicated question, one that warrants a book of its own. In this section our intention is not to

39. See, for example, Rogers (1995) and Moore (1991).

Figure 6.3. Who will buy and why?



Adopter type	Characteristic	Role and size
Innovators • enthusiast	Venturesome; Enjoys the risk of being on the cutting edge; Demands technology	Market drivers. Want more technology, better performance. (16%)
Early adopters • visionaries	Well connected; Integrated in the main-stream of social system; Project oriented; Risk takers; Willing to experiment; Self-sufficient; Horizontally connected and acts as their peers	
THE CHASM (where marketing and distribution must radically change)		
Early majority • pragmatists	Deliberate; Process oriented; Risk Averse; Want proven applications; May need significant support; Vertically connected and acts as their superiors	Followers on the market. Want solutions and convenience. (68%)
Late majority • conservatives	Sceptical; Does not like change in general. Changes under 'pressure' from the majority.	
Laggards • sceptics	Traditional; Point of reference is 'the good old days'; Actively resists innovations	Economic/ power interest different from status quo?

try to unravel it in any definitive way, but rather simply to survey some practical issues involved in it.

The template for the case studies on successful deployment programmes that provide the empirical basis of this book did not prescribe how to define success. Thus the guidance on this question offered by the studies themselves is mostly a matter of sampling the views on what constitutes success in ten different national capitals. Though that is of some interest, the issue here is methodological. What are some typical variables used to measure the impact of programmes and how should they be interpreted? To get a feel for the answer, we describe several ways that policy analysts measure programme impact and then discuss what they mean.

Volume Growth

To illustrate the simplest approach to measuring success – growth in the volume of sales – we look at some numbers from the worldwide market for compact fluorescent lamps (CFLs).

Establishment of a market for new products takes considerable time. The CFL has been a target product for many deployment activities throughout the last decade. As shown in Figure 6.4, accumulated output of CFLs has doubled almost six times between 1988 and 1999. Yearly sales for 1999 are in the order of 500 million units worldwide, which represents a tenfold increase in annual sales since 1988. It is believed that the total amount installed is some 1300 million units (IAEEL, 2000).

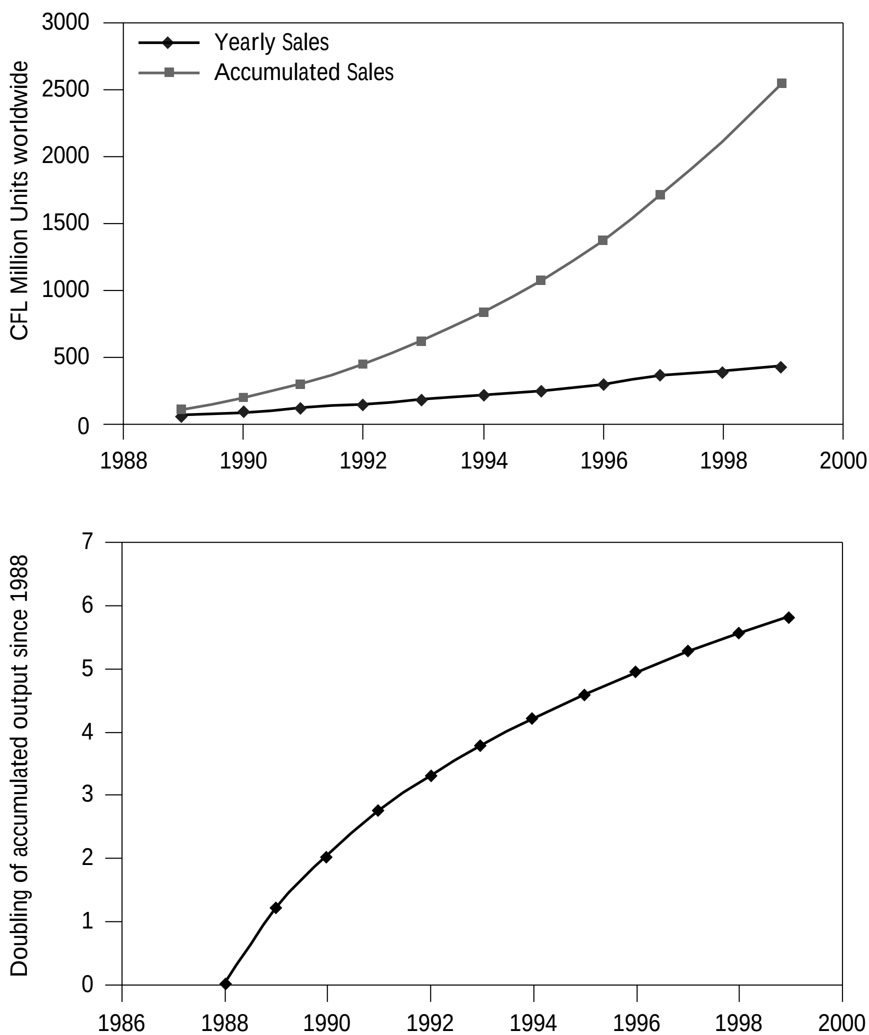
In spite of the impressive volume growth, the penetration of national markets is generally low. The total volume of light bulb sales is estimated to be in the range of 10-15 billion units per year, which means that CFL sales have a share between 0.5% and 3%.

Across the European Union the average number of light bulbs in households is 24. Table 6.2 shows the percentage of households that have a CFL and the average number per household; the data are mostly from 1995 (Palmer and Boardman, 1998). Given the low penetration of CFLs in households that own any (a bit above 10

percent), overall market penetration in these countries is on average less than 5 percent.

How much of a new technology will the market accept; what is the level of saturation? Tests of the suitability of CFLs for household

Figure 6.4. Worldwide Sales of CFLs



purposes with the present configuration of fixtures and lighting show that an average of eight light-bulbs could be comfortably replaced with CFL bulbs (Palmer and Boardman, 1998). If we assume this as the saturation level and apply a diffusion curve to the present level of market penetration as shown in Figure 6.5, it indicates that full dissemination would occur only after some 30 years.

Table 6.2. CFL Ownership in the European Union

Country	Households with CFL (%)	Average CFL per household	CFL per owning household
Belgium	29	0.9	3.7
Denmark	46	2.0	4.4
Finland	-	1.0	-
France	-	0.5	-
Germany	51	2.1	4.3
Greece	11.5	0.1	1.0
Ireland	22	0.9	4.0
Italy	55	1.1	2.0
Netherlands	62	2.7	4.5
Spain	11.5	0.2	1.7
Sweden	10	0.4	4.0
UK	23	0.7	3.0
EU average	**32**	**0.9**	**2.8**

Volume Growth and Price/Cost Trends

When a new product reaches the market and gets accepted, demand growth will bring about reductions in unit costs as scale economies are

Figure 6.5. Projected Growth of CFLs

realised and new producers enter the market. This phenomenon is part of the learning process discussed in Chapter 3 and is captured by learning and experience curves. Movements along these curves provide another way of measuring the impacts of deployment programmes – an important way, because falling unit cost is associated with the promise of further growth.

The 'progress ratio' is a parameter that summarises the relation between cumulative output and the level of price or unit cost (depending on which of these variables has been used to construct the experience curve). This ratio indicates how much the cost or price will drop with each doubling of the cumulative production.[40] For example, if cumulative output doubles along a curve with a progress ratio of 84 percent, the cost or price will have dropped by 16 percent. Figure 6.6 shows the relation between the cumulative production of PV

40. The terms 'progress ratio' and 'learning rate' are both used in the literature to describe the slope of the experience curve. Learning rate = 100 – progress ratio. For additional discussion of the progress ratio and other aspects of experience curves, see OECD/IEA (2000).

modules and their price from producer to wholesaler. The strong reduction in this price between 1984 and 1987 reflects a drastic change in annual growth rates of module sales in this period from 56 percent per year to 16 percent per year.

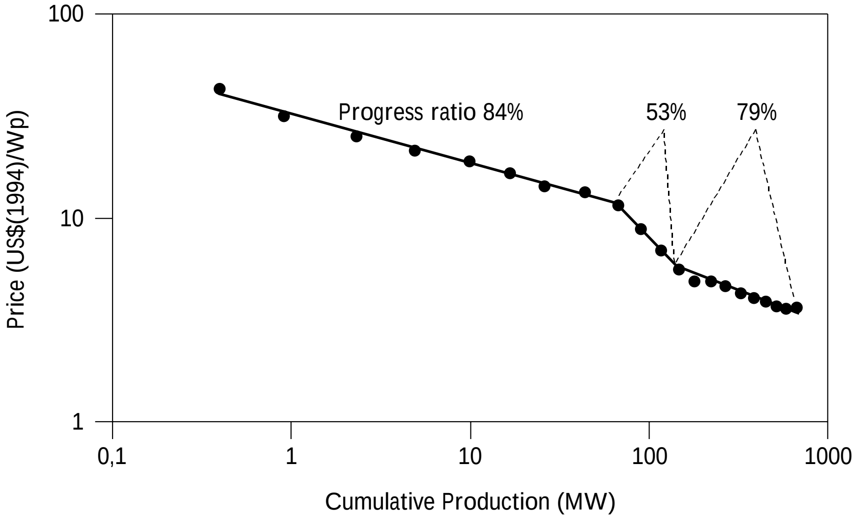
Depending on how a market is organised, it can be difficult to perceive the effect of the learning process on costs until considerable time passes. Data that allow unit costs to be closely tracked are not generally available. Normally only the price can be observed. Early producers may be able to keep the market price from falling along with unit costs to recover their development costs and earn profits. If they can, it may not be clear how much unit costs have fallen until competition, actual or perceived, brings pressure for price reductions. Figure 6.7 illustrates this effect and also how the experience curve can be used to define various stages in the market introduction process that can be used in setting targets for deployment programmes and evaluating their effects.

Attribution of Impacts to Policy Measures

Before proceeding to other frameworks for evaluating the success of policy measures, it is important to acknowledge a key issue in the discussion: judging whether a market expansion that occurs after a programme has been implemented is actually a result of the measures taken, or one that would have occurred anyway. In some cases the attribution of an increase in sales to a deployment programme appears obvious; for example, when an entirely new product has been introduced by a firm that has developed it as part of a government-supported programme. But even in that kind of case attribution requires analysis and is in principle a matter of judgement, not fact. One cannot know how history would have unfolded in the absence of the programme – the company launching the new product, or some other company, might have ended up putting the product on the market by way of a different path, one that did not depend on government support.

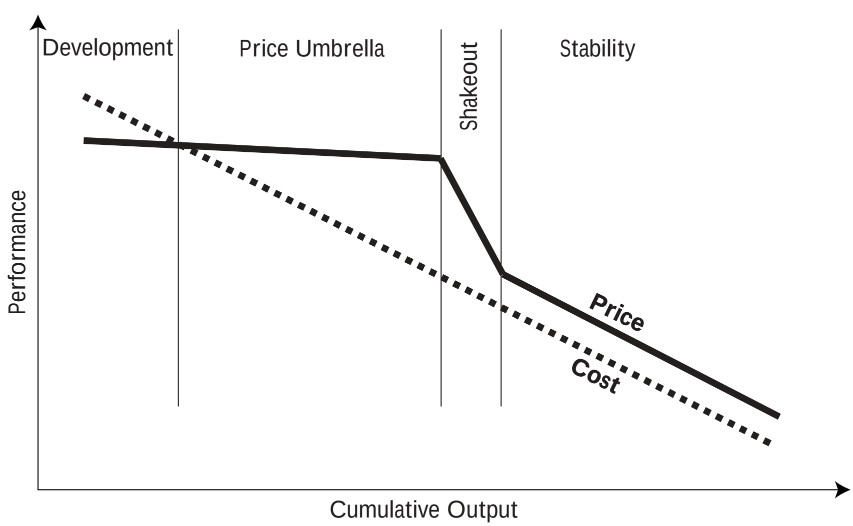
From the vantage point of people working on deployment policy these kinds of questions are to some extent academic, especially when it

Figure 6.6. Market Changes for PV Modules, 1976-1996



Source: OECD/IEA (2000)

Figure 6.7. Stages in a Market Introduction Process



Source: Boston Consulting Group (1968)

comes to discussing causality at a fundamental level. If a government is committed to supporting the deployment of new technologies, the officials who mount programmes in order to implement policy objectives have to take a practical approach to monitoring their work and evaluating whether it has been successful. Various kinds of analysis can be applied in order to make judgements that inspire confidence.

The most ambitious and convincing kind involves formal statistical analysis, in which attempts can be made to identify all of the variables that influence measures of market growth and understand how much of an observed change in them can be attributed to policy actions. It is important in this regard that specialisations in applied statistics have developed in a variety of disciplines relevant to deployment policy. Empirical analysis of the economic aspects of policy can be approached by econometricians; behavioural aspects can be studied by psychometricians, and so on.[41] The advantage of approaching evaluation in this way is that it brings much more than the minimum results necessary for "satisfying the Treasury upstairs that our policies are working". Statistical analysis can provide valuable information on consumer response to products, cost relations, externality values and other difficult aspects of policy design. The disadvantage is that it is time consuming and costly; and some types of analysis cannot even be approached without prior investment in the collection of dependable data.

Thus more pragmatic, simpler approaches to policy monitoring of the types described above and below remain important. Officials directly involved in the design and implementation of policy measures need feedback on their work that arrives more quickly and readily than the

41. As noted in Chapter 4, footnote 29, an example of a useful econometric study is Horowtiz (2001). Another example of relevant current work in econometrics is a set of papers given at the North American Conference of the International Association for Energy Economics in Vancouver, 6-8 October 2002, at a session entitled "Assessing the impact of energy conservation and energy efficiency efforts using discrete choice-related methods". Two of the papers are available on a CD-ROM Proceedings; see http://www.iaee.org/en/publications/proceedings.asp. On this subject, see also http://elsa.berkeley.edu/~train/.

results of major statistical studies. To deal with the attribution issue in a practical context it is frequently necessary to approach the interpretation of changes in market variables in a pragmatic way – with common sense, a critical eye, and as much supporting information as possible.

An illustration of a practical approach to programme monitoring is provided by a separate analysis of one of the programmes covered in the case studies (CS12). Neij (1999) reports on interviews with participants in the Swedish programme of support for high-frequency ballasts. Her findings indicate that the most important reason for buyer-interest in the new lighting fixtures had to do with lighting quality, rather than with energy efficiency. This sort of result adds credence to the hypothesis that the programme contributed to market growth that occurred after direct support from subsidies ended.

Performance Improvements

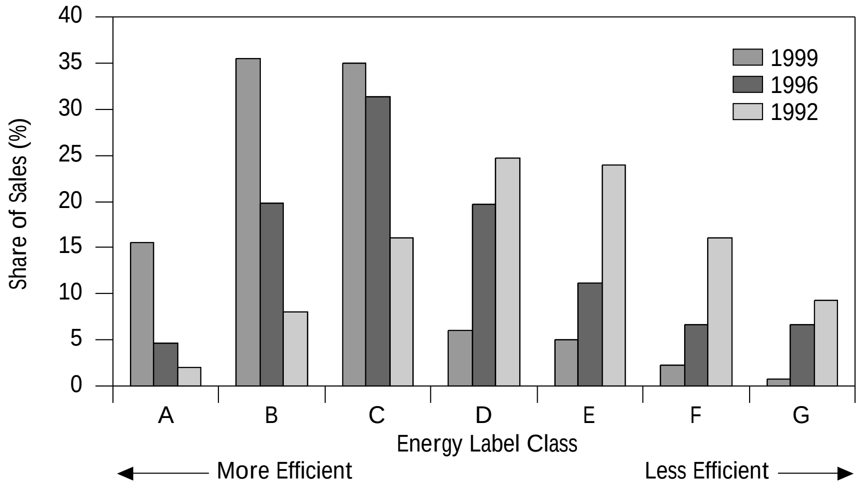
Much technological advance has its effect by way of gradually improving the performance of existing products. In these cases there is not a discernible new market to be developed, but rather the evolution of well established markets. To a great extent performance improvements are made naturally through the process of competition, but in many instances actions by government play a role in the change. Thus the impact of deployment programmes through this channel also has to be considered.

Most programme activity of this kind that needs to be monitored falls into three categories:

- Government support spurs innovations that lead to performance-enhancing technologies;
- Government activities help to focus consumer interest on better versions of a product, leading to increased sales;
- Government takes action to discourage the purchase of products that under-perform, leading to decreased sales.

Trends in the sales of household appliances in Europe provide an illustration of the kind of information needed. Figure 6.8 shows that sales of cold appliances during the 1990s drifted from lower to higher performance levels (OECD/IEA, 2001). It is believed that energy-labelling and other programmes contributed to these trends.

Figure 6.8. EU Cold Appliances Sales by Energy label



Source: EU-Save (2000)

This is a good example of a set of data that needs to be analysed econometrically with a view to estimating the portion of the trend toward higher performance that can be attributed to deployment programme activities and the portion that would have happened anyway. Such analysis would need to test for possible 'rebound effects' on energy consumption that can offset the hypothesised positive effects of deployment actions.

Benefit-Cost Analysis

None of the approaches to evaluating the success of a deployment programme discussed above is comprehensive. In each case a variable

that is viewed as the 'output' of a programme is defined and then it is a matter of keeping track of that variable and collecting associated information that allows one to interpret its movements. This is often a correct approach for the management of a programme, but it is limited in relation to making decisions about funding programmes in the first place or doing *ex post* overall programme evaluations. A more comprehensive approach is generally needed for these purposes. The usual recommendation in this regard is to apply benefit-cost analysis. Since this was discussed in the section on "Programme efficiency and success" in Chapter 4, it is mentioned here only for the sake of completeness and to note that many useful sources on the nature, strengths and weaknesses of BCA are available.[42]

Summary Comments

Whatever is the aim of a programme and the chosen measure of success, the following practical observations are relevant in shaping it and in establishing evaluation procedures:

- The attribution of impacts to measures is a matter of judgement that requires analysis;
- Good monitoring procedures should be in place early in the life of a deployment programme;
- Product innovations often lead to new behaviour from both users and producers;
- Unit cost reductions might not be detectable, only price responses can be objectively measured;
- The initial stage in the diffusion of an innovation through a market can be slow to materialise;
- Total impact takes a lot of time.

42. See, for instance, Kopp, Krupnick and Toman (1997).

CHAPTER 7: LOOKING AT POLICY-MAKING FROM MULTIPLE PERSPECTIVES

In the introduction to this book we noted the difficulties involved in drawing lessons from case studies that are very dependent on particular contexts. To respond to that challenge we proposed an analytical framework based on three perspectives, which have been described in Chapters 3-5. The discussion in each chapter shows how that particular perspective can help to throw light on the case studies. In this chapter we try to take account of all three perspectives simultaneously.

We refer to our methodology as *triangulation* – by analysing a programme from three different directions it should be possible to understand it better (Nilsson and Wene, 2002). This approach has helped us to rise above the details of the individual cases and instead focus on the thinking behind policy design and implementation. For each study, we identified the aspects of policy-making and programme design that are linked to the key factors of each of the three perspectives. We kept track of these categories of programme characteristics on large worksheets and used them to look for patterns and develop speculative hypotheses. This sifting through details and the subsequent survey of a large 'map' of the case studies allowed us to approach some key questions in a way that accounted for all the perspectives together. For example, how do the different perspectives enter into the process of developing a programme? How do the aspects of a programme that relate to the different perspectives interact in support of programme objectives? What are the factors that make a deployment programme succeed?

In the larger sense, this kind of analysis is a work in progress. It is not realistic to expect clear answers to these hard questions based on the set of case studies we have in hand. However, we found that our approach helped us to draw some lessons from the experience reported

on in case studies that are transferable across different contexts. The most important lesson of this kind is that different perspectives can lead to different results. While that observation should be evident from the discussion of the individual perspectives, we also draw it to your attention in the first section of this overview chapter by illustrating how a given policy measure can be viewed differently according to the perspective of the viewer. We then proceed through the steps of the triangulation analysis: first by reviewing some key aspects of the case studies from the viewpoint of each perspective individually and then by showing how the perspective-based views of deployment policy can be repackaged into a more holistic framework. We suggest that it is useful to attempt to synthesise the three policy perspectives discussed in this book in order to develop a more comprehensive approach to the analysis, design and implementation of deployment policy.

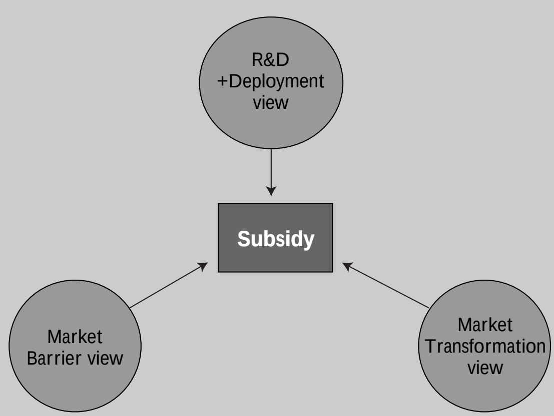
Policy Measures Viewed from Three Perspectives

It is clear from the discussion in Chapters 3-5 that each of the three policy perspectives has evolved in a particular setting, very much conditioned by the professional backgrounds and activities of the people involved in policy analysis and programme design. Thus it is not surprising that the issues surrounding the deployment of new technologies and the policies used to deal with them are viewed differently according to which perspective is favoured. This can affect how a policy measure is designed and used, which in turn can affect its results and one's evaluation of its success or failure. It is a matter of interest not only because it helps us to interpret case study material, but also because it might lead to insights on making better policy.

Because differences of interpretation of this sort are about the details and the nuances involved in policy measures, the point can be most easily conveyed by some hypothetical examples. Consider first how people coming from three different vantage points are likely to view the use of a subsidy to further the deployment of a new technology, as summarised in Figure 7.1 below.

Figure 7.1. Differing Interpretations of a Deployment Subsidy

Perspective	Function of the measure SUBSIDY
R&D + Deployment	The money should be used for investments in learning. The focus is on new products, technology characteristics and manufacturers that can move the process along. The subsidy is viewed as creating a future return in forms that cannot be predicted now. Success will be achieved when the market accepts the product on its own merits, taking account of both price and performance.
Market Transformation	The money should be used to attain interest from certain groups that could move the market. These groups are assumed to set trends and act as proponents for the improved products. The return from the subsidy is expected to come from the establishment of new preferences on the part of buyers and more interest on the part of suppliers in the business opportunities that can be created by exploiting a new technology.
Market Barriers	The money should be used to overcome a reluctance to buy new products that are superior to currently favoured products in ways that are not recognised by consumers, perhaps because they tend to over-estimate the risks involved in using the new product or because some of the benefits accrue to third parties. All customers are addressed equally. The money is spent in the public interest as viewed by the present value calculations of current buyers.



All three views of the subsidy characterised in this illustration are legitimate within their own frameworks, but each framework involves different assumptions and different views about what is important. The R&D+Deployment view starts from a position of confidence in the promise of a technology and a belief that it is necessary to try it out in order to make it work in a market context. The market transformation view reflects a parallel confidence in believing that a technology (presumably a different one, since it is ready for the market) is worthwhile for society and wants to find ways to convince others of that. The proponents of the market barriers view are more concerned with choosing the right thing to support, but tend to approach that issue in a narrow framework. In that sense they have something to learn from the other two perspectives. On the other hand, for the proponents of both the market transformation and R&D+Deployment perspectives to be successful, they too must apply some version of a net-value calculus; that is, they must choose the right consumer groups and the right technologies to subsidise if their efforts are to succeed.

Many other credible examples of this sort can be constructed. Three additional ones are presented in Table 7.1.

Perspective-based Observations

The first step in the triangulation analysis has been the thorough consideration of the case studies in relation to each of the individual perspectives separately. Here we set out some summary observations on these separate analyses. The objective is to see which issues 'bubbled to the top' when one looks at all the case studies together. This is based on a detailed accounting of individual policy measures cited in each of the studies. By identifying which issues are important in relation to each perspective we can then see how combinations of measures can be built up. This in part provides the basis for the more comprehensive perspective on deployment policy that we propose later in this chapter.[43]

43. The discussion in the three subsections that follow is helpful in understanding the types of policy measures referred to by way of shorthand labels in Table 7.3.

Table 7.1. Differing Interpretations of Deployment Measures – Additional Examples

Model	Information Dissemination	Tax-based Measures	Rules & Regulations
R&D + Deployment	Information is developed that will show how a particular technology, perhaps from a particular manufacturer, performs better than conventional technologies. Potential manufacturers may be the target for the information, rather than final users. Typical example: a demonstration project.	A tax-reduction is an incentive to develop an application or to adapt an industry to a new pattern of behaviour. The technology involved might be well-proven but the industry is risk averse or organised in such a way that a strong incentive is needed to stimulate private learning investments.	Rules are applied to define business standards and organisational behaviour and thus provide a robust framework for continuous technology learning. Administrative rules are used in order to secure fair competition and facilitate communication about agreements. Purchasing routines are a typical application and so is the use of quality assurance and environmental certification.
Market Transformation	The information focuses on performance ratings and is designed to reach customers when they are in the process of choosing a product. Typical example: labelling.	A tax or the rules for application of taxes could be used to punish the use of energy-inefficient equipment. Typical cases: special adjustments to property taxes, taxes on emissions.	Standards define how a product should perform and which of its functions are to be guaranteed. Compliance with building codes is an important example.
Market Barriers	The information deals with a broad range of characteristics of a product with a view to enabling the customer to make a better choice and calculate its consequences. Customers are informed in a general way and without specific products in mind. Typical case: bill inserts about energy efficiency sent by electric utilities to their customers.	Taxes should be as neutral as possible in terms of how they influence resource allocation. However, they can be used to correct prices that do not account for externalities and market imperfections.	Rules provide the framework for market activities in a manner that enables consistent transactions and assures entrepreneurs that certain things that affect risk are known. Rules often need to be legislated; enforcement to uphold fair competition may be necessary.

Barriers as Theories and Facts

Market barriers in the way of adoption of new energy technologies are mentioned frequently in the case studies (and the standard list of barriers, along with typical policy measures used to deal with them, is found in Table 4.1). Within the market barriers perspective, one can sometimes get the impression that it is only necessary for programme designers to devise measures that will reduce or eliminate the barriers; when these measures are implemented, rational participants in the markets concerned will embrace the new technologies without any more effort from the policy-maker. Getting beyond this theoretical position, the case studies provide evidence in support of the contention made at the end of Chapter 4 – that the barrier concept is useful for diagnosis of the problem, but is often very limited in regard to constructing specific programme measures. The latter point motivates the market transformation perspective. In sum, the economist's characterisation of markets is useful but very spare; it assumes that people behave homogenously according to strict rationality and constant preferences; and gives too little attention to how those preferences are formed and change.

The case studies indicate that policy designers draw in ideas from the market transformation perspective when dealing with market barriers. In some cases this is obvious, as in those describing bidding processes for the procurement of specified technologies. But market transformation ideas are also found in the descriptions of other programmes that did not come specifically from an application of the market transformation perspective.

Whether the ideas come from the market transformation perspective or elsewhere, the case studies taken together present a very clear indication that experience matters. Programme designers have moved from overly-simple depictions of market barrier remedies to more nuanced measures through trial and error. The studies show that successful programmes develop over time; designers acquire a deeper understanding of the problems they are dealing with and they fine-tune

programme measures accordingly. Once again, there is learning-by-doing in policy-making!

Some market barriers were referred to in the case studies more often than others. The inertia involved in traditional market organisation is mentioned often. This is important, because it indicates how incumbent technologies are fortified by institutions that have developed in response to their characteristics. It illustrates again how the identification of a type of barrier does not in itself give sufficient information on which market actors could be the champions of a change, and with which arguments. What is needed to deal with this kind of barrier is organisational learning based on the particular contexts of the old and new technologies. The case studies show instances in which change is instituted by participants in the incumbent market once it is shown that the change is warranted and has support. This in turn underlines the importance of initiatives by government.

The high cost of being the first supplier of a product is mentioned frequently. Another important category involves barriers relating to insufficient information and problems on the part of customers and users in processing information. This results in high transaction costs that hinder market penetration. The measures prescribed are mostly of the type intended to clarify and verify technology performance through the use of brochures, labels, illustrative calculations and the like. This type of information is often generic and can provide the basis for a wide range of choices made primarily by users as non-specialists.

Barriers associated with financing purchases of equipment and the risks associated with that are mentioned less frequently. The policy measures used to deal with these barriers involve 'active verification' of the performance of technologies. That is, it involves information services tailored to the needs of the individual customer; for instance, of the sort provided by energy service companies.

Price-distortion and the need to internalise costs or make other adjustments to deal with them are hardly mentioned in the case

studies; similarly inappropriate regulations are not viewed as a problem. This does not necessarily mean that these kinds of problems are unimportant to programme designers and managers; it could mean simply that they see little chance of success in dealing with such matters.

R&D as a Policy Tool

In examining the case studies in relation to the R&D+Deployment perspective, we watched for references to the state of development of technologies involved in the programmes reported on, the presence or absence of known solutions to technical barriers and whether or not the use of niche markets was considered.

In regard to the state of development of a technology, most of the case studies deal with technologies that are known and understood, but still not developed to such an extent that the market will pick them up easily. From our knowledge of the learning phenomenon we know that growth in production and sales is necessary to overcome many of the technical problems that remain (e.g., high first costs) and adaptations are necessary to make the technologies available to fit user needs and preferences. The measures needed are demonstration projects, help with organising and financing of learning investments, pilot projects to support market adaptation, etc. There are many references to these issues in the case studies.

There are also quite a few cases that deal with existing technologies that are well proven and already distributed. In these cases the matter of concern is increasing market coverage and the issues discussed relate to developing market support; e.g., training programmes for consultants and service providers.

Addressing the problem of identifying niche markets is essential when technology learning is an objective. This factor was not frequently addressed in the cases and is perhaps a neglected aspect of policy development. On the other hand, it may be that case study authors did not see the need to focus on this point. For instance, in cases in which

extensive additional research is required to find out if and how a technology will work, deployment issues will not get as much attention. If they are considered in such cases it is in relation to carefully selected producers and customers who give extensive feedback. In this kind of case the exploitation of niche markets is implicit and need not be explicitly mentioned.

Market Transformation

In searching the case studies for evidence of the market transformation perspective, we watched for references to the kinds of products being supported and the market groups being targeted. Regarding the first dimension, the case studies were categorised according to whether they were concerned with: (1) *new products* being made available; (2) *higher sales* of existing good products; or (3) *lower sales* of bad products. Twelve of the case studies involved references to the launching of new products, ten to expanding sales of existing products and in one case there was reference to an objective of reducing sales. The last case refers to a quality-label programme. In general, one would not expect much mention of an objective to reduce sales of an undesirable product because it is usually implicit in the support of a new or existing product.

In the discussion of diffusion curves in Chapter 6 various categories of buyer groups to be targeted were introduced. We identified activities in the case study programmes that could be assigned to these categories (this is admittedly an aspect of the analysis that involves rough judgements). Nine case studies referred to targeting customer groups who are *Innovators*, eleven to *Early Adopters*, twelve to the *Early Majority* – people who are pragmatic but want to avoid risk, three to *Late Majority* customers and one to *Laggards*.

Most of the deployment projects try to reach groups that are likely to lead the market; i.e., buyers who will be imitated by others. By definition this is likely to be a small part of the market and in order to get further it is necessary to reach the two majority categories. Many projects involved attempts to 'cross the chasm' between the Early

Adopters and the Early Majority, which is often the most difficult stage of transforming a market.

Most programmes focus on a small portion of a market in the hope of starting a process that will be self-supporting; thus the category of policy measures that target niche markets is important. Only one programme reported on went so far as to address the totality of a market. It is the quality-label programme mentioned above, which is mandatory. It involves a requirement that for most people does not require immediate action (since it comes in to effect only when a building is sold). Given that mandatory requirements do not easily gain public acceptance, this is an interesting characteristic. Other forms of mandatory requirements are available as policy tools (e.g., building codes).

A Simple Proposal for a More Comprehensive Perspective

Since we have argued that market development policy measures differ across perspectives, it is possible that measures designed in relation to any one perspective will not adequately account for what needs to be done to achieve overall programme objectives. In this light it is useful to think about policy measures as they would come out of a more comprehensive perspective. Our proposal is a simple one: first, step back from the complexity of the specific policy measures themselves and identify the operational objectives that need to be achieved if a market for a new technology is to be developed; then for each operational objective, identify the kind of situation in which it will play a role and list the kinds of measures that might be used to achieve it, taking care to be open to all possibilities and being sensitive to different ways of thinking.

This can be simply an intuitive approach, assuming that the people who are building up the list of objectives and measures are knowledgeable about deployment programmes and their evolution;

and that they are capable of stepping back from their experience and looking at it in a thoughtful way. Or it can be a conscious effort to meld together the distinctive aspects of the three policy perspectives we have discussed – in effect a kind of meta-analysis. In preparing this book we have been trying to engage in that kind of thinking. We have been aided by the perspective-based analysis of the case studies summarised in the preceding section. That is, we decomposed the deployment programmes studied into all of the individual policy measures taken and, to the extent possible, categorised these measures according to which of three perspectives they reflected. We found that many of the measures can be understood in terms of more than one of the three models and, even where they are different, they interact. Thus we realised that policy measures could be repackaged in a more pragmatic way into those needed to achieve 'operational objectives'. We carried out that exercise and the results are shown in Table 7.2.

At the left of Table 7.2 are eight operational objectives that are involved in technology market development programmes. At the right of each objective are some notes that suggest the kind of situation in which that operational objective would be important. The objectives can be organised into three groups, shown at the right of the table:

- *Customer relations* may need attention, meaning that the customer needs to be better served in making choices, presented with price and other incentives that will lead to clever choices, or perhaps needs to be protected from making risky choices.

- *Business and market organisation* may need adjustment. The potential demand from the public for the services of better energy technologies may have to be made manifest to business interests and the supply structure may need vitalisation.

- *Rules and institutions* governing market behaviour may have to be adjusted to allow competition to function better, to avoid favouring or disfavouring alternative technologies for extraneous reasons, or to facilitate better optimisation of an overall energy system.

Table 7.2. Operational Objectives in Deployment Programmes and their Characteristic Applications

Type	Operational Objective	Characteristic Application and Examples of Measures	
A	**Serve** the customer	The customer/user is assumed to need assistance in making better choices from among available technologies. Some relevant measures: the provision of customer-oriented information and calculation tools; and occasionally some interventions to enhance market functions, e.g., third-party financing, development of energy service companies (ESCOs), etc.	CUSTOMER RELATIONS
B	**Incentives** for the customer	Good technologies known to customers are not widely adopted because of market imperfections and externalities. Some relevant measures: internalise external costs through tax measures, adjust market structure so that those who benefit from energy efficiency can influence technology choice.	
C	**Educate** and protect the customer	Inferior technologies are overly used because of inertia on the part of both suppliers and consumers, which weakens competition from new alternatives. E.g., purchasing rules may favour low initial investments and under-estimate high operating costs.	
D	**Manifest** the demand for a change	Find niche and develop niche markets in which to launch and adapt technologies; their development could start a process of more widespread market uptake. Some relevant measures: work with stakeholders to aggregate product demand; help to finance learning investment.	BUSINESS ORGANISATION
E	**Vitalise** conservative business structure	The market has got stuck with traditional products delivered in forms that are not always favourable for customers and users. Activities to improve competition (e.g., deregulation) can vitalise market actors.	
F	**Reconsider** existing regulations and rules	Wider application of good technologies can be hampered by legislation and regulations primarily adapted to conventional technologies. E.g., liberalise regulations affecting electricity feeds from small scale combined production of heat and power (CHP) and independent power producers.	MARKET RULES & INSTITUTIONS
G	**Enhance** financial framework & conditions	Financial arrangements available to buyers may not be well adjusted to the needs of new energy technology markets and this may impede capital stock turnover and slow the adoption of new technologies. Enhancement of financial conditions may open new opportunities.	
H	**Recognise** system aspects	A technological solution designed for a specific problem can affect the output of a larger system. Recognition of the totality of the system (energy, comfort, productivity, environment, etc.) is sometimes necessary to understand and handle the technology shift. A typical instrument is the ISO 9000 and 14000 standards.	

Table 7.3 maps the operational objectives of Table 7.2 back into the conceptual categories contained in each of our three policy perspectives (though in developing these ideas the reasoning was to some extent in the opposite direction; i.e., the combination of ideas from the different perspectives led to the definition of the operational policy objectives). This suggests the kind of specific policy actions that could be taken to achieve the operational objectives. For example, for operational objective B – providing appropriate incentive structures for customers of energy technologies – the range of policy measures used to deal with two of the standard market barriers can be brought into play (those having to do with market price distortions and with decision making by people other than those who will benefit from the technology, as in the landlord/tenant problem), as can the financing of technical adaptations for better market coverage and the various market transformation measures for niche markets.

This approach can be extended to build up more comprehensive and detailed packages of individual policy actions that could be used to achieve each operational objective considered. In this short chapter it is not possible to do that, but one can see that this kind of thinking could proceed towards some sort of detailed 'handbook' that would provide the basis for a more holistic approach to deployment policy development, as well as aiding the analysis of deployment programmes that have already been undertaken, of the sort we are doing in this book. Developing such a handbook – in effect, developing a 'How to ...' manual for deployment policy, would clearly be a large project of its own.

It is acknowledged that if an analytical exercise of this sort is pursued in depth it cannot be entirely independent of context – the world is not that simple. For example, on a practical level the list of operational objectives and relevant policy measures that define our analytical framework could depend to some extent on the types and stages of the technologies for which markets are being developed and on national particularities. Doing the exercise for a new type of nuclear reactor will differ from doing it for a new type of light bulb. Nevertheless it is possible to be quite general, as we have illustrated in this discussion.

Table 7.3: Operational Objectives Related to Perspective-Linked Issues

For each operational objective shown in the left-hand column, the Xs in the matrix for that row indicate the aspects of the three perspectives that are relevant. Reading a row of the matrix tells you how the corresponding package of measures would combine ideas from the different perspectives. Reading a column of the matrix tells you the different operational objectives needed to deal with the issue concerned.

	Barrier type described in case study												**Technology R&D+D Target**				**MT Purpose**		
	Information	Transaction cost	Risk	Finance	Price Distortion	Market Org – Split incentives	Market Org – Bias	Market Org – cost	Market Org – tradition	Regulation	Capital stock turnover	Tech-specific barrier	Existing technology	Few Known solutions	Not known solutions	Niche Market addressed	New product	More good product	Less bad product
Types of Measures	Clarifying technical performance		Active verification		Correct prices	Adapt incentive structure	Adapt market routines	Adapt production	Adapt organisation	Adapt rules	Timing measures	Focus technology to market	Expand market coverage	Finance market adaptation	Finance tech development	Identify niche, negotiate	Target niches	Enable customers	Warn customers
Operational objective																			
A Serve	X	X	X	X									X					X	
B Incentivise					X	X								X		X	X		
C Educate	X						X			X			X						X
D Manifest								X						X		X	X		
E Vitalise									X				X	X				X	
F Reconsider										X			X					X	X
G Enhance			X	X	X						X			X		X	X		
H Recognise												X	X		X	X	X	X	

Further Empirical Analysis

The overall perspective we have proposed provides a framework for analysing deployment policy either as programmes are being constructed, in order to facilitate a more comprehensive approach, or in efforts to understand programmes that have already been undertaken. Many of the observations on national deployment programmes made in this book were formulated as we systematically examined the case studies in the process of constructing the model described above. We also attempted some more ambitious global analysis, which is the subject of this closing section of the chapter.

We were interested in more insight into how the programmes reported on in the case studies relate to the holistic policy framework defined above. We wanted to see the extent to which the combined approach as embodied in our operational policy objectives was used in the 22 national programmes. That is, having postulated a generalised deployment programme framework, we wanted to use it as a hypothetical criterion of comprehensiveness in relation to some actual programmes.

We thus went through each case study to infer from it the measures that were diagnosed as necessary to achieve programme objectives, identify the actual measures instituted, and record the results of the programme as reported in the case studies. (The result of this data-development effort is briefly summarised on a case-by-case basis in the Appendix to this book.) For each case study we made a judgement on how the policy measures undertaken could be categorised into packages associated with the eight generalised operational objectives defined in Table 7.2. We then made a second judgement as to whether each package of measures was actually applied. The results were tabulated, summarised and examined in search of patterns.

We have not reported these numerical results here for various reasons having to do with the problems involved in this sort of data analysis. Working up the data for such an analysis involves a considerable amount of subjective judgement. This can be dealt with by way of

cross-checking the judgements of several analysts, which is a time-consuming process that was not feasible as part of the preparation of this book and not really warranted in light of the nature of these case studies. The latter point is true because the case-study template was not designed with these sorts of questions in mind. If one wanted to pursue this line of data analysis diligently it would be desirable to do a new sample survey that would include questions defined specifically in relation to our new analytical framework. This would also get around the problem of circular reasoning involved in first designing the criterion of comprehensiveness on the basis of this set of case studies and then using it to evaluate the same set of projects according to that criterion.

All that notwithstanding, it is worthwhile noting some of the results of the exercise very briefly in order to illustrate the kinds of issues that can be considered in this framework and because they are also interesting merely as an additional way of summarising some of the information in this set of case studies. For instance, the following observations indicate which of the operational objectives defined in Table 7.2 were frequently applied in these 22 projects and which were not.

- In the area of *Customer Relations,* the most frequently applied measures and the best fit of measures to the diagnosis of what was needed is for package A, measures intended to serve the customer, whereas incentive packages (objective B) or educating and protecting the consumer (C) were either less used or less well targeted in the early stages of the programmes. That is, the latter two categories more often involved change and reconfiguration.

- In the area of *Business Organisation,* measures designed to make demand potential manifest (objective D) were more often applied and well targeted than measures aimed at vitalising business (E). The latter were in some cases not targeted in the diagnosis but later instituted.

- In the area of setting *Rules and Market Conditions,* these needs were seldom noted at the diagnosis stage. In the case of the need to

reconsider regulations (package F), this perhaps reflects that the current interest in regulatory reform is relatively new in relation to the start-dates for many of the programmes. Enhancement of the market framework (G) was also relatively little alluded to as an objective, perhaps for a similar reason, though it also should be noted that the policy instruments in this area are not usually in the hands of the energy policy makers and one should therefore not be surprised that this issue was not considered. The most frequently applied types of measure in this area are those that recognise system dependency (H). It also seems that this area more often involves trial-and-error correction than the other two.

Finally the results made it appear that in the planning and definition phase, programme managers often did not fully recognise the problems that needed to be solved, but that as information on implementation was fed back to them, project design and application was improved. For a variety of reasons, during the implementation of a programme some measures may be dropped or changed. This is hardly surprising, especially for programmes that run over a long time period. In fact, the results of the change of plans may be very positive. The changes may often be highly warranted and the outcome excellent – an illustration of the learning process that we believe to be so important. Alternatively, the changes could reflect a lack of funds, mismanagement or a change of direction in regard to government objectives.

CHAPTER 8: CONCLUSIONS WHAT HAVE WE LEARNED?

The scope for benefits to society from the deployment of cleaner and more efficient energy technologies is very great. Some of the potential for applying new technologies is not realised or is delayed because of inertia in the markets for established technologies and because so many potential buyers are not aware of the benefits available or do not find them large enough to warrant the effort involved in pursuing them actively. Yet the aggregate volume of benefits – those enjoyed directly by the buyer, combined with the benefits of a healthier environment for everyone – may be well worth the effort for society as a whole. Hence the subject of this book: what can we learn about the nature of success in technology deployment policy?

Our contention at the outset was that policy development in this area has been influenced by three overlapping perspectives. We learned in separate chapters that each of those perspectives provides a rich framework for interpreting the experience with technology deployment programmes reported on in the 22 case studies submitted to the IEA. While they overlap, each perspective emphasises different issues and has a different overall tone. The R&D+Deployment perspective focuses on the technical knowledge base and its interactions with deployment. It provides a rationale for learning investments and a future-oriented outlook. The market barriers perspective, grounded in economic theory, provides criteria for market efficiency and discipline in regard to the nature and extent of government interventions in the market-place. The market transformation perspective focuses on the practice of technology deployment, building upon the insights and techniques of the private sector and transferring this approach to the design and implementation of public policy. However, any one of the perspectives in isolation is insufficient. For example, the R&D+Deployment approach places a value on organisational learning, but transferring the understanding of that phenomenon into government policy

requires inputs from the other two approaches. Similarly the economists' tools lucidly expose important issues involved in decision-making, but their abstract nature limits their scope; dependence on them can lead analysts to overlook practical problems and dynamic processes associated with the emergence of markets for new technologies. The other two perspectives help to fill in those gaps.

Fortunately many people involved in deployment policy develop a personal perspective on their work that embodies components of all three approaches. This is something to be encouraged. The most important overall lesson learned from examining the IEA case studies is that policy-making should be approached in a comprehensive way, a way that accounts for all aspects of the innovation process. In our view, a synthesis of the R&D+Deployment, market barriers and market transformation perspectives will go a long way to achieving that goal.

We have attempted to apply this approach to analysing the case studies. In Chapter 6 we drew ideas pragmatically from the three perspectives in a discussion of analytical tools and the question of how to evaluate success in a broad context. In a more formal attempt at synthesis in Chapter 7, we described how we attempted a 'triangulation' analysis of the case studies. This involved unbundling the facts of each study and categorising them in terms of their relation to the three perspectives. This helped us to define a series of operational objectives that can be used as stepping-stones to developing packages of policy measures that draw ideas from all three policy perspectives as appropriate. Thus our analysis of the case studies led us to propose a more holistic framework for formulating deployment initiatives. We believe that its use would result in a more integrated approach to programme design and implementation. A first step in an effort to apply these ideas could be the development of a manual for deployment programmes based on the framework sketched out in Chapter 7.

Describing the more detailed kinds of insights we got from a close reading of the case studies is difficult, given the diversity and complexity of the technologies, markets and measures covered. The

summary observations below convey some of the most important lessons we perceived:

- A necessary starting point for the development of deployment measures is a recognition of the interests of all of the stakeholders in a market for an energy technology.
- Effort is needed to mobilise those interests in the pursuit of improved performance, lower costs and wider dissemination of the technology involved. The reshaping and the invigoration of interactions among stakeholders can make a major contribution to success. Interaction can be improved by removing or reducing barriers that impede market activity, facilitating communication between R&D providers and equipment suppliers, taking better account of the nature of buyer- and user-attitudes, and in many other ways.
- The various measures that make up a technology deployment programme must be coherent and harmonised among themselves and with policies for industrial development, environmental control, taxation and other areas of government activity that affect market conditions for the technology.
- Feedback mechanisms among market actors need to be well-developed and active. They can help suppliers to use R&D resources more productively and both producers and consumers to learn by doing.
- Similarly deployment programmes themselves are more likely to succeed when they involve monitoring that leads to feedback and trouble-shooting. Many of the national programmes studied were adjusted as they proceeded because managers became aware of problems in programme design and complexities in the targeted markets that had not been accounted for.
- There is much potential for saving energy hidden in small-scale purchases: the gathering and focusing of purchasing power is an important opportunity for the deployment of new, cleaner energy technologies.

- Most consumers have little interest in energy issues *per se*, but would gladly respond to energy efficiency measures or use renewable fuels as part of a package with features they do care about.

In the end it is the combined effect of technology performance and customer acceptance that make an impact on the market and hence on energy systems. Developing a deeper understanding of both, including how they are influenced by the actions of government, is an essential ingredient of effective deployment policy.

In closing we should remind ourselves why all of this matters. Why, after all, should we care enough to try to design effective, ambitious and successful deployment programmes for efficient and clean energy technologies? The answer is that we need to have new energy technologies in the market to respond to some of the grand challenges of our day – most notably the problems of climate change and other environmental impacts of energy use, but also the consequences for economic security of our continuing, even rising, dependence on fossil fuels. We need to release the potential that already exists because better technology is available but is not widely adopted. And we need to build additional potential by supporting the development and deployment of promising new energy technologies. We have discussed the importance of learning processes in this book. Realising these potentials through effective policy-making requires a commitment to learning in its broadest, most integrated and positive sense – the capacity to recognise the economic, environmental and societal challenges around us, and the willingness to respond to them with equal doses of responsibility and ingenuity.

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ANNEX: CASE DIAGNOSES, MEASURES AND RESULTS

This Annex summarises the data developed for the analysis described in the last section of Chapter 7. In addition to providing the reader with more insight into the nature of that analysis, the 22 sections below also provide some summary information on the results of the programmes reported on in the case studies.

The following headings were used for categorising the information in the box for each case study:

- **Diagnosis of measures needed** – From our reading of the case studies we inferred the diagnosis of the problems to be solved and the measures to be taken as made by the programme designers and related them to the 'operational objectives' defined in Table 7.2.
- **Match of measures to policies** – We identified the measures actually instituted as part of the programme and related them to the operational objectives as defined in Table 7.2. This provided a framework within which to focus on the effectiveness of programme design and on the evolution of the programme as it developed over time (including the possibility of changes in the diagnosis of what was needed).
- **Volume growth** – Reported growth in sales of the technology concerned or related variables.
- **Volume and market penetration** – In some cases additional quantitative information was reported on the market impact of the deployment programme.
- **Volume and price/cost** – If quantitative information on learning effects was included in the case study it is reported under this heading.

- **Attribution of impacts to measures** – Information in the case studies that had a bearing on evaluating the success of measures taken is reported under this heading.
- **Performance improvement** – Quantitative measures provided in the case studies that compare the performance of the technology covered by the programme to the conventional technologies favoured in the market.
- **Programme cost** – Overall costs of the programme.
- **Estimated savings of energy or related variables due to programme** – In a few cases estimates of this sort were available.
- **Remarks** – Each section concludes with some very brief comments about distinctive aspects of the deployment programme concerned and its success.

Where any one of these headings does not appear in a section, the relevant summary information was not provided in the case study.

Note that information on programme impacts in the sections below comes only from the case studies, which were typically based on information available in 2000. While the impacts of many of these programmes have increased since that time, the data used in this Annex have not been updated.

1. Deployment of Biomass District Heating (BMDH), Austria

Started 1980. By 1999 more than 500 small-scale plants have been established.

Diagnosis of measures needed: The programme focuses on the service needed to have customers accept and use a basically known technology, though one not being applied in this small-size range or in the target area; and on the need to vitalise the market and those

involved in it by giving them a helping hand and a concept that can be shown to work.

Match of measures to policies: The measures are according to the diagnosis, though there seems to have been a development towards several related issues, the most dominant of which fall under operational objective D of Table 7.2 (manifesting a demand for change) – to focus business interest, assure sufficient financing and above all to place the project in an overall context of seeking coherent approaches to agricultural and regional development.

Results:

- Volume growth: Up to 1999 more than 500 BMDH units established in rural areas serving 500-4 000 inhabitants. Of these 2/3 are of a size less than 1 500 kW.

- Volume and market penetration: Dissemination has grown steadily over the years up to approximately 30 sites per year. Since mid-1990 plants of less than 800 kW have become more important, whereas bigger ones are held back. These plants provide about 10% of the total heat from biofuel in Austria, which is 17% of the total Austrian heat demand.

- Volume and price/cost: There are indications that improvements have been made by the use of 'niche managers' to advise on technologies and economy.

- Performance improvement: Not known, though trouble-shooting by the niche managers likely means some improvement and standardisation.

- Programme cost: Some costs for regional development and agricultural support have to be included. The total programme required some 25 MEuro up to 1999. The subsidy could be as high as 50% of the investment.

Remarks: This is a highly innovative programme. Feedback from programme experience has led to programme adjustments, as has the identification of new groups. Policy coherence has been an objective.

2. Thermoprofit (Part of the Graz Municipal Energy Concept), Austria

Thermoprofit is a trademark for total service packages to reduce the amount of energy consumed in a building. The project certifies ESCOs as partners and uses third-party financing and performance contracting as a model.

Diagnosis of measures needed: Primarily a service package (operational objective A) to customers who have limited capacity to handle an energy efficiency project or in some cases (e.g., municipal institutions) to finance them. Also in the diagnostic framework are customer protective elements and elements aimed at reconsidering rules for this type of project.

Match of measures to policies: The measures taken accord with the diagnostics, except that the element to vitalise business seems to have grown stronger in actual applications.

Results: (Reported results are limited, since the programme began less than 2 years before the case study was written.)

- Volume growth: Several Projects have been identified.
- Volume and market penetration: Certification of 5 companies in October 1999.

Remark: Provides security for the customer by way of the authorisation of ESCOs and by transparent, standardised, certified methods for project handling; this is especially important for users with little own resources. The model has interesting characteristics since the role and development of ESCOs are often discussed.

3. Renewable Energy Deployment Initiative (REDI), Canada

Launched on April 1, 1998 as a 3-year programme that has been extended for 3 more years until March 31, 2004.

Diagnosis of measures needed: The diagnosis seems oriented to the reshaping of the market by vitalising business, aggregating demand and giving customers incentives to act.

Match of measures to policies: The measures go in the same direction as the diagnosis by manifesting demand, but the programme is wider and more general in the choice of measures used. The change pursued is tailored to have a lasting effect on several groups in the chain of goods and service delivered to customers.

Results:

- Programme cost: 8 million US$ over a 3-year period
- Attribution of impacts to measures: Indicated but unclear

Remark: The programme has an interesting architecture, which addresses several important issues, but at the time the case study was prepared it was too early to report on results. There is a sense in the diagnosis that an overall market transformation is being pursued; it would be useful to track the achievements of market participants in this programme and proceed from there.

4. Mandatory Energy Labelling of Buildings in Denmark

Developed in the context of a long history of energy auditing activities, including the Heat Consultant Scheme, which was in effect from 1982 to 1996. The development of energy labelling was needed to improve and modernise this scheme.

Diagnosis of measures needed: The description of the rationale for the programme strongly emphasises service for customers.

Match of measures to policies: The measures are consistent with the service objective but also apply strongly to operational objective C (protecting the customer, in the sense of giving them the means to understand calculations that could be biased, for example, by the choice of parameters for the lifetime of equipment and of the sources of advice) and to objective F, reconsidering the rules that guide market activities, such as the information that must be available in a purchasing situation.

Results:

- Volume growth: 40-50 000 labellings per year
- Volume and market penetration: 160 000 labellings (10% of market) reached in 3.5 years
- Volume and price/cost: 300-500 Euro per labelling
- Attribution of impacts to measures: 26% of households have implemented measures and 22% state their intention to do so in a near future
- Performance improvement: An average household could lower their energy bill by 20%
- Programme cost: 750 000 Euro per year (refers to programme development paid by the Danish Energy Agency)
- Estimated savings of energy or related variables due to programme: Savings of 130 000 MEuro have been identified (20 MEuro per annum if implemented)

Remark: This is an important programme that works by taking account of the interests of market actors and has been adapted in response to feedback from those affected. This mandatory scheme has addressed areas that are complicated and tough to deal with, in that it applies to existing buildings and its target population includes customers who have little interest and/or perception of the problem. The programme is in a form that will provide accumulated results over time, in that people implement measures when it fits into their own plans.

5. Diesel Engines for Combined Cycle Power Generation, Finland

Diagnosis of measures needed: Strong focus on operational objective H to find the correct function of a technology in relation to a larger system, making the best use of available knowledge and manufacturing capability. The case study also conveys a strong interest in industrial development.

Match of measures to policies: The measures fit the diagnosis very well. The partners use financial mechanisms and tax instruments that enable the participation aimed for.

Results:

- Volume and market penetration: The demonstration has reached a large number of important target groups (9 000 visits from 4 500 possible investors)
- Attribution of impacts to measures: Direct responses observed and incentives (tax reductions) are well tailored for users

Remark: This project focuses on product development and demonstration that involves many stakeholders and uses their experience and interest actively. The relation of the case study to deployment issues is not strong because the target is set in terms of technology and not in market terms. It could be viewed as a project that precedes deployment programmes and in that sense involves interesting promise.

6. Solar Optimised Buildings, *'SolarBau'*. Energy Efficiency and Solar Energy Use in the Commercial Building Sector, Germany

Diagnosis of measures needed: The diagnosis seems weak and split between objectives; it primarily acknowledges that demand is weak and ought to be strengthened, and that financing is a problem.

Match of measures to policies: The measures are primarily geared towards financing R&D associated with technology-specific issues as they are related to the systems function. Thus there is little coherence with the diagnosis made.

Results:

- Attribution of impacts to measures: Knowledge development among important categories of skill needed in the work (that of architects, engineers, etc.) and about critical pieces of system configuration seem well addressed.
- Performance improvement: The case study indicates that objectives have been reached (total energy demand <100 kWh/m^{2}a and space heating <40 kWh/m^{2}a). It reports that the result so far is well above expectations and points to a reduction of energy use in targeted commercial buildings, which is down to 1/5 of present average value.

Remark: The project reported on in the case study is not focused on deployment issues, it deals primarily with systems technology for a small group that want to test and demonstrate a capacity to design in a pilot scale.

7. Wind Power for Grid Connection '250 MW Wind' Programme, Germany

Started in 1989, the closing date is scheduled for 2006. Initially started as the '100 MW Wind' programme; because of a high level of demand, and the reunification of Germany, funding was expanded to a total of 250 MW in 1991.

Diagnosis of measures needed: The case study description is not very precise in terms of diagnosing targets; it gives the impression that financing or cost barriers prevent wider use of and future deployment of wind power.

Match of measures to policies: The measures applied are more distinct; it is clear that the programme sets out to improve incentives for the customer and make manifest the demand for wind development. A bit less clear, but nevertheless observable, is that the measures are directed to adjustments in the financing framework, at least in the context of this particular programme.

Results:

- Volume growth: Total wind power capacity in Germany > 5 000 MW, with 10 TWh/y production
- Volume and market penetration: Local markets (e.g. Schleswig-Holstein) are supplied up to 15% by wind power (the goal for 2010 is 25%)
- Volume and price/cost: German manufactured turbines have increased to 10% of world market and have created 15 000 jobs. Specific Investment is appr. 900 Euro/kW
- Performance improvement: Availability of turbines > 98%, output 2 000 kWh/kW
- Programme cost: 160 MEuro + 25 MEuro (for monitoring) until 2006

Remark: The programme involves a combination of incentives and other elements that are directed towards one common goal – providing incentives for output and harmonising stakeholders actions. There are also positive effects on employment.

8. Photovoltaic Power Generation Systems (from R&D to Deployment), Japan

Initially started in 1974 as a part of the 'Sunshine Project'.

Diagnosis of measures needed: There is a distinct focus on the aggregation of demand to build a market and on the development of

the product involved, both in terms of the nature of the product itself and its role as a system element.

Match of measures to policies: The application of measures seems to be a bit broader than the diagnosis; it stresses both customer and business perspectives. The close connection between the R&D programme and the deployment programme underpins and reinforces the aim to make products more available by development.

Results:

- Volume growth: 200 MW has been installed by end of 1999. Between 1994 and 1999 17000 installations have been made.
- Volume and price/cost: Cost dropped from 30 000 US$/kW (1993) to 8 000 US$/kW (1999)
- Attribution of impacts to measures: Overall impacts are evident, though the blend of measures prevents detailed analysis of each component.
- Performance improvement: As an example, integrated PV modules have been standardised and made part of accepted applications in building codes.
- Programme cost: Many components of the R&D and deployment budgets are tightly fitted and tuned together. Subsidies to customers are in the area of 20% (0.18 MY/kW of 0.93 MY/kW) of installation (1999).

Remark: The range of involvement and the balancing of resources and interests are impressive.

9. High Efficiency Heat Recovery for Domestic Ventilation in the Netherlands.

Mechanical Ventilation with Heat Recovery

Diagnosis of measures needed: The diagnosis indicates that the technology is known but not sufficiently applied according to its merits.

Hence customers and business need to be mobilised, with voluntary participation but supported by rules that facilitate solutions.

Match of measures to policies: The measures are in total harmony with the diagnosis, though the vitalisation of business indicated in the diagnosis, which required price guarantees and certification of installers, was not accepted by the suppliers.

Results:

- Volume growth: 8500 units in new houses (1999).
- Volume and market penetration: grew from 1% installation in houses built during a year (1995) to 10% (1999). The projection for year 2000 is 15%.
- Performance improvement: From 65% energy efficiency on average in normal exchangers to 90-95%. The energy use in fans separately dropped by 40% (shift from AC fans to DC fans). Also indoor air quality, thermal comfort and noise levels have improved.
- Programme cost: 200 000 Euro annually

Remark: This programme involves the use of regulatory instruments and technology development in a comprehensive strategy addressing several issues of importance for both users and suppliers.

10. The PV-Covenant in the Netherlands

Diagnosis of measures needed: According to the diagnosis the customer is the force that should drive the process of change by incentives and the aggregation of demand. The need to reach new customer groups, whose interest is not primarily technology but comfort, is addressed

Match of measures to policies: The measures also emphasise the customer role as the driving force and the use of financial and fiscal

instruments to achieve the results. The involvement of several links in the business chain is recognised and used.

Results:

- Volume growth: Goal of 7.7 MW grid-connected solar-PV before year 2000 was reached.
- Volume and price/cost: Not known, but probably a high impact, since the goal for 2007 has been raised significantly (250 MW).
- Attribution of impacts to measures: Highly probable, since the utilities are involved and have signed on to commitments within a voluntary agreement.
- Programme cost: Total amount in programme is 60 MUS$, of which 25 MUS$ for R&D, for four years.

Remark: Stakeholders on the supply side were identified and brought together so that each could use his abilities for a common goal.

11. Deployment of Renewable Energy in a Liberalised Energy Market by Fiscal Instruments in the Netherlands

Goals for 2020: a) 33% improvement of efficiency (total energy consumption should remain at the 1990 level despite economic growth); b) 10% of all energy used should be from renewable sources.

Diagnosis of measures needed: Dutch policy in this area involves components from all three of the broad categories of operational objectives; e.g., buyer incentives, vitalising of business and changing market rules.

Match of measures to policies: The measures taken match well with the diagnosis. The evolution of objectives has been influenced by the need to have flexible policies that allow innovations in both

technologies and organisation in a setting of deregulated electricity markets.

Results:

- Volume growth: Market has grown from 600 GWh to 1400 GWh in four years
- Volume and market penetration: Green Energy is used by 3.5% of all households and in some customer groups up to 10%.
- Volume and price/cost: Obviously a positive enough result, since competitiveness has been achieved. There is a shortage of contracts in the short term.
- Performance improvement: Not known, but the programme states that the measures used work fine for 'distribution' but that other policy instruments are needed to address the long lead-times in project development.

Remark: This is a comprehensive system for the maximum use of market forces in the achievement of goals by fiscal instruments. It requires careful balancing and consensus among stakeholders.

12. Market Transformation on Lighting, Sweden

Diagnosis of measures needed: The programme aimed primarily at operational objective D – the aggregation of demand for better technology.

Match of measures to policies: The measures came to have a broader range since the aggregation required supportive actions to reach a 'fuzzy' target group and to maintain the aggregated demand. Thus customer service and the development of supplementary market rules and technology systems aspect came into focus.

Results:

- Volume growth: the market grew from 10 000 to 600 000 units/year in the period 1991-96.

- Volume and market penetration: HF technology is now practically standard when refurbishing is done in the commercial sector
- Volume and price/cost: Life cycle cost for HF-lighting is lower and the prices of ballasts for HF luminaires has dropped
- Attribution of impacts to measures: Highly likely, since installation companies were allies in the programme
- Performance improvement: 10 W per m^2 vs 25 W per m^2 . However, improvements in light quality were more important for the user than the energy savings.
- Programme cost: 5.3 MEuro
- Estimates of energy savings and related impacts due to programme: Cost per kWh saved = 0,11 Eurocents

Remark: Based on a technology procurement, supporting activities in this programme were tailored to address the needs for important market stakeholders. Quick market uptake and learning effects were recorded.

13. Market Transformation on Heat pumps, Sweden

Diagnosis of measures needed: The programme aimed primarily at the aggregation of demand for better technology.

Match of measures to policies: In addition to operational objective D, measures taken in the execution of the programme seem also to have covered some aspects of customer protection and more importantly some system-functions and the interdependence between them needed to deliver the final 'energy services' involved.

Results:

- Volume growth: Sales grew from 2 000 units/year (1995) to 11 000 units/year (1997)

- Volume and price/cost: The cost of the initial-purchase package was 30% lower than the corresponding package delivered before the project.
- Attribution of impacts to measures: The market has remained on the newly attained level. According to the manufacturers, the project restored market confidence in heat pumps and led to investments and new jobs in their industry.
- Performance improvement: Equipment performance (COP) was improved by 30%
- Programme cost: 0.5 MUS$
- Programme energy savings: Initially (one year after the programme) 30-40 GWh/year

Remark: This programme acted as a catalyst to start a process that was stuck because suppliers were too small to respond to the challenge and customers were insufficiently informed on the technical aspects of the technology to be able to communicate their needs.

14. EAES Programme, the Swedish Programme for an Environmentally Adapted Energy System

This programme is primarily directed towards projects in the Baltic Region and Eastern Europe (Estonia, Latvia, Lithuania, Poland and Russia).

Diagnosis of measures needed: In the preparations it appears that the focus was on the gaps that were observable in a system of markets in transition. Customers had little information and needed service; the rules related to energy systems and the implementation of energy-related projects were inadequate for a market economy and the systems were improperly configured.

Match of measures to policies: The measures applied were in harmony with the diagnosis, except that they seem to have given more emphasis to the vitalisation of business than to the changing of rules and regulations; that is, the interactions with business under the programme have been more specific than general. The real surprise is that though financing was a primary instrument, in the end it is not an important characteristic of the programme. That is, it seems as if the financing did not need to be restructured, but financial resources had to be made available for projects of a smaller scale.

Results:

- Volume growth: Significant growth has occurred; the more than 60 projects involved represent some 75% of the entire stock of UN-FCCC registered AIJ-projects (Activities Implemented Jointly) for energy efficiency and renewable fuels.

- Volume and price/cost: Fuel costs have typically been reduced by 40% by the change from fossil fuel to biofuel.

- Attribution of impacts to measures: The direct effects can be easily observed.

- Performance improvement: During a period of some 4-5 years, programme expenditure on consultants dropped from 20% to 10% and the amount of equipment imported from 70% to 35%.

- Programme cost: 25-30 MUS$

- Estimates of energy savings and related impacts due to programme: CO_2 reductions of 300 000 tonnes per year, SO_2 3 100 tonnes per year, NO_X 170 tonnes per year. The projects have an estimated life time 15-20 years.

Remark: This programme involves an innovative use of existing knowledge and resources; it addresses important obstacles with many spin-offs.

15. Energy Efficiency Best Practice Programme, UK

Launched in April 1989, to stimulate energy savings in industry, buildings and the business use of transport energy

Diagnosis of measures needed: The programme has been totally focused on serving the customer by providing the information necessary to choose and use technologies at the high-efficiency end of the range of available technologies.

Match of measures to policies: Measures applied are totally consistent with the diagnosis; an element of buyer protection has been added, in that by using the information provided the customer acquires insight into energy-related choices that should be avoided.

Results:

- Attribution of impacts to measures: Evaluations of programme impacts are routinely carried out.

- Programme Cost: Estimated to be 30-45 Euro per tonne of carbon. Funding from the government is in the range of 30 MEuro per year.

- Estimates of energy savings and related impacts due to programme: The programme is expected to save energy according to a ratio of at least 5:1 relative to the programme funding provided. During the period 1989-99 energy savings have been estimated to reach approximately 1 000 MEuro per year, with saving of 4 Mtonnes of carbon per year.

Remark: This case study provides a good example of how a programme can develop over time and accommodate new circumstances. It covers a very wide range of applications and has an exemplary reporting and evaluation system.

16. Unconventional Natural Gas Exploration & Production, United States

Diagnosis of measures needed: The diagnosis focuses on the possible utilisation of a resource that is indicated but not fully known; the assumption is that technology development might demonstrate and facilitate future use of the resource. Programme measures need to be directed at systems utilisation and development.

Match of measures to policies: The measures undertaken show how exploitation of the natural gas resource was made possible by way of a strong financial incentive and a consequently manifest demand from customers who took the risks involved in early adoption of the new technologies. There was also significant backup of the deployment effort by way of R&D.

Results:

- Volume growth: Gas provided from these unconventional sources has grown threefold in 20 years. Growth continued after the programme when tax credits had been phased out. Proven reserves grew about 2.5 times

- Volume and price/cost: There are indications that costs could have been reduced by 50% during the time that tax credits were given

- Attribution of impacts to measures: Highly likely that the programme instigated the development of both technology and knowledge about unconventional gas reserves.

- Performance improvement: Gas has been made available from new reserves.

Remark: This is a combination of an R&D programme in a high risk activity and a system of incentives to attract developers. In regard to the latter aspect there is some resemblance with the Dutch programme reported on in CS11. However, the market concerned is very special

and it could be assumed that the number of market actors involved in it is limited and easier to approach for that reason.

17. Sub-Compact Fluorescent Lamps, United States

Diagnosis of measures needed: The target was business organisation and the primary objective to aggregate demand in order to generate interest on the part of manufacturers.

Match of measures to policies: The measures were totally in line with the diagnosis and perhaps even a bit stronger in regard to vitalising business (ensuring that manufacturers saw the possibilities and that customers were communicating their preferences effectively).

Results:

- Volume growth: The goal of one million lamps was exceeded by 50%.
- Volume and price/cost: Prevailing prices of 15-22 US$ dropped to the range of 5-8.5 US$ (depending on quantity purchased)
- Attribution of impacts to measures: 16 new models were brought to the market, enough to ensure supply capacity. Five manufacturers commercialised new products.
- Performance improvement: A CFL of smaller size to fit into fixture was developed.
- Programme cost: 342 000 US$ (for research and preparations, no incentives given)

Remark: This very inexpensive technology procurement programme was highly successful in facilitating the development of modified products and their uptake. It involved the conscious building of relations across the product distribution chain.

18. Clean Coal Technology Demonstration, United States

Diagnosis of measures needed: The operational objective is to manifest and aggregate demand for a complex product used in energy conversion systems.

Match of measures to policies: The measures are in complete harmony with the diagnosis. The challenge has been to define operational targets for the technology issues to be solved and to adjust these targets not only to the technical needs but also to the changing conditions of the market framework. This is underlined by the clear indication of measures that relate to system conditions.

Results:

- Volume growth: Forty projects in 18 states have reached completion.
- Volume and price/cost: Cheap low-NOx burners have been developed.
- Performance improvement: AFBC plants developed; IGCC and PFBC with 20-40% lower CO_2 emissions. Methods to up-grade low-ranked coal developed and commercialised.
- Programme cost: 5.6 BUS$ of which 1/3 was financed by Federal government funds.

Remark: The project illustrates how commercialisation can be achieved when industry responds to challenges made manifest by the government and technology users. It presents an interesting model for government-industry collaboration.

19. Industrial Assessment Center Program (IAC), United States

Run by the Office of Industrial Technologies, USDOE Office of Renewable Energy and Energy Efficiency

Diagnosis of measures needed: This programme is totally focused on customer service.

Match of measures to policies: The measures are primarily on customer service, but with some elements also of consumer protection and the vitalisation of business.

Results:

- Volume and price/cost: The establishment of databases and the tracking of audits/measures, as well as the high degree of implementation (50%), make a positive learning experience highly likely.
- Attribution of impacts to measures: Typically plant managers implement about 50% of the recommendations for measures that will start saving energy immediately.
- Performance improvement: A benefit/cost ratio of 8.1:1 was calculated for measures implemented in 1999.
- Programme cost: Annual budget 8.3 MUS$
- Estimates of energy savings and related impacts due to programme: Annual savings 40.7 MUS$ (app. 55 000 US$ per assessment), 1999 (composed of 9.7 MUS$ for energy, 6.6 MUS$ for waste and 24 MUS$ for productivity).

Remark: This is a strategic and well-conceived model for building a capacity for long lasting results. It involves very important side-effects relating to productivity, waste management, education and customer motivation.

20. Motor Challenge and BestPractices Programs, United States

Diagnosis of measures needed: The case study description indicates that the aggregated volume of demand is too low to provide a basis for the use of higher-performance motors.

Match of measures to policies: The measures taken do not focus directly on aggregating demand, but on providing service that will allow customers to make more educated choices.

Results:

- Volume growth: Over 10 000 purchases of premium motors.
- Volume and market penetration: The volume represents 6% of the market for premium motors.
- Attribution of impacts to measures: 10-15 % of customers implement measures that result in 6% of the market for premium motors.
- Performance improvement: The programme targets premium performance.
- Estimates of energy savings and related impacts due to programme: 24.9 MUS$ in annual savings 1999 (app. 500 GWh per year).

Remark: This programme involves a comprehensive system across industries and makes deliberate and positive use of business interests. Over a long period in which relationships were built, business and R&D issues have been effectively woven into the programme.

21. EnergyPLUS, European Union

Diagnosis of measures needed: The diagnosis has recognised that the characteristics of refrigerator/freezer technologies have developed beyond what is being communicated in the market; the labelling system is undersized and the competition has been developing towards branding rather than performance.

Match of measures to policies: The limitations of existing communication and incentives have to be overcome; aggregating purchasing power is the tool to use.

Results:

- Volume growth: Not recorded but a promising number of retailers are involved.
- Volume and price/cost: Too early to know, but niche markets identified.
- Performance improvement: Remarkable, improvements in the range of 50 % compared to the best technologies available in the market before this point
- Programme cost: 1 MEuro

Remark: The project is in an early stage and will need more time to mature before results can be observed. However, suppliers and retailers have shown remarkable interest in the early stage of the programme.

22. IEA-SolarPACES START Missions

Diagnosis of measures needed: The diagnosis points at many sorts of problems (customer, business organisation, financing) involved in getting a brand new technology into the market.

Match of measures to policies: The measures that have been given priority are those that relate to manifesting demand and to financing.

Results:

- Volume growth: A 130 MW hybrid (fossil-solar) plant is under way
- Volume and market penetration: Negligible
- Volume and price/cost: Not applicable at this stage
- Attribution of impacts to measures: Direct observation of proximate impacts is possible.
- Performance improvement: Not applicable at this stage

Remark: This programme involves a long lead time before results can be observed. So far the direct results are limited but the concept is interesting nevertheless.

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Developing markets for new energy technologies:

A review of the case studies from the market barrier perspective

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1. Introduction

The idea of a 'market barrier perspective' that provides a framework for thinking about the adoption of new energy technologies can be traced back to a policy debate of the 1980s and 90s over the extent to which government should be involved in supporting and hastening the adoption process. For many proponents of energy conservation and diversification, normal market processes were far too slow at bringing about the widespread use of new energy technologies that were urgently needed to enhance energy security and the environment. In their view this was due to various barriers in the way of the rapid market penetration of new technologies and they advocated government action to reduce or eliminate them. Some economists responded to these arguments and a debate ensued. They did not dispute the existence of obstacles in the way of new technologies, but did disagree with the advocates of government action over the appropriate role of government in mitigating the barriers. In their view government needs to be concerned only about obstacles involving 'market failure' (that is, obstacles of a nature that cannot be dealt with by normal market processes). They argued that many of the barriers identified by the proponents of more government action – barriers such as the cost of collecting information and administering market transactions, the risk of product failure, the high cost of finance for small borrowers, and others – are normal and inherent aspects of market activity that have to be allowed to influence market decisions and do not meet the market failure test.

It is neither necessary nor interesting in the present context to unravel the threads of this debate. We need only be interested in asking what it means to review the 22 case studies submitted to the project of the IEA's Committee on Energy Research and Technology (CERT) on 'Lessons Learned and Best Practices in Technology Deployment Policies' from the perspective of market barriers. Various interpretations are possible. An obvious one would be to review the policies reported on in the studies in relation to how they alleviate each of the well-known market barriers. I have rejected this approach because I think it would cover very familiar ground and not be very interesting. My choice rather is to pick up on the definition of the barrier model in the note on methodology prepared by the organisers of this workshop. They say that the market barrier model 'is the standard deployment model, consistent with a neo-classical economic viewpoint stating that it is legitimate for governments to intervene in the market to remove or reduce barriers due to market failures.' Interpreting this broadly, I took it to mean that I should read the case studies through the eyes of an economist – that is, with a view to analysing the effects of the policies being studied on market processes, to whether they have been designed in ways that will productively take account of the nature of markets, and to whether they respect a basic tenet of market economics – that government intervention in the economy should be limited to dealing with market failure.

Especially in the context of the debate over market barriers, the neo-classical economics label is often associated with a stereotype, in which the economist is viewed as being preoccupied with the pitfalls involved in governmental attempts to influence markets and arguing endlessly against government action. This is not the stance taken in this paper. The paper represents a neo-classical view only in the sense that I have had the principles of standard economic analysis in mind when I examined the content of the case studies. Moreover my personal view of applied economics is that it should focus squarely on the limitations of markets as well as on their strengths. I believe that there is an important role for government in the creation and the timely growth of markets for new technologies.

The paper is organised into sections. Section 2 is a brief discussion of some aspects of the economist's argument on the appropriate role of government and of the kind of analysis that can be based on the case studies. Sections 3 and 4 are the heart of this report – readers who are not interested in the discussion of background issues can go directly to them. Section 3 conveys the broad impressions that one gets from reading the whole set of case studies and proposes a generalised lesson derived from them. Section 4 is a more detailed discussion of a selection of the case studies and the lessons contained in them. Section 5 returns to the lessons learned in a broad context and considers some implications of the ideas discussed in this paper for the work of the IEA's Committee on Energy Research and Technology.

2. Background issues

2.1 A realistic perspective

It is helpful first to make a few brief observations that place the economist's view of the appropriate forms of government intervention into a practical perspective.

1) The standard prescription for dealing with market failure associated with energy use is that the external costs resulting from them should in various ways be internalised into market prices; and that otherwise governments should let markets develop and operate in response to supply and demand. It is true that a comprehensive and accurate internalisation of all costs would go a long way to facilitating effective technology choice. The difficulty is that internalisation has not taken place to that extent and there is no reason to expect that it will. Governments demand a high level of certainty about the results of such expensive policies before instituting them and it is very difficult to convince them of the benefits of internalisation, which will materialise gradually and in complex ways. This is especially so when the damages of externalities are not well understood (as in the case of climate change). In such a situation other measures are legitimised. Furthermore, even if internalisation were to be achieved, there can still be need for government action in regard to structural failures in markets (e.g., anomalies in decision making mechanisms in which the people who benefit from a technology decision are not the same as the people who decide) and in regard to the provision of public goods (e.g., in relation to product standards and codes, ways of communicating about technologies, education and training, etc.). This observation provides an important form of legitimacy to the kinds of policies considered in the case studies.

2) The market failure argument is usually formulated in a static framework, in which technology is assumed to be given and unchanging. Here technological change is at the centre of our discussion and we should therefore be focusing attention on dynamic, not static, issues. An important dynamic issue that has been debated by economists is the 'infant-industry argument'. This can be viewed as an earlier version of the market barriers argument that came out of the literature on international trade: a new industry (or market) needs protection from its competitors in other countries because it needs time to get on its feet. This argument earned itself a bad name in some circles because, in practical terms, once an industry had protection from international competitors it worked hard at keeping it, and was often successful. The result was a long period of protectionism and the inefficiency that results from it. While that kind of failure in policy management does not take away the underlying validity of the infant-industry argument, it does provide us with one criterion for good market development policy. Do policy measures include 'sunset clauses' of some form? Will subsidies and other forms of direct support for 'infant technologies' be eliminated when a market takes off? Similarly will they be eliminated when an infant technology has had enough time to take off but demonstrates that it is not economically viable?

3) The neo-classical market model pictures an efficient interaction between many competitive suppliers, each of whom cannot influence the operation of the market, and many consumers, each of whom has a well-defined and constant set of tastes. This is often far from reality. Energy markets are very often interactions in which the choices available to consumers and the preferences they have in regard to these choices are very much influenced by the actions of suppliers. When this occurs, especially in combination with the important external effects of energy production and use, there is a strong case for governments to be involved in helping to build workably competitive markets for new energy technologies.

2.2 Nature of the analysis

When the organisers of this exercise invited Member countries to submit case studies they asked for success stories, rather than reports on the whole range of policy experience. The discussion in this paper is thus in part a matter of celebrating success, but while doing that, also trying to understand how it came about and how problems were avoided. In most of the case studies success has been measured in terms of various practical market development objectives, such as the numbers of units of energy equipment sold relative to initial expectations, amounts of information disseminated, new market institutions developed, and so on. We want to consider whether the success achieved in the framework used by the case study writers also makes good sense in market terms. While it is difficult to do this in precise ways based on information in the case studies, we can look for evidence in them in relation to various issues. For instance, are policy measures designed in ways that make use of market processes and thereby lead to results that are cost-efficient? Does it appear that units of a new technology are being sold because policy measures have overcome market barriers, as distinct from sales merely being ‘purchased’ by way of generous subsidies to buyers? Does it appear that policy measures will lead to the evolution of sustainable unsubsidised markets? Is there evidence that the relevant market information possessed by buyers and sellers is being enhanced by the policy measures? Where the infant-industry argument is motivating a policy measure, will it be phased out in timely fashion?

With these kinds of questions in mind, each case study considered signals which sorts of market issues can be evaluated and an overall review of them can be built up in an empirical way.

For the sake of completeness, it should be acknowledged that this approach is a limited sort of economic analysis. A full analysis would involve the application of various theoretical constructs in a more rigorous manner. For instance, a benefit-cost analysis would subsume the measures of success referred to above into a generalised framework applied systematically to the policies studied. It would ask whether each policy was worth doing when the benefits of a policy action are set against a full accounting of its costs and considered relative to other public investments. Some of the reports do in fact provide data on limited forms of benefit-cost calculations, but a systematic benefit-cost approach in the present context is obviously not possible with the data supplied.

Another approach would apply econometric techniques to unravel the effects of policies from market growth that would likely have taken place anyway. This calls attention to a thorny problem associated with a lot of information in the case study reports. When levels of adoption of a technology have increased during a period in which a market development policy has been in effect, it cannot be automatically concluded that these increases are attributable to the policy. This is often implicitly acknowledged by the presentation of various forms of supporting evidence. However, that evidence is often anecdotal and difficult to evaluate. Though econometric techniques themselves involve complex interpretation, they have the advantage of being based on a systematic analysis of statistical data.[1]

3. Lessons Learned - Overview

The following observations describe my impressions from reading through the 22 case studies submitted to the CERT ‘Lessons Learned’ project.

1) The policy measures reported on in the case studies reflect an understanding that markets are complex, multi-faceted and interwoven.

2) Market development policies have to mirror this complexity. It is necessary to understand markets in depth in order to fashion policy instruments with clear and achievable performance targets.

3) Sometimes this makes it sensible to focus on groups of technologies. If the markets are interwoven, then the technology policies should be interwoven.

4) Taken together, the characteristics described above often lead to market development programmes that are large, require fairly long time horizons and involve a variety of players.

5) Arrangements to facilitate consultation with multiple stakeholders are crucial and they are very evident in the case studies. The nature of the consultation processes varies from case to case. It is sufficient in some cases to have straight-forward and limited consultations with key stakeholders during the policy design stage. Other policies have involved innovations and there are some interesting ones in the case studies. For instance, in some cases non-governmental players have a direct role in decision making and new institutional forms have been constructed with a view to taking account of the needs of multiple players on a continuing basis.

6) In most of the cases submitted, the use of market processes is quite straight-forward. In a few cases innovative ways have been found to incorporate market forces into policy measures and thereby enhance the policy outcome.

It is enticing to look for a concise way to convey the overall message contained in these observations and in the more detailed discussion in the next section. In fact, it is not difficult to formulate a short version of the lessons learned from the case studies. In my view the key idea can be summarised under a single broad assertion. *When policies are being designed to support the development of markets for new technologies, the primary focus of attention should be on the markets, rather than on the technologies.*

Think

Markets !

(not Technology)

This advice assumes that the technologies involved are already close to being marketable and it is of course intended as *a change of emphasis* rather than a suggestion to forget about the technology side of the work. To develop markets for new technologies it is necessary to focus on both the markets and the technologies to be supported. But as I am speaking to an audience that is primarily involved in science, research and development, I have no hesitation in saying that after the long process of bringing a technology to the launching stage, it is crucial at that point to bring some new thinking on to the scene – thinking that reflects experience in business, marketing, communication, finance and the economy. It is the moment at which it is necessary to understand in as much depth as possible the markets through which the technology will be sold. Market-specific characteristics will play a role as big as or bigger than technology characteristics in determining the kinds of policy measures needed. Understanding these characteristics requires a shift of perspective from that of the R&D process.

Another way to see this argument is to think of markets for energy services. You will typically find that different technologies compete for providing those services. In that case it is likely that effective policy will involve the simultaneous consideration of more than one energy technology at a time. You are very likely to miss something if your sights are too firmly fixed on a single technology. Furthermore, it is a good idea not to design policies that depend on ‘picking winners.’ Instead, focusing on the market can lead to the use of performance objectives defined by the policies themselves – such as reductions in the emissions-intensity of electricity supply or the proportion of electricity supply provided by renewables – which will leave decisions on the choice of specific technologies to the firms supplying the market.

There is evidence in many of the case studies of support for this argument. They also convey lessons that are more complex and specific. It is important now to turn to the studies in detail.

4. Lessons Learned – Individual case studies

All of the case studies provide interesting material for commentary in the framework described above. However, in a short paper it is unrealistic to go through them one-by-one and at the same time do justice to the discussion. My approach here is to consider various issues and discuss one or more case studies in relation to each issue. Other cases that involve similar experience or interesting contrasts are also brought into the discussion more briefly.

4.1 Fragmented markets

In its most basic sense, a market is simply a set of arrangements through which buyers and sellers transact the exchange of a specific good or service. Using this definition, when we talk of building '*the* market' for a technology in a complex modern economy, we are typically referring to a system of sub-markets that all together bring about the dissemination of the technology to its ultimate users. This is obvious for even very simple goods, where there are separate but connected exchanges between manufacturers, wholesalers, retailers and final consumers. But it occurs in much more complicated ways in some parts of the economy, where there can be different suppliers for the various aspects of designing, producing, installing, testing, conveying and using an energy technology. In some cases, the system of sub-markets is so extensive that it will be referred to as a sector of the economy, such as the electricity-supply sector or the building sector. Accounting for this in regard to market development policy, it is important to pinpoint the decision makers in the whole set of interconnected markets who make the key decisions in regard to using new technologies versus conventional ones. It is also necessary to account for links across markets and to include measures in the policy package that bring about adjustments in markets of secondary importance that interact with the key markets.

Several of the case studies deal with the building sector, which involves one of the most fragmented market systems of all. A large array of different market players influence technology decisions in the building sector, each type working in its own accepted niche with long-established operating procedures that are subject to much inertia. In such a setting the way to encourage greater energy efficiency is certainly not to have a separate market development programme for each building-related technology, but rather to approach the market on its own terms and find ways to encourage individual decision makers to make better energy choices. A key step in doing this occurred in the early stages of energy conservation programmes for buildings when energy service companies were developed. In effect, a new sub-market took form in the building sector to provide information gathering and analytical services for energy users. But the effective operation of the energy service market has itself been a challenge. The Thermoprofit programme, which originated in the Austrian city of Graz (Case Study ID2), is an example of a policy that is in large part intended to improve the performance of energy service companies, while at the same time contributing to the overall effectiveness of information dissemination programmes for the building sector.

In various ways the Austrian case study reflects a sensitivity to the complexity of market processes and the need to find entry points for policy within existing market structures. It has taken existing companies as a starting point and built them into a network. This facilitates information transfer, the availability of financial options, bidding procedures to assure cost controls, monitoring of results and certification. The inclusion of a quality label in the programme recognises the need to deal with market risk for building owners and introduces a potential for internal growth momentum, in the sense that more building owners and building-service consumers will become aware of the advantages of the programme as future transactions in building markets take place.

Thermoprofit also reflects the need, in relation to certain kinds of markets, to start at the local level and work up. So far, eight Thermoprofit projects, involving multiple public buildings, are completed or in operation. They involve a variety of building-related energy technologies. Other energy agencies in Austria have indicated an interest in providing the same kinds of services. Efforts are underway to develop a franchising system that will create a network of partner agencies, meaning that a local or regional effort of this sort can be developed into a multi-regional or national system.

From among the 10-or-so case studies that deal with the building sector, there are two in addition to the Austrian study that can be viewed as motivated in part by the fragmentation issue. These are the energy labeling scheme for buildings in Denmark (ID6) and the development of a market in the Netherlands for high-efficiency mechanical ventilation (ID14). They provide an interesting contrast to the Thermoprofit programme in regard to the approach taken to influencing market decisions. The Austrian programme is designed to convince decision makers to use better technologies by effectively showing them the advantages of doing so. The Danish and Dutch programmes combine this approach with some elements of regulation.

In the Danish case, the seller of a building must have an energy audit performed by an approved consultant before the sale takes place. This results in an 'Energy Label' for the building, which provides information on energy and water consumption compared to other buildings with similar use, and an 'Energy Plan', which documents the labeling information and sets out proposals for improvements in the building. This provides an incentive to the seller to make improvements before sale and benefits buyers by enhancing the likelihood that market prices will reflect differences in energy efficiency. In cases where sellers do not make recommended improvements, the programme provides buyers with information on what needs to be done and a potential source of funds for doing it (the saving due to a lower building price).

The regulatory aspects of the Dutch programme are more indirect and complex. New buildings in the Netherlands must comply with an energy performance standard. The installation of a high-efficiency ventilation system with heat recovery contributes to compliance with the standard for the building concerned. While the effects of this programme are still being evaluated, sales of this technology have been increasing substantially since it was introduced.[2]

Whether it is desirable to have a fully voluntary market development programme or one that includes regulation is obviously a very large question. Comparing these case studies draws attention to the issue, but the information in them on this point is obviously too limited to be a basis for policy advice, especially given the many other respects in which these programmes differ. There is a topic here for a useful more narrowly-focused study.

Two other aspects of these programmes contain lessons for policy makers. First, they illustrate the importance of extensive consultation processes. The Austrian and Danish approaches to doing this involved extensive consultation with stakeholders and creative approaches to keeping the stakeholders involved in the process. (The Dutch programme has a narrower focus. The main source of feedback from users in this case was a market survey.) Referring to the consultation process, the report from Denmark notes that "as a result of this work, a totally different labeling form was introduced." Secondly, the Danish and Dutch programmes were developed as a result of re-evaluating earlier market development measures that were not working well and they indicate a willingness to set out in new directions. The policies developed in all three of these cases reflect a good understanding of the nature of market processes and the scope for using them to achieve policy objectives.

4.2 Narrowly defined markets and technology development feedback

From consideration of a sectoral approach, in this section we first move down to policies that focus on more narrowly-defined markets and then in the next section up to those that are applied on an economy-wide basis.

Competitive procurement processes can be used to encourage equipment suppliers to develop and market specific types of energy technologies according to a set of specifications defined in a policy package. The procurement tool figures importantly in the case studies. It is a useful approach when technologies are close to being ready for the market but require additional development with a particular eye on what potential buyers are looking for. It is an economical tool because it combines the pursuit of technical and market development objectives in one policy and it leaves most of the detailed decisions to suppliers in the private sector, where they should be. At the same time, operating a successful procurement policy requires a lot of careful organisation. One of the American case studies (ID26) provides an illustration of how this has been done very effectively in an effort to expand the market for compact fluorescent lamps(CFLs).

In early 1998 the US Department of Energy set out to develop the market for a new generation of smaller, brighter and less expensive CFLs – a *sub-compact* lamp. A multi-stage consultation was organised with representatives of the initial target market and a comprehensive list of related stake-holder groups. This identified several market barriers, which were then used to define a procurement programme. The key barriers to be responded to by participating manufacturers were lamp size and price, but other more subtle barriers were taken on as well. For instance, to deal with product risk, the programme required manufacturers to offer an unconditional one-year warranty. The classic problem of building owners making key decisions affecting lighting, but typically not paying its operating cost, was also accounted for in the programme. Common-area outdoor lighting, for which building owners often pay the operating costs, was made part of the product specification for the sub-CFL; this enhanced the likelihood that building owners would be interested in the product.

These and other efforts brought clear returns – the initial sales goal of one million lamps was exceeded by more than 50 percent. The case study reports on problems encountered and dealt with along the road to this success. This experience illustrates that programme designers must be attentive to many aspects of the specific markets involved. For instance, there were difficulties encountered in working with small manufacturers; some companies responded negatively because they believed they were facing competition from a government-supported sales outlet; and opportunities were missed by not recognising early enough that electric utilities could play a useful role in market development.

Sweden’s procurement programmes go back to the early 1990s and are already well known in policy circles. Swedish case studies report on programmes for high-frequency electronic ballasts (ID18) and heat pumps (ID19). Both illustrate again the benefit of experience in policy design – early efforts were not particularly successful in market terms. Ultimately, however, the authors are able to report that the procurement efforts played a key role in developing these markets in Sweden, along with associated effects on exports. At the end of both case studies there are useful discussions of the details involved in designing effective procurement packages.

The classic procurement tools described above are relatively small in relation to the whole range of market development programmes, but procurement efforts can come in all sizes and shapes. The US Clean Coal Technology (CCT) Demonstration Program (ID27) is an example of applying the technique on a massive scale, though it is not usually characterised that way. Starting in 1985, it has since been implemented by way of five competitive solicitations. The CCT Program “is a partnership in which the federal government sets performance objectives, founded on national environmental concerns, and asks industry to respond with technical solutions.” The emphasis in this programme is the up-front sharing of the costs of demonstration and a competitive procurement process is an efficient way to organise this. Several successful technologies that went through CCT demonstrations are noted in the case study; some of these are still pre-competitive, some have had national and international sales volumes of several billion dollars. The case study confirms once again that success in market development policy depends strongly on learning from early experiences and on the early involvement of key stakeholders, in this case major corporations in the coal and electricity sectors.

Finally, efforts are underway to use the procurement technique in an international cooperative framework, as described in Case Study ID34 on the European Union’s Energy+ programme.[3] A pilot

project carried out over the last two years has pursued increased market penetration for highly efficient refrigerator-freezers. Ten European countries participated in the project. The core argument of this paper – that policy design for market development must be based on in-depth knowledge of the markets concerned – would suggest that the project faces major challenges. The author of the case studies acknowledges this in noting that the 10 countries are different not only in terms of climate and culture, but also in terms of the structure of markets and the political framework in each country. Not surprisingly the Energy+ programme has had to take a more fluid approach to designing procurement policies. At one level, the programme can be viewed as a focused approach to facilitating communication between end-users, policy stakeholders and appliance manufacturers. That is, it does not involve the tight link between product specifications and winners of a design competition that characterise the typical national procurement competition. Nevertheless its more flexible approach appears to be having positive results. It is too early to say anything about market impacts, but the level and nature of participation in the first round of the programme suggest that it will be worthwhile keeping track of in succeeding rounds.

4.3 Economy-wide policy packages

Any policy designed to use market mechanisms to support the adoption of new technologies has to have boundaries around it. The narrower are those boundaries the more constrained are consumers and investors in making efficient decisions within the policy framework regarding the purchase of energy services, the choice of technologies and other aspects of overall resource allocation. Broader boundaries, combined with well-designed policies, can lead to greater efficiency, but they require the coordination of a larger range of policy objectives and are more complex. Case Study ID16, on the 'Deployment of renewable energy in a liberalised market by fiscal instruments in the Netherlands,' is very broad. It shows what can be done when a government is open to the use of a variety of instruments, some of them applied at the economy-wide level, which can be coordinated and have an impact on a range of technologies simultaneously.

The key mechanisms in the Dutch renewables policy, which recognises clearly the advantages of using market processes, are:

- the application of differential taxes on energy from conventional sources and renewable sources, with significantly higher tax rates applied to conventional energy;
- tax-based incentives for investment in renewable energy and for consumers who buy 'green electricity'; and
- a tradable certificates scheme for the production of electricity from renewables.

The current policy emerged when the Dutch government recognised that a classic supply-oriented approach to developing markets for renewable energy was not going to achieve its objectives. While it continues to use supply-side instruments, it is now also taking actions that affect the demand for electricity produced with renewable resources. This reduces the risk of making bad choices as to which technologies are ultimately viable and increases the likelihood that efficient decisions will be made in regard to the allocation of resources between different types of renewable energies.

The most innovative part of the programme was a scheme for trading 'Greenlabels,' introduced on a voluntary basis in 1998. This involved a set of targets on the part of each distribution company for the amount of electricity derived from renewable sources they distributed. The producer of each unit of 10 000 kWh of electricity generated from renewables and delivered to the grid received a Greenlabel certificate in addition to the electricity price. Distribution companies that did not distribute enough eligible electricity were able to meet their targets by purchasing these Greenlabel certificates from the generating companies. This allows competition to work within a larger market than under the former system, leads to renewable-based electricity being provided by the lowest-cost suppliers and distributes the burden of subsidies for renewables more fairly. Operation of the policy has resulted in a new market for bio-energy. This year the voluntary Greenlabel system was replaced by a similar certificate system established on a legal basis and the marketing of green energy to final consumers in

a liberalized market has been introduced. It is interesting to note that the development of the scheme emerged from a consultative process among the producers.

To put the programme into perspective, it must be viewed as a long-term strategy. It is having an impact, but market penetration of renewable energies in the Netherlands is still small and below government targets. Other European countries (Denmark, Germany and Spain), which have used the more direct approach of administered prices for renewable electricity, have achieved faster results. The Dutch prefer a demand-oriented system because of its flexibility, its positive effect on resource allocation decisions and its consistency with the liberalisation of electricity markets. They acknowledge that in such a complex policy strategy, there are bound to be problems and pitfalls. This includes the operation of classic market barriers that can only be dealt with at the micro-level; for instance, the case study notes a range of difficulties faced by investors in obtaining permits for the installation of new generation facilities. In addition, short-term market conditions can be inconsistent with the achievement of targets.

The Dutch case study leads one to reflect on variations in policy culture across countries and through time. At present, policy designers in some other market economies – such as the US and Canada – are not likely to have the luxury of aggressively increasing economy-wide taxes in order to widen the gap between prices of natural gas and conventionally produced electricity on the one hand and energy from renewables on the other. It is also clear that the importance of market principles in policy design depends on when a given policy was developed and applied. Attitudes have strengthened in recent years in regard to passing market tests and there is now more awareness of the need to have policies that respond to changing market conditions. Thus it is not surprising to find that earlier programmes in support of renewables, established when regulated electricity pricing was still the norm, were built around administered pricing systems. An example is the highly successful German programme in support of wind energy, which was started in 1989. Its operation is described in Case Study ID10, 'Wind Power for Grid Connection – the 250 MW Wind Programme.'[4]

4.4 The infant-industry argument in practice

Because the infant-industry argument has a central role in legitimising market development policies, how it is applied in the case studies should be considered. A key issue is whether there is evidence that special support will be removed when that is warranted. While this matter was not usually discussed explicitly in the studies, many of the policies described have a fixed time span. Even where this is not stated explicitly, one expects that budgetary processes involve time limitations. Thus, at minimum, when the end-of-term arrives, the policy authority has to decide whether to let the termination stand or whether to extend the policy. However, 'sunset clauses' are by no means the whole solution. It can be difficult to predict how long it will take to achieve a policy objective – ending a policy too early can also be wasteful. Ideally it would be good at the outset to define the criteria for termination of a policy in terms of policy objectives. If an appropriate performance measure can be defined, it can be used to decide whether policies should be continued or terminated.

None of the case studies refers specifically to sunset clauses, but implicitly some of the policies reported on reflect this kind of thinking. The clearest case is the UK's 'Energy Efficiency Best Practice Programme (ID21, discussed further below). There is also evidence in many of the other studies that policy authorities are able to take a pragmatic and sensible approach to this problem. In others there is evidence that larger political decisions override those made by the policy designers. Finally, in certain kinds of policy measures that are applied to infant industries, termination is not an issue. For instance, labelling programmes and changes in standards and codes should be a permanent part of market infrastructure if they are appropriately defined in the first place. If continuing government expenditure to support their application happens to be necessary, it is likely to be legitimate because of the public-good aspects of such programmes.

A case study from Canada (ID3) provides an illustration of a conscious and pragmatic approach to the policy termination issue. Funding for the programme reported on, the Renewable Energy Development Initiative (REDI), was provided in 1997 for three years, beginning in 1998. REDI is intended to stimulate demand for renewable energy systems in the heating and cooling of space and water in industrial, commercial and institutional buildings. It consists of two policy mechanisms: financial incentives and targeted market development initiatives. The financial incentives involve a straight-forward approach to subsidising early users and pilot projects in a way consistent with the infant-industry argument. An early audit of the programme undertaken at the request of REDI management notes that to achieve its goals, it may need to be extended, perhaps by rescheduling existing funding to years extending beyond 2001.[5]

This case study also illustrates that policy designers can be sensitive to the public-good argument as a criterion for the policy mechanisms used and to the common-sense aspects of running efficient market development policies – namely that it is crucial to dig into the details of the structure and operation of the markets being approached. The market development initiatives used in REDI involve activities with clear public good aspects; for example, information dissemination, training programmes for industry personnel likely to involve benefits to society that cannot be fully captured by their employers at the time the training is done, the creation or updating of product standards, and so on. The steps taken to develop these targeted initiatives suggest a well-conceived and effective planning process: market assessment, strategy development, marketing research, partnership development, and finally implementation.

In case studies where programmes were undertaken far enough in the past that government support has now been terminated, it is not always clear whether a termination date was built into the original policy or whether support has been removed by the discretionary action of a later government. In the present context, with the deregulation of energy markets a favoured stance, it may not make much difference which approach to termination has been taken – governments are prone to throwing out old programmes. Unwarranted infant industry support is likely to be caught up by this.

These sorts of issues arise in some of the case studies from the US. The ‘sunset’ issue is approached directly in the US report on Unconventional Natural Gas Exploration and Production (ID24). This programme was a combination of support for R&D and direct price and tax incentives for exploration and drilling. This included tax credits and the deregulation of well-head prices for natural gas from selected sources during the period when gas prices were in general regulated. Production of unconventional gas responded strongly to these incentives. The origins of the programme go back to the late 1970s and not surprisingly over that period it has involved numerous changes. The deregulation of gas prices in 1981 ended the role of the price incentives. Tax credits for new unconventional wells ended in 1992. The case study reports that unconventional gas drilling and well completions remained strong after the expiration of tax credits, subject to short-term adjustments in response to changing market conditions, which is as it should be. The authors note that post-incentive activity was strong because “unconventional gas … technology has progressed sufficiently such that the industry remained economic and could attract capital without the need for further incentives or subsidies.” That is, the infant-industry argument was working well in relation to subsidies. In regard to the R&D aspects of the programme, the authors note that independent evaluation of some projects brought a rational end to some lines of research. They also note that during the period when a natural gas shortage in the US had turned into a surplus, R&D decisions tended to be driven more by political than analytical considerations.

This is a perceptive case study. The above observations are part of a longer set of lessons learned from USDOE’s experience with unconventional gas development policy that are worth looking at in detail.

4.5 Generic Programmes

The question of optimal programme structure and organisation should also be addressed. From the point of view of effectiveness and cost, does it make more sense to structure certain programmes

around functional and process objectives, rather than either on specific technologies or on specific markets? The answer is yes; and this is a well-established idea in most countries. When certain activities – such as information dissemination and education – are being done in high volumes, it makes sense to set up specialised units that perform these functions for a range of technologies and markets. This too is reflected in the case studies. Three case studies indicate that this kind of specialisation can be carried far and can be very effective: the UK's Energy Efficiency Best Practice Programme (ID21) and two case studies from the US – the Motor Challenge and Best Practices Programme (ID30) and the Industrial Assessment Centers Programme (ID29).

The UK Best Practice Programme is a pioneer in its area and is very highly developed. It is focused on saving energy in industry, buildings and the business use of transport and is notable in particular for being very market-oriented and having a business-style approach to management. It works by way of establishing target levels for energy and carbon savings and doing extensive assessments of the impacts of the overall programme and its constituent parts in those terms. Its strategy development process involves identifying barriers to energy efficiency, prioritising areas for action, generating a portfolio of project and promotional activities and, consistent with the above, monitoring them closely to assure that results are obtained. A sectoral approach is used – sector managers are responsible for particular areas, such as chemicals, non-ferrous metals, housing and schools. Benefit-cost criteria are stressed. The UK report notes that the activities needed to persuade target organisations to use cost-effective technologies and management techniques must provide a benefit of at least £5 per year in energy saving for every £1 of programme cost. It also reports independent estimates in 1999 of total energy savings in excess of £650 million per year and the expectation that the current target of £800 million will be achieved. This is the equivalent of 5 million tonnes per year of carbon savings.

The American BestPractices programme is an amalgamation of several energy efficiency activities of the Office of Industrial Technologies in the US Department of Energy. Case Study ID30 focuses primarily on one component of it – the Motor Challenge programme, which promotes energy efficiency in motor systems. Based on the case reports, the American programme is more decentralised than the UK approach. It centers on partnerships with key industrial trade associations, which leverages the funding provided by USDOE. Two main policy mechanisms are used: the development of information and decision-making tools; and the development of strategic partnership networks with industrial trade associations and industrial supply companies. The first category includes training programmes, which so far have been received by more than 7000 people. An independent estimate of this one component of the US BestPractice programme found that it is a cost-effective way of saving almost 25 million US$ of energy annually. The report notes, however, that Motor Challenge "has barely scratched the surface in terms of helping end-users realize system-level energy savings." To some extent this appears to be a policy choice, as the report also notes that there was more demand for inclusion in its Allied Partner programme than could be satisfied with the resources by DOE.

The second generic programme reported on by the US, the Industrial Assessment Center Programme (IAC), focuses on education and demonstrates again how creative partnering can be used to leverage government-funded programmes. In this case the key partners are universities – the programme trains engineering students in energy efficiency for small- and medium-sized manufacturing plants. The students, led by their teachers, perform energy audits and industrial assessments, following these up with recommendations to the manufacturers involved. Essentially this is an information dissemination programme, but with an interesting potential for long-lasting and continuing effects. Young engineers are being motivated in regard to energy efficiency; there is every reason to expect that they will continue to apply their knowledge throughout their careers. Even without this long-term effect, which would be difficult to monitor, an evaluation of the programme by the Oak Ridge National Laboratory concludes that in 1999 IAC energy assessments resulted in a benefit/cost ratio of 4.9 for the first year after the assessment. Thus the true ratio will be much higher because energy savings will continue to accrue in the future.[6]

4.6 Technology transfer

The principles of market-oriented energy technology policies can be applied to technology transfer and the achievements of the transfer objectives of the Kyoto Protocol, with very positive results. Case Study ID20 on the Swedish Government Programme for an Environmentally Adapted Energy System (EAES) provides a good illustration. In its simplest terms it is a loan programme designed to assist the Baltic states in making their energy systems more efficient, in both energy and economic terms, and more environmentally benign. Its main focus has been on converting heat production plants to the use of biofuels, reducing heat losses in district heating systems and improving energy efficiency in buildings. Much attention is paid to designing projects so that the loans granted will be self-liquidating. This has meant choosing projects that will be economically beneficial but have been held back due to classic market barriers (e.g., lack of knowledge and technical expertise, insufficient sources of finance, etc.). A substantial learning experience has occurred, since the local management of many small projects often had no experience of the discipline of loan management, nor of other aspects of contracting in a market environment.

This case study provides evidence that it is possible to administer a programme that works under difficult conditions and involves a real learning experience. For instance, while the market for contracts was open and competitive in all Nordic countries, in the early stages the main contractor on a project was typically a Swedish company; companies in the receiving countries were sub-contractors. More recently the situation has been reversed. With the experience gained from the programme, companies in the Baltic states are now becoming prime contractors.

Criteria of a more standard sort also indicate that this programme has achieved its objectives. Substantial reductions in energy use and costs have been achieved by way of the programme. Export markets have been enhanced for Sweden and the loan repayment record has been remarkably good. Learning and knowledge networks have also been enhanced. Projects under the EAES programme have qualified as Activities Implemented Jointly under the UN Climate programme. Small projects of this sort are usually very difficult to finance through international organisations.

A second illustration is provided by the report of the IEA Solar PACES Implementing Agreement on its START Missions (ID33). START stands for Solar Thermal Analysis, Review and Training. Missions are organised in which an international team of experts visits a host country that has favourable solar conditions with a view to identifying promising opportunities for solar thermal power generation and assisting relevant personnel in that country in the exploitation of these opportunities. Activities may include analyses of technologies appropriate for the host country and assisting in the definition of feasibility studies, the search for financing and other developmental issues. START missions carried out in Egypt, Jordan, Brazil and Mexico are described in the case study report. The mission to Egypt, the first one undertaken, contributed to tangible results. It served as an information base and a source of independent expert evaluation for Egypt's subsequent successful application to the Global Environment Facility for support of the construction of a 130 MW Hybrid Fossil Solar Thermal plant. This has led to the establishment of an international consortium that plans to develop, finance and operate the plant as a BOOT project.

5. Closing Comments

Policies in support of developing markets for new energy technologies have come a long way since they began occupying the attention of energy ministries in the mid-1970s. They are much more complex and creative. They reflect a much better understanding of market processes. One piece of evidence for this is that the market barriers issue is where it should be, not at the forefront of discussion about the legitimacy of policy as it was a decade ago, but as one part of a more comprehensive analysis that underlies effective policy design.

The benefit of experience and the willingness to redesign flawed policies comes through very strongly in the case studies as an important part of policy success. As in markets for the new energy technologies themselves, there is learning-by-doing in policy design!

One important aspect of that learning has been that serious and extended consultation, with a large variety of stakeholders in the market to be developed, is a key aspect of most successful programmes.

Finally, I want to return to the general lesson put forward in Section 3 – that it is important to have the right balance between attention to the market and attention to the new technologies that provide the starting point for policy. In the spirit of that lesson, it is desirable to pursue a synthesis of market-related thinking and technology-related thinking. The case studies, along with other bits of more casual evidence, leave me with the impression that there is a considerable understanding of this in many of the capitals, though obviously a much closer examination would be necessary to say anything definitive. However, there is one place where I can suggest that this central lesson should be applied more forcefully – to certain aspects of the International Energy Agency itself.

Let me explain my thinking in more detail in relation to the Implementing Agreement (IA) system. When the IEA was established, with its central concern for energy security, it was natural that it would develop a strong focus on R&D and the improvement of energy technology. The IA framework was a key response to that need. Most of the Agreements were set up around technologies and their work was clearly to be R&D. Times have changed and in recent years CERT and its Working Parties have understandably been focusing on the need to get more of those new technologies out there working in the economy. This has led them to encourage the IAs to put more emphasis on the deployment of their technologies. Many of the IAs, either because they shared this view or because they saw these messages as having something to do with funding, have expended a lot of effort to put more emphasis on market development. Some of this effort has undoubtedly resulted in good work, but I think that overall there has been a lot of confusion and inefficiency involved in the process. Let us consider the most important reasons for this.

The core of market development work has to be done on a national basis, though as with traditional R&D, there are bound to be parts of it that can benefit from international cooperation. However, real effort has to be put into defining which parts those are. A sufficient amount of leadership on this point has not come from CERT and the Working Parties. Simply asking the existing IAs to do it in their respective areas and not making any other changes is not the best way to proceed. When that approach was taken, there was a certain amount of bewilderment in at least some of the IAs.

In part, people in the IAs are not sure what they are being asked to do. I think this is because a lot of the work they have been doing all along has already been about deployment issues of the sort they can naturally work on. The R&D carried on by most IAs has not been the classic kind done in a laboratory that results in new hardware. It has been a kind of ‘framework R&D’ in the public domain, relating to needs such as standardisation, testing, demonstration, technical information exchange, broader information dissemination and the like. This is not the get-out-there-and-sell type of market development; but it is the kind that connects R&D with the launching of a new technology and makes the work of the market developer easier and more productive. It is useful and necessary and should be recognised for what it is.

On the other hand, the IAs are not generally well equipped for deployment work that really is close to the market. This relates to what I have been saying about the need in that context to focus on the market, rather than on technology. I think that by education, experience and perhaps by temperament, the people who know most about R&D are generally not the same people who know most about market development. I can think of several people in the IA system who have been successfully converting themselves from one area to the other. But treating the IAs as retraining programmes is not very efficient. Neither are many of the IAs currently organised in the best way to do market development. I do not mean by this that technology-oriented people should withdraw from the scene if more market development activities are to be undertaken. The combined work of technology-oriented and market-oriented specialists is necessary for successful deployment activities – it is the mix that needs adjustment if market development work is to be expanded in the IAs.

The bottom line on this issue is that CERT and the Working Parties should decide more clearly whether they want to encourage the IAs to continue with the type of R&D they have been doing all along or whether they want to encourage them to shift in a real way into market development. My own guess is that leadership on this point should be applied on an Agreement-by-Agreement basis. It makes sense for some IAs to continue doing what they have been doing. Other IAs could be encouraged to add activities that are closer to the markets related to their technologies. There is something to build on in this regard, since some IAs are already doing projects closer to the market. However, in the cases of those IAs encouraged to do new activities, there is need for innovations in structure, new personnel and new resources.

Though I hesitate to expand this discussion into other areas, the general point I'm making carries over into the IEA's committee and staff structure. Having introduced the subject, I would be dishonest if I avoided mentioning this aspect altogether. Does it really make sense to have a structure that separates work on energy policy and energy technology to the extent found in this Agency, thereby treating the two things as if they are separate issues and preserving a tendency to accentuate different approaches and encourage duplication? With one exception I will resist getting into the details of this aspect of the issue, because I think people connected with the IEA already understand its implications and because, unlike my discussion of the IAs, a substantial part of it goes beyond the topic of this workshop. The one point that I think should be mentioned concerns this audience directly. Perhaps resistance to change within the CERT community has been in part due to concern that technology and R&D would be given less importance in a changed structure. That is a danger, but I think the way to deal with it is by combating that position within a process of change, not by resisting change totally. Technology and R&D are obviously an integral part of the whole equation. They are represented in the capitals by substantial segments of energy ministries and they should continue to have a key role in IEA activities.

My last point is about language and is easier to deal with. In my view, the phrase 'technology deployment' is an ineffective way of communicating to the outside world your desire to launch major new markets for energy technologies. 'Deployment' is a military term that has no real connection with the development of markets for new technologies. I suspect that business people, consumers and other relevant groups outside of our narrow community have little idea of what we really mean by 'deployment.' I think it would be useful for everyone involved in 'market development' to use that phrase, and other ordinary words, to talk about it. Doing that would be more accurate and would convey what is meant more forcefully. Why not banish the word 'deployment' from the IEA vocabulary? It is quite easy to discuss the whole matter without using it. My evidence for that is this paper, where I have used 'deployment' only in direct quotes from the writing of other people or in this last section, where I have been discussing the work of the IEA in a way that is familiar to you.

ENDNOTES

[1] A recent study provides an excellent illustration of what can be done with econometric techniques in the area of market development policy. See Horowitz, Marvin J., ‘Economic Indicators of Market Transformation: Energy Efficient Lighting and EPA’s Green Lights’, *The Energy Journal*, Vol. 22, No. 4, 2001. Horowitz not only shows that the Green Lights market transformation programme in support of the diffusion of fluorescent lighting ballasts in the US was a very effective policy, he was also able to compare its effects with more piecemeal DSM-rebate programmes. He finds that “… it is far more cost-effective to attempt to transform a national market through long-term coordinated coast-to-coast efforts that permit market preferences to evolve and mature, than it is to temporarily manipulate local markets through piecemeal programs that are highly variable from place to place and from year to year. In short, persistent efforts to educate producers and consumers and inform them of energy efficiency benefits appear to be more capable of building sustainable sales volume and market share than the alternative of financial subsidies.” (p.121)

[2] An interesting sidelight of the Dutch case study for this audience is that it reports on the application of an output from an IEA Implementing Agreement. Consumers tend to resist purchasing high-efficiency mechanical ventilation systems due to their high initial costs. One way that the Dutch policy deals with this market barrier is through the application of a life-cycle cost model developed under Annex 27 of the Energy Conservation in Buildings and Community Systems Programme.

[3] The EU programme is not the only attempt to use this tool in an international cooperative framework. It has also been attempted in two IEA Implementing Agreements – the Demand-Side Management Programme and the Solar Heating and Cooling Progamme.

[4] An analysis of how the German programme relates to market mechanisms is more complex than can be approached on the basis of the information in case study ID10. Some comments on that issue can be found in IEA, *Energy Policies of IEA Countries, Germany, 1998 Review*, Chapters 8 and 11. For a discussion of how the programme contributed to reductions in the cost of using windpower in Germany, see IEA, *Experience Curves for Energy Technology Policy* (2000), Chapter 3.

[5] This audit is available on the Internet at www.nrcan.gc.ca/dmo/auev/Reports/Redi.

[6] It appears that the benefits and costs in this calculation refer to direct energy savings and the direct funding by USDOE, but do not account for benefits and costs accruing to the universities and students involved in the programme. One suspects that this would further increase the net benefits of the programme.

14 December 2001

Analyzing the Case Studies from the Perspective of the R&D and Deployment Model

The Rapporteur's report

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1 Introduction

The purpose of this report is to present an analysis of the case studies included in IEA's "*Deployment Case Study*" report (IEA, 2001). A draft of this report had been made available as preparation material for the IEA Workshop on "Best Practices and Lessons Learned in Energy Technology Deployment Policies" held in Paris on 28 and 29 November 2001, for which the author of this report served as a rapporteur.

The methodological setting for this report is the so-called *Triangulation Model*, according to which the IEA case study reports can be compared from three different perspectives. The purpose of this analytical scheme is to identify common elements of case studies and make the experience made during this process transferable between IEA member countries. The Triangulation Model is described in more detail in the printed part of this book, suffice it here

to say that the perspective covered in this report is RD+D (research & development plus deployment)[1].

Choosing only one specific perspective for the analysis means focusing on each mechanism one at a time. Doing so aims at illustrating one aspect of a complex system particularly well, but can sometimes lead to a description that may appear biased. Inevitably therefore there is a trade-off between clarity of presenting the selected aspect and sufficient consideration of all causes in a complex situation. Undoubtedly, both objectives are legitimate. This report therefore tries to do justice to both by first summarizing the reports contained in the volume *Deployment Case Study* from the point of view of the observed and implied (sometimes even missing from the write-ups) effects of technological learning, in particular as a consequence of public RD+D spending. In a second step, the report will extract policy recommendations that are a direct consequence of looking through the "learning glass", but also others, which are perhaps less directly related to the concept of learning.

At this point, it should also be noted that two other rapporteurs have contributed two reports on the other two perspectives of the "triangle" – i.e., using the "Barrier Model" and the "Market Transformation Model" – to this volume. Although the three perspectives are conceptually different, overlaps may occur. This overlapping occurs not only because three authors used the same set of case studies, but also because all three perspectives included in the Triangulation Model have to do with market externalities. Therefore, similar observations and policy recommendations can be made from different perspectives. In fact, some case studies prominently address the externality of information, and this aspect might even be the most suitable perspective of these case studies. There is no such thing as an exact science of case study analysis, however, and the actual choice of the given three perspectives is surely as useful as many other possible choices.

In an earlier IEA publication (IEA, 2000), research, development, and deployment have been identified as three factors, the joint effect of which can be captured by experience (or learning) curves. Learning curves will therefore be used as the formal tool to analyze the case studies from the RD+D perspective. Accordingly, the concept of technological learning is introduced in Section 2. Section 3 looks in a generic way at the policy implications of including the consideration of technological learning in public decision-making. Section 4 is the core of this report. There, all individual case study reports included in IEA (2001) are analyzed from the RD+D perspective. This includes reporting on three elaborate examples of learning-curve analysis using information from three case studies. As it turns out, most other case study reports contained at least some information that could be used to draw policy-relevant conclusions from the RD+D perspective. The observations collected in Section 4 are then, in Section 5, generalized to policy implications and recommendations that are independent from the individual case studies. Section 6 adds even more general, partly personal comments and presents some caveats that are considered important for the policy-oriented reader.

[1] A very similar acronym, RD&D is often used to stand for "research, development and demonstration", a term in which deployment is thus replaced by demonstration. Logically enough, some authors, e. g., Holdren and Baldwin, 2001, combine all of the three "D"s mentioned so far in RD^3, denoting research, development, demonstration, and deployment.

2 Learning Curves and Learning Rates

The purpose of this section is to present technological learning in a non-technical way. The use of mathematical formulae is therefore reduced to a minimum and only for the purpose of formulating in a more precise way a concept that has first been expressed in verbal form. In the same spirit, the presentation of theories is largely omitted. Interested readers are referred to the bibliographic section of this report for references to published literature on the topic, in particular Dutton and Tomas (1984), IEA (2000), and McDonald and Schrattenholzer (2001).

In fact, the main purpose of this conceptual section is to define the term *learning rate*. In short – and in its simplest form – the learning rate of a technology is the relative reduction of specific technology costs, which is postulated to accompany each doubling of cumulative installation (production, sales) of that technology. The reason why it makes sense to speak of a constant learning rate is a consequence of the assumption, made in this concept, that indeed, each doubling of cumulative installed capacity generates experience that leads to a constant cost reduction.

An almost identical concept is known as an experience curve, its name alluding to the more general notion of experience (rather than cumulative installation, etc.) as the explanatory factor of technology cost reduction. To elaborate on the somewhat subtle distinction between the two concepts would be beyond the scope of this report. Readers interested in this point are referred to IEA (2000).

One of the most well-known examples of technological learning in the energy field is that of solar photovoltaic (PV) modules. For that technology, a virtually constant learning rate of 20 percent has been observed over a long period in time. (e.g., Figure 1.)

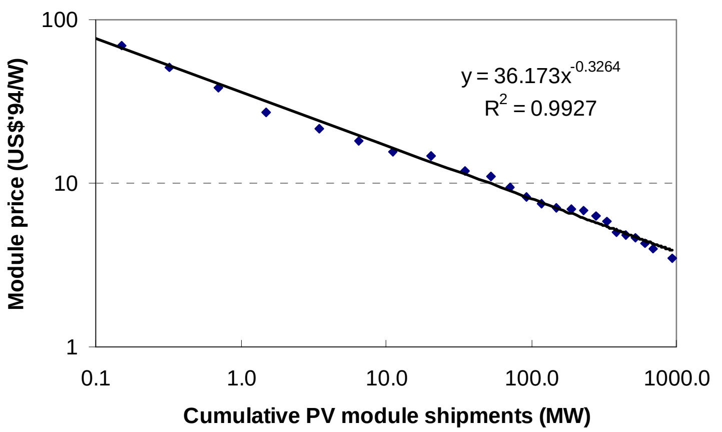

Figure 1: The experience curve of PV modules, 1968–1998. Adapted from Harmon (2000).

Figure 1 shows not only that the estimated learning curve is a good fit of the data points, but also that the postulated learning behavior extends over four orders of magnitude of experience, here expressed as cumulative shipments.

The field of technological learning has been studied by many groups and in many areas of manufacturing (Dutton and Thomas, 1984). Surveying energy technologies only, McDonald and Schrattenholzer (2001) have compiled 42 learning rates of energy technologies that were either published or based on calculations by the authors. The quantitative summary of their findings is presented in Figure 2.

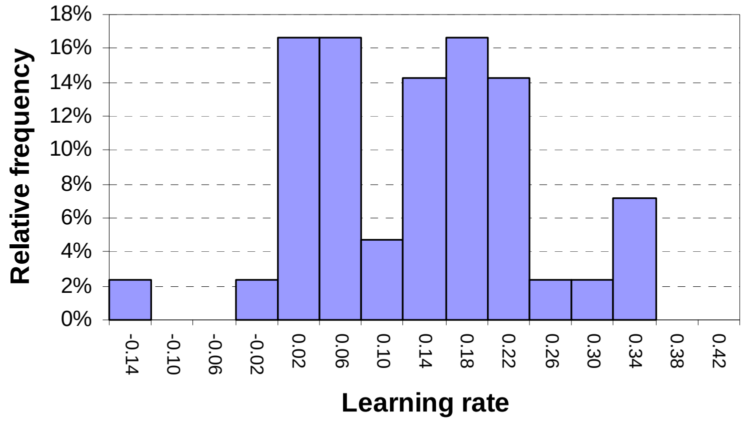

Figure 2: Distribution of learning rates of energy 42 technologies.

Among others, the figure shows that the quoted learning rate of 20 percent for solar PV is quite a typical value. Altogether, almost half of the learning rates were found in the interval between 14 and 22 percent. Another "cluster" of learning rates was found around learning rates of 5 percent. One negative "learning" rate was found, and the highest observed rate was 33 percent.

This overview is presented not to suggest a frequency distribution of *all* energy technology learning rates – the sample size of 42 would appear to low to generalize in this way – but rather to give an idea about typical values of energy technology learning rates. For a discussion of this summary, interested readers are referred to the original paper.

Several questions could be raised and discussed at this point, but we shall deal only with a few, i.e., those that are relevant for the task of screening the IEA case studies from this perspective. The first comment on this particular form of learning curve is that it does not distinguish between the three factors aggregated in the term RD+D. Preferably, the learning effect of deployment in the form of procurement (leading to an increase of total cumulative sales) should be separated from the effect of research and development. For many reasons – including clarity and simplicity – both types of expenditures are considered to contribute to the same cumulative experience, which in turn leads to technological learning. A disaggregation of impacts to these two kinds of policy measures is therefore not possible here. One methodological reason for this "parsimony" is that the study of the simultaneous treatment of two influencing factors (in so-called Two-factor Learning Curves) has begun only recently, and even more caveats apply to that method than to the "classical" method used for this report. Readers interested in early experiments with Two-factor Learning Curves are referred to Miketa and Schrattenholzer (2002).

The difference between these two factors is appreciated explicitly in Case Study ID24 on *unconventional natural gas exploration and production*. There, the authors remark that

“cutbacks in industrial R&D, the small size of DOE’s gas supply program, and the termination of the Gas Research Institute’s public R&D on unconventional gas raise serious concerns on the future pace of technology progress”.

Another comment on the particular version of learning curve given is that “specific technology cost” and “total cumulative installed capacity” are two specific measures of cost and cumulative experience respectively. Other measures of cost and experience can – and will be – chosen in the description of the IEA case studies below.

One final methodological note is that although the postulated learning process is described in a phenomenological way, this should not lead to misperception that it is automatic. On the contrary, technological learning – in particular in cases where it proceeds at high rates – is the result of the best efforts of all involved actors. In particular this means that “sit back and wait” for technological progress “fall from heaven” would be an inappropriate attitude and inconsistent with the spirit of technological learning.

As a general comment on interpretation, it should be stressed that mathematical formulations of future developments usually appear as more precise forecasts than they actually are. For policy making, this means that the deployment of mathematical tools leaves plenty of room for judgment on the side of policy makers.

3 Technological Learning and Policy Making

For policy making in the energy field, technological learning plays an important role in a situation in which a technology with learning potential is more expensive than its competitors in the market. If no-one were to buy the technology, the learning effect could set in for this technology, and the unfavorable competitive situation would persist even though taking a longer-term view would find it worthwhile paying a higher price now because it will be recovered later, i.e., after successful learning of the technology. Policymaking is therefore called upon to take such a longer-term view and organize the implementation of an optimum strategy.

To conceptualize such strategies quantitatively in the simplest terms, it is useful to think of a constant technology price in the market in which a learning technology competes. In addition, let us assume that the difference between the actual cost of the learning technology and market price is covered by some source until the learning effect leads to the learning technology’s price becoming equal to the market price. The assumed regularity of the learning curve allows calculating the total extra costs that are required to achieve this situation of market competitiveness. These costs have been termed “learning investments” (IEA, 2000) and “cumulative learning costs” (Rogner, 1998) – among others. Assuming the validity of the learning concept may thus make it optimal to actually make these learning investments despite the momentary appearance that they are uneconomic because taking a longer-term view would reveal that they are optimal in a situation in which learning investments pay back.

The concept of learning investments is a “zero-order” model of the given situation. The real situation is of course more complex than just described. This is so because market prices of other technologies need not remain constant, if only for the effects of technological learning by the competitors. Another important factor is the possible existence of niche markets, that is sub-markets, in which consumers value the learning technology higher than in the overall

market. A formal optimization of deploying a learning technology is therefore best done in an optimization model that includes the consideration of these additional factors thus allowing for a more accurate consideration of learning investments.

One example of such a modeling effort has been reported by Messner (1997), who has included technological learning in the energy supply optimization model MESSAGE. In that report, the author compares energy investment costs over time in two cases, one reference case with unchanging specific energy technology costs and one case in which technological learning is modeled as described here. The resulting (optimized) energy investments of the two cases are shown in Figure 3.

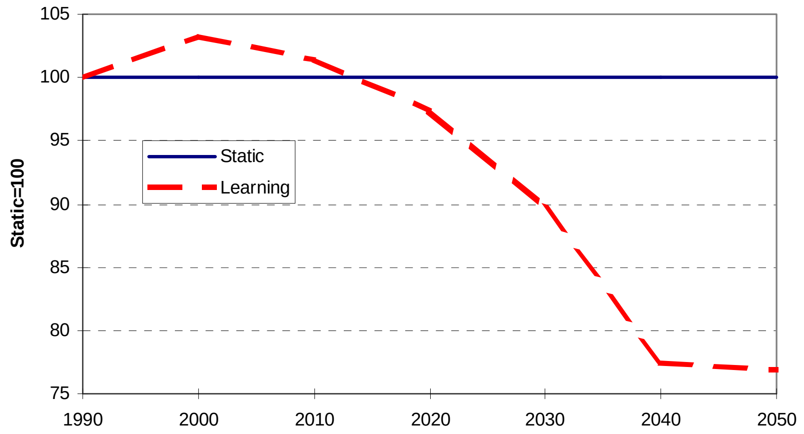

Figure 3: Annual energy investments, results of the energy optimization model MESSAGE. Comparison of two cases including one case with endogenous technological learning. Adapted from Messner (1997).

The figure confirms that it can be optimal to invest more in the near term in order to be able to harvest the fruits of these investments – in the form of lower energy costs – later.

One problem with implementing an optimal strategy of this kind is that without any correcting measures, those who pay the extra price would not be those who receive the payback (the "free-rider issue"). Public policy is therefore called upon to "even out" this imbalance. Obvious policy measures to achieve this goal include subsidies and procurement, which are among the main instruments described and discussed in the IEA case study reports.

For the analysis described in the sequel, it appears also worth noting that learning investments can also take several other forms. Among those are the stimulation of niche markets[2], technology procurement, green certificates, and minimum take prices. All these represent important measures to encourage learning investments from private and public sources.

One obstacle on the way to supporting learning technologies is the possible criticism that procurement, subsidies, and other policy measures can "distort" markets, and the arguments justifying learning investments on optimization grounds alone may not always carry enough weight. In practice, however, taking externalities such as the environment into consideration strengthens the case for such measures. This is true, in particular, for renewable-energy

[2] In niche markets, consumers' willingness-to-pay takes care of a part – if not all – learning investments.

technologies that exhibit the learning behavior. In this case, consideration of environmental externalities adds justification of their support by public funds. For renewable-energy technologies, the latter point is particularly important in a situation in which carbon emissions are penalized, e.g., should there be an implementation of the Kyoto targets and/or the flexibility mechanisms provided for in the Kyoto Protocol.

Another general argument in favor of supporting technological learning is the observation that the returns of supporting technological learning are to an extent a public good, which therefore justifies the disbursement of public funds.

Relating the "learning concept" to the policy area of deployment, what tasks are important to consider? Overall, the strategy of a public policy that responds to the possibility of technological learning would aim at identifying learning technologies and measuring their learning rates. The cost-reducing effect of deployment could then be calculated (within the boundaries of uncertainty). Also estimated learning rates may give rise to the setting of targets and to monitoring the learning process by measuring increased technological performance after the deployment. After all, success is easier to prove (and easier to be satisfied with) if targets are met. And if the application of the learning-rate concept demonstrates that success is not forthcoming – e. g., by measuring learning rates that fall short of explicit expectations – the same concept can help to justify the discontinuation of public support. Perhaps curiously, an "over-fulfillment" of expectations of certain learning rates may lead to the same conclusion to discontinue public support, but this time because the further deployment of such a successful technology is attractive enough to private investors – even without public support.

Measuring the learning rate requires the calculation of the total cumulative installed capacity (sales) of a technology. Very often, this includes the determination of total installed capacity at some point in time in the past (initial value), a task that can be difficult if not impossible. In this case, it might be possible to estimate a lower bound for the learning rate in the following way. If technological progress of a technology can be observed between the consecutive production of two equal-sized pieces (lots) of the technology in question, the cost reduction observed for the second piece (lot) in comparison with the first piece (lot) is equal to the learning rate, if the first piece (lot) was the first of its kind (because then, production of the second means the first doubling). If the first piece of the two was not the very first, the cost reduction between the two is an underestimate of the learning rate (because it then accompanies an increase of cumulative capacity by less than a doubling).

4 Technological Learning in the IEA Case Studies

Before we set out to analyze and report the most typical cases of technological learning observed in the IEA report *Deployment Case Study*, let us note that learning in the sense of daily language is of course involved in all case studies. Here, we are primarily concerned with identifying direct and indirect references to technological learning or learning investments in the individual case studies. We begin with somewhat elaborate examples of learning curves as extracted from case studies.

4.1 Numerical Examples

4.1.1 Photovoltaic Power Generation Systems (ID13)

The case study that, in the opinion of the author, is most suited to illustrate the role of technological learning in policy analysis is ID13 on *Photovoltaic Power Generation Systems (from R&D to deployment)*, reporting on the Japanese “Sunshine” project. Not surprisingly, then, that project has been analyzed extensively, for example in IEA (2000) and in Watanabe (1999). Here, the results most relevant to the subject matter will be highlighted.

At the core of the policy issue addressed by the “Sunshine” project is Japan’s share in the global learning investments (or cumulative learning costs) of solar PV. Without going into the policy question about how to share the cost of learning investments between state subsidy and investors, the Learning Curve concept can be used to calculate learning investments to be made in Japan. Assuming that technological learning of solar PV technology is based on global cumulative production of this technology, the Japanese share of global learning investments depends on the development of the global market. This situation is illustrated in Figure 4, which has been adapted from IEA (2000).

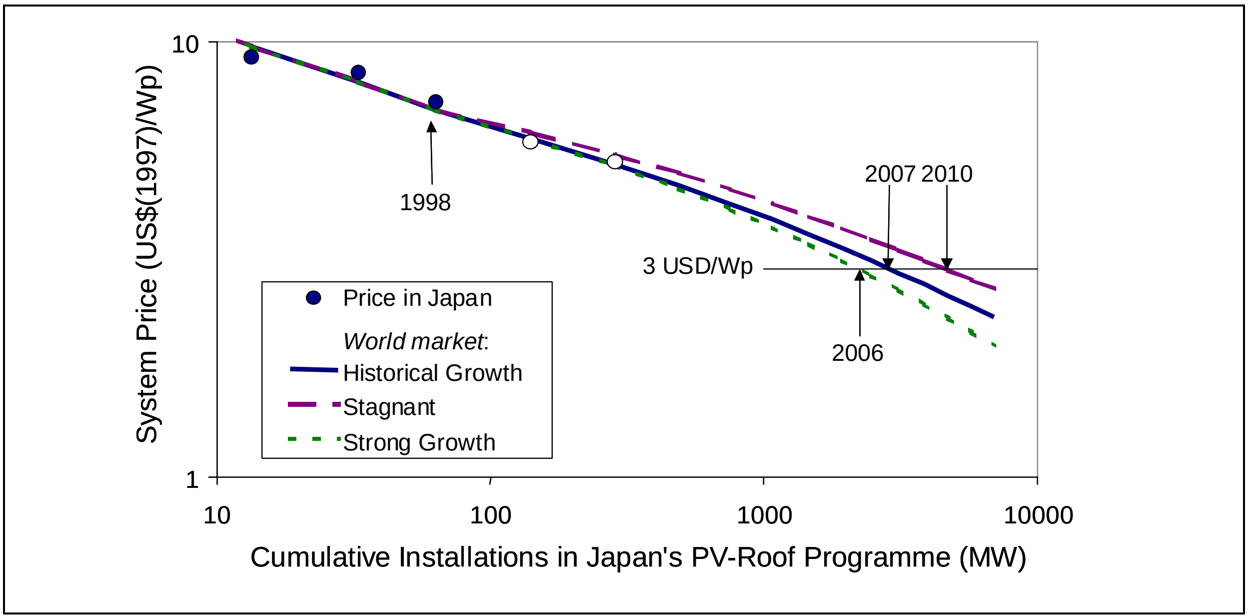

Figure 4: Three scenarios of the development of PV prices in Japan. The three scenarios reflect three alternative assumptions concerning the development of the global PV market.

Recall that total learning investments are represented by the area between the “system price” curve and the horizontal line representing the competitive price level (here: 3US$/$W_p$). As a consequence of the logarithmic scales used in Figure 4, these areas correspond to quite different amounts of Japan’s share in global learning investments as illustrated in Figure 5, which also has been adapted from IEA (2000).

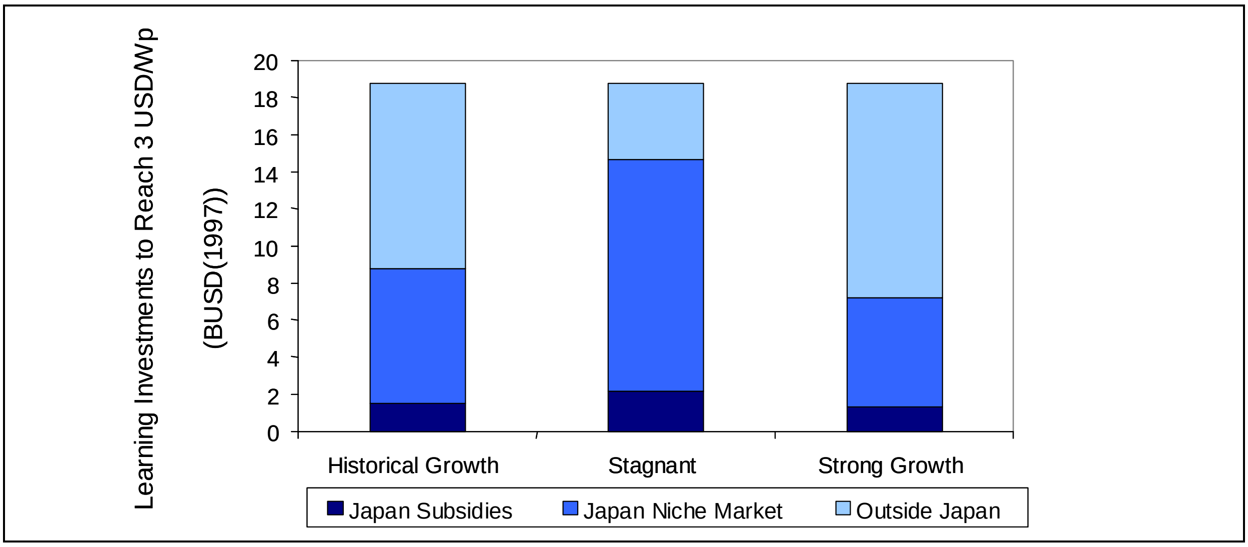

Figure 5: Global learning investments in three scenarios of global PV market development.

The difference between the lowest and the highest Japanese share in total learning investments is on the order of 8 billion US dollars. This not only means that the stakes are high for Japan, but in addition, since every buyer of PV systems profits from global learning, this piece of analysis represents a strong case for international collaboration and coordination in the field of deployment, in particular between IEA member countries. The mechanism to be harvested would be the so-called "spill-over", which in this case would cause local deployment to facilitate global learning – with higher benefits for all.

Without going into any details on the background of the distinction between "Japan Niche Markets" and total "Japan Subsidies", Figure 4 emphasizes the importance of niche markets. No attempt has been made to estimate the actual size of Japanese niche markets, the results presented here are merely quantifying their required minimum size. The point of the analysis is that if niche markets turn out smaller than the size calculated – or if the Japanese national budget turns out to be unable to accommodate for the subsidies – the entire "Sunshine" project may be in jeopardy.

4.1.2 Market Transformation on Lighting (ID18)

One case study report that provided sufficient information on cost and cumulative sales was ID18, coming from Sweden, on *Market Transformation on Lighting*. Although its title clearly refers to the Market Transformation perspective of the triangulation model, the RD+D perspective finds very suitable material to work with.

ID18 is about the

> "*…procurement of high-frequency (HF) electronic ballasts carried out in 1991 and 1992. The competition was announced in September 1991 and concluded in March 1992. The purchaser group guaranteed a direct purchase of 26 000 HF electronic ballasts, with an option on a further 26 000. In comparison with the sales of HF lighting in Sweden prior to 1992, which had amounted to about 5 000 units, this represented a significant marketing opportunity for the manufacturers*."

Several positive results (concerning energy saving, attractive payback periods, among others) are documented in the case study report, and quantitative information is provided. The later was used to estimate the learning curve based on the ID18 data (Figure 6).

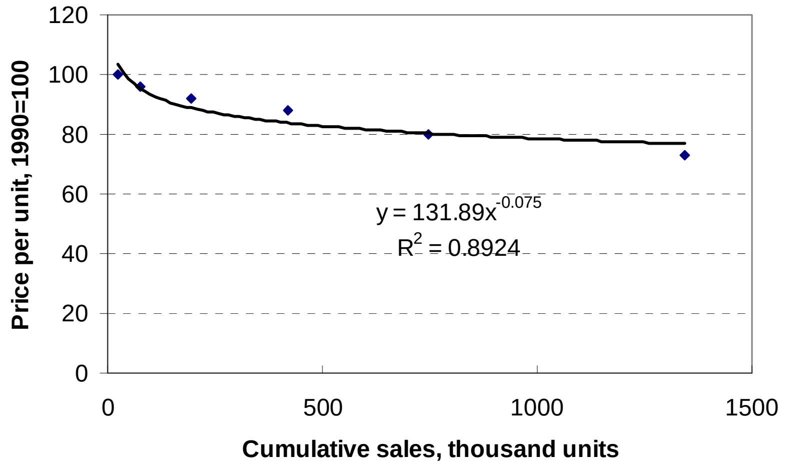

Figure 6: Learning curve for high-frequency electronic ballasts in Sweden, 1990–1995. The estimated learning rate is 5.1 percent.

Figure 6 shows that the learning rate, estimated with the original data, is approximately 5 percent[3]. Given actual sales, this learning rate led to a price decrease of HF electronic ballasts of approximately 25 percent between 1990 and 1995. This achievement was commented in the original report from several perspectives. Let us here add one aspect that uses the concept of technological learning.

One possibility of using learning curves for policy analysis is to estimate the savings by the consumers. To estimate consumers' savings, we compare actual total consumer expenditures purchasing HFLs with a hypothetical situation, in which the learning curve is extended (and the learning time shortened) by the actual direct purchase as guaranteed in the procurement program. According to the estimated learning curve, the immediate effect of the actual procurement was an HFL price reduction of 2 percent. Assuming an idealized situation, the first customer to buy an HFL after the procurement had taken place paid 2 percent less than what would have been the price without the procurement[4]. Integrated over the time interval reported in the case study report, and assuming the round number of 10 SEK as initial price[5], total savings to the consumer amounted to approximately 500,000 SEK. In light of the overall costs of the program (SEK 37 million), this may not appear very high, but it is a form of benefit over and above those mentioned in the case study report that appears worth mentioning here and considering in the design of future procurement programs.

[3] The estimation reported here is based on measuring numbers on the graphic information provided in figures of the ID18 case study report. It also includes an assumption made by the author of this report on an initial value of cumulative sales prior to 1990. Some straightforward sensitivity analysis shows that estimated learning rates do not differ very much from 5% if assumptions are varied within plausible bounds.

[4] This effect is reduced over time as a consequence of the mathematical properties of the learning curve.

[5] In the original report, prices are given in relative units only.

4.1.3 Market Transformation on Heat Pumps (ID19)

Another case study report with the "Market Transformation" perspective in its title, but which could be used very fruitfully in an analysis from the RD+D perspective, is ID19, the Swedish project on the *Market Transformation on Heat Pumps*.

Just to illustrate the potential of the data that can be collected in the course of a deployment project like this and to suggest a method of estimating learning rates in cases where data are scarce, we use a small piece of price information given in the report to give a range of plausible learning rates of heat pumps. The report quotes the expectation that "… *these factors should enable the price of heat pumps to be reduced by about 25% over the next few years*". Assuming for a moment that "the next few years" correspond to a time span in which the same number of heat pumps will be sold as up to the date of the writing of the case study report, the learning rate for heat pumps will be the same as the price reduction during that period, i.e., the estimated 25 percent reported. Looking at the sales information in the time period from 1980 through 1996, the assumption that the same number of heat pumps will be sold "over the next few years" appears optimistic. Add to this that in comparison to the learning rates observed for other energy technologies (see McDonald and Schrattenholzer, 2001 and Section 2 of this report), 25 percent is rather high, it seems like a safe conclusion that the original estimate is on the optimistic side. Of course, this conclusion is based on some guesses. At a later point, it therefore might either be substantiated or weakened depending on an estimation of the learning rate from actual past data.

4.2 The Rest of the Case Studies from the Perspective of Technological Learning

After analyzing quantitative data given in the IEA case studies report directly with the "learning curves" concept, we turn to the other case study reports to describe observations made during their analysis from the RD+D perspective.

A good qualitative example of the importance of technological learning is given in ID1 *(The Deployment of Biomass-District-Heating in Austria)*. In that case study, the author in his assessment notes that one of the problems encountered with utilizing biomass for district heating was the technical optimization of plants. Unfortunately, learning by doing was made difficult by the fact that "*operators only realized one project and had no chance to build a second better plant and the planners did not receive any feedback from technical performance measures of the plant they had built"*. This observation confirms that technological learning cannot be expected to operate all by itself and under any circumstances, but requires the actors to allow it to happen. For the sake of completeness, it should be mentioned that ID1 also comments that fast diffusion of biomass district heating was considered more important – and actually achieved – than technological learning, *albeit at the expense of the latter*.

As many other investments too, learning investments can be risky, and this can raise the required expected returns significantly above rates that would be achievable in financial markets for example. This adds a possibly desirable element to be considered in the design procurement programs, i.e., guaranteed minimum payback (ID2 on the *energetic and economical optimization of buildings*, ID3 on *Canada's Renewable Energy Deployment Initiative*).

A case emphasizing the importance of the research part of RD+D is made in the ID3 report on *Canada's Renewable Energy Deployment Initiative*), which proposes to involve more academics in deployment projects.

Learning alone is unlikely to achieve anything unless its results are communicated. This is the rationale, e.g., of ID6 (*Energy Labeling in Denmark*), which reports that *"26 percent of the owners of labeled houses tell that they have implemented energy savings shortly after buying the house and an additional 22 percent tell that they are planning to do investments from the plan in the near future"*.

A deployment program in which the learning focus was on technological performance (e.g., conversion efficiency in electricity generation) was ID8 (*Diesel Engines for Combined Cycle Power Generation*). Measuring the efficiency improvement (instead of cost reductions) as a function of the cumulative number of diesel engines can be expected to show learning curve-type behavior, and the attempt to measure the accompanying learning rates appears like a promising proposition.

Improvement of technological performance (in the form of quality improvement) was also in the focus of ID14 on the *Deployment of High Efficiency Heat Recovery for Domestic Ventilation in the Netherlands*. The same observation holds for this case study as for the previous one, i.e., performance could be measured at different points in time and under conditions that suggest the possible presence of technological learning. Judging from the wealth of data presented in the case study report, this might even be possible with existing case study data.

In ID9, (*Energy Efficiency and Solar Energy Use in the Commercial building Sector*), investment costs of HVAC (heating, ventilating, and air-conditioning) systems are reported. The costs are disaggregated by supplier and by type of building. An attempt to utilize the technological learning concept would involve making these costs as comparable as possible and measuring these costs at different points in time. Attention would also have to be paid to actually measure learning by a given learning system, e.g., by one and the same supplier.

A report on a very comprehensive case study is ID10 on the German *250 MW Wind Program*. Moreover, technological learning has played a prominent role not only in the course of the program itself, but also for subsequent policy making. The analysis of the program from the perspective of learning curves has already been published, e.g., in Durstewitz (1999) and IEA (2000). The influence of the concept of technological learning is found in the German law on Priority for Renewables, enacted in February 2000. This law not only *allows* for the experience effect, it actually uses it to *specify conditions* for a continuation of subsidies of renewable energy conversion technologies, most notably wind and solar energy.

ID15 on a deployment program for solar photovoltaic technology has set itself mainly the quantitative target of *"realizing 7.7 MW_p of cumulative grid-connected solar PV by the year 2000"*. No doubt the enthusiasm of the actors made this a useful and successful project, but setting merely a quantitative goal of this sort makes it difficult to assess the technological progress achieved in the process of carrying out the project.

A similar observation on targets that mainly concern volumes can be made for ID21, the UK *Energy Efficiency Best Practice Programme Case Study*, which is probably much better assessed from the other two perspectives of the Triangulation Model.

Similarly, ID30 on the *United States Department of Energy's Motor Challenge and Best Practices Programs* aims at promoting the diffusion of advanced energy saving technology and is therefore best analyzed from a different perspective. One remarkable statement in that report promotes a "systems approach", a point that will be taken up in the section on more general conclusions (below).

To maximize the effectiveness of learning investments, the incentive for producers of energy technologies to increase profits by improving the performance of their technology should be kept intact. It was therefore found important to leave market mechanism intact despite subsidies (ID16 on the *Deployment of Renewable Energy in a liberalized energy market by Fiscal Instruments in the Netherlands*, ID20 on the *Swedish Government Program for an Environmentally Adapted Energy System*, ID26 on the *U.S. Department of Energy's Sub-CFL Program* and ID27, *The United States Clean Coal Technology Demonstration Program*).

In addition, the report on ID26 raises an interesting point in connection with the topic of "costs versus prices". The report suggests that theoretically, it should have been possible to extract cost and price information from the participating producers of CFLs. Presumably, trying to obtain such information could have been in conflict with the confidentiality of company data. Anyway, price targets were set during the program, and an analysis of ID26 from the RD+D perspective would appear promising, should more data become available.

ID29 on the U.S. *Industrial Assessment Centers Program* would be difficult to analyze from the perspective of learning curves. However, one very interesting and rarely reported point on RD+D effectiveness is reported there. The report says that preliminary calculations indicate *"… that a cumulative federal investment of about US$80 million dollars (in nominal dollars) has engendered activity that has saved industry over US$2.4 billion (in constant 1998 dollars) from 1981 through the end of 1999"*.

ID33 on *IEA-SOLARPACES START Missions* is another example of a program in which technological learning is an essential strategic element, but which does not supply quantitative information that would permit a quantitative analysis from the perspective of learning curves. The way the START missions are performed points to an important aspect of technological progress by addressing technology transfer and again (as in the Japanese "Sunshine" Project) involves the interplay between global learning and local deployment. This appears as a very important and interesting aspect closely related to the goals of the IEA Workshop on "Best Practices and Lessons Learned in Energy Technology Deployment Policies" but perhaps slightly outside its scope.

5 Policy Implications and Recommendations

In the view of the author, the most important recommendation coming from this analysis of the IEA case study reports from the perspective of RD+D is to think in terms of quantifying the effect of RD+D on technological performance. The concept of technological learning has been presented as one suitable tool for doing so. The way to use this tool has been illustrated

by using information provided by the case study reports to address actual and hypothetical policy questions.

A policy recommendation following from this line of reasoning would be that the design of any deployment project should be explicitly aware of the possibility of technological learning. This would, first of all, mean to conceptualize a system that has the chance to learn, i.e., perform a given task more often. From the RD+D perspective, the prime purpose of basing a deployment program on this concept would be to set the stage for the identification of learning potentials. On this basis any deployment program should attempt to monitor the realization of this potential by measuring technological progress in the form of learning rates. This would not only help for the overall monitoring of ongoing projects, but also suggest further projects aiming at utilizing the learning effect to serve long-term goals of technological development. Of course, this recommendation would be too weak in cases where learning rates of a given technology have already been estimated. In such a case, a deployment project could aim at putting the expected learning at work by having procurement lead to technology costs coming down in a way described by the learning curve.

To the extent that a successful application of the learning concept requires policy intervention to balance costs and benefits carried by different economic actors, the actual functioning of the learning concept introduces an externality. Of the more classical externalities, RD+D projects address, in particular, information as the case study reports show. Within RD+D, demonstration plants are a particularly important contributor to information. Lack of consumer acceptance was identified as a crucial factor by several case study reports. Market research aiming at the identification of consumer preferences would therefore appear to be a useful tool to identify promising targets for new deployment programs.

A very general externality is the perceived risk of investment, which leads to implied discount rates that are far in excess of market rates. In a classical study, Hausmann (1979) has analyzed consumer behavior in the case of purchases of air conditioners. He found that preferences revealed by consumer purchasing decisions are consistent with implied discount rates of up to 89 percent per year, in particular in the low-income segment of customers. Presumably, this result points to a perceived risk involved in purchasing more expensive, but at the same time also more energy-efficient appliances. A very successful design element of deployment programs has therefore been to reduce the risk of such investment by guaranteeing a minimum return on investment.

Several case study reports, for instance ID30 and ID19, advocate taking a “systems view”. This is trying to break into open doors for an author with an affiliation devoted to systems analysis. Let us therefore make an attempt to expand the set of policy recommendations from a more general perspective of systems analysis. The advantage would be that by taking a “systems view” from the very beginning of deployment projects, general insights from systems analysis would find a natural way into their design.

One of the more general concepts used in systems analysis is that of diffusion. This concept very obviously is related to the very heart of deployment. It would therefore appear useful to contribute here some observations about diffusion. One is the notion of market penetration, in the energy field studied most prominently by, e. g., Marchetti (1986), who has collected a very large number of examples of diffusion not only of technologies, but also of other social, technical, and cultural phenomena. Marchetti’s examples all follow a so-called logistic curve,

an S-shaped curve with a saturation level. Two results of the study of market penetration with this conceptual model seem particularly relevant for deployment studies. The first is the insight that the speed of market penetration in early development phases of technologies is clearly limited. Taking this result into account can protect deployment projects from aspiring to reach overly optimistic goals with respect to market diffusion. The second result comes from the particular properties of the logistic function, which makes it easy to extrapolate high growth rates of a technology's market penetration for too long into the future, paying insufficient attention to the effects of the logistic curve's saturation.

To give an example from the case study reports, we can quote ID 14 in which empirical results of market penetration studies may or may not have been used. In any case, good forecasts of the market share of MVHR (Mechanical Ventilation with Heat Recovery) systems would have been clearly of high value to the project.

6 Concluding Remarks

In conclusion, let us discuss some caveats that have not been mentioned yet. One caveat concerns the difference between cost and price. The essence of the concept of technological learning is to describe technological progress in terms of cost decreases. However, technology cost data is very often proprietary information that producers are reluctant to part with. In many estimates of learning rates, price data is used instead of cost data. In contrast to cost, which is a technological characteristic, prices are the result of market mechanisms and many factors, cost being just one of them. The assumption that prices are the costs marked up by a constant factor in many cases is an over-simplification. The reason why it can nevertheless be reasonable to use prices instead of cost is that in the long run, price changes accompany cost changes. It is just that in the shorter term – particularly so during the early phases of a technology's life cycle – significant aberrations from an overall equivalence can occur[6]. If this possibility is not duly taken into account – for instance by using too short time series data for the estimation of learning rates – misleading results can be obtained in the form of too high or too low learning rates.

The difference between prices and costs gives rise to another peculiarity of measuring the success of deployment programs. The peculiarity comes from the observation that what is cost for the costumer is income for the producer. Public policy therefore may face the dilemma of not being able to accommodate both interests at the same time. Judging from the case study reports, this dilemma more often than not tends to be resolved in favor of producers rather than consumers. Presumably, this is based on the expectation that market forces will sooner or later lead to prices following costs anyway. If they do, the consumers' benefits will eventually follow the producers' profits.

Some caveats are specifically related to the risks involved in the implementation of policies that are formulated on the grounds of RD+D, in particular on the basis of technological learning. For public deployment, these risks include over-stimulation of markets, and the consequences of future learning rates being lower than expected. The latter situation would of course lead to an increase of the projected learning investments. For the private investor, investment in technological learning bears the risk of unwanted leakage ("spill-over") from

[6] Such aberrations have been explained in a plausible model by the Boston Consulting group (1968).

the knowledge stock that results from it. Such leakage might reduce the returns on such learning investment.

Having studied the IEA case study reports and attempted to analyze the quantitative information contained in them, the author cannot resist concluding this report with recommendations that concern the guidelines and instructions for authors of future case study reports. The aim of doing so is not only to make the systematic study of future case study reports an easier task for any successor in doing such a job, but also to share his opinion on how to present the results of "success stories" in a way that maximizes the chances for similar successes to be achieved by others. After all, copying success is in the best spirit of learning through experience.

The most important basis for a systematic analysis of case study reports is quantitative information. Qualifications such as "highly successful" may, for lack of concreteness, not be suitable to convince readers in other countries to follow a given example.

With this reasoning, it does not appear useful to focus a report on the benefits of a program without giving an idea about the cost side. Granted, precise information on cost and benefits might be difficult to quantify, but even a qualitative discussion of costs and benefits would often be useful.

A related point is that the results of a deployment project (in fact of any project) would appear to be particularly instructive if they were discussed relative to the development in a "control case" rather than just in absolute terms. In most cases, such a case would surely be hypothetical but even an educated guess of the consequences of non-action would appear quite instructive.

In the same spirit, praising of achievements should be balanced. The practice – every so often observed in public debates – to simply redress high project costs as "positive effect on employment" should be avoided in reports with any sort of scientific claim. True, the "employment effect" may weigh heavily, but if it does, this should be argued separately, e. g., by discussing the opportunity costs of extra employment.

As to the instructions to authors, the designers of the format for future case study reports should give clear guidelines, but at the same time also leave more freedom for the authors of case study reports. One possibility for explicitly leaving freedom of reporting might be to allow for a section in the case study report in which the authors are encouraged to report on observations and findings that they consider unique to their case study. It seems quite possible that such a section actually will contain the most interesting insights that can be drawn from the case study.

Another way of increasing the freedom of writing and the readability at the same time (and thereby the potential of a report to have its readers learn some useful lessons) would be to not insist on fixed lengths of obligatory sections. Forcing potential authors to fill sections with less informative text just for the purpose of achieving a given minimum length may well discourage the submission of case study reports or lead to a reduced usefulness for the readers.

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MARKET TRANSFORMATION PERSPECTIVE AND INVOLVEMENT OF MARKET ACTORS AND STAKEHOLDERS IN THE IEA CASE STUDIES

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1. INTRODUCTION

The success of energy policies is judged through the change that they bring forward. What really matters in the end are the market impacts - and how effectively resources (e.g. $) were employed. The success is primarily evaluated through energy efficiency improvements, the amount of GHG emissions saved and costs ($/ton CO_2). The justification may be spurred by spin-offs created such as new jobs and increased export. Any policy measure to be planned needs also to account for prevailing trends in the energy market, e.g. deregulation of the electricity and gas markets, Kyoto targets, energy security requirements, and limitations in public spending.

New technologies will play a key role in solving the future sustainable energy and energy supply demands. New technologies inherently tend to be more expensive or costly than the conventional technologies. Bringing the new technologies or technology improvements into the market in a cost-effective way and commercializing these is the main challenge faced.

Governments have a variety of different types of measures to chose from when promoting new technologies. These include in broad terms the following categories:

- fiscal measures;
- legislative and regulatory policies;
- information, labeling, voluntary and other assistance type of programmes;
- research and technology development.

In the 1990's, the concept of market transformation (MT) was originally introduced to improve energy efficiency. Later the scope of MT has been broadened to include new energy technologies more generally. Market transformation may be accomplished in several ways, e.g. strict standards or energy laws represent simple but regulative MT measures. Strategic MT often involves novel and innovative approaches, working with the market, enforcing the use of market mechanisms and basing the whole concept on voluntary actions. In this MT model, market actors, social networks and customers are the kings.

The objective of this study is to give through analysis of the IEA Case Studies a more profound insight on the importance of market transformation models and involvement of market actors in market deployment programmes and to identify MT policy options. Finally, opportunities for international collaboration will be identified.

The framework used here is based on the triangulation concept introduced by the IEA Secretariat in Paris (Figure 1). The perspective in this study is from Market Transformation but reflecting from that point also on barriers and RTD.

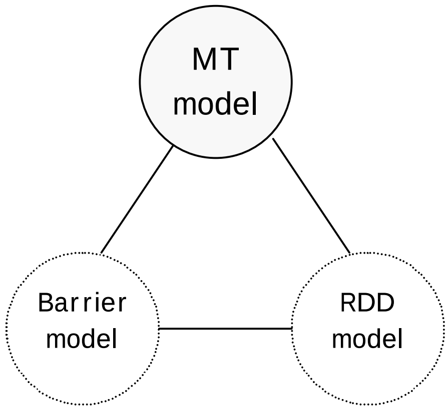


Figure 1: The IEA triangulation model.

2. WHAT IS MARKET TRANSFORMATION (MT)?

Most if not all public energy policy measures strive directly or indirectly to change the market, e.g. introducing sustainable or renewable energy sources on the market or improving energy efficiency. Working strongly with the market is increasingly a conscious policy choice and policy objective. Being first introduced in the energy efficiency context, market transformation policies are now often considered more widely as a generic energy policy instrument.

Market transformation (MT) differ from ordinary policy measures in the following:

- market transformation policies cause a durable market effect which lasts after the intervention has been withdrawn;

- it is a conscious attempt to change the market;
- if successful, then market transformation gives rise to an immediate market effect and to a major market impact on a long-term run;
- market transformation processes always show a very active and broad involvement of market actors (shareholders and stakeholders)

Figure 2 illustrates the market transformation outcome. In case of energy efficiency, MT causes a shift toward more energy efficient product categories and eventually to the disappearance of the worst efficient products. MT means better technology and higher market penetration of new technology on the market compared to the starting point.

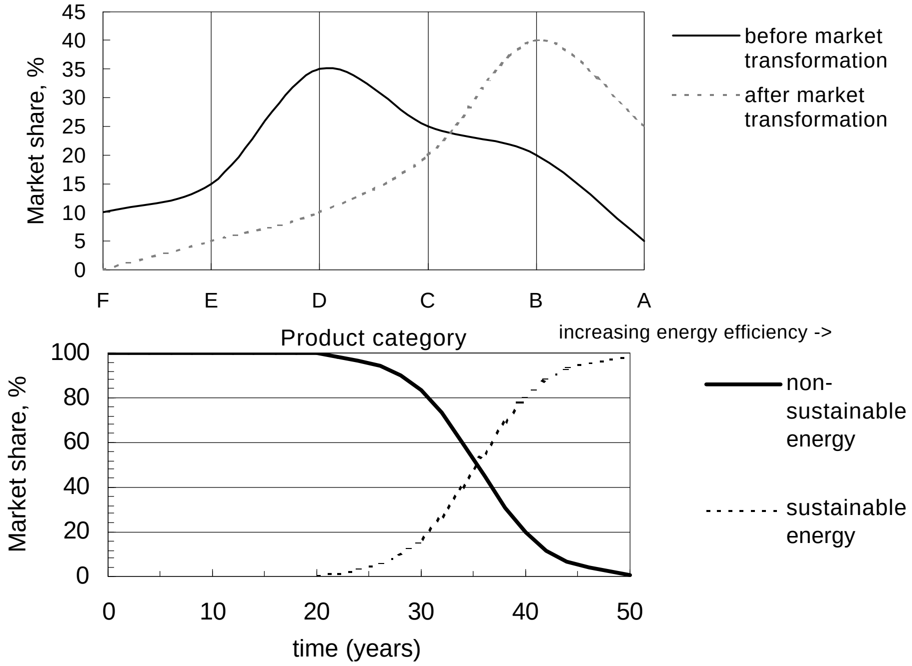


Figure 2: Illustration of the market transformation outcomes.

Market transformation raises by definition immediately a series of important questions. How can a permanent change in the market be obtained? How can the key market barriers be overcome? How to reach high market acceptance of the new technology? How to choose the right set of tools to work in the market transformation process? In the coming chapters, we will use the IEA Case studies to analyze these issues in more detail and present some generalizations for possible MT policy elements.

Market transformation can be accomplished through legislative or voluntary measures. Laws, directives, orders, norms or standards enforcing a change are simple and powerful instruments but increased regulation does not necessarily lead to effective resource utilization. Weaker regulatory measures that help to augment market transparency include labelling that can positively influence market uptake. Voluntary measures require on the other hand often skillful and imaginative approaches and working closely with the market. Resource utilization may in this case be effective but the failure rate may also be higher than in regulatory measures. The emphasis of this study is on the voluntary measures for market transformation.

It is clear that from our perspective a market change to be successful and lasting necessitates first accurate docking of the new technology and then firm lock-in into the market. In order this to happen the players in a voluntary effort need a clear knowledge and insight of the market, its structure, needs and how it works and then the necessary measures to penetrate into the market. These can only be properly addressed and tackled with if the market actors are actively involved in the process, and even more important, are strongly committed to the market transformation process.

The focus of a market transformation activity is in the market change and market outcome. Not a single measure but an integrated approach combining several measures in parallel and series will be necessary.

Hence MT involves technical and market development and behavioral changes. It also needs to carefully consider important market barriers in addition to the cost issues critical for any new technology.

3. ANALYSIS OF THE IEA CASE STUDIES

3.1 Market transformation features

The bulk of all deployment programmes presented in the IEA Case Studies work in one form or another to create a market change. The programmes have impressive number of market actors and extensive networking. They strive to push renewable energy or energy efficient technologies into the market or employ more effectively present energy sources. Several cases show great ingenuity and successful outputs.

We will employ all the 22 cases to analyze special features associated with market transformation e.g. in understanding the factors influencing technology diffusion. But the viewpoint in market transformation models is often different as they look from the market outwards towards technology aspects and not from technology to market as many of the barrier or RTD models. Market interests and outcomes dominate in MT over pure technology aspects and possibilities. Sometimes it is difficult to distinguish these differences in practice. Therefore, we employed as core projects those cases clearly linked to market transformation processes, namely

- Electronic HF ballasts for lighting systems (Sweden);
- Heat pumps for residential use (Sweden);
- U.S. DOE Sub-CFL programme (USA);
- Energy Plus Programme (EU).

The electronic HF ballasts (S, 1991-92) case is a technology procurement (TP) to provide up to 70% more energy efficient lighting systems through high frequency electronic ballasts. Heat pumps for residential use (S, 1993-95) is also a TP and aimed at providing a 30% more efficient and 30% cheaper heat pump. The Sub-CFL programme (USA, 1998) is a TP aiming at commercializing a small-size CFL at prices substantially below the prevailing market price. The Energy Plus Programme (EU, 1999-2001) is a pan-European procurement for refrigerator-freezers aimed at products consuming maximum 42% of the energy of average cold appliances. In addition, the Austrian (biomass, energy efficiency), Canadian (renewables), Dutch (energy efficiency, PV) and Finnish (cogen) cases provided good complementary views.

A quick look through the IEA case studies indicates that market transformation models are mainly used in connection with energy efficiency and energy end-use. The reason for this may be that just a few factors and a few market actors and notably the price/cost of energy dominate the choice of energy production technologies. In the end-use side, the number of actors and users is large, the spectrum of different energy-related products is broad, and the number of criteria used for selection is much larger and includes non-energy factors and features. This in turn allows more space for innovativeness in transforming the market.

In Table 1 we have assessed the case studies in terms of their relation to market transformation models and/or realized market change/impact. Eventhough not being MT models by definition, the cases included a lot of features related to MT. Several programmes demonstrate dynamic "portfolio"-thinking in the use of measures typical for market transformation models. In several cases we find a combination of RTD measures and market incentives (e.g. Japanese and Dutch PV cases). Strong network and partnerships building is found in all cases - as an example the US Motor Challenge programme which succeeded to connect 6,000-8,000 end use facilities to an information and best practice activity.

3.2 Involvement of market actors

The number of different type of market actors found in the case studies is almost overwhelming. We have compiled those found into Table 2. In broad terms, the market actors represent research, technology development, suppliers, manufactures, industries, buyers, users, and authorities.

Table 1: Summary of IEA case studies in a market transformation perspective (+ minor…+++ major)

CASE STUDY	POLICIES AND MEASURES	MARKET TRANSFORMATION
ID 1 Austria : The Deployment of Biomass-District-Heating in Austria	Subsidies, niche management	++
ID 2 Austria : Impulse Programme: Thermoprofit Programme - energy service contracting for district heating in two school buildings	Energy performance contracting, third party financing	++
ID 3 Canada: Renewable Energy Deployment Initiative - REDI	Market development, financial incentives	++
ID 6 Denmark: Energy Labeling in Denmark - Labeling Scheme for buildings	Labelling scheme, auditing	++
ID 8 Finland: Diesel Engines for Combined Cycle Power Generation	R&D, demonstration	+
ID 9 Germany: SolarBau - Energy Efficiency and Solar Energy Use in the Commercial Building Sector	R&D, parts of demonstration	+
ID 10 Germany: Germany: Wind Power for Grid Connection "250 MW Wind"-Programme	Financial incentives, subsidies, feed-in-compensation	++
ID 13 Japan: Photovoltaic Power Generation Systems (from R&D to deployment)	R&D, subsidies	+
ID 14 Netherlands: Deployment of High Efficiency Heat Recovery for Domestic Ventilation	Information, subsidies, regulation	+++
ID 15 Netherlands: The PV Covenant: R&D/Demo, deployment - Voluntary agreements	R&D, subsidies, information	+
ID 16 Netherlands: Deployment of Renewable Energy in a liberalised energy market by fiscal Instruments	Taxation, green certificates	+
ID 18 Sweden: Market Transformation on Lighting	Technology procurement, demonstration	+++
ID 19 Sweden: Market Transformation on Heat Pumps	Technology procurement	+++
ID 20 Sweden: Programme for an Environmentally Adapted Energy System - EAES	Financial schemes, joint-implementation	+
ID 21 United Kingdom: Energy Efficiency Best Practice Programme - deployment	Information dissemination, technology transfer	++
ID 24 United States: Unconventional natural gas exploration / production	Financial incentives, R&D	++
ID 26 United States: U.S. Department of Energy's Sub-CFL Program	Technology procurement	+++
ID 27 United States: Clean Coal Technology demonstration program	R&D, demonstration	++
ID 29 United States: Industrial Assessment Centers Program	Information dissemination, auditing	++
ID 30 United States: Motor Challenge and Best Practices Programs	Information dissemination	++
ID 33 International: START – Solar Thermal Analysis, Review and Training (Solar PACES)	Information	+
ID 34 European Union: Energy+ Technology Procurement Programme	Technology procurement	+++

Table 2: Different type of market actors involved in the IEA case studies.

MARKET ACTOR	ROLE (EXAMPLES)
Universities	Research
Research institutes	Research, development
Corporate research labs	Research, development
Planner, architect	Development
Consultant	Different tasks, e.g. policy
Installer	Seller
Manufacturer	Development, manufacturing
Sub-supplier	Development, manufacturing
Distributor	Buyer and seller
Wholesaler	Buyer and seller
Retailer	Buyer and seller
Purchasers	Buyer and seller
Contractors	Buyer and seller
Service company	Buyer and seller
Facility operators	Buyer
Trade associations	Buyer and seller
Branch organizations	Buyer and seller
Utilities	Buyer and seller
Energy distributors	Seller
Government agencies	Policy, support
Public institutions	Policy, support
Public authorities	Policy
Politicians	Policy
Energy agencies	Information, dissemination
Interest groupings	Users, industries
NGOs	Users
Mass media	Information, dissemination
Consumer associations	User aspects
Brokers	Financing
Lawyers	Policy, different tasks
Financial institutions	Financing
Private investors	Financing
House owner	Technology user
Consumer	Technology user
Customer	Technology user
End user	Technology user

All IEA deployment cases have formed links to different market actors in the realization of the programmes. These are called networks, alliances, agreements, partnerships, groupings etc. depending on the contents and function of the link. Actually it would be quite surprising not to see strong links being formed in any public policy initiative today. Involvement of strong and influential market actors means larger potential for the new technology to be brought to the market, e.g. better risk carrying capacity, larger purchasing power, etc. Involvement of many actors means more intensive social interaction, i.e. creative dialogue, more competition, new visions, more knowledge, more benefits and new values for the new technology.

Market actors should not narrowly be defined only as the industries that develop the products. Actually the market transformation cases indicate strongly that the buyers and users of the new technology are the critical target groups as these form the market and thus have a profound insight on how the market works and possess purchasing power. The issue of market needs is somewhat controversial: consumers normally know what he/she wants to buy but skillful marketing creates also new needs in the customer end. Creating needs definitely requires interaction between a range of market actors (e.g. the Dutch case on green certificates).

How does the involvement of market actors take place? In most cases the authorities and the public sector takes the initiative to start the market transformation process and takes the first move to link market actors to the activity. In case of the Austrian biomass district heating plants the local promoters were the initiators, a

clear self-organizing bottom-up approach. In RTD projects the initiative may come from the industries who also provide the market vision.

Government is a strong stakeholder in energy issues and in pursuing sustainability further. In market transformation processes, the stakeholder responsibilities are attached broader: making the users key stakeholders is a way to lock-in the new technology on market. The links between the market actors in MT take different forms and we could locate e.g. the following ones:

- Co-operative networks (e.g. between buyer groups);
- Competitive networks (e.g. companies offering the same product for a tender);
- Supportive networks (e.g. public support schemes);
- Business (e.g. industries joining skills to provide a new system type).

4. POLICIES TO ENHANCE MARKET TRANSFORMATION

4.1 General observations

Having reviewed and analyzed the individual IEA case studies, we next try to find out general policy frameworks employed in these and especially try to elaborate on the market transformation models employed. The Appendix describes the technology diffusion and temporal development of the perceived impacts from policy measures and MT.

A traditional way of classifying public policies and measures is to distinguish between technology development and market development, or technology push and market pull as depicted in Figure 3. The technology improvements may cause abrupt drops in the cost of the new technology e.g. through better efficiency or performance improvements. Increasing the production and utilization volume of the new technology will give arise to economics of scale and learning effects which in turn reduce the unit costs.

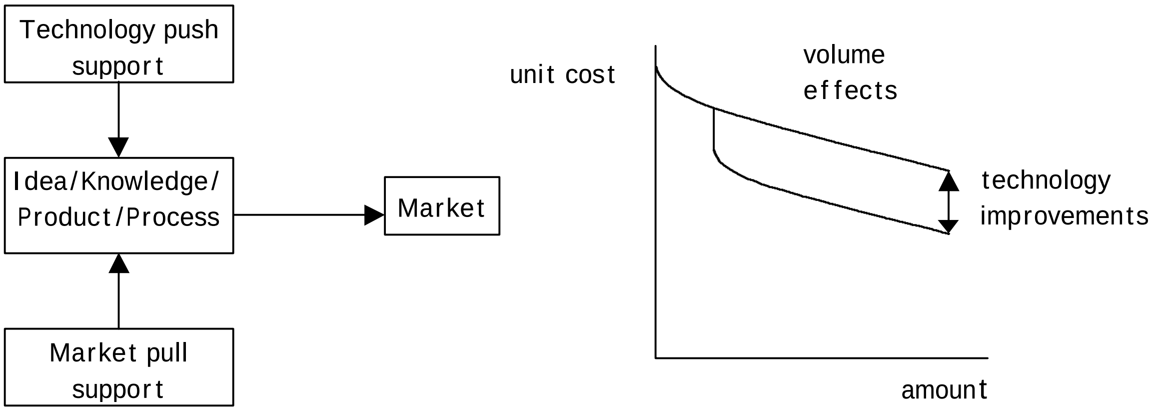


Figure 3: Crude division of public policies and measures

Another way to look on market transformation is to consider the whole innovation chain (Figure 4). The new technology needs to be brought successfully through the different stages of the innovation process. Public support may be allocated along the whole process into the separate phases. At the same time current technologies also improve and reduce their costs.

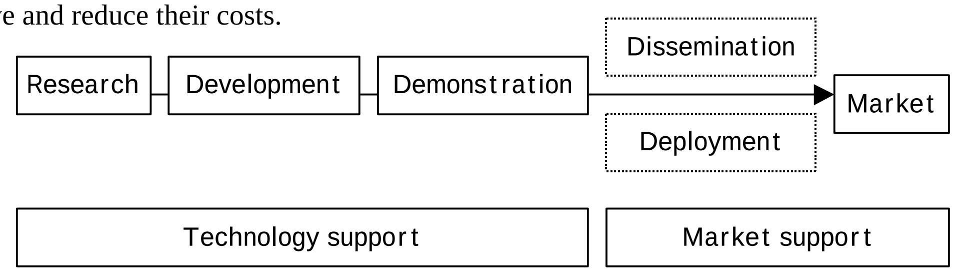


Figure 4: The linear innovation chain.

To speed up the commercialization process which may be quite long when moving along a linear process, the individual stages of the innovation chain may rather be performed in parallel (Figure 5). This would also improve information flow between the different phases and organizations involved. Also, the whole commercialization process could be handled as whole in an integrated manner improving resource utilization and increasing the chance of success. Market transformation models have similar effects as described above.

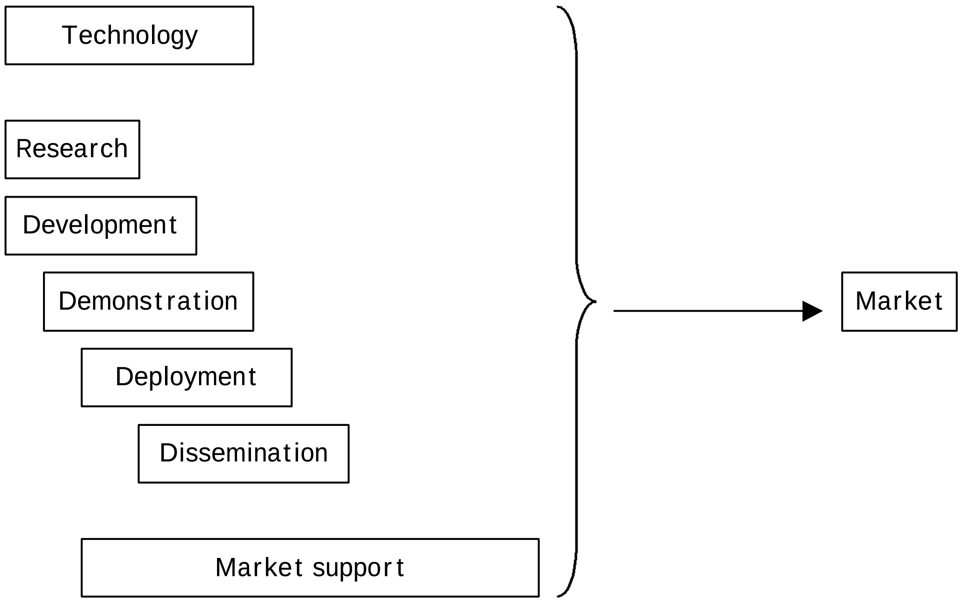


Figure 5: The concurrent innovation chain.

Finally, market transformation or commercialization may be viewed from a social and behavioral perspective. The public measures are focussed to change attitudes e.g. through increased information and understanding the benefits (e.g. business opportunities) of the new technology. When attitudes change to positive we may next expect changes in behavior and finally a concrete action (e.g. employ the new technology).

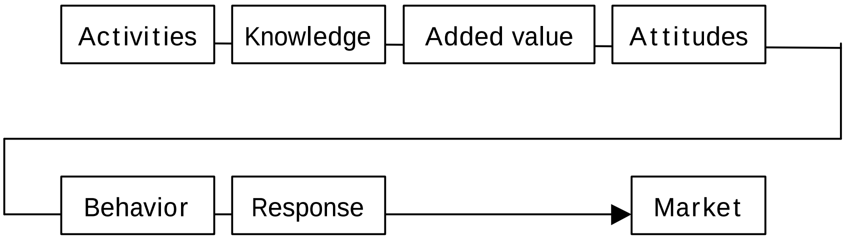


Figure 6: Market transformation as behavioral change.

4.2 Strategic niche management

Emerging technologies and new inventions may show superior technical characteristic over the prevailing technology base but are often too expensive and may even be still ill-fitted to the user needs. Existing frameworks being technological, economic or social have also an inherent resistance to large changes and tend to change incrementally only. In terms of future production, the industries have here three basic paths to choose from: 1) trying to compete with costs, 2) differentiating their products or 3) working through market niches. Of these options market the niches may offer the least risky but most rewarding strategy on a long-term run.

Niches are important platforms for new technologies to grow and evolve in scale toward large markets (Kemp, 1998). They help to set in motion interactive learning processes, institutional adaptations, networking and technical development processes necessary for wider implementation of the new technology. In practice, a niche is a protected economic space as the niche is basically outside the existing paradigms.

Thus a niche gives adequate scope for experimentation, trials and errors, modifications, product variations, etc. but at the same time embeds the new technology into the market.

Strategic niche management (SNM) is basically about creating niche platforms having a long-term strategic goal toward a major market transition. The vision is long-term but actions short-term. One of the key elements in SNM is to bring users, market actors and developers together in order to generate an interactive learning process, institutional adaptation but also immediate revenues to the businesses involved. It is a true market transition tool.

Strategic niche management starts from small and gradually grows towards high volume markets. The process is managed carefully and critically and involves in all stages many actor groups.
In creating technological niches, one has to take care that the technology options considered full-fill basic social, technological and economic preconditions. Therefore the following aspects are important guidelines for niche formation:

- target for high-value market segments;
- take full advantage of the merits of the new technology;
- choose technology options that have a large potential if being successful;
- concentrate on certain applications;
- choose first limited geographical areas or regions;
- try to tag on options with increasing returns;
- involve demanding or leading customers and users.

Strategic niche management includes facilitation of the niche process, experimentation of options and increasing the critical mass (e.g. actors, market) of the new technology mitigating a market transition. The experimentation phase is very important as this produces the final technology options that are mature for scale-up. This phase can be accomplished through a series of steps outlined in Figure 7. The basic condition for success is good design of the experiment, which necessitates careful assessment of the previously described niche guidelines and market opportunities. If the niche is successful then the market actors should be prepared to scale-up the technology. Scale-up involves always larger financial commitments and this aspect should be given thoughts already in the very beginning in the design phase, i.e. what to do if the niche is successful. The new technology may need several iterations and several niches before been fully embedded to the market.

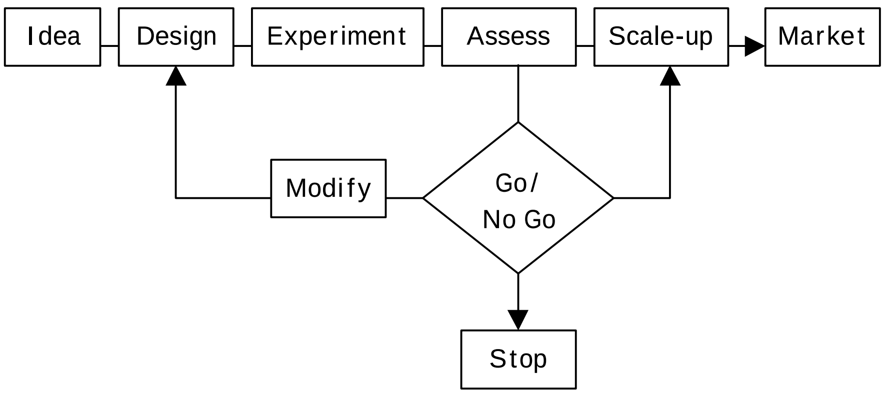


Figure 7: Bringing new technologies into the market through a controlled experimentation process.

The Austrian Biomass-District-Heating (BMDH) case demonstrates application of strategic niche management. The development started in early 1980's as a bottom-up local activity demonstrating that different actors can take care of the niche management. The public sector generously supported creating a platform and securing space for the technology deployment. The niche was local small biomass district heating systems and the key actors were the local promoters that both used and developed the systems. Starting with a certain system type, the technical development has evolved more to smaller system sizes

reflecting the market needs. The BMDH demonstrates a nice network of actors but some missing agents such as stronger integration of R&D and deployment resulted in negligible technical progress (e.g. optimization) over the years. Over 500 plants have been installed which demonstrates successful market development.

The Canadian Renewable Energy Deployment Initiative (REDI) has clearly worked through promising niche markets and applications. REDI is combining different policy measures (e.g. information, subsidies, R&D) to achieve economies of scale. Networking of stakeholders has been an important part of the REDI. The programme started in 1998 and shows many positive outcomes, e.g. increased sales.

4.3 Business concept innovation

Innovative business strategies may also be a way to accomplish market transformation. The energy sector and also several other private sectors indirectly involved in the energy field, such as the construction businesses, has traditionally given minor emphasis on innovation as a tool for creating competitive advantage. Slightly simplifying, for a traditional utility, the core business is in selling electricity to households or industrial customers and the key factor for success is the price of electricity. Moreover, the energy market has been quite regulated for a long time. In such a static environment, creating market transformation actions have been difficult.

The deregulation of the electric and gas market will increase competition. According to the Nordic experience, the electricity price will first decline, as price seems to be the major sole competitive factor. Sometimes, in order to keep the customers, utilities have sold electricity with a deficit. As an ultimate limit, those with the cheapest capacity and lowest costs for new capacity will be the winners on the market.

If not having the cheapest electricity how may a utility survive on the market on a long-term? Business concept innovations may be a possibility to increase business (Hamel, 2000). Business is not just selling a product or technology but it involves the target group to whom the product is sold and the distribution channel(s) through which the product is delivered (Figure 8). The company may gain advantage if it is able to be innovative in any of these 3 dimensions. Thus not only a new technology but a new way of bringing the product to the customer, e.g. energy service, may lead to change. The more radical the business innovation concept is the more likely the company is to accomplish a market transformation.

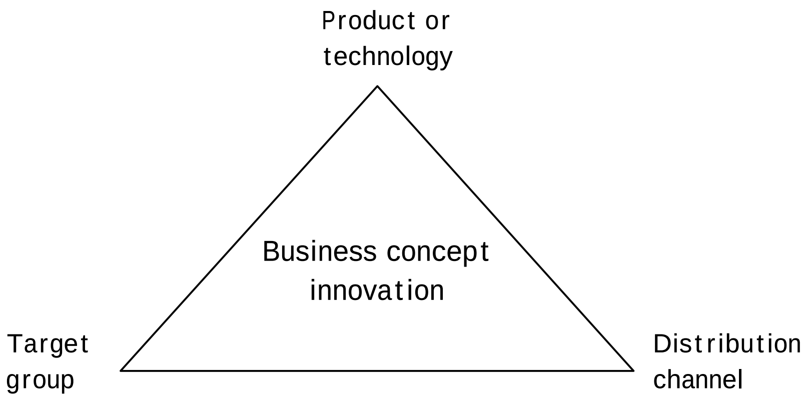
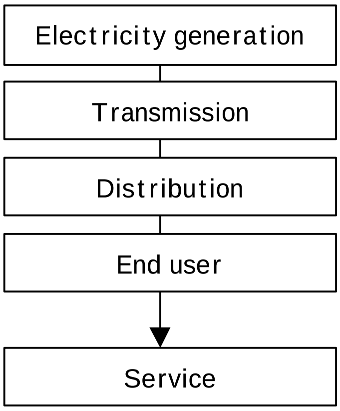


Figure 8: Business concept innovation.

Where does the money in the energy value chain go? Figure 9 shows the disintegration of the utility business. Prior to the deregulation when transmission and production was often same business, the emphasis was in the production. After dismantling of utility monopolies, the price peak is found in the distribution line as users are often locked-in to local distributors. Moving the business focus down to the end user could give rise to another distribution where most of the revenues were obtained from energy services. We may guess that this would happen if the consumer had distribution options to choose from. Historically, as governments have opened markets, the most profit has come from the part of the chain in which the user can be locked-in.



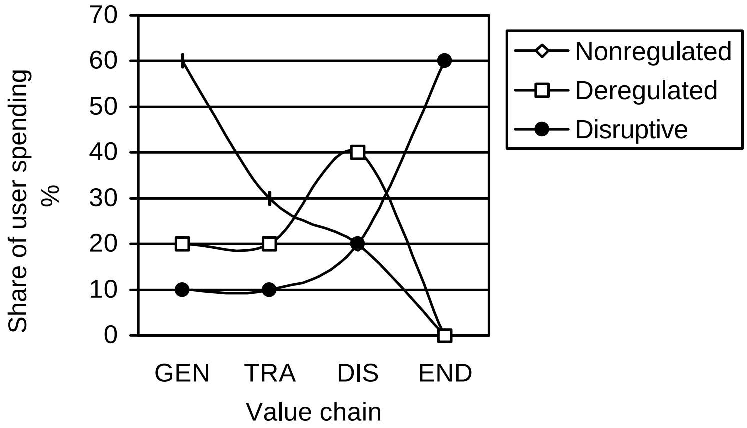


Figure 9: Value chain of electricity.

Free and open electricity markets in every point of the value chain may be the long-term sector's development. Utilities or energy companies need to find new ways to lock-in customers. One way is to offer cheaper bulk electricity with a production mix satisfying sustainability requirements on a long-term. Another way would be to attach new type of services or technologies toward the end-use (customer). These could be e.g. distributed generation, energy efficient end-use technologies, energy services, other services attached to the energy (e.g. information technology, smart home, maintenance and service). Figure 10 illustrates such a future energy business model.

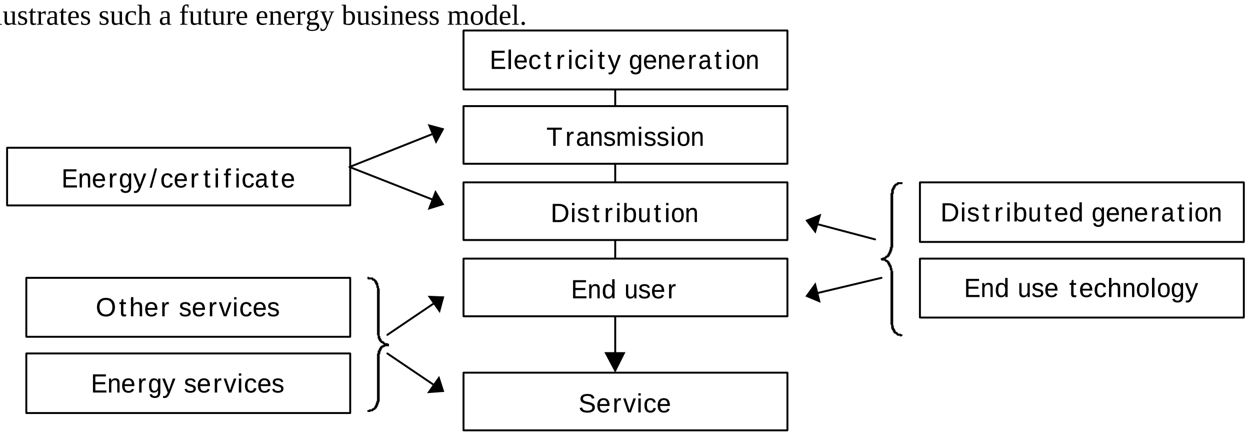


Figure 10: Example of a future energy business model.

What can government do the support such a business development? Open competition, transparency, deregulation, fair market rules are prerequisites for change in the value chain. Subsidies to centralized power production, transmission or distribution systems need to be seized if there were still any existing . On the other hand, governments may support end-use information, compensation of transaction costs and development of proper technology.

The IEA case on diesel engines for CC power generation (Wärtsilä NSD, Finland) is a good example of public policy to support new business concepts. The Wärtsilä company is world's leading company in diesel engines. The Technology Center of Finland (TEKES) supported technology development of compact and modular combined heat and power diesel systems. Later leading users and public financiers joined to realize a full-scale demonstration. These supported the business concept to provide competitive energy solutions in the end-use part and also develop total energy service concepts. These have proven to be successful and have lead into increased sales.

4.4 Procurement actions

The public sector has long traditions in using procurement. Government acts often as a procurer through its long-term buyer role or as a facilitator of networks for procurement. Public procurement has traditionally been used e.g. in military, aerospace and public works. In defense regimes technology procurement is an

often used tool to acquire advanced technical equipment. In some countries, green procurement is emerging to acquire environmentally friendly and even energy efficient products. When using procurement for acquiring better technology it may turn into a buyer-driven innovation process facilitating a major market transformation. National and multinational legislation puts legal frameworks for public procurement.

The public sector has a strong purchasing power through which it has a potential to catalyze market transformation. As a crude estimate, the volume of public procurement may come up to 20% of the GNP. Naturally, only a part of this is energy technology related. To give an example, the U.S. federal government spends some 10-20 billion $ per year on energy-related equipment and supplies.

The IEA case studies include four successful examples on procurement, and especially technology procurement. These were the following:

- Electronic HF ballasts for lighting systems (Sweden);
- Heat pumps for residential use (Sweden);
- U.S. DOE Sub-CFL programme (USA);
- Energy Plus Programme (EU).

Technology procurement (TP) is an interesting tool for promoting commercialization of new technologies. Basically it is a tool to manage the whole innovation chain and bring the new technology permanently to the market. It aggregates demand for better products to foster technical development. To be effective, technology procurement project needs supporting market actions, which makes TP more a process than a project.

The structure of a technology procurement process is shown in Figure 11.

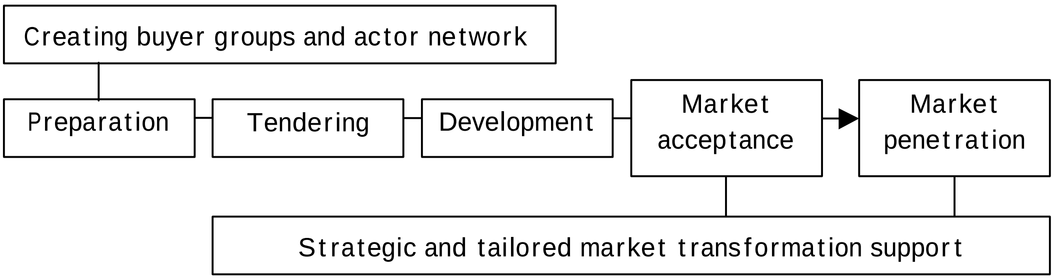


Figure 11: Technology procurement process.

One of the central steps is creation of large buyer groups which are willing to buy the new product and to create an adequate first market for it (Olerup, 2001). The preparation phase needs much vision and know-how about what is technically feasible, what should the product specifications be to attract the market, what are the present and hidden needs of the market, what are the market trends, what is the long-term potential of the new product, etc. (Lund, 1996). Therefore a strong actor network will be necessary.

The technology procurements reported in the IEA case studies show 30-70% improvements in technical performance compared to existing technologies. How much could a TP improve a product or how high improvements are worthwhile to require to avoid uncontrolled risks depends on several factors, e.g. time available, product, type of industry, etc. In principle, the larger the first market to be created is, the larger could the efforts put by the industry to develop the feature be. Technological improvement and market size has thus some correlation. Most of technical improvements demonstrated in the IEA case studies were known by the industries. Through waking up this latent potential and bringing sometimes additional skills and know-how, and an incentive for the industries to act, the TP catalyzed the technical development.

It is interesting to note that non-energy benefits and features are those attracting the buyers and this is especially true for end-use energy technologies and energy efficiency. For example in the U.S. Sub-CFL programme the key to success laid in developing shorter CFLs that fit into typical lighting fixtures. In the Swedish HF-ballast TP, the better lighting quality and increased productivity were important motives.

The first purchase follows by market acceptance which is the test for the success. At this stage a range of supporting activities may be needed to lock-in the new technology on the market. Table 3 gives a list of possible actions found. What support is needed and what is most effective need to be judged case by case (see Table 3). For public policies this means flexible policy measures and continuity in activities to ensure market penetration and market uptake.

Technology procurement is not a static policy instrument for market transformation but there are several variants that can be applied based on the local conditions and needs demonstrated also by the IEA case studies. Table 4 illustrates possible approaches.

Table 3: Example of possible MT support activities in a technology procurement process.

SUPPORTING ACTIVITIES	Electronic HF ballasts for lighting systems (Sweden)
active buyers group	X
media	X
targeted information material	X
labeling	-
standards	-
advice to professionals	X
consumer advice by telephone	-
exhibitions	X
education	X
voluntary agreements	X
active manufacturers	X
other actors on market	X
subsidies	X
national campaigns	X
regional and local campaigns	X
demonstration	-
green offices	X
accelerating market penetration	X

Table 4: Variants of procurement models.

Dimensions of a procurement Extreme 1 ↔	Extreme 2	Description of the alternative approaches
Components	Systems	The subject of may vary from specific components of a system into a whole system or facility. A single component may be a generic technology and widely applicable whereas a system may show local features. A system may give more flexibility and leave room for different approaches whereas a component is often fixed to a certain technology. The risks and complexity increase when going from a single component to a system.
National	International	Procurement is often arranged nationally, but based on procurement regulation, the competition has to be open to international manufacturers. Through international procurement the purchasing power of buyer groups is further increased and more strict criteria e.g. on technology and price could be applied.
1 stage	Multi-stage	Most procurements are single projects with static content. New ways to improve it may be to introduce a multi-stage which combines the strengths of one particular procurement approach. For example, • 1st stage national and 2nd stage international (multiplication effect) • 1st international (e.g. component) and 2nd national (e.g. system) • 1st international (manufacturers) and 2nd international (consumers)
Organized	Self-organized	Technology procurement is a strictly organized activity and requires good management to be successful. In suitable conditions, a technology procurement type of development may take spontaneously place. A TP could arise e.g. with an internal consensus-type voluntarily technology procurement where networking has played an important role.
Technology procurement	Ordinary procurement	TP sets high requirements on the technical characteristics of a product and enhances the penetration of most advanced solutions. In an ordinary procurement, the focus may be in creating more purchasing power to reduce the price of good available or best practice products.

Public	Private	Public bodies have traditionally used procurement tools. Private sector procurement is possible as well (e.g. buyer group networks). Internet could also be used to collect buyers and purchasing power.

Sometimes progress come through trial and error and programme modifications. For example, the Swedish heat pump procurement had three stages. This applies to other market transformation activities as well: for example the Danish energy labelling scheme of small buildings was once revised to fit the market conditions. Multi-stage procurements may also be used to test the concept first with small efforts before up-scaling.

Several factors contribute the success in a procurement: involvement of influential buyer groups, partnerships and networking, understanding the market, adequate commitment and continuity until lock-in occurs, flexible public resources, size of market opportunities, etc.

5. RESULTS FROM MARKET TRANSFORMATION PROCESSES

The market impacts only will reveal the true effectiveness of the different policy measures. In Table 5 and 6 we have compiled input information from the deployment programmes and outputs/outcomes. To enable initial comparisons between measures, we have also included here other actions than market transformation models (4 first in the list are typical MTs).

Table 5: Input information for selected cases.

MEASURE	NAT.	YEAR	DESCRIPTION	GOAL
Electronic HF ballasts for lighting systems	S	1991	Technology procurement of energy efficient lighting	30-70% energy savings
Heat pumps for residential use	S	1995	Technology procurement of small heat pumps	30% cheaper and 30% better HP
U.S. DOE Sub-CFL programme	USA	1998	Technology procurement of small CFLs	price< \$15-22 >2 manufactures sales > 1 M
Energy Plus Programme	EU	1999	TP of refrigerators and freezers	max 42% of the average energy
PV Covenant	NL	1997-2000	PV market deployment	Installation of systems
Biomass district heat	A	1988-2000	Small biomass district heating systems	Installation of systems
Energy labelling	DK	1997-	Mandatory energy labelling of smaller buildings	Improving building energy efficiency
250 MW wind	D	1991-1995	Wind energy deployment	Installation of systems

Table 6: Effects of selected case studies

MEASURE	COSTS	MARKET/OUTCOME AT PRG END	MARKET STATUS 2001
Electronic HF ballasts for lighting systems	\$ 5.3 M	First market ca 55,000 HFs	Sales 1.6 M units/a
Heat pumps for residential use	€ 1 M	First market 2,000 units	Sales ca 20,000 units/a
U.S. DOE Sub-CFL programme	\$ 0.3 M (programme) \$ 4 M (future)	1.5 M units sold, \$5-8.3 per unit, 5 manufacturers	Increasing
Energy Plus Programme	€ 1 M	33-35% energy use of the average, 100 buyer groups (1 M households)	Starting
PV Covenant	€ 16 M	7.7 MW_p PV	Future unclear, initially a 250 MWp programme planned
Biomass district heat	€ 100 M	500 biomass plants installed	Increasing

Energy labelling	€ 0.75 M/yr	45,000-50,000 labels/a,	25% of identified improvements realized
250 MW wind	€ 160 M	250 MW wind	German wind energy is today > 10,000 MW

In the market transformation cases, the new products have been accomplished through quite modest technology development and research efforts but causing a large market impact.

Figure 12 shows an example of the market penetration of a new technology (Austrian biomass case). The impacts come over several years and a final judgement on the success cannot therefore be done immediately after the programme end but several years later. For example, the energy impact of the highly successful HF technology procurement programme at its end is only 1% of the total perceived energy impact. The sales of the ballasts are today 30-fold compared to the first purchase ten years ago.

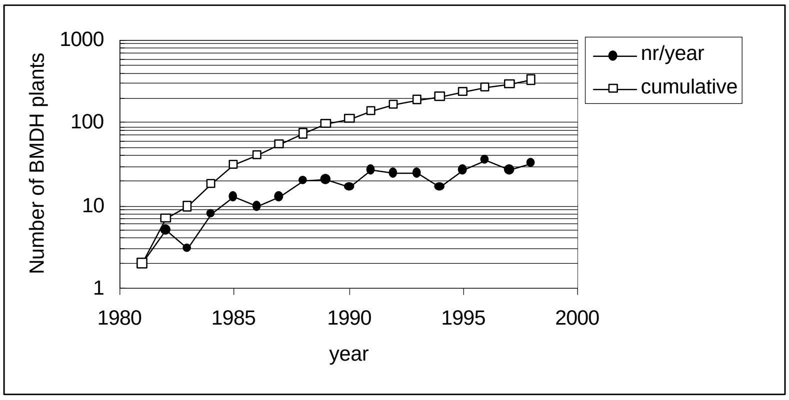


Figure 12: Diffusion of the small biomass district heating plants in Austria (number of plants shown).

A further elaboration of the HF case shows that the immediate energy effect of the technology procurement from 1991 to 1994 was about 40 GWh. Based on today's perceived cumulative effect this represents only about 1% of the total impact. In late 1999, 15% of the energy impacts had been realized. Total cumulative impact by year 2010 is expected to rise to 4200 GWh. Figure 13 shows the successful market introduction and expected trend.

As an overall judgement, all cases in Table 5 and 6 give a clear market impact. For volume-based subsidy schemes the programme costs are here 10-50 €/MWh and the programmes with a strong market transformation dimensions may come to as low as 1€/MWh or even under this. Long-term data on market impacts would enable a more accurate verification of the cost effectiveness of different measures.

The market multiplication factors of the successful market transformation programmes may be considerable. With available data we find 10-30x in ten years. Spatial diffusion of the new technology to other countries will boost additionally the multiplication.

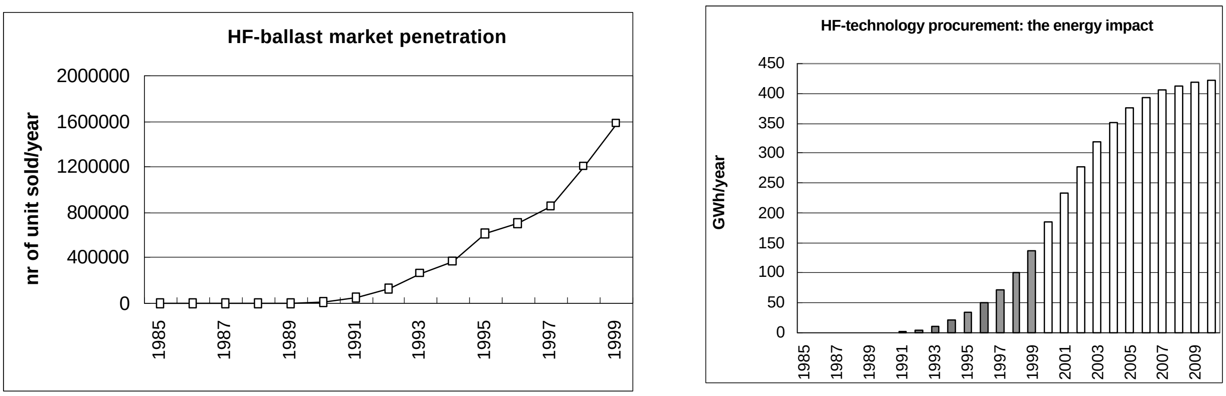


Figure 13: Market penetration and energy savings of the HF-ballasts technology procurement in Sweden.

6. TECHNOLOGY DIFFUSION

The evident slowness of market penetration of new technologies in the energy sector shown in previous chapter may directly be attached to diffusion processes and adoption rates. The market penetration of new products over time usually follows an S-curve. Sometimes the S-curve may be very smooth but often it may be irregular, asymmetric or sporadic.

Based on the IEA case studies, we may clearly link the technology diffusion to the following issues which alleviate that social networks, information and competition may be key factors in the process:

- information available and spreading of the information among the market actors and users influence adopting new technologies;
- cost and risk factors associated with the new technology (e.g. information, transactions);
- public support (e.g. financing, standards);
- how companies perceive new technologies (e.g. opportunity or threat);
- size effects (e.g. size of actor, number of users, market volume).

The IEA case studies offered several good candidates to investigate how market transformation efforts transform into technology diffusion. Taking into account the time needed in the diffusion process, we looked for older cases and the NUTEK HF-ballast/Lighting technology procurement gave an adequate historical record to analyze the diffusion in more detail.

High-frequency electronic ballasts (HF) is a core technology needed in energy efficient lighting systems and it replaces traditional ballasts in fluorescent lighting. It offers better lighting quality, better controllability and longer life. Energy savings are easily 20-25% and with improved lighting systems even up to 70%. NUTEK arranged the technology procurement to bring the HF on the market and accompanied with other sophisticated market transformation activities (e.g. information, demonstrations, incentives, etc.).

The procurement was highly successful as explained already earlier. The development of the market share is shown in Figure 14. From a modest market share of < 0.1% prior to the technology procurement and market transformation effort, the market share grow in 2000 to nearly 35%. The penetration follows well the classical diffusion model. Assuming that the prevailing trend continues, then the saturation of the HF will occur in year 2008-2010 (close to 100% market share).

The IEA case study indicates clearly that the cost of HF and HF based energy efficient lighting systems have reduced over time. Also, the market transformation process has broadened the narrow view on costs only into non-energy benefits (e.g. increased productivity through improved lighting quality) and life-cycle thinking. These factors actually may have increased dramatically the initial HF market when the good news and lowered costs/increased added values spread among the professionals. NUTEK's activity reached already in 1991 through the buyer groups formed some 30% of the total commercial premises in Sweden.

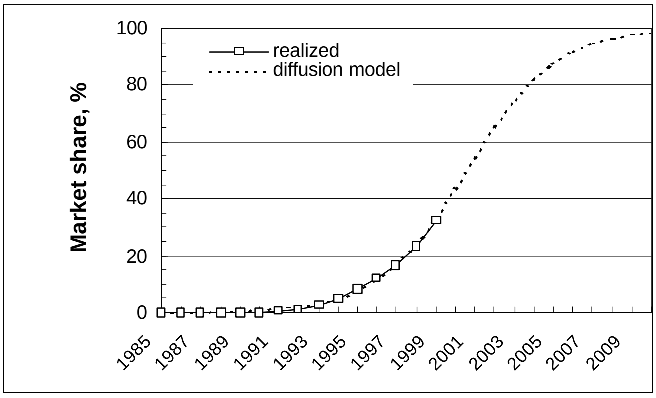


Figure 14: Diffusion of the HF-ballast on the Swedish market. Technology procurement arranged by NUTEK in year 1991 with post-project support activities extending to ca 1994.

The diffusion shown in Figure 14 looks very smooth but a closer look reveals different phases. Figure 15 shows the diffusion in logarithmic scale.

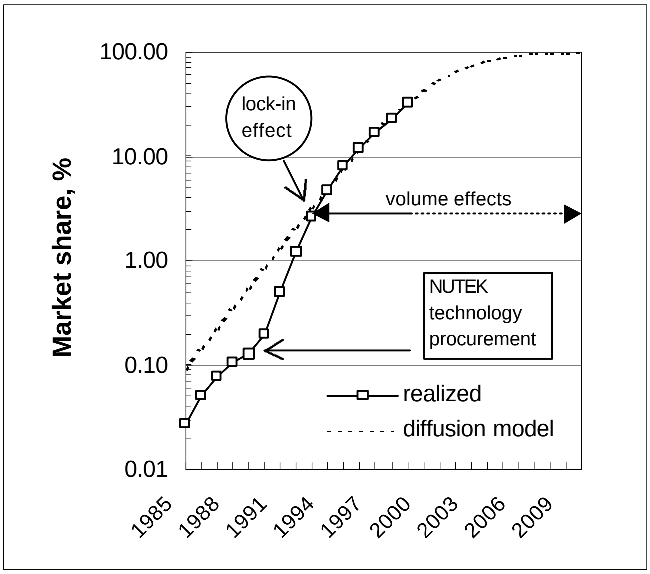


Figure 15: Diffusion of the HF-ballast on the Swedish market (logarithmic scale).

We may distinguish here three phase in the diffusion process with different penetration rates:

I. slow diffusion, diffusion prior to the technology procurement (1985-1991)
II. accelerated penetration, technology procurement phase (1991-1994)
III. stable growth of the market, post-procurement phase (1994-)

The technology procurement causes a rapid increase in the market through creation of the buyer groups and first market. Around 1994-1995 we observe that the technology diffusion starts to follow more accurately the classical diffusion model. We think this indicates lock-in of the technology on the market, i.e. HF-ballasts and energy efficient lighting has become the choice of the market. The future market evolution looks now much more deterministic. The lock-in takes here place at around a 5% market share but in addition it is worthwhile to look also on the market trend which is shown in Figure 16. The procurement causes a tremendous momentous market growth and indeed this may attract industries to move into the field. Other producers soon followed the winner of the procurement who delivered the buyer group the winning pot. Once the new technology is established on the market, i.e. the market share is high enough, the market trends and increase becomes less critical.

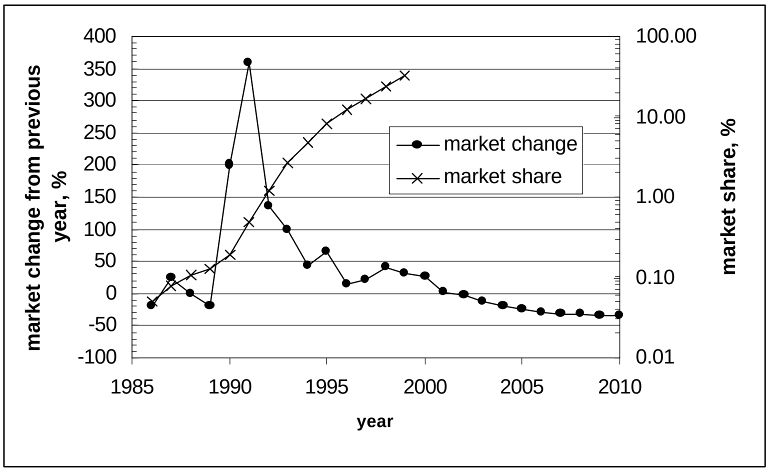


Figure 16: Market changes of the HF-ballast on the Swedish market (logarithmic scale).

In summary, we may draw some observations from the previous analysis on technology diffusion. "Early bird gets the worm" seems to be characteristic to diffusion (Geroski, 2000):

- early stage of the market transformation is critical for the further success of the new technology on the market;
- small initial effects can have large long-term impacts;
- first, early and leading users may lock-in the market into a deterministic growth mode but requires a critical market size of the new technology;
- starting small but scaling up fast if successful;
- the volume of information, number of users, size of actors affect positively the early adopting of the new technology.

There may also important wisdom to add to market transformation policies:

- focus on trying a lock-in of the new technology on the market; this may require innovative approaches depending on the case; legislative measures (e.g. feed-in laws, norms) are extreme measures to lock-in a new technology
- concentrating on early stage of diffusion in which policies may still make a difference; whence a product is established on the market it will be difficult to have influence (e.g. on the energy efficiency of the product, emissions, etc.)
- work together with users and leading market actors;
- matching technology with user needs.

There are many strategies to approach the market transformation and diffusion as illustrated by several IEA case studies. But the essence seems to be in understanding the market and its needs. To further concretize, creating a large market potential, working strongly with the market forces till a certain market share of the new technology is reached (lock-in), creating a sharp increase in the demand seems all be present in a successful lock-in mission.

Above statements may create new organizational challenges to public programmes and polices, namely increasing flexibility, working with a range of different instruments simultaneously (e.g. R&D, demonstration, incentives, networking, information, etc.), creating versatile networks of market actors, having a long-term perspective with concrete short-term objectives and providing continuity to operations.

7. DESIGNING A MARKET TRANSFORMATION PROGRAMME

To integrate the characteristics of a market transformation model into a policy measure, Figure 14 and Table 7 gives helpful generic guidelines on how to formulate the structure and central actions. The exact contents of the individual steps need to be designed case by case e.g. accounting for the local conditions and characteristics of the new technology.

8. SUMMARY AND CONCLUSIONS

The IEA Case Studies have provided a useful and unique set of information to analyze from different view points the market transformation models and involvement of market actors in the market development process. In spite of the fact that the local conditions, being economic, political or social, may differ from country to country, there are some commonalties and important observations found here that deserve to be summarized.

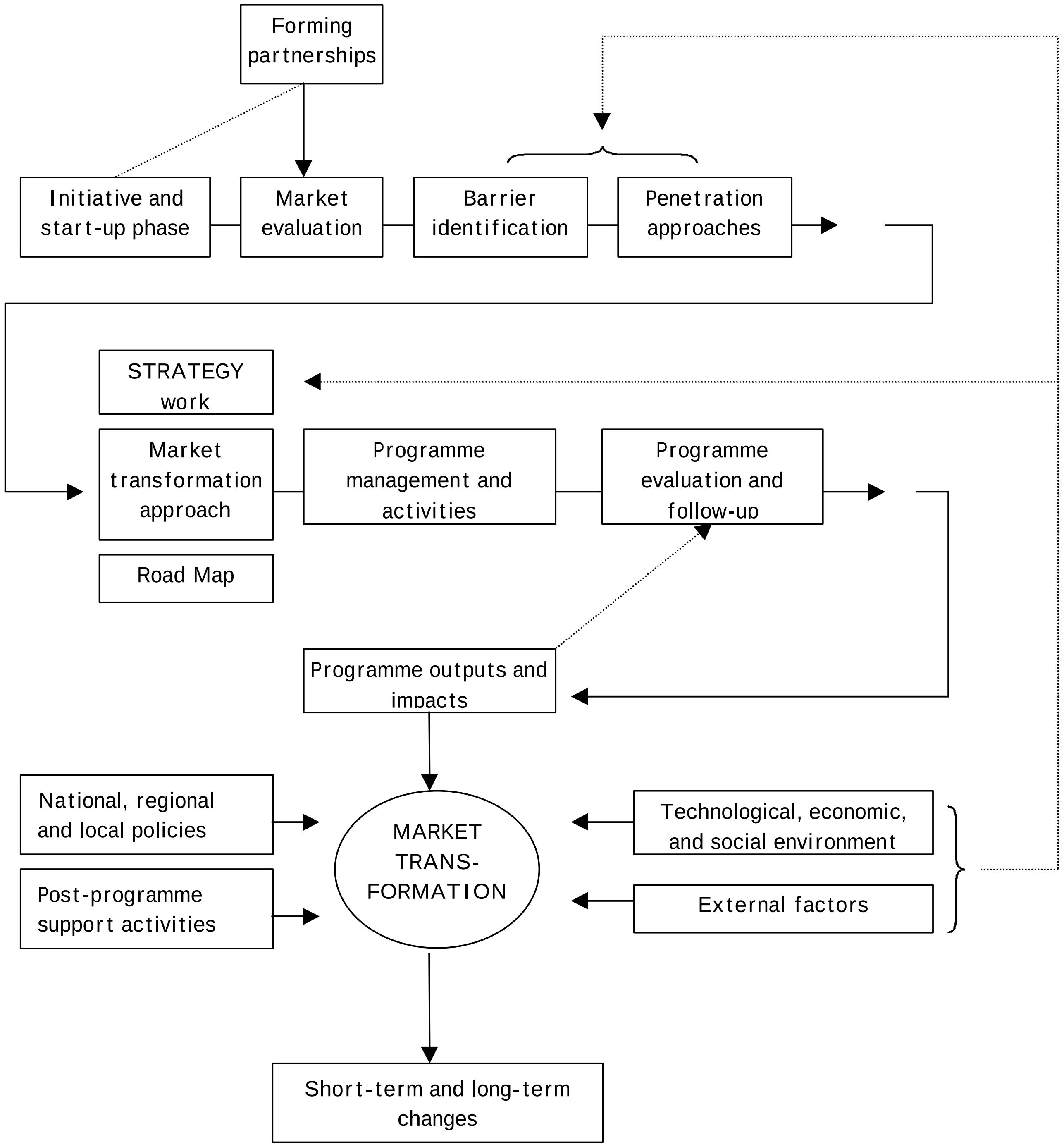


Figure 14: Flow chart of a market transformation programme.

Table 7: Steps in the programme formulation.

PHASE	CONTENTS	COMMENTS
1. Initiative	Public body Private organization	Finding the organization which has the motivation to work as catalyzing agent or shareholder

2. Partnerships	Formation of strategic partnerships Commitment, stakeholders	Users and customers Private and public bodies Large buyer groups Key market actors
3. Market evaluation	Identification of main market barriers Market segments Market needs and trends Business opportunities and motivation New markets Promising existing markets Demand niches	Understanding market structure Promising, large volume markets
4. Barrier identification	Technical, economic, social barriers Innovation environment	Accounting for the market realities and conditions
5. Penetration approaches	Technical measures Improved abilities Financial support and means Educational means Systems thinking	Look e.g. for economies of scale, increasing returns and Technology lock-in Accounting for the market realities
6. I. Strategy	Maximizing chance of success Minimizing implementation costs Right perspective	Strong market actor dialogue Start small but be prepared to scale up
6. II. Market transformation	Choosing the policy tools Creating project portfolios	Cost/benefit analysis Different MT schemes
6. III. Road map	Implementation plan of the strategy Strategic stair-cases	Strong market actor input
7. Programme management	Operations Monitoring and tracking	Networking Dissemination
8. Programme activities	Policy measures in practice	Flexibility, continuity
9. Follow-up and evaluation	Milestones Programme revisions and adjustments Assessment	Feedback Programme modifications if necessary
10. Outputs and impacts	Short-term outputs Long-term impacts	Every programme produce immediate effects but true market impacts come over several years
11. Endogenous factors	Economic, political, social and cultural environment	E.g. changes in energy prices may influence the success of the strategy
12. Supporting activities	Ensuring market lock-in	Large variety of measures available
13. Change	Market transformation	When lock-in of new technology on market the programme can stop. MT will proceed.

Market transformation (MT) is a conscious attempt to bring a new technology permanently on the market. Commercialization is the main objective. Rather than being an isolated and constrained project, MT is more of a process. Market transformation as a energy policy model is relatively new but the experiences are ample and they demonstrate many successes stories. Market transformation resembling models with strong mandatory aspects such as legislative or regulatory measures, for example laws or energy acts, were not included in our analysis work as these were not really presented in the IEA cases, but also because their resource use efficiency may be questionable.

Involvement of market actors is important for a market transformation process as a matter of fact for any successful deployment programme. Market actors are not only the industries that develop the products and new technologies, but more essential may be the buyers and the users of these. To bring effectively new technologies into the market requires good knowledge of the market structure and mechanisms. Working closely with influential buyers increase the likelihood that products brought to market will be received by buyers. In market transformation models, networking of market actors and involving leading buyers are core

actions. Employing market forces such as purchasing power, alliances and competition yields large market impacts that can be achieved even with modest RTD efforts.

We could identify different approaches to market transformation. These include for example different procurement models, strategic niche management, business concept innovation models and technology diffusion models. A brief comparison of costs associated with deployment programmes showed that MT may be a very effective tool. The public financial support in MT models goes into the commercialization process even when it were direct market support. Therefore, the results are less dependent of the amount of the financial support received whereas in many volume-based policy schemes such as investments or performance subsidies the market impacts depend strongly on the financial aid. The multiplication factor of MT programmes may thus be very high.

Market transformation needs strong partnerships. Government and authorities responsible for energy policy have often a natural role in initiating market transformation processes. There is for certain also scope for the private sector to be more active: market transformation means new business opportunities and for the energy sector under reformation it may mean new competitive advantage. But buyers and users need to be made the central stakeholders to achieve strong market penetration.

What is there for policy makers? Market transformation models means new opportunities to governments and authorities to speed up commercialization of new technologies and to improve the efficiency of public spending. In the analysis we have outlined general guidelines for formulating policies in this direction. But MT programmes may at the same time require more flexibility and continuity, more cross-border cooperation of government agencies, and more patience as the big returns come often years after the public investment is done.

What role could international collaboration play here? Market transformation and the issue of market actors' involvement in market deployment are generally still quite new approaches compared to governments' normal policy measures such as legislation, RTD support, market subsidies or information dissemination. Sharing experiences and information is a traditional way to collaborate on a new area and this would also apply to MT. International collaboration may go even beyond this. There is for sure still scope for improving market transformation models and practices and therefore joining forces in developing MT further and sharing the associated costs would be beneficial for the participants. Traditional technology based vertical international R&D collaboration would then get market-driven horizontal MT collaboration on its side. But the largest reward may in the end be obtained from collaboration which leads into involving market actors internationally in real market transformation processes, creating international networks and purchasing power to commercialize new technology world-wide.

ACKNOWLEDGEMENTS

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Creating Markets
for
Energy Technologies

Summaries of Case-Study Findings

As per November 6, 2001

Table of Contents

Characteristics of deployment cases **CS 1**

Project	Technology	Policy Mechanisms	Results/remarks
The Deployment of Biomass-District-Heating in Austria. Started 1980. By 1999 more than 500 Biomass-District-Heating (BMDH) plants have been established.	Small scale district heating plants that use wood chips, industrial wood waste or straw as fuel (BMDH) Plants usually have between 500 and 4000 inhabitants and are of predominantly rural character. Accordingly the power of BMDH plants is between a few hundred kW and up to ten MW with corresponding grids between 100 metres and 20 kilometres. About 2/3 of all plants have a power of less than 1500 kW. Larger plants > 800kW have decreased since 1994. Smaller plants are associated with a new concept: the heating plant is not designed to supply the whole village but only a few larger buildings in the vicinity.	Managed at the level of federal states („Länder“) At the policy level, the prime objective was clearly to support agriculture. The national ministry of agriculture provided a significant amount of financial resources for the programmes. The subsidies provided for agricultural co-operatives usually included both a soft loan and a direct financial subsidy with a net-cash-value corresponding to about 50% of the total investment-costs of the project. Subsidies were complemented to an approximately equal amount from the federal provinces. In 1999 approximately 11 M EURO were provided by the ministry, complimented by 7,3 M EURO from the federal states and 5,1 M EURO from the European Union regional funds. These subsidies were available only for farmers. Commercial operators as for example sawmill-owners could only receive a 30% subsidy from the environmental fund of the ministry of environment. Indirect financial support is the low VAT of 10% on wood (compared to 20% VAT generally). Focal points or “niche managers” in the federal states were an-other key-mechanism for supporting technology-deployment. Typically one to two persons per federal state.	The description of the project is made in terms of “Technology Diffusion” (adopters, laggards etc) A survey among residents showed that top motivation for residents connecting to the new BMDH was environmental protection (mentioned by 95%). 75% of the responding residents declared an important aspect for them was also the support of local farmers and local self-sufficiency. 87 % responded that the convenience of District-Heating was an important motivation. Thus local motivation is based on three basic aspects: ❑ environmental protection, ❑ enhanced heating comfort and ❑ sustainable local development.

Model	Relates to	Model issues
Market Barrier	• Biomass is a cheap fuel that is competitive with conventional fuels, but biomass boilers are more expensive than conventional boilers and a district-heating-grid is very costly. Consequently it is almost impossible to realise BMDH-projects without subsidies for the **high initial investment-costs.** • Biomass boilers for the combustion of woodwastes have been used in the forest-industry for decades, and district-heating as a technology has also existed for a long time, the combination of both elements was a real innovation. Especially its application in small scale rural areas was new and requested both modifications and improvements of the boilers and of district-heating technology. In addition to that also the concept of operating BMDH plants by agricultural co-operatives was completely new. **The technical start-up problems and the fact that the developers and operators of these plants had no previous experience** neither with the technology nor with the economics of providing energy-services were a significant barrier.	• Financing (not cost) • Information • Market Organisation

R&D Deploy-ment	While R&D was very important for technology-improvement it was not part of the state deployment-programmes but funded by national R&D-programmes and a fund dedicated to support R&D in industry with informal links between the responsible actors that created co-ordination. Research was also a main-actor. Both researchers and research-funding reacted flexibly to the sudden demand created by the new technology for reliable and environmentally sound combustion-systems. In co-operation with industry significant improvements of combustion technology were introduced. For a long time however research failed to identify and address the issue of systems performance. While boiler performance was pushed to ever further limits, no attention was given to optimising the whole design of a District-Heating-System in terms of techno-economic performance.	Systems configuration and performance
Market Transfor-mation	The deployment of BMDH started as a bottom-up-process in which individual farmers supported by a regional development agency developed the idea and realised the first projects. The success of these projects created an exceptional interest and some of the BMDH plants received thousands of visitors annually. At the beginning no formal subsidy-program was available for this innovation. The development of formal subsidy-programmes and the establishment of the different support-units in the federal states was more of a reaction to the bottom-up-development than a planned technology-deployment activity. The design of the programmes in the different states was similar: Create a subsidy scheme and provide-funding for one or two persons that help the farmers to set up their projects.	• Innovators (reacted without subsidies) • Early adopters (after subsidy and assistance scheme was created)

ACTOR RELATIONS:

The main-actors are the local promoters of the project that subsequently both develop and operate the system. Successful local promoters are personally highly motivated and that manage to create a consensus to realise the project. For these local promoters, in turn, their key-actor is the focal point in their federal state, regardless whether it is the agricultural chamber, the state energy agency, the consultant or the person in the state-government. This focal point makes feasibility studies, helps the operators to manage the complex administrative procedures for getting a subsidy, they give advise on how to create the cooperative, on how to develop the project, on the contracts with the heat-customers, etc. The niche managers also kept the contact to the boiler-manufacturers and discussed with them the different problems that occurred in the beginning. Another important group for the niche managers were the village majors. In some federal states they visited almost all majors in the whole state to inform them about the new technology and to raise interest in realising a project. Still further up the hierarchy federal state politicians played a key-role for providing sufficient financial resources needed by the rapidly expanding number of projects. These actors also need to be pleased e.g. in opening ceremonies of new plants, with lots of media and public involvement.

Too little attention was given to the role of conflicts at the local level. The consultants of the focal points were educated only in technical and economic issues. Consequently they were not able to give appropriate advise to the project-promoters on conflict-management techniques. It turned out that the state focal points had different strategies regarding pricing which led to significant differences in price-levels for district heat. In some states the focal points had a particularly strong pro-project bias in the feasibility study phase which led to the financing of projects with rather poor economic preconditions. In the course of the programmes an increasingly critical economic evaluation was implemented as a consequence of problems with projects that were economic disasters.
Important actors that did not receive sufficient attention were the planners of the projects. Consequently many mistakes were made in the beginning, the most common of which was gross overdimensioning of all components of the system.

Project	Technology	Policy Mechanisms	Results/remarks
Thermoprofit was first conceived as part of the Graz Municipal Energy Concept (Kommunales Energiekonzept KEK Graz) in Austria. Thermoprofit is a „trade mark“ for total service packages in order to reduce the amount of energy consumed in the building concerned.	Thermoprofit partners examine all possible and economic measures like: ■ Thermal insulation of roofs, ceilings and/or walls ■ Insulated vitrification ■ Conversion of the heating system ■ Redevelopment of the control technology ■ Use of renewable energy sources ■ Optimisation of housing technology ■ Efficient Lighting Thermoprofit projects can also include measures which are not related to heating or cooling systems, like for example the efficient use of power. However a primary goal of the project has to be the optimisation of the thermal energy use. The essential characteristics of Thermoprofit are: ■ reduction of energy used in buildings ■ economic advantages for owners and users of buildings ■ direct or indirect reduction in pollutants and CO_2 emissions ■ planning and implementation carried out by a Thermoprofit partner ■ guarantee that energy costs will stay below a defined limit A study of the Technical University of Vienna analysed the economic effects of increased energetic renovation through energy services in the city of Graz. In the next 15 years between 600 and 1250 million Euro of investments could be produced. Up to 700 jobs could be created through this market development. Main target groups of the project are: ➢ Municipality buildings ➢ Public buildings ➢ Residential property ➢ Businesses from trade and industry	Thermoprofit contains the key elements of Third Party Financing and Energy Performance Contracting, while being organised in a more flexible way focused less on advance financing by the contractor. It also includes models in which the ESCO optimises energy use on the basis of either an energy saving guarantee or a performance-based fee, while the owner of the building remains in charge of the financing itself. The market development is to be reached via four strategies: 1. Creation of a Thermoprofit network 2. Thermoprofit information and marketing initiative 3. Support for Thermoprofit projects, provided by the Graz Energy Agency 4. Assistance in establishing framework conditions for the smooth implementation of Thermoprofit projects The Thermoprofit Network consists of suppliers of total service packages – the so-called Thermoprofit partners. Primarily, Thermoprofit partners are prime contractors. They co-operate with regional enterprises in the execution of projects and thus contribute to stimulating the economy of the respective region. Their special characteristic is that they offer a Thermoprofit guarantee for undisturbed operation, the observance of comfort parameters, guaranteed energy and cost savings, etc. In providing the energy services required, they do not only take on comprehensive tasks on behalf of the user of the building, but also technical and economic risks.	The network was presented to ESCOs in June 1999. The first certification of companies took place in October 1999 and meanwhile 5 big companies are certified as Thermoprofit partners. Further companies show interest to participate. 8 projects are realised or in preparation: ➢ Energy Management of the Jägergrund and Webling school/Graz Walfersam, Kapfenberg: Energetic optimisation of a coliseum and school ➢ Solar installation for hot water in the school Oeversee ➢ Technical maintenance and service of the town-hall in the city of Graz ➢ Installation and maintenance of the heating and solar system in a dwelling-house (77 apartments) in Graz. ➢ Redevelopment and energetic optimisation of 3 schools in Weiz/Styria ➢ Restoration and energetic optimisation of the school Thörl/Styria ➢ Redevelopment of an indoor bath in Leoben/Styria

Model	Relates to	Model issues
Market Barrier	As part of this information campaign, property owners and users are introduced to the way this model works and to the advantages it offers. Completed reference projects are documented and introduced. In order to support property owners in the preparation of projects, they are provided with useful contacts and information and offered concrete assistance in project development.	Information and Transaction Costs
R&D Deploy-ment		Existing technology
Market Transfor-mation	Thermoprofit constitutes a **quality label** linked to a series of standards to be met by enterprises and their projects. The owners and/or users of buildings are guaranteed reliable high-quality offers. The Thermoprofit label may be used exclusively by Thermoprofit partners who will be evaluated by the Graz Energy Agency in regular intervals with regard to their observance of Thermoprofit standards. This will lead to an increase in confidence by the building owners. The initiation of Thermoprofit projects also requires a lot of information work because it is necessary to eliminate the distrust of clients. Customers who already have bad experiences with third party financing because of low quality offers are very sceptical to start new projects.	Early Majorities uptake of good technology

ACTOR RELATIONS:

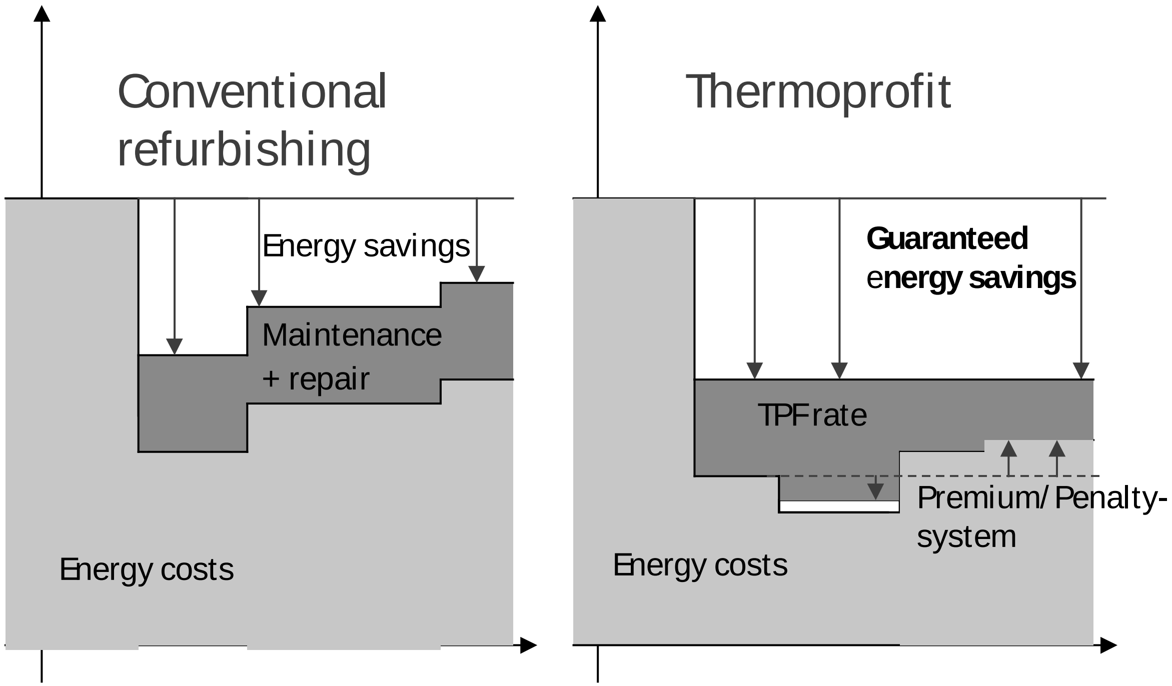
The development and dissemination of Thermoprofit is supported considerably by various public agencies, in particular by the city of Graz and the Styrian Chamber of Commerce (Wirtschaftskammer Steiermark). A close co-operation takes place with a number of further partners at institutional and expert level. These are the particular goals of this networking:

1. Reaching high quality in Thermoprofit offers and working with competent enterprises
2. Providing rational and cost-effective project handling
3. Successfully implementing a number of Thermoprofit projects
4. Finding qualified enterprises as partners for Thermoprofit

The Graz Energy Agency co-ordinates the network and acts as a turntable for Thermoprofit issues. It is responsible for the project management and in charge of implementing and supporting the required networking and marketing activities. The Graz Energy Agency is also in charge of evaluation and of preparing the certification of enterprises as Thermoprofit partners. This certification takes place every two years. In order for an enterprise to be certified as a Thermoprofit partner, or to keep its certification, it must fulfil certain conditions and observe certain quality standards in project handling. In the end, an independent committee decides whether the enterprise in question is admitted to the network and certified as a Thermoprofit partner. Certified enterprises are entitled to use the quality label.

Concerning favourable framework conditions the Graz Energy Agency is pointing out barriers for energy services in laws, decrees and subsidy guidelines, mainly on the regional government level, and making suggestions for improvements. In this area the agency is co-operating closely with politics and the authorities on the regional and on the municipal level. Within the context of realisation of a project the Graz Energy Agency offers the building owner to carry out the project controlling.

All guaranteed services like annual reduction of energy costs, quality of services and products, maintenance of comfort, realisation of investments to a certain amount, etc. are fixed by a contract. A cost-benefit analysis is performed before the implementation. The financing model is worked out in detail: the realisation of the project with Thermoprofit is compared with a conventional refurbishing TPF-model (see figure below).


Conventional refurbishing
Energy savings
Maintenance + repair
Energy costs
Thermoprofit
Guaranteed energy savings
TPF rate
Premium/ Penalty-system
Energy costs

Characteristics of deployment cases

CS 3

Project	Technology	Policy Mechanisms	Results/remarks
The **Renewable Energy Deployment Initiative** (REDI), Canada Launched on April 1, 1998 as a 3-year programme that has been extended for 3 more years until March 31, 2004.	REDI is aimed at stimulating demand for reliable, cost-effective renewable energy systems for space and water heating and cooling, with the primary goal of reducing greenhouse gas emissions. Four types of systems are supported under the program: solar ventilation air heating systems, solar hot water systems, high-efficiency/low-emissions biomass combustion systems, and ground-source heat pumps. REDI focuses primarily on buildings in the industrial, commercial and institutional sectors. All four types of systems supported under REDI are considered technologically reliable and have been used successfully in Canada and around the world. Furthermore, these systems are considered cost-effective on a life-cycle basis in several important energy markets in Canada. REDI is consistent with NRCan's corporate vision, which sees Canada becoming a world leader in applying sustainable development principles to all aspects of natural resources development.	Two policy mechanisms are used to achieve the objectives: 1. **targeted market development initiatives** as part of an overall market development strategy for a given renewable energy system and market that typically involves several steps: <u>Market Assessment</u> <u>Strategy Development</u> –Market barriers are identified and analysed (these can pertain to the manufacturers and their supply chain or to the demand side of the equation). An intervention strategy identifying concrete actions and expected results. <u>Marketing Research</u> – Marketing campaigns are often a key component, identify key communications messages and the most efficient media to deliver them. <u>Partnership Development</u> <u>Implementation</u> –often over a period of several years. 2. **financial incentives** to eligible end-users for purchasing and installing qualifying renewable energy systems. Financial incentives are used for three reasons: • An incentive can encourage a potential customer to gain experience with a product (especially a new product entering the market). • Financial incentives can help the industry achieve a sufficient number of high-quality installations to demonstrate that the renewable energy system is reliable, cost-effective and environmentally friendly. • An incentive artificially decreases the price of systems and increases demand for the system. This increased demand, should allow the industry to achieve economies of scale. Eventually, this should lead to price reductions that offset the phase-out of the financial incentive. REDI incentives are provided in two ways: **a) general Incentive** is available to a list of qualifying recipients for eligible systems (25 percent of the cost of purchasing and installing a qualifying system to max. $80 000 per installation. Ground-source heat pumps are not eligible for this, industry had requested focus on marketing activities) **b) pilot projects** are undertaken in specific markets not addressed by the general incentive. (Initially focussed on small-scale pilots for domestic solar hot water systems.)	REDI was introduced as a three-year, $12-million program (all figures in Canadian dollars). In the fall of 1996 consultations took place to examine options for improving the treatment of energy efficiency investments and investments providing heating and cooling from renewable energy sources. With respect to renewable energy investments, participants identified a range of impediments and suggested options to overcome them. As a result of these consultations, the Minister of Finance announced in the 1997 federal budget that funding of $60 million ($20 million per year for three years, beginning 1998) also incl. Energy Efficiency Programme. Advertising the incentive under NRCan's name in recognised business and engineering magazines may have had a bigger impact with customers than the incentive itself. Architects and engineers have also been targeted at trade shows and training sessions. Nevertheless, the REDI evaluation report noted that a large percentage of architects, engineers, builders and other target groups remain unaware of the program or of options for using renewable energy. Given that three years is a short time frame for achieving major impacts on the marketplace, REDI should be considered a "work-in-progress."

Model	Relates to	Model issues
Market Barrier	• Prospective customers have limited knowledge about, and experience with, renewable energy systems. Preference is usually given to well-established, off-the-shelf space and water heating/cooling solutions that are perceived to be risk-free and affordable. • Some renewable energy systems have higher purchase and installation costs compared to conventional technologies. Building owners in Canada are generally averse to increasing construction budgets unless payback periods are short. There is little incentive to minimize life-cycle costs. • Heating and cooling constitute a relatively small portion of overall building costs in Canada. Owners tend to focus instead on managing costs that are core to their business, such as labour, inventory and key input costs. Unless payback periods are extremely short, there may be limited interest in reducing space and water heating/cooling costs. • Environmental benefits arising from renewable energy systems are usually of no direct value to the building owner. Thus, environmental considerations often have limited impact on the decision-making process, except when the decision makers are willing to take into account non-monetary values. • The long period of low energy prices in Canada created a climate of comfort with end-users, where little value is placed on moving away from conventional fuels to protect against future price increases.	• Information • Risk • Market Organisation • Price distortion
R&D Deploy-ment	Negative experiences with earlier renewable energy technologies may have tarnished the reputation of certain systems. For example, system reliability issues plagued some first generation technologies introduced in the late 1970s and early 1980s. In other cases, the promised financial savings did not materialize due to the drop in oil and gas prices in the mid-1980s.	Systems performance improvement
Market Transfor-mation	Electric and gas utilities are also recognized as potential partners that could play a significant role in the deployment of emerging renewable energy systems, since these utilities have well- established relationships and high levels of credibility with energy end-users. To support these new lines of business, utilities often offer leasing or financing services, which could facilitate renewable energy projects with higher initial capital costs. Efforts are under way to secure these utilities as partners in the delivery of REDI.	Confidence in good products for majority market (priority early)

ACTOR RELATIONS:
Participants in the program include both representatives from the renewable energy industry who supply heating and cooling systems and their customers. Customers include three distinct groups involved in the procurement decision:

- engineers, architects and energy service companies (who usually specify or recommend the type of systems to be used);
- building contractors and construction trades (who install the systems); and,
- building managers and owners (who make the final procurement decision).

NRCan's *Renewable Energy Strategy* identified the supply industry – generally defined to include manufacturers, distributors and installers – as the main stakeholder to deploy renewable energy systems.

Associations consult members on the design and implementation of REDI and provide feedback to NRCan. Associations are also invited to participate in the drafting of work statements for market assessment and development studies, the selection of contractors (using the government open-bidding process) and the review of study results. NRCan also engages industry associations in implementing the recommendations arising from market assessment and development studies, providing financial support for this and other work through contribution agreements.

REDI officials also work closely with another NRCan initiative, the Renewable Energy in Remote Communities Program, which helps off-grid communities make sound energy supply decisions. Some 300 Canadian communities, mostly in remote northern parts of the country, are not connected to the main North American electricity grid and face high energy costs. These communities have been identified as a promising niche market for on-site renewable energy solutions.

<u>**Characteristics of deployment cases**</u> **CS 4**

Project	**Technology**	**Policy Mechanisms**	**Results/Remarks**
Energy Labelling in Denmark Developed in the context of a long history of energy auditing activities, including the Heat Consultant Scheme which was in power from 1982 – 1996. The development of the energy labelling was based on a need to improve and modernise this scheme.	In the Act to Promote Energy and Water Savings in Buildings (1996) the yearly energy savings and consequences for environment each year were expected to be: • 4 - 6 PJ Reduction of Heating in 2005 • 300 – 600 GWh Electricity saved in 2005 • 5 – 10 million m^3 Water saved in 2005 • 0.6 – 0.8 million tons of CO_2 pr. year in 2005 • 2 – 3 % reduction of total Heating and Electricity Consumption in the included sectors The yearly energy saving obtained by the scheme will be increasing year by year because new buildings will be labelled every year. Nearly half of these reductions are expected to come for the energy labelling in small buildings.	The scheme is mandatory and the major target is to give information to the buyers on the energy consumption and the possibilities to save energy and water. The **general rules** for the scheme are given in the Act to Promote Energy and Water Savings in Buildings from June 1996 and the two Executive Orders on Energy Labelling etc. The specific rules for the energy audit, the calculation and the proposals etc. are given in the Energy **Consultants Handbook** which is a quality manual for the energy labelling of small buildings. For the **education of the consultants** a special training course is used. The consultants have to follow a yearly additional training course on 1 day and at least four times a year the consultants receive a newsletter telling about new rules, clarifications, FAQ and general information of the development of the scheme. The **quality of the labelling** is inspected in a special quality control system including new labelling of some of the buildings chosen by a random selection, visual control of some of the labelling forms, new calculation of the consumption etc. Consultants who don't meet the quality of the labelling will lose their registration. All the costs for the energy labelling, the energy audits and for the administration of the scheme is paid by the consumers. People selling their house have to pay the consulting engineer or architect for the energy labelling, including the energy audit and the necessary calculations. The typical price for the labelling of a one-family house is 2.000 – 3.500 DKK or 300 – 500 EURO. The consultant pays an administration fee of 100 DKK or 12.5 EURO for each labelling for administration costs and a yearly fee for being registered as a consultant. The total yearly costs for the administration of the scheme paid by the consumers are 5 – 6 million DKK or about 750.000 EURO. All the costs for developing the scheme were paid by Danish Energy Agency as a part of the national budget.	Until now the known results of the energy labelling in small buildings are: • 45 - 50,000 labelling each year • nearly 70 % of all one family houses are labelled when they are sold • in all more than 160.000 buildings or more than 10 % of all one-family houses in Denmark has got an energy label in the first 3½ years of the scheme • in 1999 energy savings for more than 1 billion DKK or 130 mill. EURO was identified • the result of implementing all the possible savings would be nearly 150 mill. DKK or 20 mill EURO lower annual energy bills for the consumers • on average the one family houses could lower their energy costs with about 20 % • 26 % of the owners of labelled houses tell that they have implemented energy savings shortly after buying the house and an additional 22 % tell that they are planning to do investments from the plan in the near future

Model	**Relates to**	**Model issues**
Market Barrier	The information has to be drawn up on a standardised form and the information can be separated in three different parts with a different function.	• Information • Market

	The Energy Label is one page and it includes a standardised energy rating or labelling of the building containing information about the energy and water consumption and the CO_2 emission compared to other buildings with a similar use. The aim of the energy label is to make the consumers more aware of the energy consumption when buying real estate because the energy costs will be a large part of the future costs. *The energy plan* for the building including proposals for profitable saving possibilities for all types of energy and water use in the building and shall include an estimate of the necessary investments and annual savings of the proposals. The plan also gives information on the estimated technical lifetime of the proposals. The aim of the plan is to promote energy savings in the building and to give the new owner possibility to select the most interesting savings. *Information as documentation* of the labelling and the energy plan. The documentation contains information on the present state of the building, the heating system, the use of energy under the present owner, information on the expected use of the building and typical conditions such as price of energy, heating, size of household etc. The aim of the documented information is to give credibility to the labelling and to the plan and to give further information on the present building condition which are important for the buyer.	Organisation
R&D Deployment	NA	NA
Market Transfor-mation	The energy labelling is important because it is a way to achieve energy savings in existing buildings. Existing buildings built before high requirements for insulation were implemented. These buildings can not be addressed by traditional initiatives such as Buildings Codes or Improved Building Standards and the potential for energy savings in existing buildings are huge. The energy labelling scheme is a very large source of information on the present building stock in Denmark, because data from more than 40.000 one family houses are reported every year. This information can be used in monitoring and evaluation of other initiatives and can be used to identify possible savings and measures such as general information etc.	• Stock • All kind of actors

ACTOR RELATIONS:

The person who sells a house has to order the energy labelling and has to pay for the labelling and sometime gets a negative impact of the energy labelling. If the labelling results in a low rating of the building and the energy plan includes many proposals the energy labelling can reduce the price of the building.
It is difficult to let the buyer, who has the major interest in the energy labelling, pay for the energy labelling because often more buyers are in competition and they would either have to make a common agreement or they have to make several energy labels of the same house.

Many real estate salesmen feel that the energy labelling gives additional work to selling a house and in some cases the labelling even has to be paid by the salesmen out of the total fee for selling the house.
It is a problem for the labelling of houses that two of the important shareholders who plays an very important role in the ordering of the labelling in some cases has a very small or even a negative value of the energy labelling.

To overcome this problem there is a special rule giving, the buyer has the right to have the energy rating and an energy plan drawn up at the expense of the seller if this takes place within a reasonable space of time. This can only be used if the buyer, who is not be informed about the buildings energy labelling and energy plan before agreement to sell has been reached and the owner, on demand, has not handed over the energy rating and energy plan. The aim of this rule is of course to encourage the sellers to make the labelling before the sale, since they will have to pay for the label anyway. More sanctions or subsidy combined to the labelling would be useful in the aim to get the labelling more used and to get more energy savings from the scheme.

Characteristics of deployment cases **CS 5**

Project	Technology	Policy Mechanisms	Results/Remarks
Diesel Engines For Combined Cycle Power Generation, Finland	Product development process aiming at the realisation of a "real power plant engine". The intention is to deal with the development of an engine especially adapted to be used as prime mover in large single cycle as well as in combined cycle power plants with electrical output up to 300 MW. The program was initiated in 1995 and has reached the demonstration and verification phase. The main objectives of the program are: ❑ to create a diesel engine concept – the HOT COMBUSTION concept - specially adapted to the conditions prevailing in power plants in general and in combined cycle diesel power plants in particular ❑ to create a diesel engine – the REAL POWER PLANT DIESEL ENGINE – which is a competitive alternative to the diesel engines' main competitors i.e. the gas turbines as prime movers in both single cycle and combined cycle power plants ❑ to verify the validity of the engine concept as well as the performance of the real power plant engine in a demonstration power plant	The program has been divided into four sub-programs: 1. Evaluation of the feasibility of the novel engine concept, i.e. the HOT COMBUSTION concept 2. Verification of the novel engine concept by means of "small scale tests" in engine laboratories 3. Design and realisation of THE REAL POWER PLANT DIESEL ENGINE 4. Erection and operation of a 38 MW diesel combined cycle demonstration power plant The Technology Development Centre of Finland, TEKES, has so far funded the development and the evaluation of the feasibility of the HOT COMBUSTION concept as well as the development of THE REAL POWER PLANT DIESEL ENGINE The European Commission has via its Thermie A program contributed to the erection of the demonstration power plant. The same activity has been funded by the Ministry of Trade and Industry of Finland. The company, responsible for building and operation of the model power plant, has been awarded tax reductions by the Ministry of Finance of Finland. These are applicable to the fuel that is used for district heat production. In this case, this market has been secured by inviting the local and regional distributors and producers of electricity and district heating into a shared ownership. Wärtsilä, the main actor of the deployment program, owns 49 % of the Wasa Pilot Power Plant Ltd, i.e. the company that was founded for the erection and operation of the demonstration power plant. The remaining 51 % are equally distributed between ABB Power, Vaasan Sähkö OyAb and Etelä-Pohjanmaan Voima Oy	There are good reasons to expect that the final results will be very satisfactory: ➢ the program has resulted in a THE REAL POWER PLANT DIESEL ENGINE " that, in spite of its impressive dimensions, is fully transportable in most situations ➢ plant efficiencies widely exceeding 50% have been reached with the model power plant of 38 MW ➢ both the THE REAL POWER PLANT DIESEL ENGINE " and the model power plant have attracted a great interest among the potential end users. Up to date more than 9000 guests and among them more than 4500 investors and potential customers have paid a visit to the demonstration power plant.

Model	Relates to	Model issues
Market Barrier	In a diesel engine the waste heat leaves the engine with exhaust gas and coolant flow as well as via convection and radiation from the surfaces of the engines. Unfortunately, the total amount of waste heat carried by the coolant is unproportionally high. In combination with the fact that the exhaust gas temperatures of a modern diesel engine seldom exceed 350°C, this makes it, if not technically complicated, at least less cost effective to recover a competitive amount of heat out of the waste heat flow for generation of secondary useful power, e.g. in a steam circuit. The adaptation of a diesel engine to the conditions of a power plant must therefore primarily be directed to refining and/or re-distributing of the diesel engine waste heat flow.	Technology specific
R&D Deploy-ment	The needs of a special, power-plant-adapted diesel engine with high unit/cylinder output have been identified by those parts of the Wärtsilä organisation that are in direct daily contact with customers and end users.	Anticipated performance.
Market Transfor-mation	Not clearly stated	Demonstration for innovators

ACTOR RELATIONS:
Public institutions, national research institutes, component suppliers and end users are represented among the actors that have contributed to the implementation of the technology deployment program THE REAL POWER PLANT DIESEL ENGINE besides **the main actor, i.e. Wärtsilä.**

Among the **public institutions the** following can be mentioned:

- the European Union, Directorate-General XVII, Energy has participated in the financing of the presentation/demonstration power plant
  the Ministry of Trade and Industry of Finland has likewise participated in the financing of the presentation/demonstration power plan
- the Ministry of Finance of Finland has contributed to the coverage of operational costs of the demonstration power plant by awarding the owner of the plant tax reduction for fuel used for district heat production
- TEKES, the Technology Development Centre of Finland, has participated in the financing of the development work of both the HOT COMBUSTION concept and "THE REAL POWER PLANT DIESEL ENGINE"

Research institutions:

- VTT Energy, which belongs to the Technical Research Centre of Finland, has contributed to the realisation of the program both with theoretical evaluation of the HOT COMBUSTION concept and the initial testing ("small scale tests") of an engine built according to the this concept
- Helsinki University of Technology has, within the framework of a parallel project, developed and carried out engine tests with components designed for and adopted to the requirements prevailing in an HOT COMBUSTION engine

Among the **industrial enterprises** participating in the technology deployment program the following should be mentioned:

- Wärtsilä Corporation, the main actor in the development of the HOT COMBUSTION concept and THE REAL POWER PLANT DIESEL ENGINE. The company has, in addition to this, participated in the building of the demonstration plant and is today one of the owners of this plant.
- ABB Power, today a part of the Alstom Power organisation, that has delivered equipment to the demonstration power plant and also become a partner-owner.
- a big number of engine and power plant component and equipment suppliers, including more than 50 different companies, that can be classified as SME's. These companies have assisted in the program with, among others, their special know-how about new technologies that have been introduced when developing the HOT COMBUSTION concept

Two companies, which in this context belong to **"users"** and which have contributed in a significant way to the realisation of the program, are:

- Vaasan Sähkö Oy/AB, a local electricity distribution company and also one of the owners of the demonstration power plant
- Etelä-Pohjanmaan Voima Oy, a regional power producer and also one of the owners of the demonstration power plant

Project	Technology	Policy Mechanisms	Results/Remarks
Solar optimised buildings, '*SolarBau*'. Energy efficiency and solar energy use in the commercial building sector. Initiated by the Federal Ministry of Education and Research (BMBF), Germany, in 1995 and since 1998 carried out by the Federal Ministry of Economy and Technology (BMWi).	Demonstrate a series of pilot projects with a total primary energy demand for heating, cooling and lighting purposes below 100 kWh/(m^2a) including a space heating demand of less than 40 kWh/(m^2a). This target will be achieved by integrated concepts based on the interplay between solar passive and active approaches, advanced HVAC techniques and innovative thermal insulation measures. The program consists of various parts, comprising the development of components and planning tools, the demonstration of up to 25 pilot buildings and an accompanying evaluation and information program called SolarBau: MONITOR. SolarBau's concept is based on a sophisticated analysis of specifications and requirements to be met by non residential buildings and determining their heat and electricity consumption. An experts group was set up to develop and design SolarBau's basic concept in close co-operation with the responsible ministries. The group consisted of five representatives from: - university research - private research - architects and engineers - ministry and project management organisation The focus on office buildings; implied strategies are mostly based on passive cooling and advanced daylighting measures. Both are being addressed in the IEA Implementing Agreements 'Energy Conservation in Buildings and Community Systems' and 'Solar Heating and Cooling'.	SolarBau is part of the 4 th governmental funding program for energy research and development, therefore the R&D activities are supported according to usual funding conditions. In the demonstration part, funding is only provided for the design of prototype buildings and for monitoring activities after construction. Complementary development activities, aiming at the production of new innovative components are also supported according to R&D framework conditions. Since no subsidies are provided for investments, it is ensured that all design solutions are realised under normal economic boundary conditions.	First results show that the anticipated limits can be met without significant additional costs. However the program has not yet been finished and an advanced standard for energy consumption in commercial buildings is going to be established. The positive public response, which has led to first emulations, confirms the program's objectives. As a consequence, in future projects it will not be necessary to fund the construction phases in the same way because the standards and methods of SolarBau are well accepted. The present results, half-way through SolarBau's project period, exceed expectations by far and promise significantly reduced energy consumption of commercial buildings down to about one fifth of the present average value.

Model	Relates to	Model issues
Market Barrier	It does not suffice to know how to construct such buildings. They have to be built, critically compared with conventional buildings, well-documented, the experiences made-use of in planning and building practices and, last but not least, disseminated in training and further-education programs for planners and architects.	Risk and market Organisation
R&D Deploy-ment	The comparison of investment costs, shows that SolarBau buildings are within the range of the German reference costs for office buildings of medium to high standard based on mean building costs per m^2 usable floor area for given building types in Germany. The results so far from the SolarBau projects demonstrate that special features of advanced energy saving concepts do not necessarily have to result in increased building costs.	Systems technology (combinations of known components)
Market Transfor-mation	Customers/users are not identified except the building designers for the demonstration projects. However it is mentioned (above) that costs are compared to “medium and high standard”.	New solutions for Innovators and maybe Early Adopters

ACTOR RELATIONS:

Federal Ministries (BMBF, BMWi) Project Management Organisation (BEO)	funding and co-ordination
universities Fraunhofer Gesellschaft private institute	theoretical background development monitoring and evaluation
industry	development of new materials and systems production of innovative components market introduction
architects and engineers	construction of demonstration buildings monitoring and validation
<u>SolarBau: MONITOR</u> researchers and developers architects and engineers	communication documentation analysis training

Project	Technology	Policy Mechanisms	Results/remarks
Wind power for grid connection "250 MW wind“-programme, Germany. Started in 1989, the closing date is scheduled for 2006. (Initially the "100 MW Wind"-programme was because of the great demand, and the reunification of Germany, the funding programme expanded to a total of 250 MW in 1991.)	The figure refers to the standard power from wind turbines at a wind speed of 10 m/s. At the end of 1996, when the target total power of 250 MW had been reached, the contracting phase of the project was completed. The present total support capacity is in fact about 350 MW since the rated power given by manufacturer usually corresponds to max. power at higher wind-speeds. This capacity has been attained with a total of about 1,500 wind turbines included in the programme. The Federal Ministry for Research and Technology advertised for bids on June 6th, 1989. BMBF increased the capacity from 100 to 250 MW in February 1991. Over the years, several modifications were made to adapt to changes in the relevant legislation, e. g. the Electricity Feed Law (EFL)[1]. Latest amendment in February 1994. The deadline for bids was December 1995 and the last turbine started operation in 1998. The programme can be seen as one module among many measures with the goals to • conserve limited resources • improve the security of the German energy supply • protect the environment and the climate • increase the share of electricity generation from renewable energy sources in the national energy balance • strengthen the position of the German energy technology industry in international competition.	A broad experimental programme which would supplement the existing demonstration programmes of the EU, the energy research and some federal states. The funding procedure was based on a combination of a broad and long term R&D-programme for new wind turbine installations, in order to solve the remaining problems concerning material fatigue, subsystem interactions etc., together with strategies aimed at bringing wind technology onto the market. The tactical implementation concepts were a combination: • subsidies for operators (instead of manufacturers), • support for energy prod. (instead of installed cap.) • an obligation of the operators to report continually on operating results and to collaborate in the evaluation programme, • motivation for a continuous participation in the complete evaluation process (10 years) by making the cash flow dependent on participation, • general acceptance of the accumulation of different promotion sources such as additional state investment subsidies, • admittance of access of operators to special loans with reduced rates. [2] The financial support for the Programme came from the Federal research budget. The actual subsidy for operators in the Programme is DEM 0.06 or 0.08 per kilowatt-hour, depending on whether the electricity is fed into the grid or is being used by the owner of the wind turbines himself. The grants are limited to a maximum of 25 % of the turbine costs. Alternatively non-commercial operators had the option to choose an investment subsidy limited to a maximum of 90,000 DEM. The support of the Programme is granted in addition to the tariffs paid by the utilities under the EFL, (1991-2000, appr 0.17 DEM/kWh), or the Renewable Energy Law (since April 2000).	Allocation ~320 million DEM from the Fed. Gov. before 2006 (not incl. the measurement progr. 50 MDEM). The total specific investment costs of wind turbines were lowered to ~1,700 DEM/kW the year 2000. The specific electricity generation from wind has increased to an annual mean value of about 2000 kWh/kW. Trade of wind turbines has developed independently. The wind power capacity in Germany is >5,000 MW now, and contributes ~10 TWh/y. The availability of the turbines is> 98 %. The EFL in its revised form – the Renewable Energy Law[3]– is a driving force for investors. Wind energy is now almost 2% of the net electricity consumption of Germany. In the state of Schleswig-Holstein, wind energy is ~15% of the electricity demand (aim to reach 25% by 2010). Export of wind turbines from German manufacturers has increased to about 10%. The deployment of wind energy in Germany is also having effect on employment. Today the wind power industry accounts for about 15,000 jobs. With increasing deployment of wind turbines, the awareness of env. effects (land use, noise, effects on landscape) has increased. The acceptance of new projects is inhibited in areas of already high market penetration.

[11] Stromeinspeisungsgesetz, in force from January 1st, 1991 until March 30th,2000

Model	Relates to	Model issues
Market Barrier	Barriers addressed by the programme were the acceptance by the public of an increasing density of wind power installations in certain areas and the identification of possible environmental problems, such as land-use and noise.	Technology specific
R&D Deploy-ment	An outstanding feature of the programme is the accompanying measuring programme with the objective of acquiring and evaluating performance data from all wind turbines supported in the "250 MW Wind"-programme over a ten year period. The Programme is designed to acquire statistically relevant performance data for the practical operation of wind turbines.	Adding to technology stock and learning
Market Transfor-mation	The tactical implementation concepts were a combination of (SEE ABOVE) • subsidies for operators (instead of manufacturers), • support for the energy produced (instead of installed capacity), • an obligation of the operators to report continually on operating results and to collaborate in the evaluation programme, • motivation for a continuous participation in the complete evaluation process (10 years) by making the cash flow dependent on participation, • general acceptance of the accumulation of different promotion sources such as additional state investment subsidies, and • admittance of access of operators to special loans	• Incentivising Early majority • Good and new technology

ACTOR RELATIONS:

The implementation of the "250 MW Wind"-programme and its accompanying "Scientific Measurement and Evaluation Programme" was carried out by three major players, namely:

- The Federal Ministry for Research and Development (BMFT, 1989-1994) and its successors Federal Ministry for Education, Science, Research and Technology (BMBF 1994-1998) and the Federal Ministry of Economics and Technology (BMWi, since 1998),
- The Project Management Organisation BEO from Jülich Research Centre, and
- the Institute for Solar Energy Supply Technology (ISET) in Kassel.

The other relevant players in the programme can be identified as

- investors and turbine operators e. g. private individuals, farmers, communities, commercial companies, utilities.,
- turbine manufacturers.

The experimental programme "100/250 MW Wind" was implemented by the Project Management Organisation BEO (Jülich Research Centre) acting on behalf of the Federal Ministry of Economics and Technology and its predecessors. The "Scientific Measurement and Evaluation Programme" (WMEP)[4] is being carried out by ISET in a contract with the Jülich Research Centre. There is a strong interaction between operators and ISET which acts as an "interface" to the Research Centre Jülich and the Federal Ministry.

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[2] The DtA is a "wholly-owned development agency of the German federal government" that supports environmental protection projects.

[3] (EEG)

Project	Technology	Policy Mechanisms	Results/Remarks
Photovoltaic Power Generation Systems (from R&D to deployment) Implementing Research and Development (R&D) and Deployment Programs of Photovoltaic (PV) Power Generation Systems. Initially started in 1974 as a part of the "Sunshine Project,". It has been under the direction of the "New Sunshine Program (NSS)" since 1993 and continues today as PV systems have arisen as a solution for global environmental issues.	Program's targets and processes are: 1) Overall target The overall target of the Programs is to install PV capacity of 5000MW by 2010. This target was set June 1998, by the Advisory Committee for Energy 2) R&D Program The target of the core R&D project called "Development of Technology for Practical Application of Photovoltaic Power Generation Systems" is to realize PV prime cost of JY140/W (at 100MW production) by the end of FY2000. This target was set in the Master Plan by the Industrial Technology Council, a Minister's advisory committee consisting of representatives from academia, research institutes, mass media and energy-related organizations. Development of: ❑ Technology for Practical Application of Photovoltaic Power Generation Systems ❑ Low-energy Consumption Manufacturing Process for Solar Grade Silicon ❑ Practical Technology for High-efficiency Multicrystalline Silicon Solar Cells ❑ Advanced Manufacturing Technology Photovoltaic Power Generation Systems 3) Deployment Program The target of the Deployment Program is the establishment of a new PV market and demonstration of system endurance. Projects are planned and designed following a formal hearing involving the suppliers such as solar cell manufacturers, housing manufacturers and related organizations.	1) Overall policies i. The Advisory Committee for Energy, a Minister's advisory committee, compiles **"The Long-term Energy Supply/Demand Outlook".** Targets PV installed capacity by the end of 2010 to be 5000 MW. ii. **"The Law Concerning Promotion of the Development and Introduction of Alternative Energy"** sets targets of oil-alternative energy installed capacity, following the revision of the "Long-term Energy Supply/Demand Outlook." iii. **"The Law Concerning Promotion of the Use of New Energy"** was enacted in June 1997. It prescribes the basic policies on new energy use including PV, the guideline on new energy utilization, and the financial support measures for businesses, which use new energy. iv. **"The Guideline for Promotion of Efforts to Prevent Global Warming"** considers PV as an urgent energy supply/demand provision for the 2010 target of CO_2 emissions reduction. 2) R&D Program The R&D program budget is 100% borne by the government (private expenses are exceptional). The government provides official subsidies to NEDO for its expenses, while NEDO conducts and consigns the R&D operations to the private sector and universities. 3) Deployment Program ❑ Field Test Project on Photovoltaic Power Generation Systems for Industrial and other Applications ❑ Subsidy Program for Residential Photovoltaic Power Generation Systems ❑ Local Introduction of New Energy Promotion Project ❑ New Energy Enterprises Support Project In order to support enterprises which use new energies, NEDO subsidizes 33% of its expenses.	Approximately 200MW was installed by the end of FY1999. Especially in the residential market field, over ten thousand units have been installed annually with the help of subsidies. It is not impossible to see that residential PV systems will someday become conventional. The "Residential Photovoltaic Power Generation System Monitoring Program" materialized in FY1994. Since then, PV installed capacity has increased rapidly, and 17 thousand applicants were accepted in FY1999. Some factors of its success are: ❑ economies of scale; private companies increased their production, the PV system price decreased, the market was expanded (JY3.6M/kW approx. in FY1993 to JY0.93M/kW in FY1999) ❑ architecturally-integrated PV modules have been licensed as architectural materials by the Building Standard Law, facilitating sales by housing manufacturers

Model	Relates to	Model issues
Market Barrier	The major barrier to PV diffusion is the high cost. The generation cost of PV systems for residences, the major market, is approximately JY81/kWh, three times as expensive as that of electric power companies at approximately JY24/kWh. In this fiscal year, the number of applicants for this program exceeded the number of prospects. This program will end in FY2002. A sustainable residential PV market without subsidies is the key issue to further deployment.	Cost Market organisation Concentration on technology specific issues
R&D Deploy-ment	The R&D Program, including “Development of Technology for Practical Application of Photovoltaic Power Generation Systems” and others, has been achieving world-leading results. The factors of this success are: ❑ as the government plans and directs the long-term R&D scheme continuously and consistently, the talents from the private sector, universities and national institutes can be gathered to engage in their respective research ❑ a sufficient official budget (largest in the world) covers the R&D projects ❑ projects are evaluated appropriately, and flexibly modified However some drawbacks; ❑ several technologies were adapted to develop one solar cell, which were too advanced or improbable (inadequacy of the technology theme) ❑ some companies and researchers could not maintain their motivation in the long-term scheme (lack of motivation) ❑ Moreover, present technology is applicable to residences (competitive generation cost for residential purchase), but not advanced enough for industries and the electric power business. Therefore, in order to be applied to the electric power business, innovative and low-cost solar cells are to be developed in the future.	A process entirely built on feed-back and on creation of constellations to foster the new applications
Market Transfor-mation	Participation of the average citizen, who has seemed to be quite passive towards energy issues, will be a great force in other new energy projects, too. In addition, cooperation among the government, solar cell manufacturers, housing manufacturers and electric power companies is indispensable in deploying PV systems. Their teamwork is one of the key factors of achievements in Japan.	Consequent working towards a take-off

ACTOR RELATIONS:

The chief director of the Programs is the Ministry of International Trade and Industry (MITI) of Japan, which conducts national energy policy and industrial technology policy. The main actors and their roles for each Program are as follows:

1) R&D Program

The New Sunshine Program Headquarters in the Agency of Industrial Science and Technology is in charge of long-term planning, budget compilation and overall coordination of R&D. R&D affairs are actually conducted by the New Energy and Industrial Technology Development Organization (NEDO), which consigns projects to the private sector and cooperates with universities and research institutes. The private sector has organized the Photovoltaic Power Generation Technology Research Association (PVTEC) to carry out cooperative R&D. The national research institutes conduct basic and applied technology R&D.

2) Deployment Program

The New Energy Policy Division, Coal and New Energy Department of the Agency of Natural Resources and Energy, is in charge of promotional policy, budget compilation and overall coordination of deployment. The New Energy Foundation (NEF) carries out subsidy programs for residences, the major deployment field, while NEDO conducts various model projects and field test programs for industries and local governments. Solar cell manufacturers and housing manufacturers have organized the Japan Photovoltaic Energy Association (JPEA) to carry out public relations and dissemination in cooperation with the government.

(See also technology description)

Project	Technology	Policy Mechanisms	Results/remarks
High Efficiency Heat Recovery for Domestic Ventilation in the Netherlands. Mechanical Ventilation with Heat Recovery (MVHR)	Dwellings represent about 25-30% of all energy used in OECD countries. Energy losses due to ventilation will increase in the near future up to 10% of the total energy use. New innovative energy efficient ventilation technologies could give an important contribution to decrease energy use in the residential sector. To realise the Dutch governments policies on energy use in the built environment the Energy Performance Standard is introduced in 1995. This standard concerns the integral energy-efficiency of buildings, including energy use for heating, DHW, fans, cooling, lighting and humidification. As ventilation and air tight building have a substantial influence it is expected that Mechanical Ventilation with Heat Recovery (MVHR) will play a major role in energy-efficiency concepts for houses, complying with the required Energy Performance Coefficient. Application of MVHR was not only expected to give a contribution in decreasing (mechanical) ventilation losses. It is also a prerequisite for increasing the air tightness of dwellings as MVHR ensures a continuously ventilation. In order to achieve a substantial market penetration as well as a market acceptation a strategy plan was drawn up by Novem for a broad implementation program for MVHR.	**Dissemination** 1. Promotion and information to market parties, (Action 2.1 in table below).Creation of the Foundation for High-Efficiency Ventilation. 2. Expressing costs for ventilation as LCC (Action 3.1) Initial costs are a dominant decision factor for the selection of ventilation systems. However life cycle costs, including operating, energy and maintenance costs have a much bigger influence in the total costs during the lifetime of a building. [5] 3. Fixed prices (action 3.2) One of the objectives in the strategy plans and supporting activities (certification of installers, foundation for high efficiency ventilation) but no progress was made. This objective was not adopted by the supply side of the market. 4. Grants (action 3.3) In 2000 grants are given for high efficiency MVHR in existing dwellings (HFL 400,-- per unit, including 2 DC fans). For new dwellings MVHR is a well-accepted technology to realise the demanded Energy Performance Coefficient. For that reason grants are considered not to be necessary . **Quality Improvement (QI)** QI on process level (action 2.2) Improve and to ensure the total quality of ventilation systems a method is developed (Model quality Assurance – MQA) to realise and guard this total process**.** This is developed for ventilation systems in a publication (ISSO 61) and is used by the Dutch Installers Branch (VNI) for process certification QI on component level (action 2.1) Development and introduction of counter flow heat exchangers Deployment of DC fans **Embedding** Embedding MVHR in building regulations (act. 1.3) MVHR is rewarded in the Dutch Energy Performance Standard Standardised measurements for heat recovery efficiency and total energy performances of heat recovery units	This strategy led to an increase of the market penetration of MVHR from less then 1% in 1995 to 10% in 1999 (8500 units in new built houses). For 2000 a market share is expected of at least 15%. For conventional cross flow heat exchangers the energy efficiency is 65%. For most of the high efficiency MVHR this measured energy efficiency is 90 to 95%. Application of MVHR allows also an increase of air tightness resulting in lower air flows due to infiltration. Energy use of fans is taken into account separately. The default value for DC fans lead to 40% less energy use compared with AC fans. **Indoor air quality** Average CO_2 levels did not exceed the hygienic guideline level of 1800 mg/m^3. **Thermal comfort and noise** Thermal comfort is realised under all weather conditions without the necessity of applying reheaters; Noise levels caused by the ventilation system vary from 20 to 30 dB(A). These levels do not exceed the guideline values for system noise.

[5] Within IEA Annex 27 "Demonstration and Evaluation of Domestic Ventilation Systems a model to establish life cycle costs has been developed.

Model	Relates to	Model issues
Market Barrier	NEOM (now Novem), started a large scale market introduction in the mid-eighties, accompanied by several demonstration projects, monitoring and supporting researches. Despite these efforts the market penetration of MVHR still was less then 1%. In 1993 a market survey took place on the decision making of application of domestic ventilation systems and, particularly, the application of MVHR. In general, the main conclusions of this market survey were: - MVHR has a bad image, due to problems caused by lack of quality. This lack of quality and the absence of a market acceptation were the main barriers for a larger market introduction of MVHR. Lack of quality displays on several aspects: design, execution, quality of components, maintenance etc. - Building regulations and (initial) costs are dominant decision factors for the selection of ventilation systems. In general electricity use for fans can be reduced by 50% using DC fans instead of AC fans. Although the principle of DC technology for fans was known for years application for domestic ventilation was not common because of the extra costs for DC fans. Now the Dutch EPN also takes into account fan energy (and DC fans are rewarded in the calculations) DC fans are introduced for domestic application. All High Efficiency MVHR units have DC fans, not only for minimising of electricity use but also for improved controllability of fans.	❑ Information ❑ Costs (transaction) ❑ Technology specific ❑ Regulation
R&D Deploy-ment	The first prototype laminar counter flow heat exchanger was introduced in 1996 in a configuration with DC fans to minimise the electric support energy for fans. In 1998 the Dutch Ventilation Industry launched the counter flow heat recovery units on the market.	Development of demonstrated technology
Market Transfor-mation	Application of counter flow heat recovery is not only initiated because of the energy benefits. The efficiency of 90% results in a relatively high supply temperature (17^{0}C at outdoor temperature of –10^{0}C). This gives an improvement of the thermal comfort and reheating of the supplied air is not necessary. This also means that low induction inlet grilles can be used. This prevents problems with noise and dust deposit.	❑ Comfort aspects for majorities ❑ New Products

ACTOR RELATIONS:

The main actor for the implementation of high efficiency heat recovery in the Netherlands was Novem. In the eighties Novem (then under the name NEOM) conducted demonstration programmes and several supporting researches. In 1995 Novem initiated a strategy plan for a further market introduction and market acceptation. In 1996 the Foundation for High efficiency ventilation was established, initiated by Novem and the Dutch Ventilation Industry. The objectives and mission of the foundation is to promote a good and healthy indoor environment as well as energy efficiency by the use of balanced ventilation with heat recovery. The foundation tries to achieve this goal by giving independent and objective information, development and stimulation of market introduction of energy efficient ventilation systems.
The benefits of this foundation is that all information about MVHR is streamlined and objective. There is one organisation as counterpart for policymakers, standardisation bodies, other market parties etc. Beside six industrial parties also Novem, the Dutch Installers Branch Organisation (VNI), Gasunie and Intechnium (educational institute for installers) are members of the Foundation.
Since their establishment all major activities for communication, dissemination, quality improvement and product development are co-ordinated by the Foundation for High Efficiency Ventilation. The annual budget is approximately 200 kEuro.

General Actions ⇒ **Barriers ⇓**	**1. Dissemination**	**2. Quality Improvement**	**3. Embedding**
1. Building regulations	1.1 Emphasising role of MVHR in Building reg's	1.2 Stimulation of developments for further limitation of energy use for ventilation: - development of high efficiency heat recovery - deployment of DC	1.3 Review of NEN 5128: 1995 on rewarding heat recovery Linking limiting air tightness with MVHR Release of NEN 5138
2. Bad image and (lack of) acquaintance with MVHR	2.1 Foundation for High Effiency Ventilation (Stichting HR-ventilatie) Release of brochure with MVHR success storiezs Occupants instructions	2.2 QA document ISSO 61: Quality requirements for domestic ventilation systems Certification of installers	
3. Costs	3.1 Costs for ventilation expressed as LCC: task in IEA Annex 27	3.2 Fixed prices	3.3 Grants for MVHR

Table: strategy plan with objectives for a number of identified barriers, distributed in three general actions.

Project	Technology	Policy Mechanisms	Results/Remarks
The PV-Covenant in the Netherlands. *"To direct and guide the initial market introduction of PV-systems in the built environment."* The quantitative target is to realise **7,7 MWp** of cumulative grid connected solar PV in the built environment in the year 2000.	The **Ministry of Economic affairs** (13 MDG/y for 1-3, 20 MDG/y for 4)): 1) **R&D of solar cells**; 2) **R&D of components** for grid-connected application 3) **Product and market development** of autonomous PV systems 4) realisation of **pilot projects** "PV in the built environment" The **Energy Distribution Companies** (EDC) will strive for the realisation of 7,7 MWp cumulative installed grid connected PV power in 2000. The PV companies, **manufacturers of PV** cells and modules will strive to substantially reduce the price of PV systems (based on expected market volumes) The **building industry** will strive to take all necessary actions to realise the 7,7 MWp on roofs and buildings, possibly constructional adjustments, cost savings for roof tiles and supporting 'green financing schemes'. **R&D institutions** (ECN) will support the realisation of the targets for price reduction and reliability by implementation of R&D results and evaluation of realised projects. **Novem** will execute the National Research Program for PV. Furthermore will initiate publicity campaigns with the partners for further PV stimulation and monitor the development.	The **subsidy programme (NOZ PV)** is tuned to the goals of the Covenant and were available for demonstration projects in the built environment, for more experimental projects where new (technical) issues were demonstrated, for market introduction projects and for R&D projects on cells, modules or BOS/components. Also a specified budget is available for autonomous and export projects. The total amount of money of this program directly related to the Covenant is about 35 million Dutch Guilders per year. The ministry also stimulated PV financially by adding PV on the list of environmental measures and equipment were tax paying companies can get **fiscal advantages**. The **Energy Distribution Companies** (EDC's) made some additional **generic subsidies** (average: 3 NLG/Wp), under their Environmental Action Plan ("B-MAP"), which is financed by a small environmental tax all consumers are due to pay. Expected **cost schemes** were formulated based on the expected market volumes per year and cumulative during the Covenant period. These cost schemes served as a reference for the judgement of project proposals submitted for subsidy in the Novem NOZ-PV program. The cost schemes served as reference in the market. Tasks of Novem's NOZ PV program is also the execution of an PR and **information campaign**. Some special brochures and flyers were made specifically for the development and progress of the PV Covenant.	New products have been developed (Sunpower) and forms of co-operation between various partners in order to manage larger building integrated PV projects. The aim of 7.7 MWp and the targeted price development has been realised. (An updated strategy and a new PV Covenant for the years 2001-2007, with the aim to contribute effectively to the realisation of around 250 MWp (cumulative) by the year 2007.)[6] It is not only the actual Covenant which is important, but also that the process of writing and discussing the PV-Covenant and the underlying Introduction plan that stimulates discussion. This is a good way of getting the actual expectations and aims of parties out in the open. Moreover, the PV-Platform constitutes an important network, in which parties can meet and exchange information.

(1) [6] This stated ambition has been changed to: "Because Solar PV is still too expensive for large-scale technology push there will be no follow-up to this covenant. There will be generic support of Solar PV and also R&D aimed at cost reduction."

Model	Relates to	Model issues
Market Barrier	Market volume needed for the required cost reductions. Awareness and commitment for grid connected building integrated PV by the large market players . Opportunities for stakeholder related to the inevitable development of PV in The Netherlands and world wide.	Cost, Technology specific
R&D Deploy-ment	Deliver an effective contribution to the development of PV as sustainable energy source for the large scale application in the Dutch energy supply of the next century. More specific: a. Realisation of the number of PV systems in the built environment is necessary, according to the PV introduction Plan, to build up the needed experience for a sound future integration of grid connected PV systems in the Dutch energy supply. b. A phased development of the installed PV power, according to the *"PV Introduction Plan"* c. To contribute to the improvement of the price performance ratio of grid connected PV systems and to build on the competitiveness of PV as energy source in the Dutch energy supply d. To improve and widen the awareness of PV of industry, institutions and the society, enabling future large scale introduction of PV in The Netherlands, using the common vision of *The PV Introduction Plan*.	Existing solutions were inadequate in terms of design and price
Market Transfor-mation	(The experiences with the present Covenant and the increased goal (parties talk about 250 MWp in 2007!) make it preferable to attract new organisations to join a new PV Covenant).[7] An example is the National Association of Installers (VNI), since (the PV experience of) installers are becoming more and more crucial for large scale market introduction. Other important organisations are associations of various consumer groups such as housing associations and the National Business Association.	The chasm!

ACTOR RELATIONS:

The PV-Covenant was signed in 1997 by 15 parties: ECN, R&S (the later Shell Solar Energy), the Ministry of Economic Affairs, several Energy Utilities (Energy Distribution Companies) and their branch organisation (EnergieNed), several project developers (building industry), and Novem. In the course of 1998 and 1999, 13 more parties co-signed the Covenant, (more utilities, other PV-manufacturers and suppliers, and municipalities). The chairperson of the PV Platform is an independent person, which turned out te bean important binding factor .

Main actors:

- **Novem** is executing the Dutch National PV Programme. Therefore Novem is a ‘spider in the web’ of activities.
- The **Ministry of Economic Affairs** is providing the funds for the execution of the programme and sets the goals for PV introduction.
- The **Energy Distribution Compa**nies (EDC’s) played a leading role initiating PV-projects at the time the Covenant started, due to their position in the energy market. They have investment subsidies available for PV projects. The development of new products and services including ‘green energy’ products have started. Some of the EDC’s have build PV-systems to cover a small part of the needed green electricity by PV power. Furthermore all Dutch EDC’s have agreed on the production of 3,2% Renewable Energy by the year 2000.
- **ECN** played an important role in the development and up scaling of the Dutch Shell Solar production lines for cells and modules.
- The **Building industry (mainly project developers)** evaluated PV-application opportunities in many new housing projects. The large scale new housing programme in The Netherlands (500.000 new houses till 2007) offers good opportunities for (smaller) PV systems.
- **Shell Solar** as cell and module manufacturer increased their production capacity and started initiatives in product development (‘Sunpower’). Most of their initiatives were taken in co-operation with other Covenant partners such as an inverter manufacturer, EDC’s and the building industry. Furthermore Shell Solar and above mentioned and other organisations contributed to the initiatives for large scale projects like the 1 MWp housing project in Amersfoort.
- Due to his former experience (as a politician) and position, the **independent chairman** with his extensive network was able to bind the heterogeneous group of Covenant partners, each with their own interests.

(2) [7] This stated ambition has been changed to: "The experiences with the present Covenant make it desirable to involve other organisations"

Project	Technology	Policy Mechanisms	Results/remarks
Deployment of Renewable Energy in a liberalised energy market by Fiscal Instruments in the Netherlands The Dutch government aims at 2 major goals for 2020: a) 33% improv. of the efficiency (total energy consumption should remain at the 1990 level despite economic growth) b) 10% of all energy used should be from renewable sources	Currently, around 35 PJ (1.2 %) of the energy is from renewable sources. For 2020, the target of 10% renewable energy represents a supply of 380 PJ. Key elements of the Dutch policy for the promotion of renewable energy over the past decade were: – the energy tax on the use of electricity and natural gas – fiscal instruments to lower investment costs – voluntary agreements with the energy sector and industry (based on tradable Greenlabels) – various subsidy schemes to increase the attractiveness of new initiatives. In view of the upcoming, liberalised energy market 2 major instruments will be added in 2001: (i) a fully liberalised market for green electricity with free consumer choice; (ii) a legally based tradable certificate for renewable energy. The lay-out of the Dutch policy for renewable energy, with its focus on the demand side, has a rather unique position within Europe. Firstly, because of its focus on the demand side, and, secondly, because of its emphasis on voluntary action.	The energy tax encourages energy conservation and the use of renewable energy by making fossil energy much more expensive. The reduction in the energy tax and the zero tariff for 'green' electricity, provide a strong incentive to use renewable energy. **Support for Investments** The following schemes are available: a) *Green Funds:* Investors in "green projects" can obtain loans at a lower interest rate (about 1.5 %- point). These Funds are created by savings by private persons, who are exempted from paying income tax on the interest received. b) *Accelerated Depreciation*: The VAMIL scheme offers accelerated depreciation on equipment included in the VAMIL list. c) *Tax Credit*: The technologies on the EIA list may be offset against taxable profit. The combination of Green funds, Vamil and EIA equals a subsidy on the investment of about 25 - 35 %, depending on the profit and fiscal situation of the company. **Electricity from Renewables** The Environmental Taxes Law includes two special provisions on renewable energy: – producers from renewable energy which is delivered to the public grid are eligible for a support payment – consumers who buy "green energy" under a contract with a supplier are exempted from paying the energy tax.[8] **Green labels** (see Actor Relations below) **Green Electricity** Consumers can choose for the green electricity programme of their energy supplier. They pay an additional tariff when they buy "green electricity", but in return are exempted from paying the energy tax.	*Market penetration of renewables* During 4 years, the production of renewable electricity increased from 600 GWh 96 to 1.400 GWh in 2000. In relative terms a large increase, but still well below government targets. *Competitiveness with fossil gener.* support of producers with direct fiscal measures is only sufficient to make them competitive with fossil based generation. The sales price for sources like wind energy is still slightly above current market prices for electricity To achieve market penetration of these sources, additional measures are required. *Market share of green pricing prog* Green Pricing schemes have attracted within a short period of time on average 3.5% of all households. Some active suppliers have succeeded last year in achieving more than 10% of their customer base. In September 2001 the average was 9 % of the households participating The rapid market penetration of green energy suffers from long lead times in project development financial support instruments cannot solve these issues; other policy instruments and actions are required to shorten these lead times.

[8] The following sources qualify as "renewable" according to the energy tax: wind energy, small hydro, biomass, biogas and PV

Model	Relates to	Model issues
Market Barrier	Banks now offer lease constructions on renewable energy equipment where these fiscal measures are incorporated, making financing easy and also available to parties who are not fully able to use these instruments.	❑ Financing ❑ Transaction Costs
R&D Deploy-ment	Having the broadest range of policy instruments does not necessarily mean it creates the most effective approach. For instance, countries as Denmark, Spain and Germany reach faster growing levels of renewables than the Netherlands through their policies of feed-in tariffs[9]. The Netherlands have decided not to use this approach for 2 reasons: – fixed buying rates for grid operators do not fit well within the structure of a liberalised energy market – fixed rates do not provide an incentive for innovation, competition and reduction of production prices of renewable energy.	?? Existing Technologies
Market Transfor-mation	Green electricity tariffs vary between 6 and 7 EURO-ct / kWh Depending on the supplier, green electricity is at about the same price or slightly more expensive as regular electricity (for which the tariff includes the energy tax). On average, green electricity is sold at a premium rate of about 0 – 1 EURO-ct (excl. VAT) above the normal price. The additional tariff is used to pay the producers of renewable electricity about 2.7 EURO-ct, (green certificate in 2001) and the remaining 4 EURO-ct is used for administration, marketing and profit	Innovators and early adopters Good technology is boosted

ACTOR RELATIONS:

actor	Role	
	past decade	future (from 2001)
Ministry of Economic Affairs	develop policies; close voluntary agreements	develop policies; set rules free green energy market; close voluntary agreements
Tax Service	approve tax credits; approve exemption energy tax	approve tax credits; approve exemption energy tax
Energy distribution sector	provide subsidy to producers (upto 1997); buy for voluntary agreement (through Greenlabels from 1998)	retail selling green energy
Issuing Body	did not exist officially	issue certificates; monitor & oversee market
Traders & brokers	no role	buy & sell green energy (mainly wholesale market)
Consumers	pay levy to distributors	buy green energy
Producers	invest on subsidy	invest on market based demand
Novem; Senter	support implementation; provide subsidies	support implementation; provide subsidies

The changes in policy from more or less a supply based support over the past decade to a demand side based approach in the coming years will change the involvement and roles of the main actors. New actors (such as traders and brokers) will step in the field, while producers, retailers and consumers will operate in different settings. New actors

[9] A feed-in tariff is an obliged, fixed (high) tariff for which grid operators have to buy electricity from specific sources, such as renewable energy or combined heat and power production.

and major changes in the role of existing actors are highlighted in the table.

Green Labels: The government has made an agreement with the energy sector in 1996 concerning CO_2 reduction and market introduction of renewable energy, with a specific target for the end of the year 2000 (Environmental Action Plan 2000). Within this agreement the energy distribution companies will have to sell a quantified amount renewable electricity of 1.700 GWhe by the end of year 2000.

To cover the expenditures of the Environmental Action Plans, distributors charge consumers a levy as part of energy tariffs for gas and electricity. The maximum rate allowed by the *Energy Distribution Act* is 2.5%; in practice, environmental levies are lower. Rates are approximately 0.2 EURO-ct per kWh. In total the revenue received for the Environmental Action Plans is around 100 million Euro a year. A significant part of these revenues (approx. 40 million Euro) is used for investing in renewable energy or buying Greenlabels.

To fulfill the target of 1.700 GWh in an economically efficient way, the energy sector introduced in 1998 the Greenlabel system of tradable certificates. Producers receive such a certificate for each unit of 10.000 kWh delivered to the public grid. They can sell the certificate on the market which consists mainly of energy distribution companies. Since the start of the system in 1998, prices for Greenlabels have increased, from around 2.5 EURO-ct / kWh to 3.0 EURO-ct / kWh for recent contracts. The price rise is caused by a shortage of certificates on the market to cover the target of 1.700 GWh.

The mixture of Dutch policy instruments to strengthen the competitiveness of renewables works in two directions: (i) reducing the cost price of producers and (ii) increasing the ability to pay for renewables by end-users. A schematic representation how all instruments work together is given in fig below.

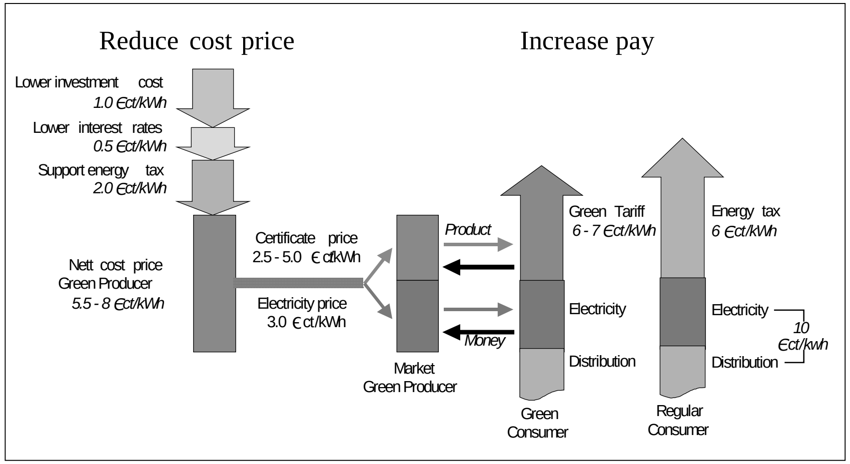

Figure Dutch policy instruments to achieve competing prices for renewable energy. On the supply side, instruments help to lower the cost price of renewables and allow competitive prices for electricity. The tradable certificate a producer receives can be sold on a separate market. Fair prices are possible through the demand side instrument of green tariffs and the energy tax.

Characteristics of deployment cases **CS 12**

Project	Technology	Policy Mechanisms	Results/remarks
Market Transformation on Lighting (Sweden) Technology procurement of high-frequency (HF) electronic ballasts was carried out in 1991 and 1992.	HF electronic ballasts replace the traditional mains-frequency iron-cored choke ballasts in fluorescent lights. HF lighting has many advantages: an improved light quality, better controllability and longer life. Taken together, these mean that lighting fittings designed for use with HF ballasts can result in electricity savings of 20-25%, with a 20% longer life. Savings of up to 70% can be expected if HF lighting systems are combined with other lighting improvements such as new luminaire designs and effective control. **As the installation of HF lighting systems is generally linked to the replacement of the luminaires, NUTEK's incentive agreements have specified a maximum specific installed lighting power of 10 W/square metre, which should be compared with the typical present-day value of 20-25 W/square metre.**	**The purchaser group** guaranteed a direct purchase of 26 000 HF electronic ballasts, with an option on a further 26 000. In comparison with the sales of HF lighting in Sweden prior to 1992, which had amounted to about 5 000 units, this represented a significant marketing opportunity for the manufacturers. The buyers' group was composed of the leading purchasers whose choice of technology strongly affects other purchasers and actors on the market, that is, opinion leaders. **The concurrent demonstration project** "Light Corridors" demonstrated installations with a wide geographic coverage. The most important results from this were the development of programme requirements for lighting power density. These requirements are 10 W/sqm installed in office rooms and 5 W/sqm in corridors. The programme requirements also contain requirements for visual comfort. After some time they became the common standards. The other result from the demonstration project was the development of a testing method for the program requirements, which enabled all manufactures to test their product. Studies on HF-lighting's effects on health and visual comfort were also included. Moreover, this project also developed methods to take lifetime operating and maintenance cost into account. The lighting luminaire manufacturers began to show a considerable commitment to this. The first published collection of examples of high quality, energy-efficient office lighting with luminaires and installation that met the requirements included 34 examples from 15 different manufacturers	**The market for HF lighting systems has grown rapidly and today accounts for about 60-70% of new luminaires. Over 600 000 were sold in 1995, and HF lighting has become standard. Compared to the situation prior to NUTEK's involvement, annual sales of HF lighting systems are now 20 times higher.** As the installation of HF systems is generally associated with the replacement of older lighting systems and can often account for savings of up to 70% in terms of the nominal lighting power per square metre, the upper limit for energy saving, resulting from the lighting fittings themselves, lower lighting power and improved control systems, amounts to over 200 GWh in total. The total cost for the NUTEK's lighting programme is estimated at SEK 37 M (~US$ 5.3 M) NUTEK's cost per saved kWh is however only SEK 0.008 (~US$ 0.0011).

Model	Relates to	Model issues
Market Barrier	The payoff time for HF lighting varies widely, depending on the installed lighting system. It is used mostly in schools, shops, swimming baths, offices, industries and the health care sector. A straight payoff time varies between 3.6 and 12 years. The energy savings justify installation of HF lighting. However, there are many other benefits such as flicker-free lighting, reduction in power demand, the use of occupation sensing control, daylight control etc. A survey shows that installation of HF lighting involves an additional cost of about	Market organisation (biased calculation and

	SEK 200-300 per luminaire. Nevertheless, despite this additional cost, the market for HF lighting systems is growing rapidly, which indicates that a high value is attached to their benefits in the form of lower running costs, reduced energy bills, flicker-free lighting etc.	costs) Transaction costs
R&D Deploy-ment	The price of HF lighting units has fallen by about 25 % between 1992 and 1995, and is expected to fall further. The European market has also grown, particularly in countries having higher electricity prices. This growing foreign market has a beneficial effect on prices.	Known but not spread technology
Market Transfor-mation	The lighting programme started with a technology procurement for electronic high frequency ballast (HF) for fluorescent lighting. Purchases in this market are made by relatively few professional buyers and/or decision makers. The main influential actors on the market are electric consultants and electric installation contractors. The more cautious actors in the early stages of the programme were the lighting luminaire manufacturers.	New products for the early adopters in several functions

ACTOR RELATIONS:
Eventually, the lighting luminaire manufacturers began to show a considerable commitment. A total of 14 manufacturers had their products tested. (NUTEK 1997-10).

All the information produced by the "Light Corridors project" was widely disseminated by targeted informational material and education, as well as by the participants in the project installations. However, these efforts were not enough to get the property owners and administrators to invest in HF-lighting, partly because of the severe recession in the economy in the early 1990s, which had a large effect on the building sector. To tackle this obstacle, NUTEK created incentive agreements whereby the property owners were given a subsidy of SEK 1,5 (~US$ 0.2) per each kWh saved in the first year. This money covered only a part of the incremental cost involved when investing in energy-efficient lighting. In order to get this subsidy, the programme requirements of 10 and 5 W/sqm installed had to be met, which was achievable only when HF-lighting was installed. About one hundred incentive agreements were signed. A survey three years later among those who have had incentive agreements showed that 72% continued to adhere to the programme requirements and thereby the HF-lighting systems.

The most important effects of the incentive agreements and the "Light Corridors " project are however the effects that they have resulted:
- an indirect effect among those involved in the agreements
- an effect among those who have heard about the programme requirements and the agreements
- an effect resulting from electrical consultants and electrical installation contractors who have been in direct contact with the incentive agreement parties or who have themselves been involved in the 'Light Corridors' project. The ripple effect is due to their continuing to recommend new lighting technology while working for other clients

Awareness changes in respect of HF lighting

Target group	1994	1996	Capacity
Installation contractors	39 %	68 %	Install the systems
Electrical consultants	64 %	94 %	Recommend the systems
Purchasers	25 %	71 %	Purchase the systems

Project	Technology	Policy Mechanisms	Results/Remarks
Market Transformation on Heat pumps (Sweden)	Problem: The heat pumps are a fairly well known product in Sweden. Unfortunately, there were some poorly performing pumps in the mid 1980s and these low-quality pumps and peoples' bad experiences with them made the total market for heat pumps collapse. In the beginning of the 1990s there were very few heat pumps for small single family houses with a floor area of 140 sqm, and an electricity need for both heating and hot water in the range of 20 000 kWh. Target: An energy-efficient heatpump (efficiency factor > 3) for a low cost (payback for installation< 7 years and for pump module< 3 y) for the small sizes. The heating energy savings from the heat pump > 8 000 kWh per year. Prices given should include installation. ❑ Refrigerant free from CFC. ❑ Simple monitoring, maintenance and service ❑ Low noise level	A technology procurement scheme was used. Potential purchasers of heat pumps were gathered together with energy experts in a working group to draft the required energy efficient performance parameters together with the other requirements for the heat pumps to be developed. A competition for heat pumps with those characteristics was announced to manufacturers willing to participate. The purchaser group guaranteed the purchase of at least 2 000 units of the winning model. The size of the initial guaranteed purchase was equivalent to about a whole year's sales in Sweden (at that time), which must also have encouraged the manufacturers to participate. The procurement programme was combined with a "package" of activities supporting the market penetration of the winning models. Methods used were subsidy for the first trial batch, positive labelling, campaigns on national, regional and local level, education of professionals as well of consumers by telephone consumer advice, information material and trade exhibitions	Six manufacturers met the performance requirements. The two winning heat pumps were over 30% more efficient and 30% cheaper than heat pumps prior to the competition. The new heat pumps have now been on the market since the end of 1995. In less than a year, sales have exceeded the target of 2 000 units, and appear to have reached 4 000-5 000 units at the end of 1996. One year after conclusion of the programme, the energy savings resulting from it are estimated as amounting to about 30-40 GWh/y. The market is growing and also includes increased exports to the other countries. Some manufacturers have reported an increase of over 100 % in turnover, with even the smallest increase amounting to 30 %. This has resulted in new investment in additional production capacity and a substantial increase in employment within the companies concerned.

Model	Relates to	Model issues
Market Barrier	See "technology" above: "The heat pumps are a fairly well known product in Sweden. Unfortunately, there were some poorly performing pumps in the mid 1980s and these low-quality pumps and peoples' bad experiences with them made the total market for heat pumps collapse." See "Actor relations" below:	❑ Performance-cost characteristic was judged

	" Market characterisation: Fifteen manufacturers have a combined market share of approximately 90% of the market for heat pumps in the small power class suitable for single family homes.	unfavourable ❑ Existing companies where to small or un-focused to take on the challenge
R&D Deploy-ment	Increased sales on the domestic market, and favourable export prospects, have resulted in significant optimism and openness among the manufacturers, thus strongly powering further development. The increased sales volume has meant that economies of scale are beginning to appear in production, thus opening the way to reducing the prices. In addition, economies of distribution and reduced sub-contractor prices have also occurred. Together, the manufacturers estimate that these factors should enable the price of heat pumps to be reduced by about 25 % over the next few years.	Positive reactions to feed-back from the market uptake
Market Transfor-mation	There are many different arrangements for heat pump systems, depending on where the heat source is, how the heat is distributed in the house and how the maximum output power of the heat pump compares with the maximum power demand of the house. A heat pump either saves electricity or replaces the use of other energy carriers by electricity, but the installation was complicated both to design, calculate, purchase and install.	The appeal to other customer groups than innovators and early adopters.

ACTOR RELATIONS:
NUTEK has arranged three technology procurement projects in the heat pump sector. The first two, which were more in the nature of market surveys and smaller demonstration projects, were operated between 1990 and the beginning of 1993, but were not particularly successful in market terms. The third project ran from December 1993 until September 1995. Its objective was to encourage the development of reliable, cheaper and improved heat pumps for detached houses. The purchaser group consisted of a mixture of potential buyers, which also included members from the other Nordic countries. In addition to helping to draft the performance specification, the purchaser group guaranteed purchase of at least 2 000 units of the winning model.

Market characterisation: Fifteen manufacturers have a combined market share of approximately 90% of the market for heat pumps in the small power class suitable for single family homes. The other actors in the market are the utilities, heating, water and sanitary consultants, and installation companies. The purchasers are single-family house owners. Approximately 1/3 of all the single-family houses have direct electric heating, and a total of 250 000 houses were built in the 1970s, and should be renovated soon.

Characteristics of deployment cases **CS 14**

Project	Technology	Policy Mechanisms	Results/remarks
EAES Programme, the Swedish Programme for an Environmentally Adapted Energy System. This programme is primarily directed towards projects in Baltic Region and Eastern Europe (Estonia, Latvia, Lithuania, Poland and Russia).	The main activities are directed towards a reduction of emissions, hazardous to the climate and the environment, from oil or coal-fired energy production plants. Conversion of heat production plants to the use of biofuels: The existing boilers have been equipped with a prefurnace and simple fuel, ash and flue gas systems in order to keep costs down. Reduction of heat losses in district heating systems: The district heating systems have been complemented with water treatment facilities and substations in order to stop corrosion an to improve temperature control in the houses. In some cases pipes have been added or replaced and small, inefficient boiler houses closed down. Labour intensive methods have been used to keep investment costs at a minimum. Energy efficiency in buildings: The windows have been weather-stripped, the attics insulated and the internal heat distribution systems adjusted	The basic strategies for the projects are defined by the following key words/phrases: • Quick implementation, standard solutions • Affordable investments on favourable, but commercial, terms • Reliable, proven and sustainable technology Financing of the projects are provided though loans and a clear combination of cost-efficiency and substantial results in the form of climate and environmental improvements were imperative. Furthermore it was important to be able to offer implementation solutions which were based on well established and sustainable technology and a short implementation time. Thus, there was no incentive for implementing projects that were not profitable within a reasonable time-frame. The main direction was therefore on projects which otherwise were not to be implemented due to barriers such as scarcity of capital, high capital costs, lack of information, inadequate access to economic or technical expertise etc. The guarantees for the loans often were provided and decided upon by municipal authorities, later on when the municipal companies were included in the legislation for private companies in the respective Baltic states the securities usually have the form of registered mortgages or pledge agreements. Only in a very few cases state guarantees have been provided. The loans are mostly provided with a maturity period of 10 years including a grace period of 2 years and at a rate that is low but market-adapted (STIBOR+). The idea was furthermore that the projects to be implemented generally should have a pay-off period of less than 10 years.	The investments for a total of more than 60 projects, represent about SEK 225 million In addition to these costs, NUTEK has provided consultancy support for around SEK 40 million. The direct reductions in hazardous emissions are estimated at: • CO_2 300,000 tonnes/year • SO_2 3,100 tonnes/year • NO_x 170 tonnes/year Operational experience from 1-3 heating seasons show that the fuel costs for heat production in the boilers have been reduced by an average of 40 %. Job opportunities have been created in the extraction and production of biofuels sector . The investments for boiler conversions, per tonne of reduced CO_2 emissions, are around SEK 545, counted over one year only, while the lifetime of a converted boiler is estimated to be 15-20 years. The specific investment cost for other types of projects is highly variable. NUTEK has estimated this cost factor to be equal to the grant part, i.e. SEK 80/tonne CO_2.

Model	Relates to	Model issues
Market Barrier	Low technical and performance standards in existing production plants, distribution and end-use, due to lack of contemporary know-how and inadequate legislative and institutional framework. The often unclear legal status as regards ownership of residential buildings is an obstacle for obtaining financing for energy efficiency measures.	❑ Technology specific capacity

	Another barrier is lack of financial resources for investment in the energy sector and insufficient capabilities in preparation and implementation of new investment projects.	❑ Financing ❑ Regulation inadequate
R&D Deploy-ment	The Baltic Sea Region has been one of the supreme testing grounds for the AIJ process. On the UNFCCC AIJ-list there are 96 projects of which 76 concern Energy Efficiency and Renewable Energy. Out of these 76 there are 52 registered in the Baltic Sea Region. That means that an overwhelming majority of the knowledge that the AIJ projects where supposed to create, in terms of how barriers can be overcome, is first-hand knowledge in this particular region	*Known technology but not known how the AIJ instrument should work*
Market Transfor-mation	The programme was primarily directed towards small and medium-sized projects which until then had generally been considered as administratively too cost-demanding for implementation within programmes introduced by international financing institutions. The direction towards municipalities and municipal heating companies was also an area where the barriers for obtaining financing at reasonable conditions were the greatest.	Good (reliable) technology for the Early Majority

ACTOR RELATIONS:

The loan is given by the Swedish Administration NUTEK/STEM. The loans are mostly provided with a maturity period of 10 years including a grace period of 2 years during which the interest accumulates. The interest rate is set to STIBOR + x% where x is depending on the type of project and the borrower. Security is given by local municipality guarantees or by mortgage.

The project management is done by the local staff, having a local budget and using local labour and material as much as practically possible. Therefore, the local management is one of the main factors to be evaluated before a project is initiated. The local project management is, however, guided through the entire process by NUTEK representatives. One important assignment for the Swedish consultants when a potential project was located, either through direct search activities or through proposals from central authorities, was to get an overview of the real costs and the consumption of fuels, production demand etc.

An important feature of the EAES Programme is the fact that all procurement are made in open competition where Swedish companies, companies in the other Nordic countries as well as local companies in the respective recipient countries can participate provided they can offer equipment and services of the required technical standard.

Through the projects Swedish companies have gained experiences of the working conditions in the respective countries and a fruitful long-standing cooperation have been developed between Swedish and local companies of benefit for both sides. Local companies get increased possibilities to adapt their technological standards to international requirements and thereby improved export possibilities. Swedish companies increase their competitiveness, including on third markets, through such cooperation. It has many times been verified from the participating Swedish companies, which often are small or medium-sized, that the EAES Programme has opened up market possibilities which they otherwise had not been able to exploit due to lack of knowledge and/or that such activities would have been considered too risky. Through the EAES Programme these companies, together with their local partners, have got good reference plants which have rendered them a number of other customers in the respective countries, i.a. forest industries and wood-working industries.

For the plant-owners and local suppliers the projects have provided a possibility to get practical learning-by-doing experience of market economic conditions. It often happens nowadays that the local Baltic company takes the role of main contractor and the Swedish company participates as sub-contractor. Over the years an increasing cooperation between local experts and consultants and Swedish consultants have been developed. Today, very often local consultants are engaged as sub-consultants to the Swedish firms engaged.

Project	Technology	Policy Mechanisms	Results/remarks
Energy Efficiency Best Practice Programme (EEBPP), UK Launched in April 1989, to stimulate energy savings in industry, buildings and the business use of transport energy The overall objective of the EEBPP is to stimulate energy savings worth £800 million/year (1990 prices) by the year 2000[10], equivalent to carbon savings of about 5 million tonnes/year.	The Programme is designed to help organisations cut energy bills by 10-20%, by providing the independent advice and assistance needed to persuade them to use cost-effective technologies and management techniques. It must provide a cost benefit of at least £5/year of energy savings for every £1 of tax payer's money used to fund the Programme. The Programme offers impartial information and advice, targeted to individual queries. Covers management techniques, including training, as well as technologies. Covers all the main industry sectors, the industrial utilities and commercial and fleet transport. It also encompasses cross-sectoral areas like compressed air, combined heat and power (CHP) and management techniques. The buildings component addresses domestic housing, public sector buildings and commercial and industrial premises. This component also encompasses cross-sectoral areas like insulation, lighting, CHP and management techniques. EEBPP aims to help both organisations in major energy using sectors which have agreed commitments under the Negotiated Agreements and others, large and small, without discounts from the Climate Change Levy, to reduce their energy costs and their exposure to the Levy The EEBPP has also been instrumental in promoting the use of CHP, working with the Government to help it achieve its target of 10,000 MWe installed by 2010. The EEBPP has setting up and running the CHP Club, designed to help CHP users exploit the new, positive opportunities to develop CHP schemes.	The core output of the Programme is a portfolio of descriptive or prescriptive publications, which range from detailed technical reports to simple leaflets. The majority of publications fall into four categories: • Energy Consumption Guides that benchmark energy performance in specific sectors of industry and building stock, and show patterns of energy consumption to enable readers to establish their relative energy efficiency performance, with suggestions of ways to improve it; • Good Practice Case Studies and Guides that describe the application of proven energy-saving measures and techniques; • New Practice Case Studies and Reports that detail independent monitoring of the first application of innovative energy efficiency techniques and practices; • Future Practice Profiles and Reports that describe the R&D projects supported by the Programme, with the aim of developing tomorrow's solutions. In addition, information is made available on CD-ROM and in other multimedia formats. Extensive programme of events - workshops, site visits, seminars, conferences, exhibitions, and so on - for every sector that is active. All events are carefully tailored to specific audiences and energy efficiency messages. Many of the events are hosted or co-sponsored by other organisations, such as professional or trade associations, which not only shares the costs, but also encourages outside organisations to endorse the Programme message, thereby enhancing its credibility. The key issue today is to maintain the literature library and deliver savings, with the information, both directly and through third parties.	Savings resulting from the Programme have exceeded expectations. Early positive results lead to that the target for the year 2000 was significantly increased already 1994. By 1999 the Energy Efficiency Best Practice Programme had stimulated energy savings in excess of £650 million/year equivalent to over 4 million tonnes/year of carbon savings. These savings show that the Programme is on line to achieve its overall target of £800 million/year, equivalent to 5 million tonnes/year of carbon savings. Analysis shows that the EEBPP produces savings at a cost of around £20-30/tonne of carbon savings, making it a highly cost-effective programme. A new body, the Carbon Trust., an independent not-for-profit body was launched in April 2001 to take on the management and commercial development of the business (including business transport) elements of the EEBPP, enabling it to deliver tailored information and advice direct to business, carry out on-site energy audits and provide support to fund to development of low carbon technologies.

(1) [10] New target to be defined

Model	Relates to	Model issues
Market Barrier	The EEBPP is a comprehensive technology transfer information dissemination programme that has successfully and cost-effectively addressed the information/market barrier In the UK, industry and buildings account for some two-thirds of total energy consumption, making a substantial contribution to national carbon dioxide emissions. Energy use in these areas could be reduced by some 20-30% using currently available, proven cost-effective energy efficient technologies and management practices. Through promotion of results from successful demonstration projects, the Programme aims to stimulate senior management commitment, and to overcome resistance arising from the perceived risk of investment in new technology.	Transaction costs Risk perception
R&D Deploy-ment	Offers support for research and development of new energy efficient technologies and techniques, and uses the considerable management and technical skills within the Programme to identify and address gaps in knowledge.	Undefined but primarily existing technology
Market Transfor-mation	The EEBPP sets out to address the gap between what is currently achieved and what could be achieved with best practice, by promoting technology and management practices. Training initiatives aim to involve all the workforce, overcoming the human barrier to improving energy efficiency, mainly resulting from a fear of change.	Majority addressed with good technology

ACTOR RELATIONS:
Since 1 April 2001, EEBPP has come under the Carbon Trust, operating it on behalf of DEFRA. In the short term, the industrial component (including commercial and fleet transport) is managed by ETSU, part of AEA Technology plc); the buildings component is managed by BRECSU (part of BRE Ltd) who act in Agency roles. Where there is a potential overlap in areas of responsibility, ETSU and BRECSU consciously work together to co-ordinate their activities, sharing knowledge to benefit the Programme. While recognising the need to work in different ways appropriate to the diverse energy use sectors, constant liaison and comparison of Programme management methodologies ensures maximum efficiency of the EEBPP.

Both contractors adopt the sector approach, with sector managers responsible for particular areas, such as chemicals, non-ferrous metals, housing and schools. On the technology side, sector managers work with equipment manufacturers and users to generate, collate and disseminate authoritative, information to relevant parties. Technical projects, such as New Practice and Good Practice Case Studies, are monitored independently by contractors appointed by ETSU and BRECSU. With non-technology areas, such as management techniques, it is important to involve everyone in the workforce, so sector managers work with, for example, the Chartered Institute of Management and trades unions. Again, any results are verified independently by appointed contractors. The close working relationships with other relevant organisations are a cornerstone of the Programme's success.

In summer 2001, acting through the Lead Subcontractor for EEBPP, Quantum Partnership Ltd, the programme has been separated into nine elements, the management of each of which is being subject to a separate Call for Tenders; at the time of writing (September 2001) the successful bidders were being selected

Project	Technology	Policy Mechanisms	Results/remarks
Unconventional natural gas E&P. U.S.	The gloomy, almost crisis-like outlook for the future of domestic natural gas in the late 1970's set in motion a set of national-level energy initiatives for adding new gas supplies. (1) The joint government/industry R&D programs in tight gas, gas shales and coalbed methane by the Department of Energy's Office of Fossil Energy (DOE/FE) and the Gas Research Institute (GRI) that established the essential exploration and production technology; and, (2) the unconventional gas economic incentives (Section 29 tax credits) that buffered the economic risks faced by the early set of unconventional gas developers and helped attract scarce investment capital to this emerging resource.	Two separate economic incentives to encourage the development - - incentive pricing and tax credits. **Incentive Pricing** Under NGPA. The first set of economic incentives for encouraging exploration and development of unconventional gas were set forth in the Natural Gas Policy Act of November, 1978. Section 107 of this act deregulated the well-head sales price of natural gas from Dervonian-age gas shales, coal seams and geopressured brines. Section 102 of this Act enabled tight gas to become eligible for the highest ceiling price within the NGPA regulated categories, providing this resource with modest economic incentives. Section 29 **Tax Credit**. A separate set of economic incentives for unconventional gas were placed into The Crude Oil Windfall Profits Tax Act of 1980. Section 29 of this act provided tax credits to qualified unconventional gas wells and formations. While producers needed to select which set of incentives to use, the deregulation of natural gas in 1981 made this choice moot. With amendments, the Section 29 tax credit qualifying period for new unconventional gas wells lasted until the end of 1992, with tax credits provided for gas produced through 2002. The incentive provisions of the Section 29 tax credit were designed to reward efficient unconventional gas development and performance. And they did. During a time when national average wellhead natural gas prices were between $1.50 and $2.50 per Mcf, the tax credit for tight gas was about $0.50 per Mcf and for gas shales and was on the order of $1.00 per Mcf for coalbed methane, adding considerable economic value to the efficient production of these resources.	**Response to Incentives.** industry's development and production of unconventional natural gas responded strongly **a)** Section 29 "legally eligible" tight gas, with many undeveloped basins and readily available technology, grew from 240 Bcf in 1980 to 1,180 Bcf in 1986, plateauing thereafter. **b)** Lacking a sufficient base of technology, coalbed methane had little opportunity to use the tax credits until the end of the 1980's. Even with late start, by the end of the period over 5,000 CBM wells were drilled and completed **c)** Drilling for gas shales increased substantially averaging over 1,200 wells per year in the last six years of tax credits. **Post Tax Incentive Activity.** A most significant outcome of the tax incentive program was that drilling and completions stayed strong after the expiration of the tax credits: **a)** After a brief lull, tight gas well completions rebounded to 3,000 wells per year. **b)** Coalbed methane well completions slumped somewhat in the mid-90's but now have reached new highs **c)** Gas shale well drilling has averaged 900 wells per year for the six years since the expiration of the tax credits, only somewhat less than the 1,200 wells per year prior. Unconventional natural **gas provided** 4,500 Bcf of supply in 1998, up from 1,500 Bcf twenty years ago. **Proved reserves** of unconventional gas are 52 Tcf, up from less than 20 Tcf twenty years ago; remaining recoverable resources of unconventional gas are estimated at 370 Tcf to 500 Tcf.

Model	Relates to	Model issues
Market Barrier	A poorly understood, high cost energy resource, one that the U.S. Geological Survey had not even included in its national appraisals of future gas resources (until their most recent 1995 assessment)	❑ Market organisation (cost) ❑ Technology specific
R&D Deploy-ment	The reason for the strong post tax incentive activity was that unconventional gas exploration and development technology had progressed sufficiently such that the industry remained economic and could attract capital without the need for further incentives or subsidies.	Technology stock growth, high risk not known solutions
Market Transfor-mation	The unconventional gas economic incentives (Section 29 tax credits) that buffered the economic risks faced by the early set of unconventional gas developers and helped attract scarce investment capital to this emerging resource.	Innovators and Early adopters among developers

ACTOR RELATIONS:

Tight Gas Sands. By the mid-1970's, industry knew that large quantities of natural gas resources existed in tight (low permeability) formations. However, the flow and production of gas from most of these tight formations was too low to support economic recovery. A handful of independents explored for areas where nature had sufficiently fractured this tight rock to make it productive, but generally with a poor record of success. The combined DOE, GRI and industry R&D programs, plus a set of modest tax incentives, unlocked the gas resource held in these tight rocks.

Gas Shales. At the start of the R&D Program, the Appalachian Basin gas shales were a small, declining resource. Annual new well drilling averaged only 200 wells and proved reserves were about 1 Tcf. By 1998, Proved reserves were 5 Tcf, Over 16,000 productive gas shales wells were drilled from 1978 to 1998.

Coalbed Methane. The combination of building a scientific base of knowledge, fostering appropriate technology and providing economic incentives launched the birth of a new natural gas industry -- coalbed methane -- now with nearly $10 billion of capital investment. Much of the early development was by independent production companies such as Devon Energy, Meridian Oil and Taurus Energy, who saw their gas production, reserve holdings and market capitalization rise sharply.

Geopressured Methane. While considerable geologic and reservoir knowledge was gained, no commercial natural gas production was established for this resource. Still, the R&D program in geopressured methane helped bring a strong dose of reality and understanding on the viability, or lack of, for this gas resource and helped dispel the speculation that "a 1,000 years of natural gas" was at hand.

Among the many "lessons learned," ten stand out:

- ❑ Government supported R&D can be highly successful, providing significant benefits to the domestic economy..
- ❑ Establishing a scientifically-based knowledge base "the intellectual foundation," is an essential first step.
- ❑ Joint industry/government partnerships and implementation help leverage R&D resources and bring commercial practicality to the program.
- ❑ A critical mass of funding and sufficient time are essential for achieving success, particularly for ambition, breakthrough efforts.
- ❑ Independent evaluation of fundamental assumptions while often unwelcomed, is essential for avoiding wasting scarce R&D resources.
- ❑ Cost reductions and efficiency improvements in geologically based technologies rely as much on adapting the technology to the geologic setting as on fundamental breakthroughs
- ❑ Efficiently disseminating technology to industry requires a comprehensive program of technology transfer ranging from publications for the informed layman to high visibility field demonstrations
- ❑ Economic and tax incentives can greatly accelerate industry's adoption of technology; helping assemble capital; lowering economic risk; challenging the financial community's imagination
- ❑ Special purpose "performance based" rather than broadly structured or "input based" economic incentives are a key to success.
- ❑ For maximum effectiveness, the incentives need to be sufficiently attractive and long lasting but also have a "sunset provision."

Characteristics of deployment cases **CS 17**

Project	Technology	Policy Mechanisms	Results/remarks
SUB-CFL PROGRAM, U.S.	A program designed to speed the market introduction in the United States of a **new generation of smaller, brighter, and less expensive compact fluorescent lamps (CFLs).** The program, called the DOE Sub-CFL Program, emphasized the small size of the lamps, intending to overcome one of the primary market barriers to wider market acceptance of this technology. CFLs often do not fit into lighting fixtures designed for typical incandescent lamps. The long-term goal of the program was to expand the market for CFLs by inducing manufacturers to develop and sell new CFLs that are shorter and lower cost than most CFLs then in the market. The medium term objectives of the program were to: ❑ induce at least two manufacturers to commercialise new, smaller CFLs; ❑ induce the commercialisation of a low-cost, 15 W integral CFL less than 5 inches (127mm) in length; ❑ implement a program that offered CFLs at prices substantially below the then prevailing market price of \$15-\$22, and; ❑ sales of at least one million units.	Technology procurement is a method to pull new technologies and products into the marketplace through competitive procurements backed by large volume buyers. Generally, it involves a multi-step process requiring: T Organization of target large volume buyers and market influencers (such as utilities); T Interaction with those buyers to understand their business and technology needs in detail; T Definition of their technology needs in the form of technical specifications, and acquisition of their commitments or intentions to purchase new products meeting those specifications; T Dissemination of those specifications for expert appraisal by potential manufacturers of the newly defined product; T Issuance of a competitive solicitation to potential suppliers, requesting bids for new products meetings those specifications, as well as the price at which they are willing to offer the products; T Selection of one or more winners from those bids; T Completion of agreements with the winning bidders establishing the terms and prices by which third party purchasers might purchase; T Implementation of promotion/ marketing programs to maximize the purchase of the newly available products.	The program: 1)successfully introduced 16 new lamp models into the U.S. market; 2) achieved this aggressive response from the lighting industry without advanced guaranteed purchases, which are typical in technology procurement programs, and; 3) it exceeded its program sales goal of one million lamps by more than 50%. ❑ The program induced five manufacturers to commercialize new products. ❑ September 2000, delivered prices for the various products ranged from \$4.95 to a high of \$8.20, For the 2-½ year operation of the program, total DOE expenditures amounted to \$342,000. This budget covered technical research, market research, interaction with potential buyers and manufacturers, development of technical specifications, RFP development and issuance, award evaluation, CFL performance testing, promotion, and other miscellaneous program tasks.

Model	Relates to	Model issues
Market Barrier	induce at least two manufacturers to commercialise new, smaller CFLs; implement a program that offered CFLs at prices substantially below the then prevailing market price of \$15-\$22,	Market organisation tradition High costs as barriers
R&D	induce the commercialisation of a low-cost, 15 W integral CFL less than 5 inches (127mm) in length;	Existing technology

Deploy- ment		(availability)
Market Transfor- mation	It was developed primarily in cooperation with the multi-family housing industry, the primary target market sector, but also encouraged participation by other high volume buyers and market intermediaries, such as electric utilities, universities, government agencies, lighting retailers, public housing authorities, and hotel/motel companies.	❑ Several different actors along the distribution chain ❑ Essentially addressing Majority issues

ACTOR RELATIONS:
The main actors involved in the implementation of this program and their roles were:

1) *Private multi-family housing owners and operators*: They were used to identify the key market barriers to wider spread use of CFLs, and their guidance was used to design a program that met their needs. This sector was also the primary market target for the program.
2) *Multi-family housing trade associations*: During program design, discussions were held with several trade associations for the purpose of soliciting their guidance and their assistance in communicating and promoting the program to their members.
3) *CFL manufacturers*: Extensive discussions were held with a large number of CFL manufacturers that were considered to be potential bidders. These meetings were used to alert the manufacturers to the program, to solicit their interest, and to seek their review and critique of both the program design and technical specifications.
4) *Utilities*: While individual utilities were not engaged in the development and design of the program, program designers believe this was an oversight. Given the important role they've played in using and promoting the program, their involvement at an earlier stage would probably have produced a program better suited to their use.
5) *Consortium for Energy Efficiency (CEE) and Northwest Energy Efficiency Alliance (NEEA)*: Both of these organizations are market transformation organizations[11].
6) *Retailers*: Based on the assumption that the majority of program sub-CFL sales would be sales directly from manufacturers to large volume buyers, such as multi-family housing companies, retailers were not asked to participate in program design. However, once sub-CFLs were made available through the program, the new products and prices were attractive enough to spur significant involvement by retailers, particularly cooperatives that buy products for the thousands of small, independently owned hardware stores in the U.S.

A technology procurement program was designed to maximize the chance of success. The key design elements, and a short justification for each follow.

1) *Two-phase approach*: The program was implemented in two phases, with the first lasting five months, and the second lasting 24 months. The purpose of the first phase was to test the logistical operation of the program and to test the market reaction to products offered. Furthermore, the first phase was designed to attract bids based on products already available in the market, while the second phase was designed to attract newly developed products. The time consumed by phase I was intended to allow manufacturers more time to develop the new-to-market products expected in the second phase.
2) *Web-based ordering*: To keep implementation costs down, a newly developed web site was used as the primary channel for distributing information about the program, as well as for ordering products made available through the program
3) *Strong warranty*: Knowing of the multi-family industry's dissatisfaction with previously available CFLs, and of their hesitancy to purchase products with which they were not familiar, the program required manufacturers to offer an unconditional one-year warranty, which essentially eliminated risks of participation by multi-family owners and operators.
4) *Cold start capability*: Most lighting costs in multi-family property are billed directly to tenants. However, common area lighting, a large fraction of which is located outdoors in climates that experience low winter temperatures, is billed to the property owners.

[11] Market transformation program is a term used in the U.S. to describe a new generation of conservation programs that are more carefully designed to exploit market forces than the previous generation of utility-sponsored conservation programs, and that are designed to have their market effects be self sustaining after cessation of the programs.

5) *Emphasis on size*: Recognizing the importance of small size in overcoming market resistance to purchase CFLs, the program emphasized size reductions by not only setting difficult-to-meet size requirements[12], but by also awarding extra evaluation points to bidders by the extent to which they reduced size beyond the minimum requirements.
6) *Multiple suppliers*: Given DOE's previous experience with technology procurement, the program was designed to increase the chance that more than one bidder would be awarded an agreement to supply products through the program. Multiple suppliers allow program implementers to drop suppliers for performance or product quality reasons without having to suspend the program or issue a new RFP because other suppliers are available to continue supplying products.
7) *Participation by buyers outside of the multi-family housing sector*: While the target market sector was the multi-family housing industry, the program was designed to allow participation by utilities, government agencies, schools, and retailers. Program designers believed potential product demand by these other sectors would increase the number and aggressiveness of bids submitted by CFL manufacturers, without appreciably increasing program costs or complexity (since no subsidies were involved).

[12] The program's technical specifications restricted participation to those lamps meeting the following maximum length requirements: 15-16W (133mm); 18-20W (140mm); 23-28W (152mm); 30+W (178mm). A typical general service incandescent lamp of 60 - 100W is 113mm long.

Project	Technology	Policy Mechanisms	Results/remarks
The United States Clean Coal Technology Demonstration Program Launched in 1985, the Clean Coal Technology Demonstration Program (CCT Program) is a cost-shared, technology development effort supported jointly by the United States Department of Energy (DOE) and the private sector.	Clean coal technologies (such as IGCC) being demonstrated in the CCT Program offer utilities an option to reduce greenhouse gases (GHG) by as much as 25 percent with first generation systems through enhanced efficiency. Commercialization of atmospheric fluidized-bed (AFBC) and pressurized fluidized-bed combustion will also serve to reduce GHGs. The first solicitation **(CCT-I)** for clean coal projects resulted in a broad range of projects being selected in four major product markets: I. Advanced electric power generation II. Environmental control devices III. Coal processing for clean fuels IV. Industrial applications. **CCT-II** became the centerpiece for satisfying the recommendations contained in the Joint Report of the Special Envoys on Acid Rain (86). The goal was to demonstrate technologies that could achieve significant reductions in the emissions of precursors of acid rain, namely SO_2 and NO_x. **CCT-III** furthered the goal of the CCT-II and added technologies that could produce clean fuel from run-of-mine coal. **CCT-IV** called for energy efficient, economically competitive technologies capable of retrofitting, repowering, or replacing existing facilities, while at the same time significantly reducing SO_2 and NO_x emissions. **CCT-V** focused on technologies applicable to new or existing facilities that could significantly improve efficiency and environmental performance.	The projects are selected via a competitive solicitation process administered by the U.S. DOE. The U.S. Congress sets the goals for each solicitation. The Department of Energy translates the congressional guidance into performance-based criteria and developed approaches to address "lessons learned" from previous solicitations. The criteria and solicitation procedures are offered for public comment and presented at pre-proposal conferences.	Over half of the 40 projects in 18 states have reached successful completion. As the electric generation market moves from a regulated industry to a free market, the CCT Program has kept pace with the changes. The CCT Program is demonstrating the first generation of many technologies that will be needed in a competitive power generation market. Five competitive solicitations sponsored by the U.S. DOE resulted in selection of the most advanced coal-based technology concepts available anywhere in the world. Federal funding was leveraged twofold through partnerships encompassing utilities, state governments, technology developers, and research organizations. To date more than $5.6 billion has been expended, with industry and states investing two dollars for every one from the federal government. The advancements in coal use technology resulting from the CCT Program will reduce dependence on foreign energy resources and create an international market for these new technologies. The Worldwide market for power generation technologies could be as high as $80 billion between 1995 and 2020.

Model	Relates to	Model issues
Market Barrier	The CCT Program was established to demonstrate the commercial feasibility of CCTs to respond to a growing demand for a new generation of advanced coal-based technologies characterized by enhanced operational, economic, and environmental performance.	Technology specific
R&D Deploy-ment	Established to demonstrate the commercial feasibility of CCTs to respond to a growing demand for a new generation of advanced coal-based technologies characterized by enhanced operational, economic, and environmental performance. Clean coal technologies being demonstrated under the CCT Program are establishing a technology base that will enable the U.S. to meet more stringent energy and environmental goals.	Known technology with high cost
Market Transfor-mation	The CCT Program is demonstrating the first generation of many technologies that will be needed in a competitive power generation market. These new technologies will be far more efficient than existing plants and environmentally benign.	New Technology for innovators

ACTOR RELATIONS:

The CCT Program implementation principles are:

- Strong and stable financial commitment for the life of the project, including full funding of the government's share of the costs;
- Multiple solicitations spread over a number of years, enabling the CCT Program to address a broad range of national needs with a portfolio of evolving technologies;
- Demonstrations conducted at commercial scale in actual user environments, allowing clear assessment of the technology's commercial potential;
- A technical agenda established by industry, not the government, enhancing commercialization potential;
- Clearly defined roles of government and industry, reflecting the degree of cost-sharing required;
- A requirement for at least 50 percent cost-sharing throughout all project phases, enhancing participant's commitment;
- An allowance for cost growth, but with a ceiling and cost-sharing, recognizing demonstration risk providing an important check-and-balance to the program;
- Industry retention of real and intellectual property rights, enhancing commercialization potential;
- A requirement for industry to commit to commercialize the technology, reflecting commercialization goals; and
- A requirement for repayment up to the government's cost-share upon successful commercialization of the technology being demonstrated.

Public and private sector involvement is integral to the CCT Program process and is crucial to the program's success. The CCT Program was created as a joint government-industry initiative. It is a partnership in which the federal government sets performance objectives, founded in national environmental concerns, and asks industry to respond with technical solutions. After the U.S. DOE selects the projects most suited to accomplish solicitation objectives and establishes performance measures, industry takes the lead in project management and assumes responsibility for commercialization. In this cooperative effort, industry retains its rights to the real and intellectual property generated through the development and commercialization of the technology in return for assuming at least 50 percent of the project costs.

Project	Technology	Policy Mechanisms	Results/remarks
Industrial Assessment Center Program (IAC) is run by the Office of Industrial Technologies within the U.S. DOE Office of Energy Efficiency and Renewable Energy	The strategic goals of the IAC program reflect the strategic goals of the Office of Industrial Technologies (OIT): ❑ partnering with the industry, OIT will motivate and will assist industry develop technology solutions ❑ A 25% improvement in energy efficiency and 30% reduction in emissions for the vision industries by 2010. ❑ A 35% improvement in energy efficiency and 50% reduction in emissions by 2020. ❑ The OIT, through partnerships with industry, government, and NGOs, develops and delivers advanced technologies and practices to assist industry in meeting challenging goals in the areas of energy efficiency, and global competitiveness. The IAC program has been training university engineering students in energy efficiency practices for small and medium-sized manufacturing plants (SICs 20 □ 39) since 1976. The program reflect the broader range of the services offered which now include a waste and productivity assessment along with the traditional energy audit. The primary teaching mechanism has been a paper analysis of a plant's energy bills, physical layout, and short description of operations followed by a one-day hands-on walk-through of the plant.	The program is fundamentally an information dissemination program through energy audits. Congressional appropriations in recent years have been about 8 million dollars U.S. annually. These funds cover all administrative expenses incurred both by DOE headquarters and its two field managers. In addition, each of the 26 universities receives a stipend to conduct in-house training of faculty and students in preparation for the comprehensive assessments performed. Each of the students who conduct the assessments is paid by the IAC (with DOE funds) on an hourly basis for their involvement in the assessments. The Industrial Assessment Centers program enables eligible small and medium-sized manufacturers to have comprehensive industrial assessments performed at no cost to the manufacturer. The manufacturers, however, do bear the cost of implementing the recommendations they decide to adopt.	The program offers students an opportunity to gain actual plant floor experience which has translated into better job offers and has established a cadre of engineers loyal to their energy efficiency roots who continue to espouse energy efficiency practices and technologies throughout their careers. Plants managers typically implement 50% of the recommendations for immediate savings, and adopt an awareness of energy, material, and labor inefficiencies that allows them to continue to make similar improvements, over time, both at the original plant where the assessment took place, as well as at other company locations. The program uses a well-established database[13] to track savings resulting from recommendations generated during IAC site assessments. As a result of the 734 assessments conducted in 1999, over 2.5 trillion btus are saved annually. Energy dollar savings of over $9.7 million annually are augmented by $6.6 million in waste savings and over $24 million in productivity savings. Total annual savings from 1999 were 40.7 MUSD, or $55,429 per assessment. Since the entire IAC budget was $8.3 million, these savings equate to a 4.9 to 1 benefit/cost ratio for year one alone. These savings will continue to accrue annually. This does not include the cost of the implementations that is born by the plants themselves. When the lifetime benefits of 1999 implementations are compared against the sum of federal and private sector outlay we see an aggregate benefit / cost ratio of 8.1 to 1 History of over 9500 audits completed which comprise a powerful database of identified opportunities and paybacks for implemented recommendations.

(1) [13] http://oipea-www.rutgers.edu/database/db_f.html

Model	Relates to	Model issues
Market Barrier	The free assessment serves an important contributory role (whether it be the initial raising of awareness, or the final input into a decision-making process already begun) in each plant's decision to implement energy savings recommendations.	Transaction Cost and Information
R&D Deploy-ment	One example of the long-term effect of IAC alumni are the substantial number of program alumni who serve in positions of influence for Energy Service Companies that are dedicated to finding and implementing long-term energy savings solutions for industry. Substantial projects undertaken by these alumni include the building of co-generation facilities for energy-intensive industrial users that promise to save enormous amounts of energy for the next 20 to 30 years.	Capacity building and experience feed-back related to known technology
Market Transfor-mation	The intent of the program is not to gain a one-time quick fix, but rather to facilitate a long-term change in awareness, attitude and behavior that will ensure energy savings, waste savings, and productivity gains on a permanent basis. So it is the change in the human decision-makers and advisors that is perhaps the most interesting and long-lasting effect of the IAC program	Adding knowledge to majority of the market. Good products?

ACTOR RELATIONS:

Teams of engineering faculty and students from the centers, currently located at 26 universities around the country, annually conduct roughly 25 energy audits or industrial assessments and provide recommendations to manufacturers to help them identify opportunities to improve productivity, reduce waste, and save energy. These teams of engineering students led by university professors form the core of the technology diffusion mechanism. There are two field managers who oversee 13 schools each. These field managers, also associated with universities, serve both an administrative and a supervisory function. The U.S. Department of Energy funds the program, oversees the field managers and conducts an annual "Directors' Meeting" where a cross-pollination of best practices takes place. The IAC program, the field managers, and many of the schools also maintain websites. Self-help material downloadable from these websites has also proved to be of great benefit for many industrial manufacturers and consultants who might not otherwise be eligible to receive an assessment.

The key elements of the IAC program's success are:

1) well-trained faculty at the participating universities;
2) mentor/protégé relationship among students;
3) small team size (8 - 10 students);
4) real world hands-on approach to teaching;
5) polite and positive attitude of students toward their industrial hosts; and
6) practical solutions with proven payback (nothing exotic) to real problems.

It was surprising to find that two indirect pathways to energy savings had such significant impacts: alumni influence on future decisions, and website dissemination of best practices, are also substantial key elements of the IAC's program success.
Finally, there was a danger that each IAC could operate as an island unto itself. Greater integration of the IACs with each other and with other beneficial programs and initiatives of the Office of Industrial Technologies is being sought. A committee comprised of four center directors has been formed to investigate channels for greater interaction and integration with other OIT programs. A number of initiatives have been started to incorporate IACs with the Industries of the Future approach that is the hallmark of OIT. That means that rather than concentrating exclusively on small and medium-sized facilities, IACs are now venturing into larger plants that are common to the nine energy-intensive "Vision Industries" that comprise the "Industries of the Future" (Agriculture, Aluminum, Chemicals, Forest Products, Glass, Metalcasting, Mining, Petroleum.)

Characteristics of deployment cases

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Project	Technology	Policy Mechanisms	Results/remarks
US DOE Motor challenge and Best Practices Programs run by the Office of Industrial Technologies within the Office of Energy Efficiency and Renewable Energy.	• **Promote a "systems" approach** Careful matching of the elements of a plant system (in the case of motor systems – motors, controls, couplings, and process machinery) to the work to be performed yields far more savings than upgrading just the individual components. The Motor System Market Assessment found that over 71 percent of total potential savings came from systems-level measures such as improving the configuration and control schemes in pump, fan, and compressor systems. • Business motivations (of end-users, manufacturers, and vendors in technical information and energy efficiency) The program emphasises not only the energy savings associated with improved system efficiency, but other benefits of efficiency improvements such as increased control over production processes, reduced waste, and an improved production environment for workers. BestPractices also works with manufacturers and vendors to identify and exploit competitive advantages associated with promoting efficient systems and the benefits of life cycle costing. A recent evaluation of the Motor Challenge program found that 67% of all savings resulting from program activities during the period from program inception through 1998 could be attributed to these actions.	Cost shared (50/50) plant wide assessments to help IOF manufacturing plants develop a comprehensive strategy to increase efficiency, reduce emissions, and boost productivity. To participate companies must commit to replicate the implementation of identified opportunities in their other similar plants over a period of several years. The results of the audits are developed into case studies which are widely shared within industries and are available on the Office of Industrial Technologies web-site. www.oit.doe.gov The policy mechanisms used successfully by **Motor Challenge** to implement the program fall into two main categories: 1) information and decision-making tool development and dissemination, and 2) development of strategic partnership networks with industrial trade associations and industrial supplier companies. (See details below under Actor relations.) **BestPractice** offers the same types of information and services as were offered through the Challenge programs such as information materials and services on industrial equipment and systems, decision-making tools, technical training, and other resources. In addition, BestPractices now offers assistance for assessing plant operations, including: • Free, one-day assessments of small- to mid-sized plants by university-based OIT Industrial Assessment Centers • Cost shared plant-wide assessments to help IOF manufacturing plants develop a comprehensive strategy to increase efficiency, reduce emissions, and boost productivity • Showcase Demonstrations held at manufacturing sites; provide the public opportunities to understand the benefits of emerging technologies by seeing them applied in real-use conditions. The effort includes an independent third party to validate technology performance and costs in comparison to baseline practice; each technology with validated performance benefits will receive an OIT Certificate of Recognition. • To validate performance and reduce the perceived risks associated with emerging technologies, BestPractices offers cost-sharing support to facilitate technology adoption. OIT Technologies eligible for implementation assistance must have completed the full-scale demonstration phase.	The evaluation conducted in 1999 found that the Motor Challenge is responsible for US$24.9 million in annual energy savings, is highly cost-effective, and has just begun to reach US industrial end users. Training produced the greatest benefit, followed by use of MotorMaster+ software. ❑ Energy savings totaled 498 GWh/y estimated at $24.5million 1998 ❑ Of users, 10-15 % undertook changes to motor system design, purchase, and maintenance practices that they said would not have been made in the absence of the program ❑ Key personnel identified in 3,510 facilities that account for 14 percent of total industrial motor system energy use, or roughly 95,000 GWh per year. ❑ Users attributed the purchase of 10,170 premium efficient motors to the influence of the program This is roughly 6 percent of all premium efficient motors 1998 to the industrial sector. To summarize, Motor Challenge has barely scratched the surface in terms of helping end-users realize system-level energy savings.

Model	Relates to	Model issues
Market Barrier	Existing industrial equipment and services markets (both supply and demand) traditionally focus on components rather than systems. This piecemeal approach to industrial motor-driven and steam systems in the US typically results in less than optimal system operation, reliability, and efficiency. The main barrier to the program has been the industry's failure to focus on energy efficiency, since energy has been relatively cheap. Furthermore, manufacturers are reluctant to tamper with tried and true production systems to pursue what they believe to be small percentages of energy savings. Management has tended to emphasize production quotas as opposed to efficiency gains.	❑ Technology specific ❑ (Relative) cost ❑ Market organisation
R&D Deploy-ment	Advanced technologies developed with OIT support are regularly emerging from research and development and are ready for demonstration and use. BestPractices offers expanded support to help deliver these solutions to industry through showcase demonstrations and technology implementation. Over 140 Advanced technologies developed with OIT support have been commercialized since 1978 and DOE has identified almost 160 technologies that are emerging from research and development that may bee ready for demonstration and use over the next several years.	Builds the technology stock
Market Transfor-mation	Strategic partnership with industrial trade associations and industrial suppliers provided a significantly larger impact with less program resources than the direct contact approach.	Good technology. Communication with actors according to their own situation and in line with their business interest

ACTOR RELATIONS:
The US DOE, OIT employees have formed the administrative backbone of the program, with technical support being provided by the Lawrence Berkeley National Laboratory, Oak Ridge National Laboratory, and the National Renewable Energy Laboratory. In addition. Washington State University provided technical support in development of software tools and in staffing the OIT Information Clearinghouse which can been reached using a free telephone number. OIT also relies heavily on the internet to disseminate program information. The website www.oit.doe.gov receives over 300,000 page views monthly and over 90,000 downloads of information.

The Motor Challenge program began developing partnerships with key industrial trade associations shortly after the program was launched. Partnerships were developed with the American Water Works Association, Compressed Air & Gas Institute, Electrical Apparatus Service Association, Hydraulic Institute, Technical Association of the Pulp & Paper Industries (TAPPI), Consortium for Energy Efficiency, and several regional utility groups. These partnerships enabled the program to develop a very broad reach to industry with a modest level of support from USDOE.

The Motor Challenge program is also part of the Allied Partner initiative established recently that already includes over 225 companies and organizations nationwide. The Allied Partners cooperate with the program in promoting energy efficient motor systems through distribution of information materials, technical tools, and sponsoring technical training and workshop events. Allied Partners are companies and organizations that provide products and services to industry through the course of regular business contacts. Allied Partners are not paid to use program offerings or to promote more energy efficient motor-driven systems; they choose to participate based solely on sound business reasons.

1. Information and Decision-Making tools

a) Decision-Making Software

   MotorMaster+ Motor Selection and Management Software. MotorMaster+ contains a database of efficiency, price, and other catalog information for more than 25,000 three phase, integral horsepower electric motors produced by major manufacturers. *Pump System Assessment Tool – PSAT*, estimates pump system efficiency based on a limited number of on-site measurements. *ASDMaster*, assesses the feasibility and cost-effectiveness of adding Adjustable Speed Drive controls to a motor system. *AirMaster*, provides an assessment of a compressed air system based on a guided set of on-site observations and measurements.

b) Training Programs. Technical training sessions cover a wide range of plant system topics including: use of the software above

c) Showcase Demonstration Case Studies. Develop information on the field performance of energy efficient motor systems and design practices. In exchange for technical assistance from the Program's technical experts, customers arrange for monitoring and verification of energy savings associated with various system efficiency measures. Motor Challenge used the documentation of the Showcases to develop case studies which facility managers could use to assess the applicability of similar measures to their own facilities. To date, 16 technical case studies have been developed.

d) Technical Tip Sheets, Fact Sheets, Sourcebooks

e) Information Services Information Clearinghouse provided answers to technical questions over the phone, and compiles and disseminates technical information on a wide variety of topics. The program also developed and maintained a frequently visited internet web site and a bi-monthly newsletter (Energy Matters) distributed to over 25,000 individuals, and through an Allied Partner network.

2. Strategic Partnerships

Motor Challenge developed partnerships with trade associations representing important groups of end-users, manufacturers, and vendors in the industrial markets. The basic partnership approach has been to harness OIT's technical resources to address plant-related technical issues and opportunities that affect a broad range of the associations' members.

a) *The Compressed Air Challenge:* an industry partnership between Motor Challenge and the Compressed Air & Gas Institute (CAGI),

b) *Pump System Initiative*. The Hydraulic Institute (HI). HI has formed a "Life Cycle Costing" committee with DOE's facilitation assistance that will be developing products to assist end users address life cycle cost factors in managing and maintaining their pump systems.

c) *Pulp and Paper Industry Initiative*

d) *Electrical Apparatus Service Association (EASA) Initiative*.

Motor Challenge changed and adapted over the years. Some of the problems or weaknesses that led to the modifications are mentioned below. These were endemic to the "Challenge" programs that preceded the BestPractices Program:

- Initial attempts to sign up Partners met with some resistance. Reporting data on energy consumption and production was seen as one possible explanation.
- The Allied Partner program was originally focused on Motor Challenge and later on the other Challenge programs. It has been significantly broadened beyond the Challenge programs to include all Best Practices including those resulting from OIT sponsored collaboration to develop new technologies. In addition, to continuing efforts to obtain participation from individual companies the current program focuses increased attention on establishing Allied Partnerships with key nationaland regional trade associations, national equipment manufacturers and distributors, industrial consulting firms, utilities with large industrial loads, along with state agencies and non-government organizations who work directly with industry.
- Separate "Challenge" programs were set up to specialize in different technology areas. This was not the most efficient way to work with or deliver a broad range of information and assistance to industry. As a result, OIT initiated BestPractices, which integrates all of the previous "Challenge" programs.

Project	Technology	Policy Mechanisms	Results/remarks
Energy + A pan-European procurement project for refrigerator-freezers (Austria, Finland, France, Germany, Italy, the Netherlands, Norway, Portugal Sweden, and the U.K), January 1999 until June 2001 **Domestic refrigerators and freezers are responsible for and 6% of Europe's final electricity use meaning about 2% of Europe's GHG emissions related to human activities.**	Increase market penetration of efficient refrigerator-freezers on the European market by: • making the best existing units available from more manufacturers throughout the Union, and by making these models the choice of more customers. • contribute to earlier commercialisation of units that are even *more energy efficient* through a technology competition. Refrigerators are fairly standardised products sold on a highly international market. Being the most common cold appliance sold in Europe, with approx. 45% of total annual cold appliance sales of 18-19 million units, they also represent a significant energy saving potential. The main barrier to the large diffusion of already existing efficient units seemed to be the high sales price, which appeared to be the result more of branding and marketing policies than expensive technical components.	The policy mechanism used, often referred to as procurement, is in principle: The project group gathered strong, influential purchasers from the whole Union and, together with them, drew up specifications for a refrigerator-freezer with good energy and environmental qualities <u>that also possessed certain user-related characteristics of importance to the buyers.</u> These specifications were then presented to manufacturers to show them that there is a market for these highly efficient products and to point out what features the buyers are looking for. By doing so the project intended to spur manufacturers to develop or make such units available on a larger scale. Energy+ was carried out in two rounds after each of which a list of qualifying products was compiled and publicised. The second round also contained a technology competition. The project. contained the following five main phases of work: Phase 1 Feasibility study (more detailed studies focusing on refrigerator-freezers and their market specifics). Phase 2 Definition of process (i.e. letter of intent, *energy+* lists, updates), aggregation of buyers, development of mandatory specifications and optional requirements. Phase 3 Results and follow up of Round 1, Publication of Round 2 specifications, publication of requirements for the *energy+* award competition. Phase 4 Tender/development period, aggregation of additional buyers and supporters for Round 2. Phase 5 Evaluation and selection of *European energy+ Award* winners, additional marketing, testing and follow up of the project. Dissemination activities were part of all the five phases above.	For the first round, a list of units that met the *energy+* mandatory specifications and that were available on the market by December 2000 was compiled and published. This first round list was updated once in September 2000. The second round was dedicated to *energy+* appliances available in 2001. The publication of the second lists was also co-ordinated with the announcement of the winners of the *energy+* award competition The total budget of the project amounted to approx. one million Euro and involved ten countries during 2,5 y. Approximately 100 organisations joined as institutional buyers, retailers or supporters. These represent more than 15.000 retail outlets and manage a total of more than one million dwellings. By the time of the last update of the lists (April 2001) four manufacturers had submitted 16 qualifying products to be included in the lists. Two of these products were *European energy+ Award* winners. These units are the most energy efficient on the European market today and have values believed to come close to, the most stringent minimum level for future class A. One can thus draw the conclusion the project has contributed to an earlier introduction of highly efficient units on the European market.

Model	Relates to	Model issues
Market Barrier	One of the main barriers at European level was identified as the lack of experience and therefore confidence in the process as such. The main barrier to the large diffusion of already existing efficient units seemed to be the high sales price, which appeared to be the result more of branding and marketing policies than expensive technical components	Market Organisation (cost and business tradition)
R&D Deploy-ment	Production of such highly efficient units was not considered to imply any major technical problem for manufacturers.	Existing and known technologies
Market Transfor-mation	When the European Union introduced its labelling scheme for refrigerator-freezers only a few appliances qualified for the most stringent level "A". A quick evolution of the energy efficiency of products available on the market has, however, made it necessary to revise the criteria (the levels and principles for which has been proposed by the *Cold II* study presented in Spring 2001). Since it will take a few years for the new requirements to come into force, the e*nergy+* project has had and continues to have an important role in giving visibility to the most efficient products available and helping the manufacturers and buyers distinguish them from the "normal" A-rated units. The project has also, through the award competition, contributed to an earlier introduction of even more efficient appliances than what existed on the market when the project was launched.	Good and new products to the market. Aimed at early adopters and early majority

ACTOR RELATIONS:

Buyers and supporters

The term "buyer group" has been defined in a broad sense, since the role of the *energy+* buyer group was different from similar groups used in more traditional procurement projects. This was mainly due to the important role of retailers in a European context. Thus, the "buyer group" included retailers, institutional buyers (such as housing companies and holiday resorts), and supporters (such as national and regional energy agencies, and environmental NGOs who in their daily work inform about and push for energy efficient products). These actors were important collaborators when defining the technical and functional specifications presented to manufacturers.

All of the buyers and supporters have signed a declaration where they state their intent to buy and/or promote e*nergy+* appliances. The declaration is non-binding, but it nevertheless represents an effort on behalf of the signatory to penetrate and acknowledge the technical requirements, and an important moral commitment to the process.

Characteristics of deployment cases **CS 22**

Project	Technology	Policy Mechanisms	Results/remarks
The IEA-SOLARPACES START Missions Since 1977, IEA/SolarPACES has pursued a focused program of research and development in the field of concentrating solar power and chemical energy systems. In October, 1995, the concept of the START Mission was developed. The goal of these Missions is to help nations develop a rational approach to the deployment of solar thermal electric systems within their country	Systematic development of three concentrating solar power (CSP) technologies—troughs, towers, and dishes—has led to the ever-increasing ability of these technologies to concentrate and harness solar energy for electricity production and other uses with efficiency, reliability, and cost effectiveness. Our vision within the IEA/SolarPACES community is that by 2010, CSP technologies will be making a significant contribution to the delivery of clean, sustainable energy services in the world's sunbelt. The first step in realizing grand market-introduction plans is to develop initial project opportunities. SolarPACES is helping identify the most promising projects by sending experts to selected sunbelt countries.	The following three objectives help us achieve to expand our IEA/SolarPACES role from one which has been focused largely on technology development to one addressing the full range of activities necessary to overcome barriers to large-scale adoption of solar thermal technology. 1. Support TECHNOLOGY development by leveraging national resources for research and development through international cooperation. 2. Support MARKET development to reduce financial, political, market and institutional hurdles to commercialization of solar thermal technology. 3. Expand AWARENESS of the potential of solar thermal technologies (including long term fuel supply and the potential for solar chemistry). The START Mission Head identifies together with the Host the policy mechanisms and support instruments for which the host country may be eligible and reviews such policies and instruments during the mission itself for applicability to the identified solar thermal project opportunities. Each Mission means the concentrated joint effort of an international team of SolarPACES experts and representatives of the respective country, and may include • analysis of appropriate solar thermal power technologies • review of specific sites for solar thermal power projects • review of the terms of reference for detailed feasibility and implementation studies • development of a concept of financial engineering based on the applicable law • identification of potential funding sources and options for specific projects • comparison of power generation costs in the country.	The START Mission has become a successful tool of deployment policy by the example of the first Mission to Egypt. Now in the implementation of the 130 MW Hybrid Fossil Solar Thermal (HFST) Power plant project at Kuraymat with private participation and a 50 Mio USD grant of the GEF. Publication of the RFP for Kuraymat is scheduled for early 2000; award of BOOT contract for end 2000; after a 18-24 month construction period, the Kuraymat hybrid fossil solar power plant shall start operation in 2004. In March 1997 a team visited Jordan and recommended the integration of a parabolic trough or solar tower system in a base-load 130-MW fuel-oil-fired steam plant. May 1997, a Team visited Brazil. The Mission was able to bring expertise and tools to Brazil for studying and designing solar power plants. A solar thermal dissemination mission was conducted in October 1998 in Mexico City

Model	Relates to	Model issues
Market Barrier	In addition to the technical hurdles we have focused on for the past two decades, we are facing numerous non-technology-related barriers to solar thermal's achieving wide spread contributions to sustainable energy and a cleaner environment.	• Market Organisation

	Obstacles and threats: • Energy market deregulation and low energy prices, including a market-push toward use of the least-cost power option, while ignoring the cost of external environmental impacts of competing technologies. • Uncertainty about cost, performance, and reliability. • Perceived risks of high capital-cost projects. • Intellectual property protection issues. • Funding decreases in national solar thermal R&D programs. ***Challenges:*** • Establishing appropriate market entry incentives, including equitable taxation relative to conventional energy products, carbon taxes or renewable energy tax credits • Removing legislative and regulatory barriers to the supply of CSP to the grid. • Increasing support for the development of effective tools for assessing the true value of renewable technologies incl. externalities. • Improving the attractiveness of investment opportunities in CSP technologies	• Risk – Uncertainty • Regulation • Price distortion • Information
R&D Deploy-ment	The START missions have proven to be instrumental in linking the various national solar thermal R&D policies of the fourteen SolarPACES member states represented by the SolarPACES Executive Committee with the needs of the host countries, the capacity of the involved industry and the financial support schemes of multilateral development agencies.	Technology stock
Market Transfor-mation	The START mission serves as a catalyst for condensing available transnational expertise, industrial technologies, international financing support elements and an existing political will in the host countries into a feasible solar thermal project proposal. A weakness of the START Mission was its lack of outreach to international development organizations, Concentrating solar power rarely surfaces on these organizations' vistas, leaving a broad gap in medium- to large-scale renewable power options for developing countries.	❑ New Technology ❑ Innovators

ACTOR RELATIONS:
The main actors of the START missions and their roles are discribed in detail in the START Mission Procedures endorsed by the SolarPACES Executive Committee: Organization's from a country's energy and electricity sector, interested in the development of solar thermal projects may formulate a proposal to host a SolarPACES START Mission to the SolarPACES Executive Committee via its Secretariate. Such proposal must discribe

- the host organization's interest and expectations in the field of solar thermal technologies
- the host organization's role in the host country's energy policy making and energy project implementation process
- the specific solar thermal project opportunities, that the host organization would like to analyze and review in a START mission
- the solar thermal technologies, in which the host organization would like to receive information and training

In case the proposal is accepted by the SolarPACES Executive Committee, the host organization will be requested to fill out a preparatory START Mission Questionaire for efficient execution of the missions.
The START Mission experts are selected by the START Mission Coordinator and the interested host organization according to the expertise profiles required for the respective mission from an expert shortlist. Funding of the expert's time spent in the preparation, conduction and reporting of the Mission will be provided in kind by the SolarPACES member that has nominated the expert. The participation of additional experts from industry, electric utilities and financing institutions may be decided by the START Mission Coordinator on a case by case basis. The final report of each START Mission will be edited by the Mission Head with the active support of the participating experts in English language. It will include the information provided by the host organization in the host country questionnaires, the findings of the mission and an executive summary.

Creating Markets
for
Energy Technologies

Case Studies

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The Deployment of Biomass-District-Heating in Austria

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Introduction

Since 1980 a new technology providing domestic heating in rural areas was introduced: small scale district heating plants that use wood chips, industrial wood waste or straw as fuel. By 1999 more than 500 Biomass-District-Heating (BMDH) plants have been established.

The principle of a BMDH is simple. A big boiler filled with biomass heats water, that passes through a grid of insulated pipes and supplies the energy for the heating of individual houses and enterprises in a village. Austrian villages with BMDH plants usually have between 500 and 4000 inhabitants and are of predominantly rural character. Accordingly the power of BMDH plants is between a few hundred kW and up to ten MW with corresponding grids between 100 metres and 20 kilometres. About 2/3 of all plants have a power of less than 1500 kW.

The introduction of BMDH was not managed at a national level but at the level of federal states („Länder“). The different attention given to the deployment of this technology in the nine federal states had strong effects on the different diffusion characteristics in these states. While the early innovators - the states of Lower Austria, Upper Austria, Salzburg and Styria - started diffusion in 1980 and reached the level of maximum annual dissemination in 1993, the laggards Burgenland, Carinthia, Tyrol and Vorarlberg had the first plants established in 1990. Figure 1 shows the diffusion in the early innovating states. It is interesting to note, that small plants (< 800 kW) start a new cycle of diffusion in the most recent years, while larger plants > 800kW have decreased since 1994. Smaller plants are associated with a new concept: the heating plant is not designed to supply the whole village but only a few larger buildings in the vicinity. This is both more economic and easier to organise.

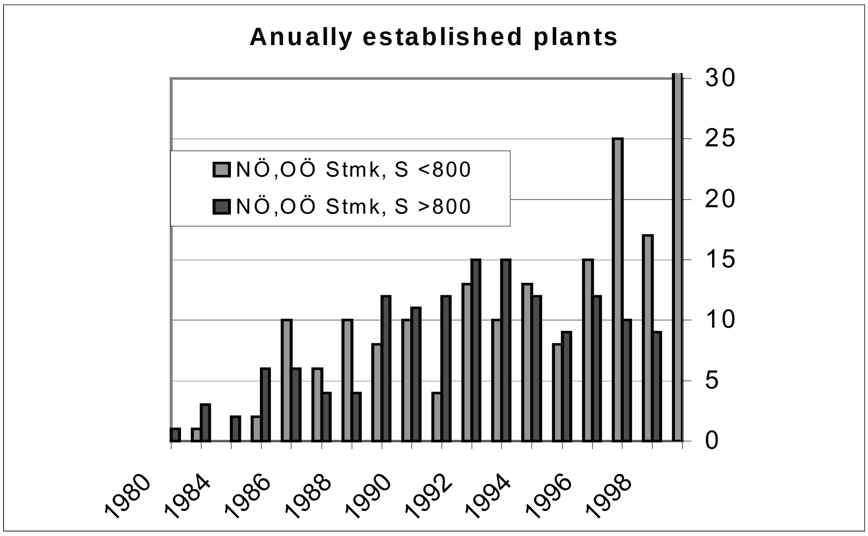

Figure 1: Diffusion of BMDH in 4 states – the influence of plant size on diffusion

The case of BMDH in Austria is interesting for a number of reasons:

It is a rather successful case of renewable energy diffusion

while being a success in numbers of deployed plants the diffusion process was not a success in terms of technical performance of plants and learning speed.

These deficiencies can be clearly related to weaknesses in the management on the technology-deployment-program. It is an interesting case example as its success is based to good part on a strong bottom-up-movement, while at the same time significant conflicts took place at the local level during the implementation-process. Thus it serves as an example for the complex issue of public acceptance of renewable energy technologies.

(2) Objectives of the program

As the deployment of BMDH was both the result of local initiatives and public policy it is useful to consider both the objectives of the local project promoters and of the program-managers at the level of federal states. At this level, the policy level, the prime objective was clearly to support agriculture. In Austria most farmers are both owners of farmland and forests. Especially in the mountainous areas the economic situation of farmers is very difficult. The deployment of BMDH should give farmers the opportunity to build up a new source of income by providing energy services. Consequently most resources dedicated to the development of BMDH came from agricultural funds. Only in a later phase of deployment also environmental subsidies contributed to the financing of plants.

At the local level the motivations for deploying the new energy system were different. A survey among residents[1],[2] showed that top motivation for residents connecting to the new

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[1] Rakos, C.: Doctoral thesis „Fünfzehn Jahre Biomasse-Nahwärmenetze in Österreich", Technische Universität Wien 1997. This theses was written in the course of the EU funded project "Pathways from small scale experiments to sustainable regional development" "EXPRESS PATH", CEC Contract No EV5V-CT92-0086. See also:

[2] Danielsen, O., Koukios,E., Rakos, C.: „Pathways from Small Scale Experiments to Sustainable Regional Development" („EXPRESS PATH"), CEC Contact No. EV5V-CT92-0086. The project was

BMDH was enviromental protection (mentioned by 95%). 75% of the responding residents declared an important aspect for them was also the support of local farmers and local self-sufficiency. 87 % responded that the convenience of District-Heating was an important motivation. Thus local motivation is based on three basic aspects: enviromental protection, enhanced heating comfort and sustainable local development.

The objectives of the federal agriculture ministry have been described most recently in the federal decree 21 200/50/II/00 of 27th July 2000. In this decree that enacts the new subsidy program for BMDH the following motivations are mentioned: creation of new possibilities for income in rural areas, creation of added value in rural areas, creation of jobs and contributions towards securing the existence of farms. In another programmatic document, the “Austrian Program for the Development of rural areas”; part 2 chapter 11.3.5 two additional motivations are mentioned: making a contribution to the fulfillment of the Kyoto-Agreement and making a contribution to the policy goals as stated in the Whitebook for Renewable Energy of the European Commission.

The programmes for the deployment of BMDH addressed two barriers:

While biomass is a cheap fuel that is competitive with conventional fuels, biomass boilers are significantly more expensive than conventional boilers. Also the establishment of a district-heating-grid is very costly. Consequently it is almost impossible to realise BMDH-projects without subsidies for the high initial investment-costs.

While biomass boilers for the combustion of woodwastes have been used in the forest-industry for decades, and district-heating as a technology has also existed for a long time, the combination of both elements was a real innovation. Especially its application in small scale rural areas was new and requested both modifications and improvements of the boilers and of district-heating technology. In addition to that also the concept of operating BMDH plants by agricultural co-operatives was completely new. The technical start-up problems and the fact that the developers and operators of these plants had no previous experience neither with the technology nor with the economics of providing energy-services were a significant barrier. In order to overcome these barriers focal points were established in the states promoting BMDH.These focal points were small institutions that facilitated the technology-deployment-process and gave advice to the developers of new projects. They were established either at the agricultural chambers, within the state-administration, as independent consulting-institutions that received public funding or within existing state energy agencies.

(3) Process of definition and design of the program

The deployment of BMDH started as a bottom-up-process in which individual farmers supported by a regional development agency developed the idea and realised the first projects. The success of these projects created an exceptional interest and some of the BMDH plants received thousands of visitors annually. At the beginning no formal subsidy-program was available for this innovation. The development of formal subsidy-programmes and the establishment of the different support-units in the federal states was more of a reaction to the bottom-up-development than a planned technology-deployment activity. The

funded within the framework of the Socieconomic Environmental Research Area of the Environment Research Programme of DG XII.

design of the programmes in the different states was similar: Create a subsidy scheme and provide-funding for one or two persons that help the farmers to set up their projects. While R&D was very important for technology-improvement it was not part of the state deployment-programmes but funded by national R&D-programmes and a fund dedicated to support R&D in industry with informal links between the responsible actors that created co-ordination.

The programmes were not directly affected by liberalisation as the heat-market has always been open for competition. There was an indirect effect of market-liberalisation, however, as some utilities entered the market seeking a stable complementary business. As significant subsidies were only available for farmers, these utilities created interesting new forms of co-operation with farmers co-operatives to establish and operate BMDH-plants jointly.

Consumer choice is an issue, when a BMDH project is planned and as many customers as possible are needed. In this case a positive public perception of the project however is critical. Suggestion, to establish laws for mandatory connection to District-Heating-grids equally to the mandatory connection to the waste-water-system were repeatedly put forward. Such legal provisions were not made in any of the Austrian States however

(4) Main-actors and their roles

From the local point of view the main-actors are the local promoters of the project that subsequently both develop and operate the system. Successful local promoters are typically well respected young residents of the village that are personally highly motivated and that manage to create a consensus in the whole village to realise the project. For these local promoters, in turn, their key-actor is the focal point in their federal state, regardless whether it is the agricultural chamber, the state energy agency, the consultant or the person in the state-government.

This focal point helps them in all aspects of the project. The focal point makes feasibility studies, helps the operators to manage the complex administrative procedures for getting a subsidy, they give advise on how to create the cooperative, on how to develop the project, on the contracts with the heat-customers, etc. The function of these focal points might be best described by the concept of „Strategic Niche Management“ that has been developed in modern innovation theory[3]. Thus their role is very important for the whole technology deployment process. Unfortunately there was a mismatches between the significant resources available for subsidies and the small resources for the focal points, a fact that a led to significant setbacks and inefficiencies.

Who were the main-actors for the “niche-managers”? On the one side it were the officials at the state and the federal level, that were responsible for subsidies. The niche managers also kept the contact to the the boiler-manufacturers and discussed with them the different problems that occurred in the beginning. Another important group for the niche managers were the village majors.In some federal states they visited almost all majors in the whole state to inform them about the new technology and to raise interest in realising a project. Still further up the hierachy federal state politicians played a key-role for providing sufficient financial resources needed by the rapidly expanding number of projects. These actors also

[3] Kemp,R., Rip,A., Schot,J.: Constructing Transition Paths Through the Management of Niches. Paper for the Workshop „Path Creation and Dependence“, Copenhagen 1997.

need to be pleased e.g. in opening ceremonies of new plants, with lots of media and public involvement.

Important actors that did not receive sufficient attention were the planners of the projects. In Austria planners are typically small companies with only few employees and a fairly broad portfolio of projects. None of the planners that designed BMDH-systems in the beginning had any experiences with District-Heating-Technology. Consequently many mistakes were made in the beginning, the most common of which was gross overdimensioning of all components of the system.

Research was also a main-actor. Both researchers and research-funding reacted flexibly to the sudden demand created by the new technology for reliable and environmentally sound combustion-systems. In co-operation with industry significant improvements of combustion technology were introduced. For a long time however research failed to identify and address the issue of systems performance. While boiler performance was pushed to ever further limits, no attention was given to optimising the whole design of a District-Heating-System in terms of technoeconomic performance.

(5)Policy mechanisms

The main-policy mechanism used was to give subsidies for investment-costs.

While the programmes for deploying BMDH were managed at the level of federal provinces, the national ministry of agriculture provided a significant amount of financial resources for the programmes. The subsidies provided for agricultural co-operatives usually included both a soft loan and a direct financial subsidy with a net-cash-value corresponding to about 50% of the total investment-costs of the project.

In 1988 the ministry started to subsidize BMDH with 950 k EURO, a sum that increased continuously up to 7,3 M EURO in 1993. This subsidy was complemented to an approximately equal amount from the federal provinces. In 1999 approximately 11 M EURO were provided by the ministry, complimented by 7,3 M EURO from the federal states and 5,1 M EURO from the European Union, that contributed subsidies since the Austrian accession from regional funds.

These subsidies were available only for farmers. Commercial operators as for example sawmill-owners could only receive a 30% subsidy from the environmental fund of the ministry of environment.

Besides the subsidies procurement also played a key-role at the local level, as public buildings as schools, the townhall, etc. are often among the largest heat-users in the villages. The connection of all public buildings in a village was in many cases a very important support for the District-Heating-Project. At the federal level systematic procurement policies were never established however, due to conflicts of interests between the different ministries.

Another indirect financial support is the low VAT of 10% on wood (compared to 20% VAT generally).

Also as mentioned the focal points or “niche managers” in the federal states were an-other key-mechanism for supporting technology-deployment.Typically one to two persons per federal state were responsible for the management of BMDH start up.

Another support mechanism applied at the national level (and only informally connected to the deployment programmes at federal state level) were R&D policies. These were based to one part on a very efficient fund for company research that provides 50% support for R&D in small and medium scale enterprises.To the other part they were based on long term R&D programmes of the ministry of science and research (now ministry for traffic, infrastructive and technology). National R&D funds dedicated to biomass research in the 1990s were in the order of magnitude of 5 M EURO per year.

(6) Monitoring and evaluation-process

Monitoring and evaluation took place primarily at the level of individual projects. As mentioned a key-role in this process was taken by the focal points which performed an in depth evaluation of every project before suggesting it for subsidies. They also performed an informal ex post monitoring by keeping the contact to the individual plant-operators for example in regular annual meetings etc.

In contrast to the evaluation at the project level, no regular evaluation was made at the program level - at least for the part of the federal subsidy program. A first evaluation was made only recently, more than 10 years since the beginning of the programm. More recently also a number of evaluations were made for the subsidy-programmes at the state level.

Due to the fact that the state programmes were fairly independent a consistent monitoring and evaluation of the whole process never took place. A consistent and comparative evaluation of the work of the focal points was not performed either. Consequently deficiencies in the work of these focal points were overseen and had serious impacts on the overall success of the program. Among these deficiencies are three important problems:

Too little attention was given to the role of conflicts at the local level. The consultants of the focal points were educated only in technical and economic issues. Consequently they were not able to give appropriate advise to the project-promoters on conflict-management techniques.

It turned out that the state focal points had different strategies regarding pricing which led to significant differences in price-levels for distrcit heat. Particulary negative consequences arose for the operators in states with low price levels.

In some states the focal points had a particulary strong pro-project bias in the feasibility study phase which led to the financing of projects with rather poor economic preconditions. In the course of the programmes an increasingly critical economic evaluation was implemented as a consequence of problems with projects that were economic desasters. With respect to the monitoring of technical plant performance a number of studies were made (Stiglbrunner[4], Rakos[5], Stockinger[6]). The first of these studies gave an early indication of the serious lack of technical optimisation. However, unfortunately nobody felt responsible to act upon this issue.

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[4] Stiglbrunner, R., Lübke, A., 1992, Bericht Betriebsdaten; Hackgutheizungen in Oberösterreich. Österreichische Arbeitsgemeinschaft für eigenständige Regionalentwicklung. Wien.

[5] Rakos: see above

[6] Stockinger, H.: "Systemanalyse der Nahwärmeversorgung mit Biomasse". Doctoral Thesis, Technical University of Graz 1998.

The researches that found out about the problem felt only responsible for submitting the study, the focal points did not feel responsible for the topic of technical planning, the operators only realised one project each of them and had no chance to build a second better plant and the planners did not receive any feedback from technical performance measures of the plant they had built. This led to the fact that after 15 years little progress had been made with respect to critical plant parameters as specific electricity consumption heat losses etc[7]. Only after the most recent study dedicated to system optimisation[8]in 1999 an expert group addressed this issue and agreed upon technical performance criteria that were specified as a type of technical standard (ÖKL-Merkblatt Nr.67). The. performance criteria laid down in this document have to be met as a precondition for receiving a subsidy since 2000. At the same time seminars were offered for planners in which they learned how to meet the new technical standards. These courses were a great success and were attended by a large number of planners. As a result of the reform process all newly established plants have to deliver data on plant-performance on an annual basis for a national benchmarking exercise and to verify, if the new standards are met.

(7)Discussion of Results

Achieved Objectives

The programmes presented in this article were certainly highly successful with respect to the actual implementation of the technology. By 2000 more than 500 BMDH-Plants have been established in Austria. While this is a large number of plants, in terms of energy the contribution is limited.The energy provided by these plants corresponds to less than 10% of the heating energy provided by conventional fuel wood in individual households. Which is in turn about 17% of the whole heating energy-demand of households.

The programmes were also successful in most villages in creating a positive image of heating with biomass. A survey among district-heating-customers shows a very high degree of satisfaction. Another achievement of the programmes was certainly the development of a mature plant technology. However, this achievement took too long to be realised. With sufficient ressources and attention to this issue technological learning could have happend much faster.

Additional income from the forest,a key program target, could be achieved to some extent. However the amount of woodchips from the forest used in BMDH-Plants is below 20% of total fuels used in this plants due to cost-reasons. Most plants use bark and woodwastes from sawmill industry.

Key-elements of Success

Three elements of success can be identified: the provision of significant subsidies, a significant bottom-up interest to realise projects and the existence of focal points, that facilitated technology deployment and project development. Another natural reason for success was the abundance-of cheap biomass in Austria.

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[7] Rakos: see above
[8] Stockinger: see above

Subsidies

The fact that subsidies were not only high (50% of investment costs), but also available in sufficient amount was certainly a key-element of success. Total subsidies available for the development of BMDH rose progressively together with the deployment rate thus anabling a continued development without financial disruptions.An important contribution to the ability to provide rising financial resources was the accession of Austria to the European Union, which allowed access to resources from the regional funds that added considerably to the national and federal state subsidy-budgets.

Focal points for program-management

A key-role of these focal points or “strategic niche managers” has been discussed. They were responsible for preparing feasibility studies, consulting project developers, managing administrative barriers and for facilitating communication between all related players in the technology deployment-process.

Bottom-Up-Interest

Bottom-up-interest in BMDH was a key-driver for the whole deployment process. This bottom-up-interest cannot be explained by a strictly economic point of view as district-heating with biomass was more expensive than conventional heating-systems in most cases. Of course district-heating improves heating-comfort considerably in areas where natural gas is not available. Technological studies have shown that the community-aspect of the project is a very important driver. The project is an opportunity to enhance community cohesion, it adds to the self-respect of the village and can also be an issue of competition between neighbouring villages.

Main-sources of problems

A main-source of problems could be called „disintegrated support-policies“. This means that different parts of the administration were responsible for different aspects of the program on the national and on the state-level. These distributed responsibilities led to gross mismatches of the resources available for subsidies and the ressources, for the operation of the focal points and for evaluation and monitoring. They also led to the lack of integration of deployment-policies and R&D policies. As a consequence the key issue of techno economic optimisation was not addressed for more than 15 years of deployment.

Another interesting-source of problems was created by what could be called “periferal technologies“. In this case the periferal technology is the domestic heating-system that distributes the heat in the house.

The house heat distribution system were often inadequate for connection to a district heating system. Local plumbers were not educated to adapt and connect the “secondary side” properly to the district heating system which led to significant problems, economic losses and angry customers. Later specialised companies were established that adapted these secondary side in most new BMDH projects. An obvious problem for the deployment of the technology were of course the low energy prices during the observed period. Optimistic assumptions that energy prices would rise again created significant problems for many heating-plants that were established under these assumptions. The most recent developments of oil prices improved the economic situation of BMDH plants. Price insecurity

of could speed up a new diffusion phenomenon – so called micro grids. These are very small BMDH projects that are easier to organise as no consensus of the whole village has to be achieved. Typically microgrids suplly heat to a few neighbouring houses or larger buildings.

Impulse Programme: Thermoprofit

Introduction

Thermoprofit is a „trade mark“ for total service packages in order to reduce the amount of energy consumed in the building concerned. Thermoprofit was first conceived as part of the Graz Municipal Energy Concept (Kommunales Energiekonzept KEK Graz) in Austria. Aim of the impulse programme is to disseminate Thermoprofit as a tool for energetic and economical optimisation of buildings. As part of the Thermoprofit-service, a specialised enterprise – the so-called Thermoprofit partner – is carrying out an overall energy related optimisation for the building.

The essential characteristics of Thermoprofit are:

- reduction of energy used in buildings
- economic advantages for owners and users of buildings
- direct or indirect reduction in pollutants and CO_2 emissions
- planning and implementation carried out by a Thermoprofit partner
- Thermoprofit guarantees that energy costs will stay below a defined limit

Thermoprofit contains the key elements of Third Party Financing and Energy Performance Contracting, while being organised in a more flexible way. In particular, Thermoprofit is focused less on advance financing by the contractor. It also includes models in which the ESCO optimises energy use on the basis of either an energy saving guarantee or a performance-based fee, while the owner of the building remains in charge of the financing itself.

While Thermoprofit projects are above all designed for the renovation of existing buildings, they can also be applied to the construction of new buildings. The complete range of possible and economical measures able to produce "Thermoprofit" is examined in every case in order to find the best possible solution in terms of optimisation.

The Thermoprofit model was primarily developed for the owners of larger real properties. The model is profitable for all kinds of public buildings, for residential property developers, banks, insurance companies and businesses from trade and industry.

The Thermoprofit- Project **“Improving the Energy Management of the Jägergrund primary and Webling secondary school in Graz/Austria”** was realised with the innovative Thermoprofit-model, developed by the Graz Energy Agency. It took place in the period from May 1999 till Janurary 2000, when the contractor was commissioned. The measures include the heating system, electrical installations and construction measures as well as motivation and training of the users of the building. The special innovation of the project in comparison to other TPF-projects is the inclusion of constructional measures and the contractual

guarantees for energy savings, comfort parameters and services. The project won the contracting prize „Energieprofi 2000“ from the Austrian federal ministry for the environment. For further details see attachment.

Objectives of the program

With the help of energy services that include financing schemes, obstacles standing in the way of rational energy utilisation can be overcome. At present, however, these innovative models are still largely unknown and their potential is far from being fully utilised. With the impulse programme Thermoprofit the confidence in the functioning of TPF models can be enhanced. The medium-term goal of the impulse programme is to disseminate Thermoprofit as a tool for the energy-related and economical optimisation of buildings. These innovative approaches and solutions are supposed to develop from their current status as model projects into established modes of practice in this field. This will lead to a saving of energy costs, a reduction in energy consumption and environmental pollution, and a stimulation of the regional economy.

A study of the Technical University of Vienna analysed the economic effects of increased energetic renovation through energy services in the city of Graz. In the next 15 years between 600 and 1250 million Euro of investments could be produced. Up to 700 jobs could be created through this market development.

The market development and penetration of Thermoprofit is to be reached via four main strategies:

1. Creation of a Thermoprofit network
2. Thermoprofit information and marketing initiative
3. Support for Thermoprofit projects, provided by the Graz Energy Agency
4. Assistance in establishing framework conditions for the smooth implementation of Thermoprofit projects

Process of definition/design of the program

Thermoprofit was developed within the Graz Municipal Energy Concept. The development of Thermoprofit contained the following steps:

1. Market analysis, conception and development of the programme
2. Development, realisation and documentation of model projects (positive examples)
3. Development of a network with ESCOs (Thermoprofit-Partners)
4. Marketing initiative: Activities for communication and networking to disseminate the developed solutions and to inform potential users and multipliers

5. Competent and neutral support of building owners during preparation and implementation of the project
6. Support of suppliers: standardised project implementation (contracts, bidding procedure), project-controlling
7. Continuous project realisation

Main target groups of the project are:

- Municipality buildings
- Public buildings
- Residential property
- Businesses from trade and industry

The Graz Energy Agency functions as a turntable, competence centre and impetus behind Thermoprofit. It takes care of the promotion, relevant networking activities and evaluation of the programme.

The definition of the programme was worked out by a project-team consisting of representatives of the Chamber of Commerce, the Chamber of Labour, the City of Graz, the Energy Representative of Styria and the Graz Energy Agency.

Main actors and their roles

The Thermoprofit Network consists of suppliers of total service packages – the so-called Thermoprofit partners. Primarily, Thermoprofit partners are prime contractors. They co-operate with regional enterprises in the execution of projects and thus contribute to stimulating the economy of the respective region.

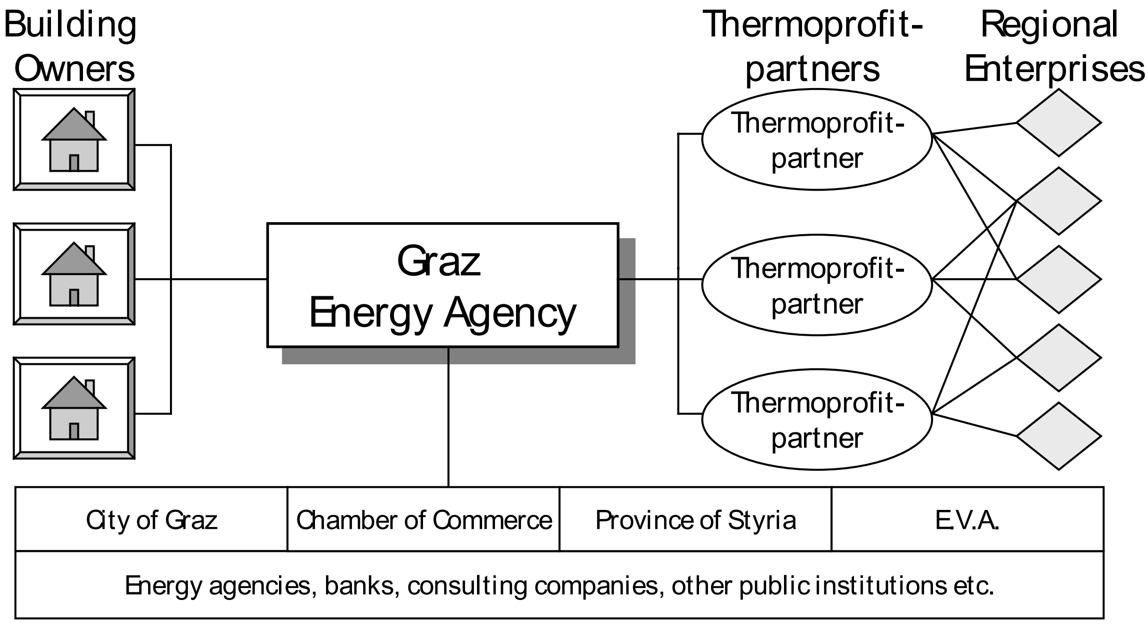
Their special characteristic is that they offer a Thermoprofit guarantee for undisturbed operation, the observance of comfort parameters, guaranteed energy and cost savings, etc. In providing the energy services required, they do not only take on comprehensive tasks on behalf of the user of the building, but also technical and economic risks.

Thermoprofit constitutes a quality label linked to a series of standards to be met by enterprises and their projects. The owners and/or users of buildings are guaranteed reliable high-quality offers. The Thermoprofit label may be used exclusively by Thermoprofit partners who will be evaluated by the Graz Energy Agency in regular intervals with regard to their observance of Thermoprofit standards. This will lead to an increase in confidence by the building owners.

The development and dissemination of Thermoprofit is supported considerably by various public agencies, in particular by the city of Graz and the Styrian Chamber of Commerce (Wirtschaftskammer Steiermark). A close co-operation takes place with a number of further partners at institutional and expert level.

These are the particular goals of this networking:

1. Reaching high quality in Thermoprofit offers and working with competent enterprises
2. Providing rational and cost-effective project handling
3. Successfully implementing a number of Thermoprofit projects
4. Finding qualified enterprises as partners for Thermoprofit



The Graz Energy Agency co-ordinates the network and acts as a turntable for Thermoprofit issues. It is responsible for the project management and in charge of implementing and supporting the required networking and marketing activities.

The Graz Energy Agency is also in charge of evaluation and of preparing the certification of enterprises as Thermoprofit partners. This certification takes place every two years. In order for an enterprise to be certified as a Thermoprofit partner, or to keep its certification, it must fulfil certain conditions and observe certain quality standards in project handling. In the end, an independent committee decides whether the enterprise in question is admitted to the network and certified as a Thermoprofit partner. Certified enterprises are entitled to use the quality label.

Concerning favourable framework conditions the Graz Energy Agency is pointing out barriers for energy services in laws, decrees and subsidy guidelines, mainly on the regional government level, and making suggestions for improvements. In this area the agency is co-operating closely with politics and the authorities on the regional and on the municipal level.

Policy mechanism used

The policy mechanism used by the programme is based on an information campaign. Information and communication activities as part of the impulse programme are primarily directed to private and public owners of larger real properties. These are above all the municipalities, public authorities and institutions at Federal Government or regional level, co-operative building societies, property management firms, banks, insurance companies, business enterprises, etc.

As part of this information campaign, property owners and users are introduced to the way this model works and to the advantages it offers. Completed reference projects are documented and introduced. In order to support property owners in the preparation of projects, they are provided with useful contacts and information and offered concrete assistance in project development.

The Graz Energy Agency is preparing information materials for this campaign (e.g. a Thermoprofit folder providing target group-specific information). In addition, informative events and workshops are organised for the owners and users of buildings and the municipality's representatives in charge. A first focus is put on public buildings, especially on buildings of towns and communities.

The information campaign is supported by the City of Graz and the Chamber of Commerce.

Monitoring and evaluation process

Evaluation factors of the impulse programme are

- Market development: Number of Thermoprofit Projects, investments
- Environmental benefits: reduced energy supply, reduced CO_2 emissions
- High quality energy services
- High quality of the projects (satisfied customers, guaranteed energy savings, quality of energy services, etc.)
- Notoriety and acceptance of Thermoprofit as a trade mark

Concerning the development and realisation of concrete projects the typical procedure of a Thermoprofit-Project is described below.

Development of a Thermoprofit-Project

Responsible	Project Phases
Energy Agency	**1. Data collection and rough energy analysis**

- data collection and evaluation
- rough energy analysis
- estimation of energy saving potentials and investment costs

Responsible	Project Phases
Energy Agency (Building Owner)	**2. Project development**

- Project management, time-table etc.
- Developing the appropriate Thermoprofit-model: financing model, performance, guarantees etc.
- Checking financing options and subsidies
- Conception of bidding procedure and assessment criteria
- Comparison between the Thermoprofit-model and the conventional realisation of the project
- Providing a written report as a basis for the decision by the building owner

Decision Making

Responsible	Project Phases
Energy Agency	**3. Pre-Selection of Qualified ESCOs**

- Preparing a project information
- Public advertising and informing potential bidders
- Evaluation of the documents sent by the ESCOs
- Recommendation of qualified ESCOs to the building owner

Responsible	Project Phases
Energy Agency	**4. Documents for the bidding procedure**

- Deciding on measures and performance to be implemented and on ESCOs to be invited to bid
- Developing the Thermoprofit contract
- Preparing the documents for the call for bids
- Sending the documents to selected ESCOs (approx. 5)

Call for bids

ESCOs

- Working out the bids by the ESCOs

Energy Agency
ESCO
Building Owner

5. Selection of the best offer & contract negotiations

- Providing information during the procedure
- Evaluating and assessing the bids
- Negotiating the bids and the contract with the 3 best ESCOs
- Continuously revising the bids assessment
- Final assessment of the bids and recommendation (report)

Signing the Contract

⇩

Implementation of the project

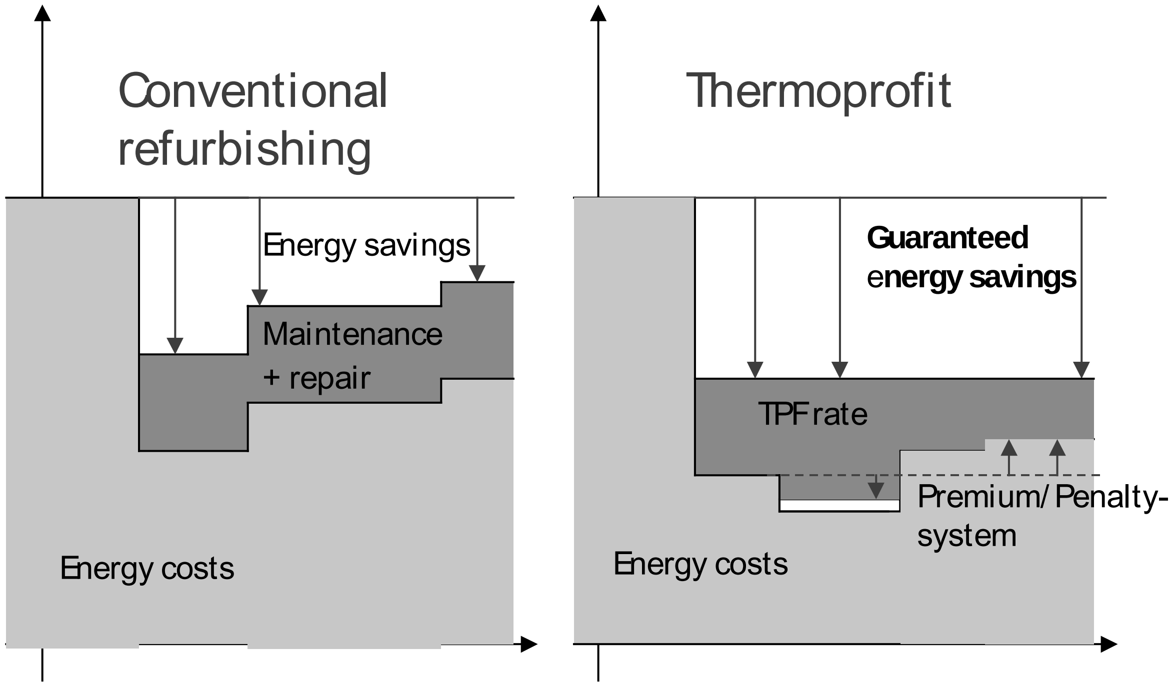
Energy Agency

6. Documentation

- Proposals for an effective project controlling
- Documentation of the project for the public

Within the context of realisation of a project the Graz Energy Agency offers the building owner to carry out the project controlling.

All guaranteed services like annual reduction of energy costs, quality of services and products, maintenance of comfort, realisation of investments to a certain amount, etc. are fixed by a contract. A cost-benefit analysis is performed before the implementation. The financing model is worked out in detail: the realisation of the project with Thermoprofit is compared with a conventional refurbishing TPF-model (see figure below).



Discussion of results

The main activities of the impulse programme have started during 1998 and several materials have been worked out. The Thermoprofit network was presented to ESCOs in June 1999 with the objective to inform about the network and awake the interest of energy contracting suppliers.

The first certification of companies took place in October 1999 and meanwhile 5 big companies are certified as Thermoprofit partners. Further companies show interest to participate.

Several materials like a Thermoprofit map or animated power point presentations to promote the impulse programme were worked out. Through press activities and presentations at conferences and events Thermoprofit was introduced to the public.

An Internet-Platform with information about Thermoprofit was developed. The platform consists a database where Thermoprofit partners can present their company. A database with success stories about Thermoprofit projects is available. Moreover, interactive tools

which give the opportunity to find partners for a project and to exchange information are provided.

At the moment an information campaign especially designed for municipalities is conducted.

Concerning the development of the Thermoprofit network it is sometimes difficult to persuade the ESCOs to accept the quality standards defined by Thermoprofit. In the beginning ESCOs consider it as an interference in their business policy, before they realise their advantages. A standardised quality label enhances the acceptance of customers.

As it appears, a stronger involvement of ESCOs is necessary concerning the working out of regulations and principles for the market and to get feedback on the so far realised objectives. Thus, in a next step a workshop with ESCOs will be organised to discuss the organisation and aims of the network. Further workshops for the exchange of relevant know-how (e.g. legal information about third party financing, etc.) will be prepared. An annual Thermoprofit meeting is planned where all relevant key-actors are invited. This meeting serves as a possibility to exchange information and experiences. Activities of the passing year will be presented and goals for the future will be discussed and worked out.

The initiation of Thermoprofit projects also requires a lot of information work because it is necessary to eliminate the distrust of clients. Customers who already have bad experiences with third party financing because of low quality offers are very sceptical to start new projects.
The Thermoprofit quality standards and guarantees help to reduce the existing barriers. The initiation of new projects is getting easier as first Thermoprofit projects are successfully implemented.

The Graz Energy Agency supports building owners with development and implementation of TPF projects. The main focus is on public buildings, but also interest from the estate market is shown. First concrete Thermoprofit projects, like the above mentioned Energy Management of the Jägergrund and Webling primary and secondary school were carried out. Also a Thermoprofit project for a housing estate including a solar collector system is carried out. All in all about 8 Thermoprofit projects are realised or in preparation:

- Improving the Energy Management of the Jägergrund and Webling primary and secondary school/Graz
- Thermoprofit-Project Walfersam, Kapfenberg: Energetic optimisation of a coliseum and primary school by a comprehensive TPF package
- Solar installation for hot water in the grammar school Oeversee in Graz
- Technical maintenance and service of the town-hall in the city of Graz with a Thermoprofit-model
- Installation and maintenance of the heating and solar system in a dwelling-house (77 apartments) in Graz.
- Redevelopment and energetic optimisation of 3 schools in Weiz/Styria
- Restoration and energetic optimisation of the primary school Thörl/Styria
- Redevelopment of an indoor bath in Leoben/Styria

Other Austrian energy agencies are also interested to co-operate with Thermoprofit and to offer the same kind of services. Currently a franchising system is worked out to form a network of “partner agencies” and to promote Thermoprofit as a joint initiative. Through this system Thermoprofit can get a more than regional importance.

Training and co-operation of the partner agencies is difficult as there is a lack of staff and know-how. Thus, the over-all realisation of Thermoprofit-projects by the partner agencies is sometimes a problem and support by the Graz Energy Agency is required. The sphere of activities of local energy agencies is wide and it is not possible for them to concentrate mainly on Thermoprofit. Also the instructions concerning marketing, promotion, project development of Thermoprofit, etc. are sometimes considered as patronizing. Although the proceedings are discussed with partner agencies and their objections and proposals are considered.

Despite some difficulties modifications of the programme are not necessary so far. Although the programme is still in the development the response up till now is promising and the first objectives were successfully achieved.

CS 3

Canada's Renewable Energy Deployment Initiative

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Natural Resources Canada

Introduction

The introduction should give some initial information on the program name, the country where the policy has been implemented, the technology involved and the sectoral application(s), and the period covered (starting date and closing date, if applicable). A paragraph summarising the reasons why the case study is particularly interesting should also be included.

Suggested length: about ½ page.

The **Renewable Energy Deployment Initiative** (REDI) was launched on April 1, 1998, by Natural Resources Canada (NRCan), the department responsible for energy at the federal level in Canada. REDI is aimed at stimulating demand for reliable, cost-effective renewable energy systems for space and water heating and cooling, with the primary goal of reducing greenhouse gas emissions. REDI is a product of Canada's unique energy situation and international climate change commitments.

Four types of systems are supported under the program: solar ventilation air heating systems, solar hot water systems, high-efficiency/low-emissions biomass combustion systems, and ground-source heat pumps. REDI was introduced as a three-year, $12-million program (all figures in Canadian dollars). However, the 2000 federal budget provided funding to extend the program for an additional three years, until March 31, 2004.

Canada is blessed with abundant and varied energy resources, including conventional oil and gas, oil sands, hydroelectricity and coal. As a result, Canada enjoys relatively low energy prices, stable supplies and a well-established infrastructure for conventional energy sources. This makes it difficult for new contenders – including emerging renewable energy sources – to make inroads in the marketplace.

Canada is also an energy-intensive country because of its northern climate, long distances for moving people and goods, the structure of its economy and its favourable energy prices. On a per capita basis, Canada is a large producer of carbon dioxide, the principal greenhouse gas contributing to climate change. NRCan introduced REDI to accelerate the deployment of low- or zero-emission renewable energy technologies that can displace fossil fuels.

REDI focusses primarily on buildings in the industrial, commercial and institutional sectors, with the expectation that investments in these buildings will have a greater impact (i.e., larger emission reductions per dollar invested) than would be the case in the residential sector. Intervention in the residential sector is more limited and is achieved through pilot projects.

Participants in the program include both representatives from the renewable energy industry who supply heating and cooling systems and their customers. Customers include three distinct groups involved in the procurement decision:

I.engineers, architects and energy service companies (who usually specify or recommend the type of systems to be used);

II.building contractors and construction trades (who install the systems); and,

- building managers and owners (who make the final procurement decision).

A key objective of REDI is to ensure that this “decision-making triumvirate” is knowledgeable about and comfortable with renewable energy systems in order to sustain REDI-induced market growth after the program ends.

Objectives of the Program

Have strategic goals (such as energy security, global climate change, pollution abatement, economic productivity, etc.) been used to define the goals of this technology deployment programmes?

This section should provide information on the stated objectives of the programme, referring to the official documents where these objectives are established, both as general policy objectives and as specific goals. (Example of general objective: reducing carbon emissions from energy sector, as stated in First National Communication to UNFCCC; example of specific objective: installation of 100 MW wind power capacity). Specific barrier(s) to technology diffusion addressed by the programme should also be discussed.

Suggested length: about ½ to 1 page.

The Government of Canada has supported the development and deployment of renewable energy technologies for more than 20 years. This support was triggered by the oil supply disruption of the late 1970s and early 1980s, when federal energy policy focussed on reducing Canada’s dependence on imported oil. Off-oil fuel substitution programs were

viewed as critical to ensuring that Canadians had access to a secure and competitively priced energy supply. As a result of these programs, natural gas and, to a lesser extent, bioenergy experienced increased use in Canada.

With the collapse of world oil markets and the deregulation of Canada's natural gas markets in the mid-1980s, oil and gas prices dropped and the issue of energy security became less pressing. These developments significantly slowed the market penetration of many emerging renewable energy sources, including wind and solar energy. However, over the past decade the global problem of climate change has become a new driver for federal support for renewable energy.

Canada's commitment to renewable energy was reaffirmed in 1996, with the release of NRCan's *Renewable Energy Strategy*. The Strategy is a blueprint for cooperative action with stakeholders to accelerate the development and commercialisation of emerging renewable energy sources and the evolution of a more dynamic and self-sustaining renewable energy industry that will become a leading provider of energy solutions in Canada. This, in turn, will help Canada reduce greenhouse gas emissions and meet its international climate change commitments.

REDI was launched two years later as a component of the Strategy and part of a package of initiatives to help Canada achieve its Kyoto Protocol target of reducing greenhouse gas emissions to six percent below 1990 levels by the period between 2008 and 2012. At the time of REDI's launch, the markets for renewable energy heating and cooling systems were very small, but technology developments and economic intelligence pointed to significant market potential. Nevertheless, REDI is not in itself a short-term answer to the climate change challenge; it is only one element of a long-term Canadian strategy that incorporates a variety of responses.

In addition to responding specifically to the climate change challenge, REDI is consistent with NRCan's corporate vision, which sees Canada becoming a world leader in applying sustainable development principles to all aspects of natural resources development. As well, it will help Canada's thriving energy industry expand into new and growing world markets.

All four types of systems supported under REDI are considered technologically reliable and have been used successfully in Canada and around the world. Furthermore, these systems are considered cost-effective on a life-cycle basis in several important energy markets in Canada. Nevertheless, several barriers and challenges are restricting their rapid deployment, including the following:

III.Prospective customers have limited knowledge about, and experience with, renewable energy systems. Preference is usually given to well-established, off-the-shelf

space and water heating/cooling solutions that are perceived to be risk-free and affordable.

IV.Negative experiences with earlier renewable energy technologies may have tarnished the reputation of certain systems. For example, system reliability issues plagued some first generation technologies introduced in the late 1970s and early 1980s. In other cases, the promised financial savings did not materialize due to the drop in oil and gas prices in the mid-1980s.

V.Some renewable energy systems have higher purchase and installation costs compared to conventional technologies. Building owners in Canada are generally averse to increasing construction budgets unless payback periods are short. Where construction budgets are pre-determined, increasing the cost of the heating system would require cuts in other areas of the project. As well, if an owner does not expect to pay the future operating costs of the building (either because the building will be sold or because costs will be passed on to tenants), there is little incentive to minimize life-cycle costs.

VI.Heating and cooling constitute a relatively small portion of overall building costs in Canada. Owners tend to focus instead on managing costs that are core to their business, such as labour, inventory and key input costs. Unless payback periods are extremely short, there may be limited interest in reducing space and water heating/cooling costs.

VII.Environmental benefits arising from renewable energy systems are usually of no direct value to the building owner. Thus, environmental considerations often have limited impact on the decision-making process, except when the decision makers are willing to take into account non-monetary values.

VIII.The long period of low energy prices in Canada (from the mid-1980s to 1999, with the exception of the oil price spike around the Gulf War of 1990-91) created a climate of comfort with end-users, where little value is placed on moving away from conventional fuels to protect against future price increases.

REDI is working with the industry to address these barriers and challenges and to better position renewable energy to compete with conventional energy solutions in the years ahead.

Defining and Designing REDI

This section should provide information on the process followed to define this specific technology deployment programme and its goals. Have the industry and consumer organisations been involved or consulted in the design of the programme? Have links with R&D policy been taken into account and how? How are policies of market liberalisation and new attention to consumer choice factored in?

Suggested length: about ½ to 1 page

Two separate consultation processes influenced the design and implementation of REDI. Both processes involved key stakeholders from the renewable energy industry, resulting in strong industry support for this initiative.

In the fall of 1996, NRCan and the federal Department of Finance undertook consultations to examine options for improving the treatment of energy efficiency investments and investments providing heating and cooling from renewable energy sources. With respect to renewable energy investments, participants identified a range of impediments and suggested options to overcome them. As a result of these consultations, the Minister of Finance announced in the 1997 federal budget that funding of $60 million ($20 million per year for three years, beginning in 1998) would be set aside for programs to promote energy efficiency investments in commercial buildings and investments in renewable energy for heating and cooling.

Based on the feedback received during the 1996 consultations, and within the overall framework of the *Renewable Energy Strategy*, NRCan subsequently developed a proposal for a new program to address market development issues for the renewable energy industry. In August1997, a consultation document for the proposed Renewable Energy Deployment Initiative was distributed to approximately 40 industry and government stakeholders to seek comments before completing the design of the program. Overall, the proposal was well received and most of the recommendations put forth were addressed in the final program design.

Yet another consultation process – this one involving a broad cross-section of Canadians who provided input on Canada's Kyoto implementation strategy – may result in future changes to REDI. Through this process, which took place in 1998 and 1999, a roundtable of stakeholders considering emission reduction opportunities for buildings recommended that REDI be expanded into other markets and other renewable energy technologies. As a result, some changes to REDI were announced in June 2001 and additional ones may be considered in the future.

Key REDI Participants and their Roles

This section should provide information on who are the main actors involved in the implementation of the policy/programme and what is their specific role. Actors may include Government agencies or institutions, producers of the technology (industry or members of an industry association), users (other industries or consumers via consumer associations) and trade associations (providing technical assistance or monitoring and verification), lobby groups or NGOs.

Suggested length: about ½ to 1 page.

NRCan's *Renewable Energy Strategy* identified the supply industry – generally defined to include manufacturers, distributors and installers – as the main stakeholder to deploy renewable energy systems. With this in mind, REDI has established partnerships with key industry associations, such as the Canadian Solar Industries Association, the Earth Energy Society of Canada and the Hearth Products Association of Canada. These partnerships have been mutually beneficial in that they encouraged industry "buy-in" to REDI while maximizing the program's usefulness to the industry.

REDI and industry associations work together in a number of ways. For example, the associations regularly consult members on the design and implementation of REDI and provide feedback to NRCan. Associations are also invited to participate in the drafting of work statements for market assessment and development studies, the selection of contractors (using the government open-bidding process) and the review of study results. NRCan also engages industry associations in implementing the recommendations arising from market assessment and development studies, providing financial support for this and other work through contribution agreements.

Partnerships have also been developed within NRCan to efficiently and effectively deliver REDI. The program authority (or sponsor) – NRCan's Energy Resources Branch – has contracted specific tasks to other groups in the department while retaining overall responsibility for REDI. For example, program administration and interface with the public is undertaken by NRCan's Office of Energy Efficiency, which manages a related program offering a financial incentive for the design of energy-efficient commercial buildings. Technical expertise for REDI is provided by the Energy Technology Branch, which manages NRCan's research and development programs for renewable energy. REDI officials also work closely with another NRCan initiative, the Renewable Energy in Remote Communities Program, which helps off-grid communities make sound energy supply decisions. Some 300 Canadian communities, mostly in remote northern parts of the country, are not connected to the main North American electricity grid and face high energy costs. These communities have been identified as a promising niche market for on-site renewable energy solutions under NRCan's *Renewable Energy Strategy*.

Although end-users and their associations would appear to be natural partners for a market deployment program such as REDI, little interest has been shown by these groups. End-user associations, including engineering and architectural societies, are generally focussed on broad issues affecting their memberships, rather than on discrete issues of interest to REDI. To date, a successful partnership has been developed with the Federation of Canadian Municipalities, which is one of the first energy end-user groups in Canada to become actively involved in reducing greenhouse gas emissions.

Electric and gas utilities are also recognized as potential partners that could play a significant role in the deployment of emerging renewable energy systems, since these utilities have well- established relationships and high levels of credibility with energy end-users. Several utilities in Canada have developed new lines of business – such as providing space or water heating/cooling equipment or home renovation services – to take advantage of their market position. To support these new lines of business, utilities often offer leasing or financing services, which could facilitate renewable energy projects with higher initial capital costs. Efforts are under way to secure these utilities as partners in the delivery of REDI.

Although the participation of academics and independent organizations in REDI is viewed as useful (e.g., to ensure impartiality and credibility), limited resources are available for this effort. Nevertheless, some success has been achieved. For example, the National Solar Test Facility (NSTF), an independent body that conducts research on solar energy equipment, agreed to review REDI's quality assurance requirements and to propose specific criteria for solar systems supported by the program. This has led to the creation of a committee of government and industry representatives who assess the suitability of proposed solar equipment under the program. The NSTF also tests systems to ensure that they meet REDI's eligibility criteria. In a separate project, work is under way to review and update relevant equipment and installation standards promulgated by the Canadian Standards Association.

REDI Policy Mechanisms

This section should provide, with some detail, a description of the specific policy mechanism used by the programme (e.g.: subsidies, taxes, tax credits, mandatory standards, guaranteed price schemes, information programmes, technology procurement schemes, Government purchase programmes, combinations of fees and rebates, voluntary agreements, etc.). Information is also requested on how and by whom the programme is funded (if funding is required) and on what is the amount of financial appropriations involved from the Government (if any). Mention of other costs (administrative costs, for example), if applicable, would be also helpful.

Suggested length: about 1-2 pages.

Two broad policy mechanisms are used to achieve REDI's objectives: targeted market development initiatives and financial incentives.

The term “targeted market development initiatives” refers to a broad range of activities delivered as part of an overall market development strategy for a given renewable energy system and market. Development and implementation of such a strategy typically involves several steps:

IX. Market Assessment – Detailed market assessment studies are undertaken to define existing markets and identify promising new markets. At the heart of such studies is an analysis of the economics of renewable energy systems compared to conventional solutions. If the studies demonstrate that significant potential markets exist, NRCan may develop and implement a market development strategy.

X. Strategy Development – A market development strategy identifies a course of action to accelerate the deployment of a specific renewable energy system in a given market or set of markets. First, market barriers are identified and analysed (these can pertain to the manufacturers and their supply chain or to the demand side of the equation), and then an intervention strategy is outlined identifying concrete actions and expected results.

XI. Marketing Research – Given the lack of consumer awareness about some renewable energy systems, marketing campaigns are often a key component of a market development strategy. Marketing research may be necessary to guide these campaigns. For example, research on consumer attitudes and motivation in choosing energy systems allows REDI to identify key communications messages and the most efficient media to deliver them.

XII. Partnership Development – Implementing a market development strategy may require the participation of one or more partners. For example, participation of the supply industry is key, and the involvement of other partners may be needed to address specific barriers. Partners may be able to deliver market development activities in a more efficient and cost-effective manner than NRCan.

XIII. Implementation – As a result of the previous steps, a wide range of implementation activities are undertaken by NRCan and its partners, often over a period of several years.

To date, REDI has created market development strategies for ground-source heat pumps, solar water and air heating systems and biomass combustion systems. All three strategies

have focussed on the industrial, commercial and institutional markets. A fourth study is under way on the residential solar pool heating market. All strategies and their related studies are made available to stakeholders to promote transparency and partnerships.

As noted earlier, REDI market development strategies typically involve a range of activities. For example, information campaigns to raise awareness of the environmental and cost benefits of renewable energy systems are a major component of all market development strategies. The information provided ranges from general consumer advertising to detailed technical information for architects and engineers. Many of the documents produced are published by NRCan, which ensures their recognition by end use customers as impartial and of high quality.

Other market development activities are aimed at improving the industry's ability to meet increased demand for its products and services. In this regard, funding is sometimes provided to industry associations to develop and deliver training programs for professionals involved in the selection, design and installation of renewable energy systems. REDI funds have also supported the development and dissemination of a pre-feasibility analysis software tool called RETScreen™. This software allows for an early assessment of the energy performance and cost effectiveness of a given renewable energy project without a large outlay of money by the proponent.

In some cases, REDI market development strategies may involve the use of other policy instruments. For example, the creation or updating of standards – combined with information campaigns to increasing awareness of these standards – can help increase consumer confidence in renewable energy systems and guard against low-quality systems and installations.

Most market development activities are delivered through direct spending by NRCan. When specific activities involve partners such as industry associations, NRCan may seek a funding contribution from the partner. However, given the limited financial resources of these associations, their contributions are often small and of an in-kind nature.

REDI's second broad policy mechanism is to provide financial incentives to eligible end-users for purchasing and installing qualifying renewable energy systems in Canadian facilities. Financial incentives are used for three reasons:

XIV. An incentive can encourage a potential customer to gain experience with a product (especially a new product entering the market), with the expectation that the customer will be satisfied and will purchase additional systems in the future, even in the absence of an incentive.

XV. Financial incentives can help the industry achieve a sufficient number of high-quality installations to demonstrate that the renewable energy system is reliable, cost-effective and environmentally friendly. This will set the stage for further installations after the incentive has lapsed.

XVI. An incentive artificially decreases the price of systems, providing shorter payback periods for customers and increasing demand for the system. This increased demand, sustained over a period of time, should allow the industry to optimize its production and distribution practices and achieve economies of scale. Eventually, this should lead to price reductions that offset the phase-out of the financial incentive.

REDI incentives are provided in two ways: a general *REDI Incentive* is available to a list of qualifying recipients for eligible systems; and pilot projects are undertaken in specific markets not addressed by the general incentive.

The *REDI Incentive,* initially offered to business customers and later extended to institutional clients as well, offers a financial contribution of 25 percent of the cost of purchasing and installing a qualifying system in a Canadian facility, to a maximum of $80 000 per installation. Ground-source heat pumps are not eligible for this incentive, because the industry had instead requested a stronger focus on marketing activities.

To qualify for the incentive, systems must meet detailed terms and conditions, including strict quality criteria for the system hardware and installation. In the case of biomass systems, an emission standard must also be met. Where the system is purchased and installed under an energy performance contract, the energy service company may receive the incentive.

The *REDI Incentive* is also available to departments and agencies of the federal government. As Canada's largest enterprise, the federal government represents a promising market for the renewable energy industry. Furthermore, federal leadership in implementing sustainable development practices in its own operations is another means to encourage the use of renewable energy systems. The availability of the incentive is being promoted through NRCan's Federal Buildings Initiative, which promotes energy efficiency retrofits of federal facilities through the use of energy performance contracts.

With respect to incentives for pilot projects, REDI has initially focussed on small-scale pilots for domestic solar hot water systems. A call for partners interested in managing such pilots has resulted in three projects being launched in specific geographical areas. These pilots are being delivered by local non-governmental organizations closely associated with municipal governments. Additional domestic solar hot water pilot projects are being negotiated. REDI will also consider pilot projects in other markets and considers unsolicited proposals for incentives on a case-by-case basis. Criteria for approval include the level of awareness generated by the project and the potential for replication.

Monitoring and Evaluation Process

This section should contain information on what processes and mechanisms, if at all, have been put in place to monitor the implementation of the programme and to evaluate its outcome. Hence information requested concerns the main actors or institutions involved in the monitoring process, the existence of "checkpoints", the existence of feedback systems designed to adjust the programme to changing or unforeseen conditions. Further information is needed on both the ex-ante and ex-post evaluation process: e.g. whether it is designed into the programme (e.g. a cost-benefit analysis is performed either before or after the implementation), who are the subjects performing the evaluation, what are the criteria for the evaluation, and whether there are explicit ways to incorporate learning from that experience into new programmes. It would be interesting, for instance, to know whether, due to these review mechanisms a program has been changed in mid-course.

Suggested length: about 1-2 pages.

At its inception, a broad range of performance indicators were identified to help evaluate REDI's impact. However, since REDI was the first government attempt to stimulate the market for renewable energy heating and cooling systems since the oil and gas price collapse of the mid-1980s, no specific targets were announced. The program authority also recognized that performance measurement could be difficult in the short term because several years will be required to fully implement REDI's market development strategies. As a result, their true impact will be felt only in the medium term.

Nevertheless, various mechanisms have been developed to allow financial auditing and performance measurement of REDI. These include a detailed database that documents the receipt and processing of applications for the *REDI Incentive*. As well, a financial audit was performed during the second year of REDI (at the request of the program authority) to determine whether the program incorporated all the features needed to ensure proper financial administration. The audit report was generally positive and was posted on NRCan's web site at http://www.nrcan.gc.ca/dmo/auev/Reports/Redi/index_e.html. The program authority developed a plan to address the auditors' recommendations.

During REDI's third year, recipients of a financial incentive and suppliers of renewable energy systems were asked to complete a detailed questionnaire about the first two years of the program. The purpose of the questionnaire was twofold: to measure the level of customer satisfaction with renewable energy systems, and to provide feedback on the program itself. The questionnaire, with a response rate of about 50 percent, proved to be useful in identifying minor issues with a few installations which NRCan is addressing. A shorter survey is being developed to obtain timely feedback on system performance.

Also in REDI's third year, a formal evaluation of the program was performed by an external contractor. The objective was to gather information on the key results achieved by REDI over its first two-and-a-half years and to help NRCan make decisions on the future direction of the program. Information was gathered through a review of program files; analysis of relevant publications and research; and structured interviews with program staff and a random sample of incentive recipients for each system type across geographical areas. The evaluation was generally positive and contributed to the renewal of the program for a further three years (until March 31, 2004). A plan has been developed to address recommendations in the evaluation report.

Finally in regard to monitoring and evaluation, NRCan has produced two year-end reports for REDI stakeholders describing activities implemented under the three market development strategies and listing the recipients of the *REDI Incentive*. A third report being prepared for 2000-01 will include statistics on the financial value of systems installed, their energy contribution and estimates of greenhouse gas emission reductions.

REDI's Results to Date

This section should focus on the evaluation of the results of the programme. In particular, whether the objectives of the programme have been attained, whether the results can be and have been quantified, what are the direct (on deployment of the targeted technologies) and indirect impacts (reduced GHG emissions, increased industrial competitiveness, job creation, etc.).

This section should also give an overall evaluation of the policy or programme under examination and discuss the key elements of its success or the main sources of problems and failures (at least three failures/weaknesses and as many as wanted strengths or positive elements should be mentioned). The dynamic relationship among the parties involved in the programme implementation is probably a key element to be analysed here.

Suggested length: about 1-2 pages.

REDI' first three years have been deemed a success by major participants and evaluators. Early implementation of the market development strategies and aggressive, targeted advertising of the *REDI Incentive* have created awareness of, and interest in, renewable energy options for space and water heating and cooling. One industry representative was of the opinion that advertising the incentive under NRCan's name in recognized business and engineering magazines may have had a bigger impact with customers than the incentive itself. Architects and engineers have also been targeted through presentations on REDI and RETScreen™ at trade shows and training sessions.

Nevertheless, the REDI evaluation report noted that a large percentage of architects, engineers, builders and other target groups remain unaware of the program or of options for using renewable energy. Given that three years is a short time frame for achieving major impacts on the marketplace, REDI should be considered a "work-in-progress." The program's extension for an additional three years will result in greater awareness and increased deployment of various renewable energy systems.

As noted earlier, ground-source heat pumps are not eligible for the *REDI Incentive*; instead, work has focussed on developing and implementing a market development strategy for these systems. A key element of this strategy is to establish a national coalition comprising representatives from various levels of government, the supply industry and electric and gas utilities. This approach, which has been successful in the United States, will allow Canada's ground-source heat pump industry to take advantage of the utilities' financial viability and customer networks. Given the cost effectiveness of ground-source heat pumps in many markets (based on life-cycle costing), utilities can earn significant revenues from these systems by providing leasing or financing services to customers. Efforts to build a national coalition in Canada have been well received by several major utilities, and the coalition is expected to be in place later in 2001.

Although REDI has increased awareness of renewable energy systems, this has not yet resulted in significant growth in overall sales. This is particularly true for the first two years of the program. Anecdotal evidence indicates that, compared with pre-REDI years, some suppliers realized a twofold increase in sales in the first two years of the program, while others experienced only a marginal increase in sales. The situation changes significantly during the third year, when momentum generated by the increased awareness is reflected in both the number of applications to REDI and the number of projects that received contributions. In fact, more projects were funded in the third year of REDI than in the first two years combined. Similarly, the number of projects funded in the fourth year of REDI is expected to exceed the total for the first three years combined.

It should be noted that there is usually a significant time lag between the receipt of an application, which demonstrates a customer's intention to install a qualifying system, and the provision of the incentive, which is made only after the system has been installed. This reflects the time required to secure financing, obtain permits and approvals, select an architect and builder, and install the system. This process can take more than a year. This is viewed as another indicator that REDI's extension until 2004 will result in progressively more installations under the program.

Although REDI has received applications from almost all parts of Canada, the program has generated interest in two provinces in particular: Quebec and Ontario. Notably, these provinces experience higher natural gas costs because of their distance from production areas in the Canadian west (natural gas is the fuel of choice for space and water heating in most parts of Canada). In fact, the recent increase in natural gas prices in Canada may provide yet another boost to the deployment of renewable energy systems. Rising prices are expected to encourage consumers to consider renewable energy alternatives, given their lower and more predictable operating costs.

The market readiness of the renewable energy systems supported by REDI, together with their general environmental appeal, have been key elements behind the program's success. The ability of some industry members to include the incentive in their sales approach has

also been a factor. However, REDI's impact could have been greater if the three market development strategies had been developed and implemented more quickly. Delays were due in large part to limited human resources at both NRCan and its partner industry associations. Although outside contractors have been used to do much of the work, the efforts required by NRCan and association staff have proved more substantial than anticipated.

For more information on Canada's Renewable Energy Deployment Initiative and renewable energy in general, contact Richard Godin, Senior Advisor, Renewable Energy Policy, Telephone (613) 992-9845; E-mail address: rigodin@nrcan.gc.ca

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CS 4

Energy Labelling in Denmark

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Introduction

The name of the scheme is Energy Labelling in Small Buildings. The scheme is implemented in Denmark, but some other countries have implemented or are implementing similar labelling schemes based on the Danish experiences.

The Danish energy labelling is mandatory in all new and existing buildings of less than 1.500 m² used as residences, public institutions, private service or trade. Buildings used for production and buildings with very low energy consumption are not included. The most important target groups for the scheme are one-family houses and owner occupied flats.

The energy labelling is based on an energy audit made by an approved consultant, typically an architect or an engineer. The energy labelling must be made by the seller before sale of property, and it must be available before the sale. The labelling results in two different papers:

- *an Energy Label* including information on consumption of energy and water compared to other buildings with a similar use
- *an Energy Plan* including proposals for improvements and documentation for the labelling.

The energy labelling of small buildings is an important part of the overall Danish energy policy to meet the targets from Rio and Kyoto called *Energy 21.* The energy labelling was implemented January 1 1997. The scheme is still running and no closing is planned.

The energy labelling is important because it is a way to achieve energy savings in existing buildings. In most European countries existing buildings built before high requirements for insulation were implemented are a very large part of the building stocks. These buildings can not be addressed by traditional initiatives such as Buildings Codes or Improved Building Standards and the potential for energy savings in existing buildings are huge.

There is another scheme in Denmark concerning large buildings called Energy Management in Large Buildings but it is different in many ways and is not included in this paper.

Objectives of the program

The energy labelling scheme is a part of the overall Danish policy to reduce the emission of greenhouse gases and especially is an important part of the policy to reduce the energy consumption in existing buildings.

It is a long term initiative because a large new potential for energy savings is identified every year and because most of the savings have a long technical lifetime and many will even last until after 2030 without any additional costs.

The energy labelling of small buildings is based on a national Danish act from 1996*, Act to promote energy and water savings in buildings*. The act also gives the rules for the Energy Management in large Buildings, special rules for public buildings and rules for maintenance schemes for heating systems or other large energy consuming installed devices.

When the Act to Promote Energy and Water Savings in Buildings was laid down in 1996 the yearly energy savings and consequences for environment each year were expected to be:

- 4 - 6 PJ Reduction of Heating in 2005
- 300 – 600 GWh Electricity saved in 2005
- 5 – 10 million m^3 Water saved in 2005
- 0.6 – 0.8 million tons of CO_2 pr. year in 2005
- 2 – 3 % reduction of total Heating and Electricity Consumption in the included sectors

The yearly energy saving obtained by the scheme will be increasing year by year because new buildings will be labelled every year. Nearly half of these reductions are expected to come for the energy labelling in small buildings.

In addition to the saving of energy and less environmental impact the energy labelling has a positive impact on local employment because energy savings in buildings in general requires a large amount of local work.

Process of definition/design of the program

The energy labelling in small buildings in Denmark was developed in the context of a long history of energy auditing activities, including the Heat Consultant Scheme which was in power from 1982 – 1996. The development of the energy labelling was based on a need to improve and modernise this scheme.

The energy labelling was developed by the Danish Energy Agency in close co-operation with some private consulting companies. Repesentives for consultants, consumers, real estate salesmen and other bodies took a small part in the development of the scheme.

When the scheme came into force in 1997 it was exposed to a lot of critics from different sides, for instance because the consumers and the professional users wanted more information, found the labelling to colourful and found that some of the calculation rules were wrong. The Danish Energy Agency decided to redesign the formula for the labelling and to change some of the rules for the labelling. This new design was done in the period June 1997 to June 1998, and it was done in close co-operation with all major groups with interest in buildings sale and labelling, this includes representatives for consumers, lawyers, real

estate sales agencies, architects, engineers, handicraftsmen, the finance sector and experts in communication and experts in different parts of technology in the labelling.

As a result of this work a totally different labelling form was introduced in July 1998, with far more information on the actual building and heating installation, much new and additional information to the consumers in the labelling, some assumptions used by the labelling and many specially made conclusions and remarks from the consultant in each labelling. Some of the rules for calculating consumption ware changed as well, for instance the way a cellar or special equipment in the building was treated.

The new scheme came in act into power in July 1998 and was well received by consumers and all the important professional users of the labelling. Especially the faith in the labelling was improved and the total amount of information was better accepted.

Main actors and their roles

The overall administrator of the scheme is the Danish Energy Agency, part of the Civil Service of the Danish Government. All major rules for the Energy Labelling of Small Buildings are given by the Danish Energy Agency. But a special council for the energy labelling is established and all the decisions on approving consultants, control of the quality, education of consultants, handling of complaints from consumers etc. are made by this council.

The council has a special secretary, which is placed at the Danish Technological Institute. The secretary is responsible for the actual training course, the information for the around 800 consultants and for the collection and validation of data from the labelling, because all labellings must be reported. All costs for the secretary and the budget for the council are based on an administration fee paid by the consultants.

The members of the council for the energy labelling are representatives for different organisations or bodies of Consumers, Real Estate Salesmen, Lawyers, Engineers, Architects, Tradesmen, Assurance companies and Power Production and representatives without vote from the Ministry of Energy & Environment and the Ministry of Building & Construction. A representativ for Danish Consumers Council is the President of the council.

The energy consultants play a very important role in the scheme as the persons, who actually carry out the labelling. In order to be approved as an energy consultant the consultant must be a trained engineer, architect, construction designer or the like and must have at least 5 years documented, relevant experience in building technology and energy consultancy. The consultants must have a compulsory professional liability insurance and must have taken the admission course for the Energy Labelling Scheme and must have passed a special test.

Other professional groups are also taking a part in the implementation of the energy labelling and the information about the rules. For instance the real estate agencies have an obligation to tell both the selling part and the buying part about the rules for the labelling. But other groups such as banks and lawyers have been used as carriers of information to the consumers.

Policy mechanisms used

The scheme is mandatory and the major target is to give information to the buyers on the energy consumption and the possibilities to save energy and water. The information has to be drawn up on a standardised form and the information can be separated in three different parts with a different function.

The Energy Label is one page and it includes a standardised energy rating or labelling of the building containing information about the energy and water consumption and the CO_2 emission compared to other buildings with a similar use. The energy label also contains information on the expected total energy and water consumption in the building in a reference year (average of 25 years) and the energy costs in this particular building. The

use of energy and the costs are calculated under normal conditions concerning behaviour, use of building and a typical family size, from the registration of building parts and the heating system etc. The aim of the energy label is to make the consumers more aware of the energy consumption when buying real estate because the energy costs will be a large part of the future costs.

The energy plan for the building including proposals for profitable saving possibilities for all types of energy and water use in the building. Furthermore the energy plan shall include an estimate of the necessary investments and annual savings of the proposals. The plan also gives information on the estimated technical lifetime of the proposals. This information should give the consumer a possibility to calculate how profitable the individual proposals are under a given financing. The aim of the plan is to promote energy savings in the building and to give the new owner possibility to select the most interesting savings.

Information as documentation of the labelling and the energy plan. The documentation contains information on the present state of the building, the heating system, the use of energy under the present owner, information on the expected use of the building and typical conditions such as price of energy, heating, size of household etc. The aim of the documented information is to give credibility to the labelling and to the plan and to give further information on the present building condition which are important for the buyer.

The general rules for the scheme are given in the Act to Promote Energy and Water Savings in Buildings from June 1996 and the two Executive Orders on Energy Labelling etc. in Buildings and on Fees and Liability Insurance for Energy Labelling in Buildings from September 1999.

The specific rules for the energy audit, the calculation and the proposals etc. are given in the Energy Consultants Handbook which is a quality manual for the energy labelling of small buildings. The calculation of the use of energy is based on standards for calculation on heating needs in buildings and specific developed rules for energy efficiency in the heating system and for the calculation of electricity and water consumption in small buildings.

For the education of the consultants a special training course is used. The consultants have to follow a yearly additional training course on 1 day and at least four times a year the consultants receive a newsletter telling about new rules, clarifications, frequently asked questions and general information of the development of the scheme. The information for the consultants are based on experience from the quality control, reported energy labelling and technical research and development.

The quality of the labelling is inspected in a special quality control system including new labelling of some of the buildings chosen by a random selection, visual control of some of the labelling forms, new calculation of the consumption etc. Consultants who don't meet the quality of the labelling will lose their registration.

Complaints about the energy labelling of a building are treated by the council of the energy labelling of small buildings and the secretary. If larger failures are identified the consultant has to provide a new labelling and can be held responsible for economic losses by the owners. If the consultant doesn't meet the requirements the council can withdraw the registration or can make additional quality inspections.

The energy consultants have to be insured with a liability insurance, which can cover losses made by a failure or wrong information in the energy labelling or energy plan. The insurance must be kept in force at least 5 years after the labelling. There are maximum prices for the energy labelling of a typical one family house but the consultants are in a competition for lower prices.

In addition to the information given to the consumers on the energy labelling and the energy plan there is additional standard information material, for instance in brochures. A new

Internet site giving information in accordance to the measures in the energy plan and giving good advice when carrying out the energy savings is under construction and will be operating by the end of 2000.
Professional parties in financing and sale of real estate are used to pass on information to the consumers. For instants real estate salesmen have to give information of the rules for the energy labelling whenever they sell a building.
All the costs for the energy labelling, the energy audits and for the administration of the scheme is paid by the consumers. People selling their house have to pay the consulting engineer or architect for the energy labelling, including the energy audit and the necessary calculations. The typical price for the labelling of a one-family house is 2.000 – 3.500 DKK or 300 – 500 EURO. The consultant pays an administration fee of 100 DKK or 12.5 EURO for each labelling for administration costs and a yearly fee for being registered as a consultant. The total yearly costs for the administration of the scheme paid by the consumers are 5 – 6 million DKK or about 750.000 EURO.
All the costs for developing the scheme were paid by Danish Energy Agency as a part of the national budget, and the Danish Energy Agency provides the consumers with all additional information on the labelling scheme and additional information on the proposed energy savings.

Monitoring and evaluation process

Every energy labelling must be reported to the secretary of the council for the energy labelling, this includes the date, information on the building, the information registered by the audit, most of the calculation results and all proposals from the energy plan including investment, estimated saving and the proposal. All data are registered in a database and are controlled on receipt by the secretary. Labelling data not meeting the requirements or suspicious data are investigated further.

The data in the database are on regular basis used to calculate the number of labelled buildings and it is compared to the buildings sold. The data are also used to calculate the number of proposals, the investments and the possible savings and a lot of other information from the scheme.

The quality assurance system is designed to identify the general situation of the labelling and to identify special problems in the labelling. The general status and the problems are used for information to the consultants in training courses or in the regular information letters. Whenever it is necessary additional training or additional control is carried out.

There have been made several quantitative and qualitative investigations on the consumers acceptance of the scheme and the number of measures carried out and investigations of the barriers for the use of the scheme and for carrying out the energy savings. The results have been used for improvement of the scheme.

A large evaluation of the energy labelling of small buildings is going on until the end of 2000. The aim of the evaluation is to find out whether the goals for the scheme are reached until now, how many savings are actually carried out, to find possible barriers for the full implementation of the scheme and to propose possible improvements of the scheme and if necessary to propose needs for further information on the energy labelling or on the energy plan. The evaluation is done by a large consulting engineering company and some experts in communication (PR) etc.

It is expected that the evaluation will lead to further improvement and development of the energy labelling of small buildings.

Discussion of results

Until now the known results of the energy labelling in small buildings are:

- 45 - 50,000 labelling each year
- nearly 70 % of all one family houses are labelled when they are sold
- in all more than 160.000 buildings or more than 10 % of all one-family houses in Denmark has got an energy label in the first 3½ years of the scheme
- in 1999 energy savings for more than 1 billion DKK or 130 mill. EURO was identified
- the result of implementing all the possible savings would be nearly 150 mill. DKK or 20 mill EURO lower annual energy bills for the consumers
- on average the one family houses could lower their energy costs with about 20 %
- 26 % of the owners of labelled houses tell that they have implemented energy savings shortly after buying the house and an additional 22 % tell that they are planning to do investments from the plan in the near future

The evaluation will give more information on the obtained results.

Problems:

A large problem in the scheme is that the person who sells a house has to order the energy labelling and has to pay for the labelling and sometime gets a negative impact of the energy labelling. If the labelling results in a low rating of the building and the energy plan includes many proposals the energy labelling can reduce the price of the building.

It is difficult to let the buyer, who has the major interest in the energy labelling, pay for the energy labelling because often more buyers are in competition and they would either have to make a common agreement or they have to make several energy labels of the same house.

Many real estate salesmen feel that the energy labelling gives additional work to selling a house and in some cases the labelling even has to be paid by the salesmen out of the total fee for selling the house.

It is a problem for the labelling of houses that two of the important shareholders who plays an very important role in the ordering of the labelling in some cases has a very small or even a negative value of the energy labelling.

To overcome this problem there is a special rule giving, the buyer has the right to have the energy rating and an energy plan drawn up at the expense of the seller if this takes place within a reasonable space of time. But it can only be used if the buyer, who is not be informed about the buildings energy labelling and energy plan before agreement to sell has been reached and the owner, on demand, has not handed over the energy rating and energy plan.

Forces:

The energy labelling scheme has identified a large energy saving potential in existing buildings. Energy savings witch would be difficult to identify in other ways.

The energy labelling scheme is a very large source of information on the present building stock in Denmark, because data from more than 40.000 one family houses are reported

every year. This information can be used in monitoring and evaluation of other initiatives and can be used to identify possible savings and measures such as general information etc.

CS 5

DIESEL ENGINES FOR COMBINED CYCLE POWER GENERATION

WTFI/Gösta Liljenfeldt 22.10.2000

Introduction

Engine building has long traditions in Finland. Actually, engines have been built in this country already before the nation became independent. Today, there are two Finnish companies continuing this tradition: Sisu Diesel and Wärtsilä Corporation. Of these, Sisu Diesel specializes in high-speed engines for tractors, combined harvesters, military vehicles and other mobile applications. Wärtsilä – the short name for Wärtsilä Corporation - is today in the global aspect the leading manufacturer of medium and low speed diesel and gas engines for marine and stationary applications.

Up to the end of 1980's, Wärtsilä's activities were totally dominated by manufacturing and sales of marine engines. However, throughout the second half of the1980's and the whole of the following decade intensive work was laid down into creating a wider business basis by the development of manufacturing and sales of engines and equipment for power stations operating on diesel and gas fuels. With this investment Wärtsilä has in an essential way contributed to the fact that diesel and gas engines all through the 1990's have become increasingly popular as prime movers for power plants with electric output from a few megawatts up to 200 … 300 MW.

One could claim that Wärtsilä went ashore with nothing but marine equipment when they first entered the power plant market. The engines that were sold to power customers were on the whole identical to those used in ships and other marine installations. There were only minor application details that were adjusted according to the special conditions and requirements of power stations. A significant potential for specializing was recognized, and the decision to develop a "real power plant engine" was taken in 1994.

In the following the ongoing product development process aiming at the realisation of a "real power plant engine" is shortly described. The intention is to deal with the development of an engine especially adapted to be used as prime mover in large single cycle as well as in combined cycle power plants with electrical output up to 300 MW. The program was initiated in 1995 and has at the moment this is being written reached the demonstration and verification phase.

The case study is of general interest as it does not only cover the development of a special product but also the introduction of new technology as well as the demonstration of functionability of this technology in a commercial application/environment.

Objectives of the program

Today and with access to all the facts and knowledge that have appeared during the process, one could easily claim that special attention was paid to the environmental and climate factors when the program was first drawn up. Anyhow, to do so would be nothing but a reconstruction of facts and thus no such claims will be presented in this context! Due to the fact that Wärtsilä is a privately owned enterprise for which profitability to a very large extent is the primary value and goal of all activities, it is natural that the business economy point of view has played a decisive role in the setting of the program goals. If the outcome of the efforts for whatever reason is a product not only corresponding to the set program goals but also fulfilling the high environmental requirements, etc., is quite another story!

The main objectives of the program are

1. to create a diesel engine concept – the HOT COMBUSTION concept - specially adapted to the conditions prevailing in power plants in general and in combined cycle diesel power plants in particular
2. to create a diesel engine – the REAL POWER PLANT DIESEL ENGINE – which is a competitive alternative to the diesel engines' main competitors i.e. the gas turbines as prime movers in both single cycle and combined cycle power plants
3. to verify the validity of the engine concept as well as the performance of the real power plant engine in a demonstration power plant

The medium speed 4-stroke diesel engines that enabled Wärtsilä to gain significant shares of the power plant market during the late 1980's and especially during the 1990's were more or less identical to the engines delivered for marine applications. A characteristic feature of these engines is that they are "outstanding" among the thermodynamic engines when it comes to the ability to transform fuel energy into mechanical work. With the largest medium speed diesel engines existing today, a thermal efficiency of over 47 % is achieved. Thanks to its high efficiency, the marine diesel engine is well fitted to be used as prime mover in a single cycle power plant.

Like all the other thermodynamic engines, a diesel engine generates not only useful power but also some waste heat. In a diesel engine the waste heat leaves the engine with exhaust gas and coolant flow as well as via convection and radiation from the surfaces of the engines. Unfortunately, the total amount of waste heat carried by the coolant is unproportionally high. In combination with the fact that the exhaust gas temperatures of a modern diesel engine seldom exceed 350°C, this makes it, if not technically complicated, at least less cost effective to recover a competitive amount of heat out of the waste heat flow for generation of secondary useful power, e.g. in a steam circuit. The adaptation of a diesel engine to the conditions of a power plant must therefore primarily be directed to refining and/or re-distributing of the diesel engine waste heat flow. Of course, this development must

not have a negative impact on the otherwise eminent engine performance in single cycle applications.

From the maintenance point of view, it is essential that a power plant is built up of a reasonable amount of prime movers/power units. This means that conventional diesel engines with cylinder output seldom exceeding 1000 … 1500 kW become a less attractive alternative as the power plant output increases. Therefore, the development of the REAL POWER PLANT DIESEL ENGINE must result in a product that gives a higher unit output than the present day power plant prime movers do. All the same, the engine with a higher unit output must still be transportable, meaning that the engine weight should not create an obstacle for transportation of the engine with the available transportation methods and along common transportation routes.

To enable a credible verification of both the HOT COMBUSTION concept and of the performance of the new engine, the demonstration plant must comprehend all the features that can be expected to be present in a full-scale power plant. This means that the demonstration plant must have the equipment needed for heat recovery and generation of secondary mechanical power. In addition to this, the plant must be equipped with the necessary equipment for exhaust gas cleaning.

It is unavoidable that the erection and operation of a model plant of this kind creates significant costs. Thus it is of high importance for the plant economy to be able to sell the products, in this case electricity and district heat. Access to the local distribution networks for electricity and district heating has to be secured in one way or another. One natural way of doing this is to establish a co-operation with the local power and district heat producers and distributors.

Process of definition/design of the program

As this case study deals with a technology deployment program primarily carried out by a privately owned company, Wärtsilä Corporation, it is only natural that the process for definining and drawing up of the program follows the routines established within this company. The needs of a special, power-plant-adapted diesel engine with high unit/cylinder output have been identified by those parts of the Wärtsilä organisation that are in direct daily contact with customers and end users. In this particular case, Wärtsilä's Power Plant business unit has identified the needs to update the company's power plant engine portfolio.

Wärtsilä's Technology unit has been responsible for creating a detailed specification for the novel engine concept as well as for THE REAL POWER PLANT DIESEL ENGINE. Both the specification and the implementation plan of the program have been drawn up in close co-operation with Power Plant, Service and Manufacturing units.

The decision to carry out the technology deployment program was made by Wärtsilä's top management.

Main actors and their roles

Public institutions, national research institutes, component suppliers and end users are represented among the actors that have contributed to the implementation of the technology deployment program THE REAL POWER PLANT DIESEL ENGINE besides the main actor, i.e. Wärtsilä. Among the public institutions the following can be mentioned:

- the European Union, Directorate-General XVII, Energy has participated in the financing of the presentation/demonstration power plant

- the Ministry of Trade and Industry of Finland has likewise participated in the financing of the presentation/demonstration power plant

- the Ministry of Finance of Finland has contributed to the coverage of operational costs of the demonstration power plant by awarding the owner of the plant tax reduction for fuel used for district heat production

- TEKES, the Technology Development Centre of Finland, has participated in the financing of the development work of both the HOT COMBUSTION concept and "THE REAL POWER PLANT DIESEL ENGINE"

Research institutions:

- VTT Energy, which belongs to the Technical Research Centre of Finland, has contributed to the realisation of the program both with theoretical evaluation of the HOT COMBUSTION concept and the initial testing ("small scale tests") of an engine built according to the this concept

- Helsinki University of Technology has, within the framework of a parallel project, developed and carried out engine tests with components designed for and adopted to the requirements prevailing in an HOT COMBUSTION engine

Among the industrial enterprises participating in the technology deployment program the following should be mentioned:

- Wärtsilä Corporation, the main actor in the development of the HOT COMBUSTION concept and THE REAL POWER PLANT DIESEL ENGINE. The company has, in

addition to this, participated in the building of the demonstration plant and is today one of the owners of this plant.

- ABB Power, today a part of the Alstom Power organisation, that has delivered equipment to the demonstration power plant and also become a partner-owner.

- a big number of engine and power plant component and equipment suppliers, including morethan 50 different companies, that can be classified as SME's. These companies have assisted in the program with, among others, their special know-how about new technologies that have been introduced when developing the HOT COMBUSTION concept

Two companies, which in this context belong to category "users" and which have contributed in a significant way to the realisation of the program, are:

- Vaasan Sähkö Oy/AB, a local electricity distribution company and also one of the owners of the demonstration power plant

- Etelä-Pohjanmaan Voima Oy, a regional power producer and also one of the owners of the demonstration power plant

Policy mechanism used

In order to facilitate the monitoring and the control of the progress of the development process, a four-step method has been found useful. The program has thus been divided into four sub-programs as follows:

1. Evaluation of the feasibility of the novel engine concept, i.e. the HOT COMBUSTION concept
2. Verification of the novel engine concept by means of “small scale tests” carried out in VTT Energy’s and in Wärtsilä Corporation’s engine laboratories

3. Design and realisation of THE REAL POWER PLANT DIESEL ENGINE

4. Erection and operation of a 38 MW diesel combined cycle demonstration power plant

When executing the individual sub-projects, public product development support has been used whenever possible. Consequently, the Technology Development Centre of Finland, TEKES, has so far funded the development and the evaluation of the feasibility of the HOT COMBUSTION concept as well as the development of THE REAL POWER PLANT DIESEL ENGINE with totally xxxx MEUR.

The European Commission has via its Thermie A program contributed to the erection of the demonstration power plant with x MEUR. The same activity has been funded with xxx MEUR by the Ministry of Trade and Industry of Finland.

The company, that has been founded to take care of the building and operation of the model power plant, has been awarded tax reductions by the Ministry of Finance of Finland. These tax reductions are applicable to the fuel that is used for district heat production. In this way, the Ministry of Finance helps to reduce the net operation cost that otherwise totally had to be carried by the owners when, to keep the plant in operation, the products must be sold to prices that do not fully cover the costs for the production of district heat and electricity.

The erection and operation of an expensive demonstration power plant can only be justified with the provision that it is in one way or another guaranteed that it is possible to operate the power plant over a longer period of time. This means that a primary requirement is that a market really exists for the products, in this case district heat and electricity, and that the power plant has access to this market. In this case, this market has been secured by inviting the local and regional distributors and producers of electricity and district heating into a shared ownership.

Wärtsilä, the main actor of the deployment program, owns 49 % of the Wasa Pilot Power Plant Ltd, i.e. the company that was founded for the erection and operation of the demonstration power plant. The remaining 51 % are equally distributed between ABB Power, Vaasan Sähkö OyAb and Etelä-Pohjanmaan Voima Oy

Monitoring and evaluation process

To the extent that the technology deployment program has been executed as a part of Wärtsilä's activities, this company's established routines for monitoring and evaluating of the progress of a product development program have been followed. For the most important sub-programs included in the current technology deployment program, special project organisations have been created comprising as well operative as monitoring and advisory elements. In such an organisation the **project leader** has the ultimate responsibility for the realisation of the product development project. For the practical work the project leader has a **project team** headed by a **project manager**. In its daily work the members of this project team consults both internal and external experts, e.g. component experts, calculation experts and application experts.

The project organisation includes two elements with monitoring and/or advisory functions. These are the **Advisory Board** and the **Support Group**. In the Advisory Board there are senior representatives of both the Wärtsilä Corporation management and the involved business area managements. Before start-up of a new project, the project leader is expected to present the project plan for approval to the Advisory Board. Further, he reports throughout

the project process to the board about the progress of the project. Usually the Advisory Board meets two or three times during the execution of a typical product development program.

The members of a Support Group are typically senior management level technical experts . The Support Group has, primarily, an advisory function as a test forum for the solutions created by the project tea. However, the Support Group is also a monitoring element as it can either accept or reject the suggested technical solutions. The Support Group meets as often as the project related activities require. In practice, this means that the group meets at least 2 to 3 times a year during the whole development project. During the most intense periods of the project the Support Group may meet much more frequently, for instance once a month.

During the execution of the technology deployment program the technical part of the activities has been submitted to external evaluation at two different occasions. In both cases VTT Energy was entrusted with the evaluation work. In the beginning of the program VTT Energy carried the responsibility for the realisation of the first sub-project, i.e. "Evaluation of the feasibility of the novel engine concept”. After start-up of the model power plant, VTT Energy has carried out and reported the measurements that are required when benchmarking the plant performance against the expectations.

In a project of the current type, also the external financiers have to look after their own interests. TEKES expects that the receiver of financial support reports the technical progress and the cost development on a regular basis, in general every six months. Usually either the project leader or the project manager is responsible for reporting the technical progress. The cost development report is preferably compiled by the support receiver’s Business Control and audited by a CPA auditor.

In addition to the above, it can be mentioned that the European Commission, for its part, has monitored the progress of the technology deployment program by auditing the model power plant at three different points of time. For this purpose the Commission has utilised the skills of external energy experts.

Discussion of results

Even though the technology deployment program is not yet brought to an end, there are a considerable number of good reasons to expect that the final results of these efforts will be found very satisfactory:

- the positive statements, that VTT Energy made as a result of their evaluation of the new engine concept

- the results of the small scale tests that have been performed in a laboratory environment both at VTT Energy and at Wärtsilä clearly indicate that the waste heat distribution in the engine can be refined and the engine thereby adapted to the requirements set for a THE REAL POWER PLANT DIESEL ENGINE, if and when a conventional marine diesel engine is modified to meet the specifications for an HOT COMBUSTION engine

- the program has resulted in a THE REAL POWER PLANT DIESEL ENGINE " that, in spite of its impressive dimensions, is fully transportable in most situations
- plant efficiencies widely exceeding 50% have been reached with the model power plant of 38 MW
- both the THE REAL POWER PLANT DIESEL ENGINE ", e.g. the Wärtsilä 64 V-engine, and the model power plant have attracted a great interest among the potential end users

Under the heading “Conclusions” in the evaluation report made by VTT Energy on the HOT COMBUSTION concept it is stated

“The total efficiency of the hot combustion diesel combined cycle will be over 56.5 per cent measured from shafts when the size of the plant is reasonable and the jacket temperature is 150 degrees C. Thus the 55 per cent (net) target is realistic ....”

Tests with engines equipped with power unit components according to the HOT COMBUSTION concept have been made both by VTT Energy and by Wärtsilä. The results are particularly encouraging as they show that it is possible, not only to increase the amount of **recoverable** exhaust gas heat by up to 15 … 20 %, but also to improve the thermal efficiency of the diesel engine with up to 1%-unit, when the combustion chamber is provided with thermal insulation and the amount of scavenging air is reduced in accordance with the HOT COMBUSTION concept.

The sub-project specifically aiming at the realisation of “the real power plant diesel engine” has resulted in a medium speed engine capable of producing a cylinder output of 2000 MW and more. The engine, the cylinder diameter of which is 640 mm, is called Wärtsilä 64. It is a really big diesel engine, which in its V-version with 12 ... 18 cylinders is very well fitted to be used as prime mover in both single and combined cycle power plants with output of 100 MW and above. In its V-version the engines are built from modules, the weight of which in no case exceeds 250 ton. The intention is that, when the situation so requires, the modules can be transported to the site of the power plant one-by-one and then the engine is assembled on site. Thanks to the modular build-up the transportability of the engine is secured even under very unfavorable conditions as regards available means of transportation as well as transportation routes.

Thermal plant efficiencies of up to 53% have been recorded when operating the 38 MW demonstration plant. These plant efficiencies have been achieved with a relatively small size power plant. Thus there are good reasons to expect that plant efficiencies of 55% and above can be realised in large power plants, where not only the prime movers but also the equipment used for waste heat recovery and generation of secondary mechanical power have been optimized for best possible performance. As all experience gathered during more than 6000 hours of mixed commercial and experimental operation of the plant indicates that the exhaust cleaning equipment (DeNOx- and DeSOx-equipment) is working according to expectations, one can only conclude that all main goals defined for this technology deployment program have been achieved!

Based on the above one could easily get the impression that the program has been run until now without a single setback. This is however not the case! During the 6000 hrs of operation of the demonstration plant technical difficulties interrupting the operation have occurred to an extent widely exceeding what is considered acceptable for a plant in commercial operation. It is the reliability of engine components manufactured from new materials and according to new technologies that has caused the problems. As a consequence several engine components have been updated and exchanged during the time the plant has been in operation. The power plant is equipped with two large 12-cylinder medium speed engines and consequently it is easy to realize that the component exchange operations are both time consuming and expensive.

The fundamental reasons to the technical problem that have occurred during the execution of the technology deployment program can mainly be found in a somewhat too optimistic program plan as well in shortages in the communication between users and suppliers of engine components manufactured from new material according to new manufacturing technologies. The original project plan set up for the realisation of the technology deployment program included sub-programs aiming at the verification of the functionability of the new engine concept. However no specific plans for the verification of the durability and reliability of the new components were made. It was simply assumed that it would be possible to demonstrate the durability of these new components during the normal operation of the model plant. Some of the costs burdening the project as a consequence of unsatisfactory reliability of new engine components could most likely have been avoided, if and when these components had been subject for small scale endurance tests in laboratory environment during the early stages of the realisation of the program.

To some extent, the occurrence of problems and disturbances during the realisation of the program and, above all, during the operation of the demonstration plant can be explained by shortages and misunderstandings in the communications between the users and suppliers of new technology and materials. Looking back at the execution of the project one can only conclude that the users and the suppliers do no always understand each other! In this specific case the user is an engine manufacturer owning highly specialised and advanced knowledge about his own product. In his daily communication with the component suppliers, the engine specialist expects the component supplier to be familiar with the vocabulary used in the engine world. Thus he tends to use professional wordings and notions that in the

worst case are completely meaningless to a supplier lacking the necessary knowledge about engines. It is quite obvious that this may have disastrous consequences, for instance, in cases where the component supplier is expected to judge the functionability and reliability of his own product when it used in the environment where the engine manufacturer intend to use it. In this context it has to be pointed out that it is not only the end user that may fail when communicating with other people. This may easily happen to the supplier as well with equally serious consequences.

Although there have occurred some disturbances during the realisation of the program the general impression is that there have been more successes than setbacks and further that the successes have been much more important than the setbacks. Among the key elements behind the successes registered during the execution of the program the following have to be mentioned:

- a competent, motivated and enthusiastic technical staff has carried the main responsibility for the realisation of the program
- the program has been subject to solid financial support and in this aspect the public funding has been of great importance
- local and regional power distributors and producers have been engaged in the realisation and the operation of the demonstration power plant.

Finally, it is worth mentioning that up to date more than 9000 guests and among them more than 4500 investors and potential customers have paid a visit to the demonstration power plant. The popularity of the power plant can only be interpreted as a success from the project point of view!

SolarBau – ENERGY EFFICIENCY AND SOLAR ENERGY USE IN THE COMMERCIAL BUILDING SECTOR

A German demonstration program for the non residential building sector

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INTRODUCTION

The following report presents the description and initial evaluation of the German RD&D program for solar optimised buildings, the so called 'SolarBau Program', which was initiated by the Federal Ministry of Education and Research (BMBF) in 1995 and since 1998 carried out by the Federal Ministry of Economy and Technology (BMWi). Consisting of a number of demonstration projects, spread over all regions of Germany, the program's objective is to demonstrate the feasibility of highly energy-efficient buildings for non residential purposes with special regard to solar optimisation. The technical concepts for all buildings are based on an integrated approach considering heat and electricity consumption. Started in the year 1995, the program was planned to cover a period of 10 years with a budget of approx. 5 MEURO/a.

OBJECTIVES OF THE PROGRAM

The sector of non residential buildings was selected with special regard to the large potential for saving energy and the promising dissemination effect, resulting for instance from the increasing importance of the trade and the services sector in Germany. Considering the present situation in Germany, 16% of the final energy consumption is caused by small scale commercial consumers. Trends, as recently published by PROGNOS 99 [9] and considering the whole sector until 2020 are predicting a slight decrease related to 1995. However more sophisticated analyses show different tendencies, depending on the type of consumer. For instance for the expanding service industry sector and to a less extent the trade industry an increasing energy demand of 19% and 8% are expected. Energy savings due to reduced heat consumption are going to be partly compensated for by increasing demand for electricity.

Being part of the 4 th German Energy Research and Development Program, SolarBau is one of the major activities in the framework of rational use of energy. Addressing particularly the

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[9] PROGNOS 99: Die längerfristige Entwicklung der Energiemärkte im Zeichen von Wettbewerb und Umwelt, Basel, 1999

typical properties of commercial buildings, the program is striving to take up existing energy saving opportunities. Its main object is to develop and prepare technical and scientific background information for future legal measures such as the German energy saving ordinance, which should limit energy consumption in the building sector.
SolarBau's general objective is to demonstrate a series of pilot projects with a total primary energy demand for heating, cooling and lighting purposes below 100 kWh/(m^2a) including a space heating demand of less than 40 kWh/(m^2a). This target will be achieved by integrated concepts based on the interplay between solar passive and active approaches, advanced HVAC techniques and innovative thermal insulation measures. The program consists of various parts, comprising the development of components and planning tools, the demonstration of up to 25 pilot buildings and an accompanying evaluation and information program called SolarBau: MONITOR.
Besides the advanced technical targets, economic aspects will be an important consideration for the SolarBau projects. In this context it is anticipated that additional expenses for the integrated design process should as far as possible be compensated for by lower investments for the HVAC–installations and reduced maintenance costs.

PROCESS OF DEFINITION/DESIGN OF THE PROGRAM

SolarBau's concept is based on a sophisticated analysis of specifications and requirements to be met by non residential buildings and determining their heat and electricity consumption. An experts group was set up to develop and design SolarBau's basic concept in close co-operation with the responsible ministries. The group consisted of five representatives from:

- university research
- private research
- architects and engineers
- ministry and project management organisation

MAIN ACTORS AND THEIR ROLES

As in the conception phase, the main actors playing a role in the SolarBau program come from various branches of research, industry and public bodies. The responsibilities are allocated as illustrated in Tab. 1. Although competence and experience of a participant in the field of energy saving engineering is important, it is not the only criteria for participation. Additionally the readiness to contribute to the accompanying SolarBau: MONITOR program, which is based on a high degree of co-operation during all project phases, is being pre-condition to participate.

Main actors and their roles in the SolarBau Program	
Federal Ministries (BMBF, BMWi) Project Management Organisation (BEO)	funding and co-ordination
universities Fraunhofer Gesellschaft private institute	- theoretical background - development - monitoring and evaluation
industry	- development of new materials and systems - production of innovative components - market introduction
architects and engineers	- construction of demonstration buildings - monitoring and validation
SolarBau: MONITOR researchers and developers architects and engineers	- communication - documentation - analysis - training

Tab. 1 Main actors and their roles in the SolarBau program

POLICY MECHANISMS USED

As already mentioned, SolarBau is part of the 4 th governmental funding program for energy research and development, therefore the R&D activities are supported according to usual funding conditions. In the demonstration part, funding is only provided for the design of prototype buildings and for monitoring activities after construction. Complementary development activities, aiming at the production of new innovative components are also supported according to R&D framework conditions. Since no subsidies are provided for investments, it is ensured that all design solutions are realised under normal economic boundary conditions.

MONITORING AND EVALUATION PROCESS

The monitoring, evaluation and documentation in SolarBau is being carried out by independent institutes and companies. An internet platform at www.solarbau.de (German) provides information for participants as well as for the general public. Project reports are being produced regularly and workshops are being held to provide information on the experience gained.

Special emphasis in the area of evaluation has been given to the generation of a neutral basis, allowing the comparison of energetic properties of the monitored objects. Up to now, in the framework of SolarBau eleven non-residential buildings are under construction or have

been already erected. Tab. 2 gives an overview on the building types, net floor areas and status of completion and Tab. 3 contains a description of applied measures and components [10].

Project name	***Location***	***Building type***	**Net floor area**	**Status**
ECOTEC	Bremen	office	3436 m²	finished
Passivhaus Wagner	Coelbe / Marburg	office	1948 m²	monitoring
Hübner	Kassel	production	2122 m²	monitoring
Fraunhofer-Institut für Solare Energiesysteme FhG	Freiburg	research institute	14001 m²	under construction
DB Netz	Hamm	office	5974 m²	monitoring
Fachhochschule Bonn-Rhein-Sieg	St. Augustin	university	26987 m²	monitoring
Gesellschaft für Innovation und Transfer GIT	Siegen	offices and laboratories	3300 m²	planning
Passivhaus Lamparter	Weilheim	office	1488 m²	monitoring
Technische Universität Braunschweig	Braunschweig	computer centre	9415 m²	under construction
SurTec	Zwingenberg	production and office	4423 m²	under construction
Zentrum für umweltgerechtes Bauen ZUB	Kassel	training and research	1108 m²	under construction

Tab. 2 Demonstration projects, status May 2000

According to the focus on office buildings the implied strategies are mostly based on passive cooling and advanced daylighting measures. Both are being addressed in the IEA Implementing Agreements ‘Energy Conservation in Buildings and Community Systems’ and ‘Solar Heating and Cooling’.

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[10] Voss, K. (FhG-ISE), Löhnert, G. (solidar) and Wagner, A.(Uni Karlsruhe): ‚Towards lean Buildings – Examples and Experience from a German Demonstration Program for Energy Efficiency and Solar Energy Use in Commercial Buildings’

	Titel	ECOTECC	Wagner	Hübner	FhG-ISE	DB AG	FH-BRS	GIT	Lamparter	TU-B	SurTec	ZUB
Methods	Integrated planning		+	+	+	+		+	+	+	+	+
	Simulations	(+)	+	+	+	+	(+)	+	+	+		+
Strategies	Reduction of space heating demand	+	+	+	+	+	+	+	+	+	+	+
	Passive cooling		+	+	+	+	+	+	+	+	+	+
	Daylighting		+	+	+	+	+	+	+	+		+
	Renewable energy use	+	+	+	+		+		+			
Tech nolo gies and mea sure	Atria				+	+	+			+	+	+
	Transparent insulation						+					
	Solar thermal	+	+	+	+				+			
	Solar electricity	+			+		+		+			
	Heat recovery	+	+	+	+	+	+	+	+		+	+
	Nocturnal ventilation		+	+	+	+	+	+	+	+	+	+
	Slab cooling											+
	Ground heat exchanger		+	+	+	+	+	+	+	+	+	+

	Combined heat & power		+		+		+					
	Combined heat + power + cooling				+							
	Heat pump	+						+				
	Biomass											
	Advanced controls	+	+		+	+	+	+	+			
	Rain water treatment		+	+					+		+	
	“Ecological materials”			+			+		+			+

Tab. 3 Technologies and Strategies

The comparison of investment costs, as indicated in Fig. 1, shows that SolarBau buildings are within the range of the German reference costs for office buildings of medium to high standard as published by the ‘Construction Costs Information Centre’ of the ‘German Chamber of Architects (BKI)’, based on mean building costs per m^2 usable floor area for given building types in Germany. The results so far from the SolarBau projects demonstrate that special features of advanced energy saving concepts do not necessarily have to result in increased building costs.

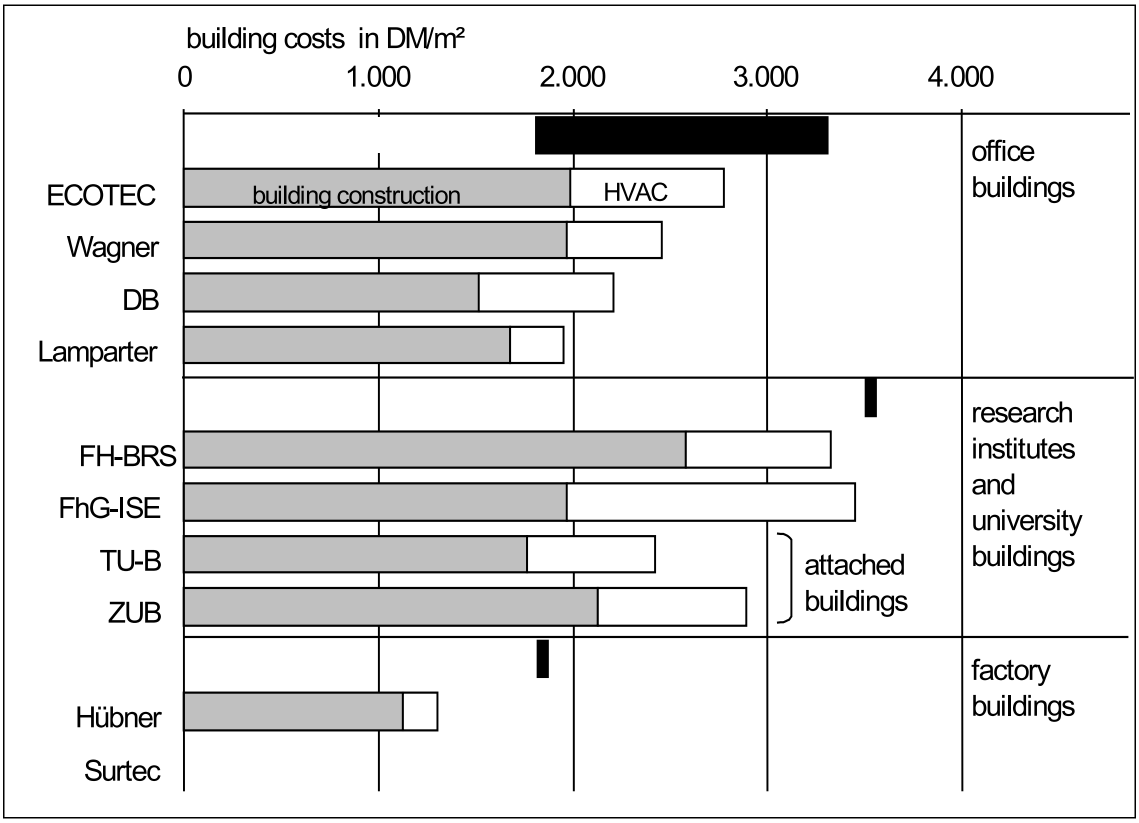

Fig. 1 Investment costs incl. tax per net floor area for construction and HVAC system, excluding planning and site costs. Black bar: Range of reference costs for conventional building practice, Germany (BKI99), Ref.: [10]

DISCUSSION OF THE RESULTS

With regard to energy consumption, data acquisition started recently. First results show that the anticipated limits can be met without significant additional costs. However the program has not yet been finished and an advanced standard for energy consumption in commercial buildings is going to be established. The positive public response, which has led to first emulations, confirms the program's objectives. As a consequence, in future projects it will not be necessary to fund the construction phases in the same way because the standards and methods of SolarBau are well accepted.

The present results, half-way through SolarBau's project period, exceed expectations by far and promise significantly reduced energy consumption of commercial buildings down to about one fifth of the present average value. However, it does not suffice to know how to construct such buildings. They have to be built, critically compared with conventional buildings, well-documented, the experiences made-use of in planning and building practices and, last but not least, disseminated in training and further-education programs for planners and architects.

GERMANY:
WIND POWER FOR GRID CONNECTION
"250 MW WIND"-PROGRAMME

Introduction

The German government has been promoting the deployment and development of wind energy for several decades. One of its most important strategic measures for the promotion of wind energy technology is the "250 MW Wind"-programme for Germany. The programme was started in 1989, the closing date is scheduled for 2006.

The "250 MW Wind" funding programme (initially the "100 MW Wind"-programme) was first published in the Bundesanzeiger in June 1989. Because of the great demand, and the reunification of Germany, the funding programme was expanded to a total of 250 MW in 1991. This figure refers to the standard power from wind turbines at a wind speed of 10 m/s. At the end of 1996, when the target total power of 250 MW had been reached, the contracting phase of the project was completed. The present total support capacity is in fact about 350 MW regarding the rated power given by each manufacturer as this usually corresponds to maximum power at higher wind-speeds. This capacity has been attained with a total of about 1,500 wind turbines included in the programme.

The "250 MW Wind"-programme is designed to acquire statistically relevant performance data concerning the practical operation of wind turbines in the Federal Republic of Germany. An outstanding feature of the programme is the accompanying measuring programme with the objective of acquiring and evaluating performance data from all wind turbines supported in the "250 MW Wind"-programme over a ten year period. The technological and scientific areas of this supportive measure WMEP11 are being implemented by ISET12 in Kassel.

Objectives of the Programme

According to the announcement in the Bundesanzeiger, the main policy objective of the "250 MW Wind"-programme was to increase the deployment of wind power in Germany and to obtain statistically verifiable data from the practical operation of wind turbines in the Federal Republic of Germany. Over a period of ten years, wind turbines from a large number of different manufacturers were to be funded and tested at various locations and for a variety

[11] WMEP: Wissenschaftliches Meß- und Evaluierungsprogramm – Scientific Measurement and Evaluation Programme

[12] ISET: Institut für Solare Energieversorgungstechnik – Institute for Solar Energy Supply Technology

of applications. The continuous evaluation and publication of the results of this programme would support the further development of wind energy technology and its integration in the German energy supply.

In combination with other governmental strategic plans and programmes the "250 MW - Wind“-programme can be seen as one module among many measures with the goals

- to conserve limited resources
- to improve the security of the German energy supply
- to protect the environment and the climate
- to increase the share of electricity generation from renewable energy sources in the national energy balance and
- to strengthen the position of the German energy technology industry in international competition.

However, the government did not specify targets to achieve a defined wind power capacity or share of electricity supply within a fixed time scale. The principle motivations and specific goals of the funding measure were

- the stimulation of commercial manufacturing facilities for the series production of wind turbines,
- the further development of turbine technology,
- the improvement of efficiency and economic aspects and
- the foundation of an inland wind energy market which did not exist before 1990.

Barriers addressed by the programme were the acceptance by the public of an increasing density of wind power installations in certain areas and the identification of possible environmental problems, such as land-use and noise.

Process of definition/design of the programme

In 1988 the "100 MW Wind“-programme started with the commissioning of the expert study “Experimental Programme Wind” by the former Federal Ministry for Research and Technology (BMFT) represented by the Research Centre Jülich – BEO –. The study was awarded to the German consultant “Fichtner Development Engineering”. The main objectives of this study were

- to verify the demand for a broad “Experimental programme wind energy” of the order of magnitude of 100 MW_{el} ,
- to examine whether such a programme could deliver findings for research and development to justify financing with funds of BMFT,
- to define targets for research and development,
- to define the strategies to reach the targets as quickly as possible,
- to propose administrative and organisational measures for the implementation and
- to make a rough estimate of the financial means which had to be provided.

This expert study recommended certain strategies for the implementation which were included in the final definition of the programme. These strategies refer to the:

- **assessment basis:** The promotion targets for an efficient and trouble-free operation of wind turbines based on the consideration of the combination of the amount of funding with the electricity produced. Since the operators have a strong motivation to maximise the energy yield they will carefully select efficient turbines and sites and will make an effort to achieve a trouble-free turbine operation. Since the annual fund transactions are designed as payment in arrears the operators obligation to report can be ensured over the whole term of validity of the promotion campaign.
- **quota of encouragement:** Based on model calculations of economic viability under relevant conditions regarding lifetime, interest rates, efficiency, O&M costs, and average electricity feed-in conditions, the promotion was decided to be 0.08 DEM/kWh as an operational cost grant for commercial operators. Non-commercial operators had a choice between the operational cost grant or a value-equivalent investment grant in order to minimise the risk of loss of one's livelihood and to stimulate an additional demand.
- **duration and general conditions:** The duration for observation was fixed to a ten year period in order to retrieve reliable information concerning lifetime, operational performance, and costs. The implementation phase was planned to spread over five years in order to allow for capacity limits of the manufacturers. The total running time of the programme thus resulted in 15 years. The general conditions which the turbines in the experimental programme had to meet were related to approval by authority, for instance statics and noise.

The Federal Ministry for Research and Technology advertised for bids for the experimental programme "100 MW Wind" on June 6th, 1989. As a result of the enormous response, BMBF increased the capacity from 100 to 250 MW in February 1991. Over the years, several modifications were made to adapt to changes in the relevant legislation, e. g. the Electricity Feed Law (EFL)[13]. The last amendment was published in February 1994. The deadline for bids was December 1995 and the last turbine started operation in 1998. Almost 1600 turbines with 350 MW rated power have been supported in the experimental programme "100/250 MW Wind"-programme.

Main actors and their roles

The implementation of the "250 MW Wind"-programme and its accompanying "Scientific Measurement and Evaluation Programme" was carried out by three major players, namely:

- The Federal Ministry for Research and Development (BMFT, 1989-1994) and its successors Federal Ministry for Education, Science, Research and Technology (BMBF 1994-1998) and the Federal Ministry of Economics and Technology (BMWi, since 1998),
- The Project Management Organisation BEO from Jülich Research Centre, and

[13] Stromeinspeisungsgesetz, in force from January 1st, 1991 until March 30th,2000

- the Institute for Solar Energy Supply Technology (ISET) in Kassel.

The other relevant players in the programme can be identified as

- investors and turbine operators e. g. private individuals, farmers, communities, commercial companies, utilities., as well as
- turbine manufacturers.

The experimental programme "100/250 MW Wind“ was implemented by the Project Management Organisation BEO (Jülich Research Centre) acting on behalf of the Federal Ministry of Economics and Technology and its predecessors. The “Scientific Measurement and Evaluation Programme” (WMEP)[14] is being carried out by ISET in a contract with the Jülich Research Centre. There is a strong interaction between operators and ISET which acts as an “interface” to the Research Centre Jülich and the Federal Ministry.

Policy mechanisms used

The aim of the policy measure was to implement a broad experimental programme which would supplement the existing demonstration programmes of the European Union, the German Ministry responsible for energy research and some federal states. The funding procedure was based on a combination of a broad and long term R&D-programme for new wind turbine installations, in order to solve the remaining problems concerning material fatigue, subsystem interactions etc., together with strategies aimed at bringing wind technology onto the market.

The main tactical implementation concepts were a combination of

- subsidies for operators instead of manufacturers,
- support for the energy produced instead of installed capacity,
- an obligation of the operators to report continually on operating results and to collaborate in the evaluation programme,
- motivation for a continuous participation in the complete evaluation process (10 years) by making the cash flow dependent on participation,
- general acceptance of the accumulation of different promotion sources such as additional state investment subsidies, and
- admittance of access of operators to special loans of the Deutsche Ausgleichsbank (DtA) with reduced interest rates for loans. The DtA is a “wholly-owned development agency of the German federal government” that, among other activities, supports environmental protection projects.

The financial support for the "250 MW Wind“-programme came from the Federal research budget. The actual subsidy for operators in the "250 MW Wind“-programme is DEM 0.06 or 0.08 per kilowatt-hour, depending on whether the electricity is fed into the grid or is being used by the owner of the wind turbines himself. The grants are limited to a maximum of 25 percent of the turbine costs. Alternatively non-commercial operators had the option to choose an investment subsidy limited to a maximum of 90,000 DEM. The support of the

[14] WMEP: Wissenschaftliches Meß- und Evaluierungsprogramm

"250 MW Wind"-programme is granted in addition to the tariffs paid by the utilities under the Electricity Feed Law (January 1991 until March 2000, table) or the Renewable Energy Law (since April 2000).

Year	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
EFL-tariff [DEM/kWh]	0.1661	0.1653	0.1657	0.1693	0.1728	0.1721	0.1715	0.1679	0.1652	0.1613

Table: Annual rates of the EFL from 1991 until March 2000

The Renewable Energy Law which fixes the initial compensation rate to 0.178 DEM/kWh for a five year minimum period has been in force since April, 1st 2000. A prolongation of the initial compensation rate will depend on each turbine individually according to a turbine specific reference yield at a reference site.

The funding measure was limited to a total installation capacity of 250 MW, related to a wind speed of 10 m/sec. This corresponds to a total rated capacity of 360 MW. The amount of financial appropriation is estimated to total about 320 million DEM to be spent by the Federal Government before 2006. This does not include the costs for the additional measurement programme WMEP of about 50 million DEM.

The "250 MW Wind"-programme can be considered as an important element of the wind energy success story in Germany. As a result of the subsidies granted in the frame of the programme and the national Electricity Feed Law, the total specific investment costs of wind turbines could be lowered to about 1,700 DEM/kW in the year 2000. The specific electricity generation from wind has increased to an annual mean value of about 2000 full load hours (kWh/kW).

Expectations have been surpassed almost by a factor of four with regard to the capacity installed in 1996, to the market stimulation achieved, and with respect to the total electricity contribution of wind power to the demand of the whole country. Meanwhile the inland trade of wind turbines is developing completely independently of the "250 MW Wind"-programme. The installed wind power capacity in Germany surpassed the 5,000 MW level in June 2000 and contributes with approximately 10 TWh per year. The overall availability of the turbines exceeds 98 %. The Electricity Feed Law has contributed significantly to this success and is now in its revised form – the Renewable Energy Law (EEG) – a driving force for investors.

Wind electricity generation has increased from about 0 % in 1989 to almost 2 percent of the net electricity consumption of Germany in 2000. Regionally, for instance in the Federal state of Schleswig-Holstein, the share of wind energy is about 15 percent of the electricity demand with an overall aim to reach 25 percent contribution by 2010. This impressive development was achieved as a result of the stimulation of wind power deployment by the "250 MW Wind"-programme, the competition between several manufacturers on the market and the fact that wind turbines can be operated profitably. The export of wind turbines from German manufacturers has increased continuously to about 10 percent as a result of its success on the domestic market as well as the good reputation of these proven technologies. The deployment of wind energy in Germany is also having an impressive effect on

employment. The "250 MW Wind"-programme has helped to create jobs. It is estimated that today the wind power industry accounts for about 15,000 jobs in Germany.

However, with increasing deployment of wind turbines in Germany, the awareness of environmental effects such as land use, noise and effects on the landscape has increased in parts of the population. Thus the acceptance of new projects is inhibited in areas of already high market penetration.

Monitoring and evaluation process

The "250 MW Wind"-programme is designed to acquire statistically relevant data concerning the practical operation of wind turbines in Germany. Therefore an intensive evaluation programme was prepared during the planning phase of the main programme. The technological and scientific areas of this supportive measure, the "Wissenschaftliche Meß- und Evaluierungsprogramm" (WMEP), are being implemented by the Institut für Solare Energie-versorgungstechnik (ISET) in Kassel. The WMEP is collecting and evaluating performance data from all funded wind turbines over a ten year period. The following areas are the main focal points of this evaluation:

- wind resources, e.g. local and regional distribution of wind resources in Germany, wind conditions at specific sites,
- turbine performance, e.g. energy production and consumption of wind turbines, periods of grid interconnection, periods of full and partial load, performance characteristics,
- reliability, e.g. technical availability, causes of faults, bad performance, component breakdowns, and
- economic aspects, e.g. income through the operation of the WT, costs related to maintenance, repair and insurance.

As a funding condition, participants in the programme are required to keep a log book for each funded turbine and to record information on:

- basic technical data concerning each turbine, method of grid connection, topography of the site etc.,
- energy production and consumption, the acquisition of monthly figures through regular readings of calibrated electricity meters,
- malfunctions, repair and maintenance: these are reported on form sheets which are submitted to the central processing division after each occurrence,
- operating costs: fixed costs for maintenance contracts, insurance and other costs are documented.

The main actors in the monitoring and evaluation process are ISET and the Research Centre Jülich. The amount of administrative work required, the recording equipment used and the long distances between plant sites in Germany, make the support of local contractors necessary. The success of the project is being helped by four institutes acting as subcontractors with their expertise in the field of wind energy. They supervise the on-site installation and operation of the measuring equipment and help the operators to keep their log books. They are:

- Deutsches Windenergie-Institut GmbH, Wilhelmshaven, in Lower-Saxony and Bremen,
- Wind-consult GmbH, Bargeshagen, in the eastern states,
- Windtest Kaiser-Wilhelm-Koog GmbH, Kaiser-Wilhelm-Koog, in Hamburg and Schleswig-Holstein and
- Institut für Elektrische Energietechnik, Universität Gesamthochschule Kassel, in the remaining states.

There is intensive and continuous communication between all partners involved in the project during all phases.

The installation phase is supervised by ISET and its subcontractors in order to verify that the proposer has installed exactly the turbines for which he had made an application and which have been approved with regard to site, type of machine, rated power, rotor diameter and hub height as well as the correct installation of the necessary additional equipment such as calibrated electricity meters and stipulated interfaces for the measuring equipment. ISET reports regularly on the process.

ISET controls the delivery of quarterly reports. If necessary ISET admonishes belated operators with their liability to submit documents.

The subcontractors verify sporadically the meter readings of the operators. The Research Centre Jülich crosschecks with ISET the accuracy of statements from the operators prior to authorisation of the payments of subsidies to the operators.

Discussion of results

The accompanying measurement programme is a very helpful tool for the evaluation of the results of the programme. The following major results have been observed:

- an overall improvement of the state of the art in wind energy technology,
- an increase of the availability of wind turbines in Germany up to 98%,
- a gain of relevant know-how on maintenance and operating hours,
- the issue of public acceptance could be discussed “on site”,
- the programme made a major contribution to the international break-through of wind power.

In addition, the Electricity Feed Law, garanteeing specific minimum prices for electricity generated from renewable energy including wind power, was very helpful towards the success of the programme.

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Photovoltaic Power Generation Systems (from R&D to deployment)

Introduction

Japan has been implementing Research and Development (R&D) and Deployment Programs of Photovoltaic (PV) Power Generation Systems. The R&D Program initially started in 1974 as a part of the "Sunshine Project," launched to develop oil-alternative energy after the oil crisis in 1973. It has been under the direction of the "New Sunshine Program (NSS)" since 1993 and continues today as PV systems have arisen as a solution for global environmental issues.

The R&D Program has resulted in reducing PV system cost, consequently, contributing to the Deployment Program for full-scale promotion early on. Legal preparations, technological standards preparations and subsidy programs establishment are under way.

So far, the Programs have taken Japan to the largest PV installed capacity in the world. Therefore, the Programs should be included here as a lesson for other countries which aspire to the same mission.

Objectives of the program

Japan's energy supply such as crude oil and coal depends largely on imports from abroad. The supply of crude oil is actually 100% imported. Our objective of new and clean energy development and deployment is to reduce these dependencies and to diversify energy resources as well as to solve global environmental issues.

Japan has revised "The Long-term Energy Supply/Demand Outlook" in June 1998, which set a target for new energy installed capacity with the target for PV of 5000MW by the end of 2010.

The major barrier to PV diffusion is the high cost. The generation cost of PV systems for residences, the major market, is approximately JY81/kWh, three times as expensive as that of electric power companies at approximately JY24/kWh. Therefore, in order to achieve mass production, PV cost needs to be at least competitive with conventional electric power cost by developing technology and establishing large markets in parallel.

Process of definition/design of the program

Since the R&D and Deployment Programs are under the direction of separate agencies, each Program's targets and processes are separated as follows:

1) Overall target

The overall target of the Programs is to install PV capacity of 5000MW by 2010. This target was set in the Long-term Energy Supply/Demand Outlook and the Oil-alternative Energy Supply in June 1998, by the Advisory Committee for Energy, a Minister's advisory

committee consisting of representatives from academia, research institutes, mass media, energy-related organizations and consumers.

2) R&D Program

The target of the core R&D project called "Development of Technology for Practical Application of Photovoltaic Power Generation Systems" is to realize PV prime cost of JY140/W (at 100MW production) by the end of FY2000. This target was set in the Master Plan by the Industrial Technology Council, a Minister's advisory committee consisting of representatives from academia, research institutes, mass media and energy-related organizations.

3) Deployment Program

The target of the Deployment Program is the establishment of a new PV market and demonstration of system endurance. Projects are planned and designed following a formal hearing involving the suppliers such as solar cell manufacturers, housing manufacturers and related organizations. While carrying out the project, requests and opinions from consumers such as individuals, private companies and local governments are fed back, following which the project is flexibly modified.

Main actors and their roles

The chief director of the Programs is the Ministry of International Trade and Industry (MITI) of Japan, which conducts national energy policy and industrial technology policy. The main actors and their roles for each Program are as follows:

1) R&D Program

The New Sunshine Program Headquarters in the Agency of Industrial Science and Technology is in charge of long-term planning, budget compilation and overall coordination of R&D. R&D affairs are actually conducted by the New Energy and Industrial Technology Development Organization (NEDO), which consigns projects to the private sector and cooperates with universities and research institutes. The private sector has organized the Photovoltaic Power Generation Technology Research Association (PVTEC) to carry out cooperative R&D. The national research institutes conduct basic and applied technology R&D.

2) Deployment Program

The New Energy Policy Division, Coal and New Energy Department of the Agency of Natural Resources and Energy, is in charge of promotional policy, budget compilation and overall coordination of deployment. The New Energy Foundation (NEF) carries out subsidy programs for residences, the major deployment field, while NEDO conducts various model projects and field test programs for industries and local governments. Solar cell

manufacturers and housing manufacturers have organized the Japan Photovoltaic Energy Association (JPEA) to carry out public relations and dissemination in cooperation with the government.

Policy mechanisms used

1) Overall policies

i. The Advisory Committee for Energy, a Minister's advisory committee, compiles "The Long-term Energy Supply/Demand Outlook". The present outlook was revised in June 1998 and agreed in Cabinet Council in September 1998. It targets PV installed capacity by the end of 2010 to be 5000MW.

ii. "The Law Concerning Promotion of the Development and Introduction of Alternative Energy" sets targets of oil-alternative energy installed capacity. The present target of 5000MW PV installed capacity was agreed in Cabinet Council in September 1998, following the revision of the "Long-term Energy Supply/Demand Outlook."

iii. "The Law Concerning Promotion of the Use of New Energy" was enacted in June 1997. It prescribes the basic policies on new energy use including PV, the guideline on new energy utilization, and the financial support measures for businesses, which use new energy.

iv. "The Guideline for Promotion of Efforts to Prevent Global Warming" was devised in June 1998 following COP3. It considers PV as an urgent energy supply/demand provision for the 2010 target of CO_2 emissions reduction.

2) R&D Program

The R&D program budget is 100% borne by the government (private expenses are exceptional). The government provides official subsidies to NEDO for its expenses, while NEDO conducts and consigns the R&D operations to the private sector and universities.

i. Development of Technology for Practical Application of Photovoltaic Power Generation Systems (since FY1974-, covered 100% by official budget, BJY7.28 for FY2000)

Objectives:

For solar cell manufacturing technology, in order to reduce solar cell cost, thin-film solar cells (amorphous silicon, CdTe, CIS, thin-film polycrystalline silicon solar cells, etc.) have been under development. Target for manufacturing prime cost by FY2000 is JY140/W (at

100MW production). In parallel with this, for system technology, hardware such as architecturally-integrated PV modules, as well as software such as solar cell and system evaluation technology, and grid-connection technology for mass production is also under development.

ii. Development of a Low-energy Consumption Manufacturing Process for Solar Grade Silicon (FY1997-FY2000, 2/3 official budget and 1/3 private budget, BJY0.53 for FY2000)

Objectives:

In order to reduce the cost of Solar Grade Silicon (SOG--the raw material of thin-film polycrystalline silicon solar cells), the main product in the present market, manufacturing technology has been under development. The target by the end of FY2000 is less than JY2300/KG for feedstock and less than JY300/KG for ingot production cost by electromagnetic casting.

iii. Development of Practical Technology for High-efficiency Multicrystalline Silicon Solar Cells (FY1999-FY2002, 100% official budget, BJY0.56 for FY2000)

Objectives:

In order to increase the conversion efficiency and to reduce the cost of thin-film polycrystalline silicon solar cells, the main product in the present market, manufacturing technology has been under development. Target manufacturing prime cost by the end of FY2002 is less than JY147/W (at 100MW production). Target efficiency is more than 20%.

iv. Development of Advanced Manufacturing Technology for Photovoltaic Power Generation Systems (FY2000-FY2004, 50% official budget, BJY1.24 for FY2000)

Objectives:

In order to firm up all developed manufacturing technology for further cost reduction and mass production, collaborative projects are being carried out between private companies and NEDO with expenses shared.

3) Deployment Program

i. Field Test Project on Photovoltaic Power Generation Systems for Industrial and other Applications (since FY1998-, covered 50% by official budget, BJY4.0 for FY2000)

Objectives:

In order to demonstrate the efficacy of PV systems and to standardize and adapt the PV systems for full-scale and diverse promotion, collaborative demonstration projects between

private companies, local governments and other organizations' PV owners and NEDO have been carried out with expenses (1/2 respectively) shared.

ii. Subsidy Program for Residential Photovoltaic Power Generation Systems (FY1997-, JY180,000/kW official budget since September 2000, with the remainder borne by the applicant, BJY14.5 for FY2000)

Objectives:

In order to promote PV systems full-scale, to reduce cost further and to establish a sustainable PV market, the subsidy program for individual PV owners is conducted intensively over a fixed period by NEF.

iii. Local Introduction of New Energy Promotion Project (FY1997-, 50% official budget—out of a total FY2000 budget of BJY6.43 for renewable energy)

Objectives:

In order to accelerate the promotion of the use of new energy-saving technology, the subsidy project is conducted by NEDO for local governments which carry out such activities.

vi. New Energy Enterprises Support Project (FY1997-, 33% official budget-out of a total FY2000 budget of BJY11.49 for renewable energy)

Objectives:

In order to support enterprises which use new energies, NEDO subsidizes 33% of its expenses.

Monitoring and evaluation process

1) R&D Program

i. Monitoring process

The Master Plan for the R&D Program under the Agency of Industrial Science and Technology is scheduled and evaluated by the Industrial Technology Council.

For example, the "Development of Technology for Practical Application of Photovoltaic Power Generation Systems" experiences interim evaluations every three or four years. The results are evaluated and the ensuing schedule is revised if necessary.

On the other hand, it has been a trend for governmental programs to go through rigid evaluation. Consequently, no longer does the Industrial Technology Council direct both scheduling and evaluations, an evaluation council has recently been established especially for evaluations. Under the evaluation council, Subcommittees consisting of neutral experts from academia, the technological field and the mass media are organized for each project. The final evaluation of the results and a decision on project

continuation are made. In the case of continuation, the Master Plan is rescheduled based on their remarks.

ii. Evaluation contents

Evaluations are made on the following items:

A. Project design and operation

- Objective
  - adequacy of the technology research items for project policy
  - flexibility of the project depending on the national/international situation
  - accuracy of the possibility of technological application
  - accuracy of understanding of related technology trends
- Target
  - validity of the target index
  - adequacy of the target (including budget, duration)
- Schedule
  - adequacy of the schedule, investigation
  - adequacy of R&D items to achieve the target
  - flexibility of schedule modification
- Necessity for governmental participation
  - clarification of reasons why the government needs to participate
- R&D operation structure
  - sufficiency of the cooperative structure among industry, academia and the government
  - leadership ability of project leaders

B. Project results

Evaluations of the project on the whole and each elemental technology are made on the following items:

- Specific achievements
  - sufficiency of the achievement in the context of the objective/aim and the target
  - significance of the achievement (world leader, international contribution, originality, etc.)
- Application, promotion, public relations

- adequacy of the application outlook after the project is concluded
- clear technical target for application
- potentiality for ripple effect on various fields
- pending patents
- sufficiency of public relations (to experts and the general public)

2) Deployment Program

Mainly the Agency of Natural Resources and Energy and the Advisory Committee for Energy conduct the Deployment Program. Until recently, new energy programs were evaluated in general, not in details of each energy category or project. However, as environmental issues pose elusive solutions such as at COP3, and new energies including PV face great anticipation, the New Energy Committee was organized in December 1998 under the Advisory Committee for Energy. It counsels on promotional trends in each new energy, policy streams, future policies, international positions and so on. At present, it provides counseling on promotional policies, including previous situations and effects, from which it will form future policies by the summer of FY2001.

Discussion of results

1) Overall discussion

The overall target of the R&D and Deployment Programs in Japan is PV installed capacity of 5000MW by the end of FY2010. Therefore, the final results will not be apparent till that time. Currently, installed capacity seems to be growing every year.

The significant feature of the Programs is not the prominent amount of the official budget, but the preparation for future mass deployment following achievement of the target. Approximately 200MW was installed by the end of FY1999. Especially in the residential market field, over ten thousand units have been installed annually with the help of subsidies. It is not impossible to see that residential PV systems will someday become conventional.

Participation of the average citizen, who has seemed to be quite passive towards energy issues, will be a great force in other new energy projects, too. In addition, cooperation among the government, solar cell manufacturers, housing manufacturers and electric power companies is indispensable in deploying PV systems. Their teamwork is one of the key factors of achievements in Japan.

The target of 5000MW PV installed capacity is not the goal but a target in the process. It still does not compare when converted to oil supply (1220kl) nor CO_2-emissions reduction (1600t). Further deployment of several more MW will be targeted in the future. Although the official target capacity has not yet been published, the government has been taking into consideration future perspectives and projects.

2) Program discussion

i. R&D Program

The R&D Program, including “Development of Technology for Practical Application of Photovoltaic Power Generation Systems” and others, has been achieving world-leading results. The factors of this success are:

- as the government plans and directs the long-term R&D scheme continuously and consistently, the talents from the private sector, universities and national institutes can be gathered to engage in their respective research
- a sufficient official budget (largest in the world) covers the R&D projects
- projects are evaluated appropriately, and flexibly modified

Not every project has been successful. The factors of failures include:

- several technologies were adapted to develop one solar cell, which were too advanced or improbable (inadequacy of the technology theme)
- some companies and researchers could not maintain their motivation in the long-term scheme (lack of motivation)

Since the R&D Program is now being contributing to the Deployment Program, private sector participants are facing the decision whether or not they should adopt PV technology for future business. Some of them have decided to withdraw. Consequently, the government has taken into consideration maximizing the adequacy of both the technology scheme selection as well as the budgetary focus.

Moreover, present technology is applicable to residences (competitive generation cost for residential purchase), but not advanced enough for industries and the electric power business. Therefore, in order to be applied to the electric power business, innovative and low-cost solar cells are to be developed in the future.

ii. Deployment Program

The most successful Deployment Program in Japan is the "Residential Photovoltaic Power Generation System Monitoring Program," which reflects the characteristics of Japan's Programs.

In Japan where electricity is distributed throughout the country and supplied steadily while a blackout is rare, the determinant of electricity selection is the price. Therefore, at the first stage of the Deployment Program when support was essential to encourage such expensive PV systems be deployed, subsidy programs were the means to establish the new market.

The "Residential Photovoltaic Power Generation System Monitoring Program" materialized in FY1994. Since then, PV installed capacity has increased rapidly, and 17 thousand applicants were accepted in FY1999. The factors of its success are:

- economies of scale; private companies increased their production, the PV system price decreased, the market was expanded (JY3.6M/kW approx. in FY1993 →JY0.93M/kW in FY1999)
- surplus electricity purchase system by electric power companies with equivalent surplus and demand power prices materialized

- increased awareness of environmental issues; expense is still high even with subsidies for general consumers
- architecturally-integrated PV modules have been licensed as architectural materials by the Building Standard Law, facilitating sales by housing manufacturers

On the other hand, the drawbacks of this program are:

- the businesses by solar cell manufacturers and housing manufacturers have been assured by subsidies, resulting in a market size that depends on the amount of the subsidies
- the amount of subsidy was fixed during the first stage, and the system price bottomed-out as a result (subsidy is now at a fixed rate per kW)

In this fiscal year, the number of applicants for this program exceeded the number of prospects. This program will end in FY2002. A sustainable residential PV market without subsidies is the key issue to further deployment.

Deployment of High Efficiency Heat Recovery for Domestic Ventilation in the Netherlands

1. Introduction

Dwellings represent about 25-30% of all energy used in OECD countries. Energy losses due to ventilation will increase in the near future up to 10% of the total energy use (lit 1). In energy efficient dwellings energy losses for ventilation, infiltration and support energy (fans etc.) can account for more than 40% of the total energy use of dwellings. New innovative energy efficient ventilation technologies could give an important contribution to decrease energy use in the residential sector. To realise the Dutch governments policies on energy use in the built environment the Energy Performance Standard (EPN; NEN 5128, lit 2) is introduced in 1995. This standard concerns the integral energy-efficiency of buildings, including energy use for heating, DHW, fans, cooling, lighting and humidification. As ventilation and air tight building have a substantial influence in the EPN it is expected that Mechanical Ventilation with Heat Recovery (MVHR) will play a major role in energy-efficiency concepts for houses, complying with the required Energy Performance Coefficient. Application of MVHR was not only expected to give a contribution in decreasing (mechanical) ventilation losses. It is also a prerequisite for increasing the air tightness of dwellings as MVHR ensures a continuously ventilation.

In order to achieve a substantial market penetration as well as a market acceptation a strategy plan was drawn up by Novem for a broad implementation program for MVHR. This strategy led to an increase of the market penetration of MVHR from less then 1% in 1995 to 10% in 1999 (new built houses). For 2000 a market share is expected of at least 15%.

2. Objectives of the program

2.1. Background

The introduction of MVHR for the residential sector in the Netherlands took place in the early eighties. The first step was a research, followed by a report, on the application of MVHR in Dutch houses. NEOM (the formal Netherlands Organisation for Energy and the Environment, now Novem), started a large scale market introduction in the mid-eighties, accompanied by several demonstration projects, monitoring and supporting researches. Despite these efforts the market penetration of MVHR still was less then 1%. In 1993 a market survey took place on the decision making of application of domestic ventilation systems and, particularly, the application of MVHR (lit. 3).
In general, the main conclusions of this market survey were:

- MVHR has a bad image, due to problems caused by lack of quality. This lack of quality and the absence of a market acceptation were the main barriers for a larger market introduction of MVHR. Lack of quality displays on several aspects: design, execution, quality of components, maintenance etc.
- Building regulations and (initial) costs are dominant decision factors for the selection of ventilation systems.

2.2. Strategy plan and objectives

To encounter these problems and barriers for further application and market acceptation Novem drew up a strategy plan in 1995. This plan included:

- strategies and actions for quality improvement:
  - on process level
  - on component level
- embedding of MVHR in building regulations i.e. in the Energy Performance Standard
- promotion and information to market parties (principals, builders, installers, consumers)

In table 1 a summary is given of the strategy plan with objectives for a number of identified barriers, distributed in three general actions.

General Actions ⇒ **Barriers** ⇓	**1. Dissemination**	**2. Quality Improvement**	**3. Embedding**
1. Building regulations	1.1 Emphasising role of MVHR in Building reg's	1.2 Stimulation of developments for further limiation of energy use for ventilation: - development of high efficiency heat recovery - deployment of DC	1.3 Review of NEN 5128: 1995 on rewarding heat recovery Linking limiting air tightness with MVHR Release of NEN 5138
2. Bad image and (lack of) aquintance with MVHR	2.1 Foundation for High Effiency Ventilation (Stichting HR-ventilatie) Release of brochure with MVHR success storiezs Occupants instructions	2.2 QA document ISSO 61: Quality requirements for domestic ventilation systems Certification of installers	
3. Costs	3.1 Costs for ventilation expressed as LCC: task in IEA Annex 27	3.2 Fixed prices	3.3 Grants for MVHR

3. Design of the program

3.1. Dissemination

Promotion and information to market parties

One of the most important actions in the Novem strategy plan was the streamlining of information and promotion activities by the founding of the “Stichting HR-Ventilatie” (Foundation for High-Efficiency Ventilation). In the chapter 4 their role is further explained. (action 2.1)

Expressing costs for ventilation as LCC

Initial costs are a dominant decision factor for the selection of ventilation systems. However life cycle costs, including operating, energy and maintenance costs have a much bigger influence in the total costs during the lifetime of a building. Within IEA Annex 27 “Demonstration and Evaluation of Domestic Ventilation Systems a model to establish life cycle costs has been developed. In this model LCC is linked with a model for determining the reliability of ventilation systems as function of the basic quality and level of maintenance. It also includes costs for non-scheduled maintenance due to ventilation related damage to the building (lit. 5). (action 3.1)

Fixed prices

Although this was one of the objectives in the strategy plans and supporting activities in this field are organised (certification of installers, foundation for high efficiency ventilation) no

progress was made in this field. This objective was not adopted by the supply side of the market. (action 3.2)

Grants
In 2000 grants are given for high efficiency MVHR in existing dwellings (HFL 400,-- per unit, including 2 DC fans). For new dwellings MVHR is an important measure and a well-accepted technology to realise the demanded Energy Performance Coefficient. For that reason grants are considered not to be necessary to stimulate a further market introduction. (action 3.3)

3.2. Quality improvement

Quality improvement on process level
To improve and to ensure the total quality of ventilation systems a method is developed (Model quality Assurance - MQA) to realise and guard this total process. The primary objective of the process of realisation of a ventilation system (or a climate installation in general) is to build an installation that meets the Terms of Reference with respect to indoor climate, energy consumption and cost. To this effect design guidelines will have to be followed and tests will have to be carried out.

The model quality Assurance (MQA) system makes it possible to obtain a clear cut view of a climate installation during the process of realisation, so that it becomes clear what requirements will have to be met and which design guidelines, communication and tests will have to be carried out. Figure 1. schematically represents the MQA.

Management Aspect	**Realisation process climate installation**				
	1. programme	2. design	3. work out	4 realisation	5 management
0. general					
1. organisation					
2. communication					
3. requirements					
4. means					
5. buy					
6 time					
7. financial					
8. realisation					
9. experience					

This MQA is developed for ventilation systems in a publication (ISSO 61; lit.3) and is used by the Dutch Installers Branch (VNI) for process certification (action 2.2).

Quality improvement on component level

Development and introduction of counter flow heat exchangers:

In 1996 the Dutch ventilation industry started to develop a new type of MVHR units. These heat recovery units were based on the application of counter flow heat exchangers. In general from a thermodynamic point of view a laminar heat exchange is the best solution for heat exchangers (Bejan 1982). One stipulation is that the distance of the flux is small. The distance between the heart of the warm and cold flow must be as small as possible either the contact surface area must be maximal. Triangular or rectangular parallel canals with a counter flow cope with these conditions. In relation to turbulent flows as in cross flow heat exchangers the efficiency of laminar flows is much higher. Theoretically an efficiency of 100 % is possible. The laminar canal heat exchanger has the distinction with other types of laminar exchangers that the canals for both media have the same shape and that every canal wall for one medium is also the wall for the other medium. The ratio wall to canal volume is maximal.

One of the main difficulties was the connection of the canals with the collection canals. This problem is solved by making the connection in two steps:

1. Re-organising canals by replacing every uneven column one canal-height vertically thus introducing rows with alternating supply and exhaust flows;
2. Omitting the walls closing the flow direction left and for the other right and so on.

By applying this principle it is possible to produce laminar counter flow heat exchangers in mass production at relative low costs.

Application of counter flow heat recovery is not only initiated because of the energy benefits. The efficiency of 90% results in a relatively high supply temperature (17^{0}C at outdoor temperature of –10^{0}C). This gives an improvement of the thermal comfort and reheating of the supplied air is not necessary. This also means that low induction inlet grilles can be used. This prevents problems with noise and dust deposit. The first prototype laminar counter flow heat exchanger was introduced in 1996 in a configuration with DC fans to minimise the electric support energy for fans. In 1998 the Dutch Ventilation Industry launched the counter flow heat recovery units on the market. (action 2.1)

Deployment of DC fans:

Not only ventilation losses have to be taken into account also the support energy, needed for fans, is important. DC fans have a higher efficiency then the traditional AC fans especially in cases of lowering the air flows. In general electricity use for fans can be reduced by 50% using DC fans instead of AC fans. Although the principle of DC technology for fans was known for years application for domestic ventilation was not common because of the extra costs for DC fans. Now the Dutch EPN also takes into account fan energy (and DC fans are rewarded in the calculations) DC fans are introduced for domestic application. All High Efficiency MVHR units have DC fans, not only for minimising electricity use but also for improved controllability of fans. (action 2.1)

3.3. Embedding

<u>Embedding of MVHR in building regulations</u>
MVHR is rewarded in the Dutch Energy Performance Standard NEN 5128: 1998.

To enable standardised measurements for heat recovery efficiency and total energy performances of heat recovery units Dutch Standard NEN 5138 is released. This standard is comparable with EN 308.

In chapter 5 this is further explained. (action 3.1.)

4. Main actors and their roles

The main actor for the implementation of high efficiency heat recovery in the Netherlands was Novem. In the eighties Novem (then under the name NEOM) conducted demonstration programmes and several supporting researches. In 1995 Novem initiated a strategy plan for a further market introduction and market acceptation. In 1996 the Foundation for High efficiency ventilation was established, initiated by Novem and the Dutch Ventilation Industry. The objectives and mission of the foundation is to promote a good and healthy indoor environment as well as energy efficiency by the use of balanced ventilation with heat recovery. The foundation tries to achieve this goal by giving independent and objective information, development and stimulation of market introduction of energy efficient ventilation systems.

The benefits of this foundation is that all information about MVHR is streamlined and objective. There is one organisation as counterpart for policymakers, standardisation bodies, other market parties etc. Beside six industrial parties also Novem, the Dutch Installers Branch Organisation (VNI), Gasunie and Intechnium (educational institute for installers) are members of the Foundation.

Since their establishment all major activities for communication, dissemination, quality improvement and product development are co-ordinated by the Foundation for High Efficiency Ventilation. The annual budget is approximately 200 kEuro.

5. Policy mechanisms used

<u>MVHR in building regulations:</u>

Building regulations in the Netherlands are given in the so-called Building Decree. The Building Decree has four parts:

- Safety
- Health
- Usefulness
- Energy

Every regulation must “fit in” in one these starting points. Two very important aspects of the Building Decree are:

- Every demand or regulation is given as a performance criteria: this means there are **no** prescriptions about what kind of materials should be used or thickness of etc. etc.
- One is free to arrange or divide a building or dwelling: this means that the performance criteria are given in such a way that they are independent of arrangement of rooms in

building. This also means that you can rearrange rooms in a building without getting into conflict with the building regulations.

In the chapter energy only three regulations are given. For dwellings is this in:

art. 70: Limitation of transmission losses

art. 71: Limitation of air permeability of the building envelope

art. 71a: Energy Performance of a building

Regulations on energy only apply for **new** buildings (not for existing buildings).

Most important is art. 71a Energy Performance. The energy performance is a one-number value in which the total energy performance of a building is expressed. This is called the Energy Performance Coefficient (EPC). The EPC is calculated by the so called Energy Performance Standard (NEN 5128 and NEN 2916). It contains:

- Energy use for heating, including:
    - Transmission losses
    - Ventilation and infiltration losses
    - Passive and active solar gains, internal gains
    - Efficiency and support energy for heat generation
- Energy use for DHW
- Energy use for fans
- Energy use for lighting (only non residential buildings)
- Energy use for cooling (mostly non residential buildings)
- Energy use for humidification (mostly non residential buildings)

In the building decree the demands on the Energy Performance Coefficient for all kinds of building types (residential and non residential) are given. You are free to select your own set of energy efficiency measures to cope with the required EPC. In other words you can compensate less thermal insulation with energy efficient installations (heat pumps, heat recovery) and/or sustainable energy. The energy performance standard was introduced in 1995. Ever since the EPC was sharpened in 1998 and, next, in 2000.

Energy use for ventilation is taken into account in energy use for heating (i.e. ventilation losses) and energy use for fans. Ventilation losses include three parts: infiltration, mechanical ventilation and use of ventilation provisions (grilles and windows). The mechanical air flow can be reduced by multiplying with a factor (1 – the energy efficiency). For conventional cross flow heat exchangers the energy efficiency is 65%. For cross flow heat exchangers the default value for energy efficiency is 75%. However, if the energy efficiency is determined by measurements according to standard NEN 5138 the measured efficiency can be applied. For most of the high efficiency MVHR this measured energy efficiency is 90 to 95%.

Application of MVHR allows also an increase of air tightness resulting in lower air flows due to infiltration.

Energy use of fans is taken into account separately. The default value for DC fans lead to 40% less energy use compared with AC fans. However, if you select more energy efficient DC fans, you can calculate with the real input power. This can result in 50 to 60% less energy use in the energy performance calculations.

6 Monitoring and evaluation process

6.1. Background

As the requirements on energy efficiency, reflected in the Energy Performance Coefficient, rapidly increases in the Netherlands, discussions arose on indoor environment in energy efficient houses. There is an awareness of the role of ventilation, and as a result the possible contradiction between IAQ, thermal comfort and energy use for ventilation losses. In 1999 and 2000 a programme is carried out to investigate indoor air and ventilation quality in new built energy efficient homes (i.e. complying with the latest Dutch Energy Performance Standard) with different types of ventilation systems and especially focussing on high efficiency heat recovery. One of the goals of this programme is to study the impact of strengthening the national requirements on energy efficiency on the indoor environment regarding IAQ, ventilation and thermal comfort. In this programme several parties will co-operate like Novem, several regional health care organisations, the Dutch ventilation industry and Gasunie. The Foundation for High Efficiency Ventilation is responsible for researching the performances on IAQ, ventilation and energy use of the counter flow heat exchangers in practice. Therefor in 1999 in six low energy houses a measurement and evaluation program was carried out. A next project has followed in 2000. This case study will focus on the results of the first project.

6.2. Energy performances of counter flow heat recovery units

The energy performance of heat recovery units can be measured by the Dutch standard NEN 5138: Heat Recovery in Residential Buildings - Determination method. This method is more or less similar to the European standard EN 308 but is in its boundary conditions more suitable for measuring domestic ventilation units. In NEN 5138 a standardised method is given for measuring the energy efficiency and the Performance Factor of domestic heat recovery units. The Performance Factor is defined as the yearly (useful) saved energy divided by the needed electrical input for fans. In table 2 the measured energy performances under laboratory conditions are given.

Table 2. Energy performance (laboratory conditions – NEN 5138)

Manufacturer/type	**Energy efficiency (%)**	**Electrical input (W)**	**Performance Factor (-)**
Brink Renovent HR	96	46	9.8
Itho Ecofan HRU	97	40	10.4
J.E. Stork Air WHR 90	96	48	8.6

In six demonstration houses counter flow heat recovery units of manufacturer Brink were applied. The energy performances in practice were determined by real time measuring the in and outgoing temperatures of the air flows. For correcting temperature efficiency to energy efficiency the in and outgoing mass flows were also measured. The average measured energy efficiency in practice is 85%. This is less then the measured energy efficiency under laboratory conditions. The difference is caused by the instability of the measurements, especially the fluctuations of the in and outgoing air flows and the accuracy of temperature measurements. The gas savings vary from 210 to 290 m^3 nat. gas/year. The average electricity consumption for fans was 200 kWh/year. By using flow controlled DC fans the problem of instability is solved now. Measurements in the second project (using flow controlled fans) show that the average efficiency in practice is 92%.

Ventilation performances and air flows

The total ventilation as well as the separate ventilation components were measured as follows:

- Total average air change rates during 8 weeks by passive tracer gas method (PFT)
- Air tightness of building envelope by Dutch standard NEN 2686: Air Leakage of Buildings - Method of Measurements.
- Monitoring use of fans by datalogging.
- Inventory of use of other ventilation provisions by questionnaires.

Total air change rates were measured in habitable and service rooms (figure 2) as well as for the whole building (figure 3). These total air change rates include mechanical air flows (MVHR-unit), infiltration of air through the building envelope and window airing. The air leakages of the dwellings are measured by pressurisation tests (blower doors). The air tightness is expressed as the airflow through the building envelope at a pressure difference over the envelope of 10 Pa ($q_{v;10}$). The $q_{v;10}$ values of most dwellings were between 60 and 80 dm^3/s. This corresponds with n50 value of 1.6 to 2.2. The measured $q_{v;10}$ values are given in figure 4

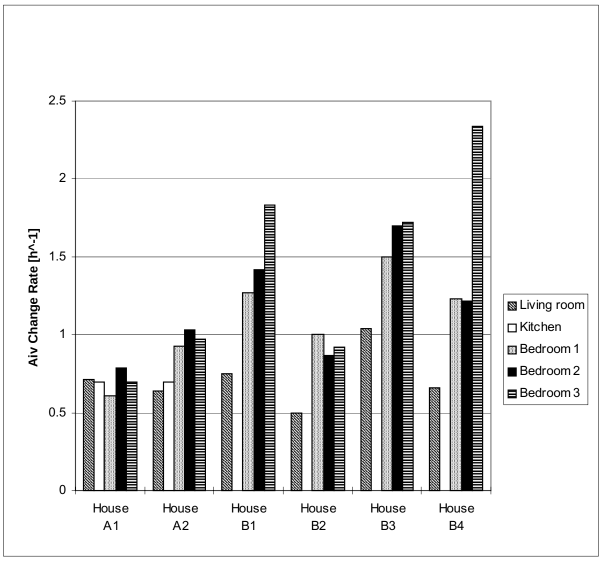

Figure 2. Measured air change rates in rooms

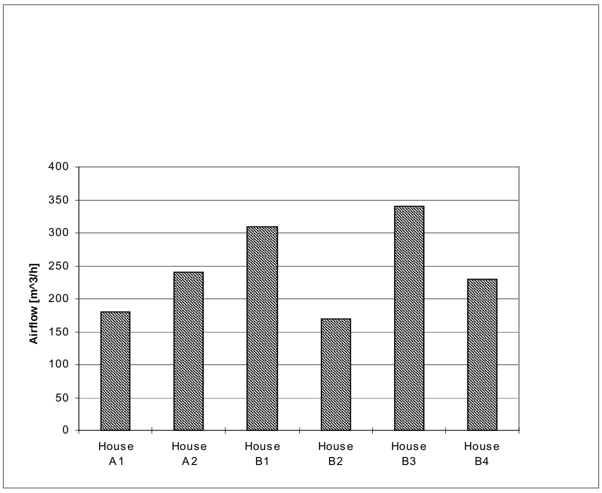

Figure 3. Total air flow rates in dwellings

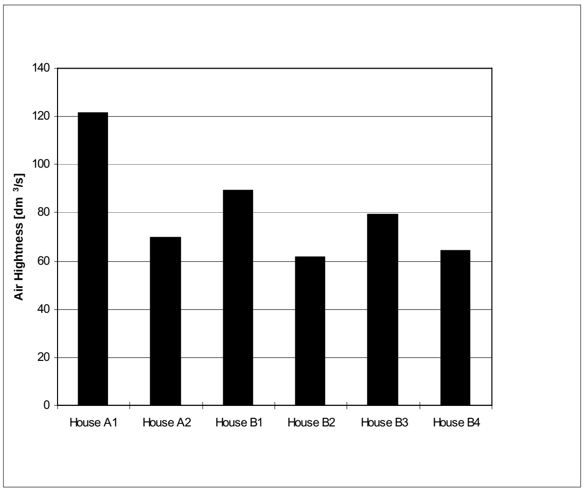

Figure 4. Measured air leakage at 10 Pa

Indoor air quality

In figures 5 to 8 the measured concentrations CO_2, CO, TVOC (related to CH_4), as well as the relative humidity are given. These concentrations were measured real time during one week. In figure 9 and 10 measured concentrations of NO_2 and Radon are given.

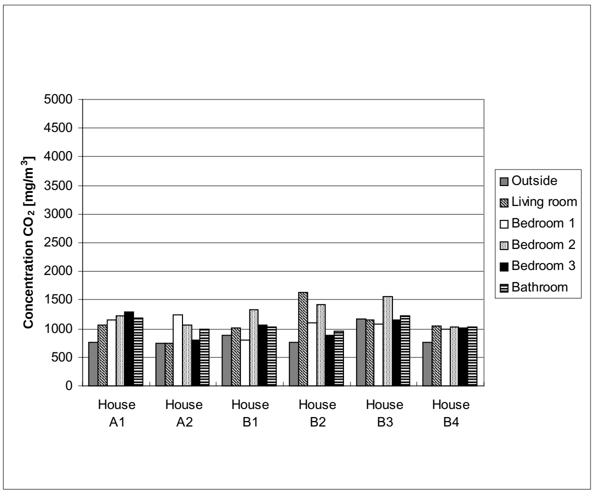

Figure 5. Measured CO_2 concentration

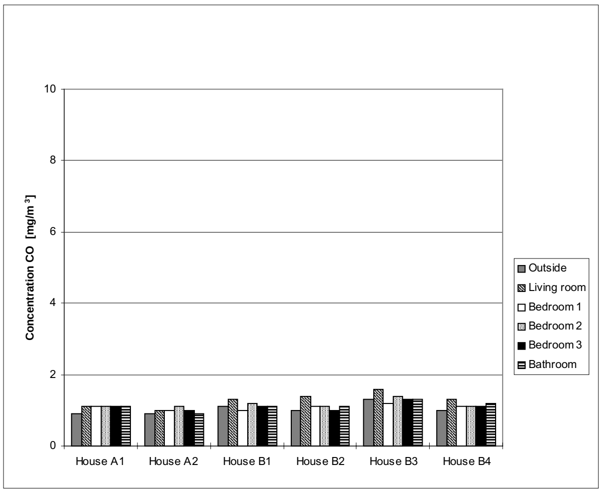

Figure 6. Measured CO concentration

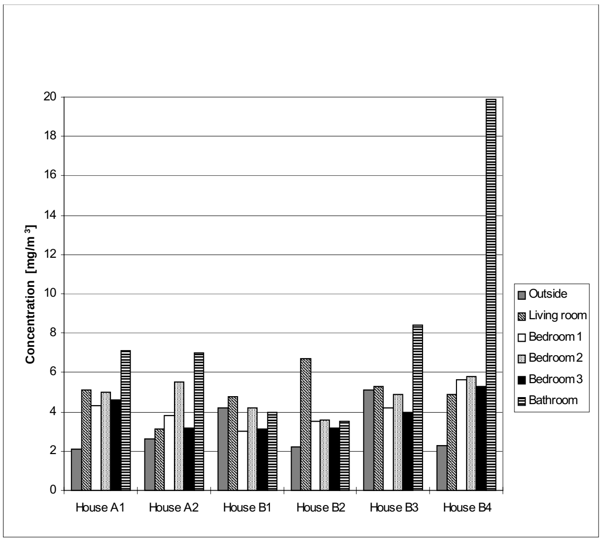

Figure7. Measured TVOC concentration

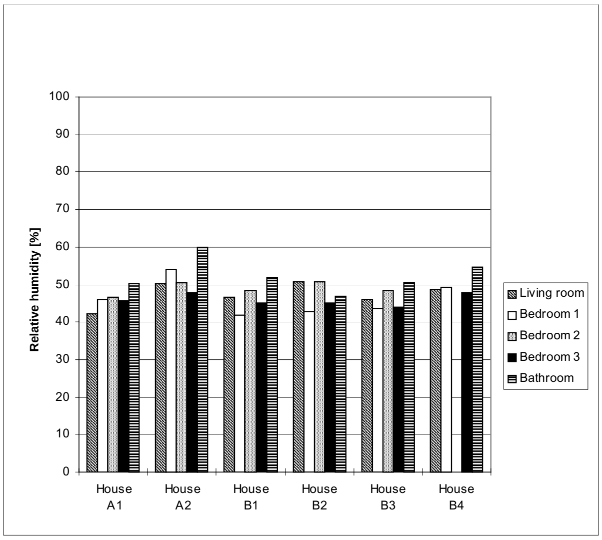

Figure 8. Measured relative humidity

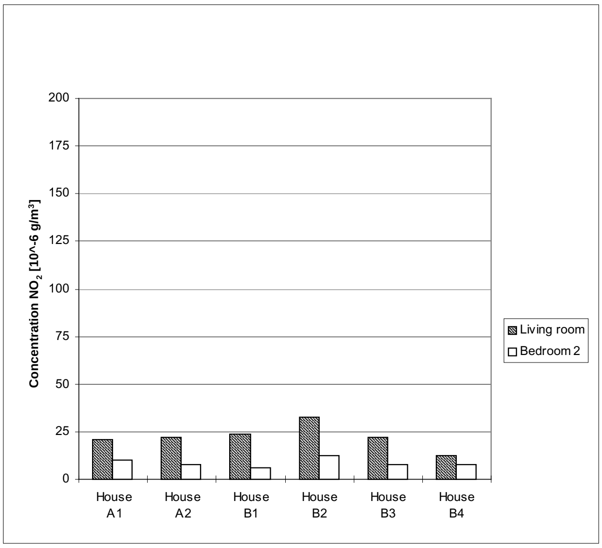

Figure 9. Measured NO_2 concentration

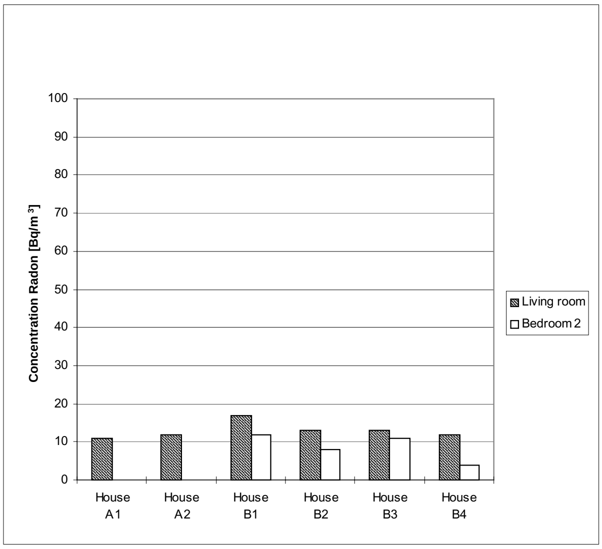

Figure 10. Measured Radon concentration

Thermal comfort and noise

Thermal comfort and noise (i.e. the absence of noise) are two of the most important parameters for occupants to assess the quality and appreciation of ventilation systems. Thermal comfort is measured in the middle of the living room at 0.1 m and 1.1 m. Local thermal comfort is evaluated on draught. Figure 11 shows the PD values calculated from measured air velocity, air temperature and turbulence.

System noise was measured in the middle of the living room and in one of the bedrooms. The fans were switched to the middle position, corresponding with the nominal air flows according to the Dutch building regulations. Figure 12 shows measured A-weighted noise levels.

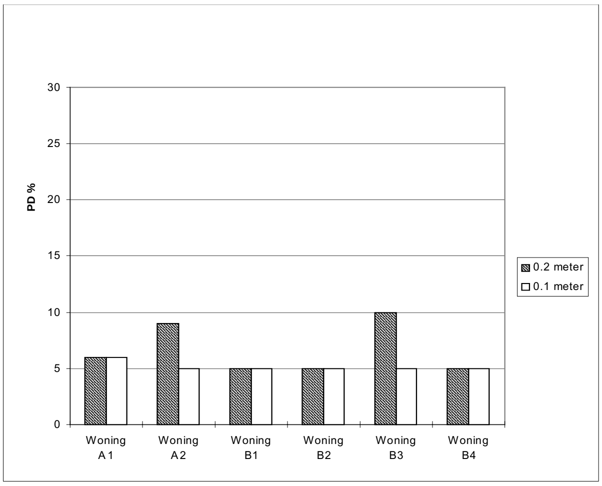

Figure 11. Measured PD value in living room

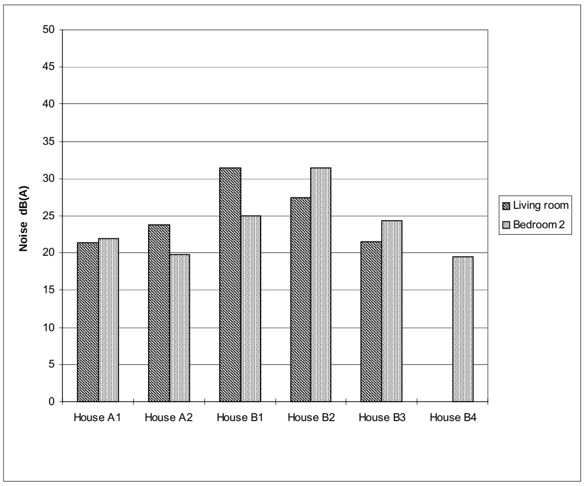

Figure 12. Measured noise levels

7 Discussion of results

7.1. Measurements

Indoor air quality

Average CO_2 levels did not exceed the hygienic guideline level of 1800 mg/m^3. However, during nighttime in a number of houses this level was frequently exceeded in bedrooms. This is mainly caused by the fact that occupants use the low position of the fans, without using additional ventilation provisions. Using the middle position of the fans or opening windows lead to a much lower CO_2 concentration in bedrooms. CO and NO_2 concentrations appear to be far below the guideline values. This is due to the fact that there are no or limited sources within the houses. All houses have gas stoves for cooking. In two houses occasionally higher CO levels were measured, caused by tobacco smoke. In most of the bathrooms TVOC concentration show high peaks in the morning, caused by use of cosmetics and cleaning. The ventilation systems were able to lower these peaks to normal concentrations within an hour.

Thermal comfort and noise

Counter flow heat recovery units are developed to realise a healthy and comfortable indoor environment combined with extreme low energy use for ventilation losses.

The overall conclusion is that counter flow heat recovery units can provide an indoor environment that meets the guidelines concerning indoor air quality, thermal comfort and noise levels. Thermal comfort is realised under all weather conditions without the necessity of applying reheaters; the (thermal) efficiency of approximately 95% is enough to secure a supply temperature of just a few degrees under room conditions. Noise levels caused by the ventilation system vary from 20 to 30 dB(A). These levels do not exceed the guideline values for system noise.

Use of the ventilation system

Questionnaires as well as monitoring switching times of fans show that occupants do not have an optimal use of the ventilation provisions. It was not clear if this is caused by lack of information, indifference or that occupants are well conscious of not using the ventilation provisions. Despite this observation it is remarkable that performances on both energy, indoor air quality and thermal comfort were very good. Although occupants behaviour is dominant in the total air change rates the minimum ventilation performance of the systems is sufficient to provide a healthy indoor environment in an air tight dwelling.

7.2. Market penetration

In table 3 a summary is given of the residential building volume in the Netherlands, the development of the Energy Performance coefficient, and the market share of MVHR. The numbers of MVHR units from 1997 to 1999 are based on sales data of the Dutch ventilation industry. The number for 2000 is a prognosis, based on the first half-year sales data. The data for 2001 and further are market prognoses from the Foundation of High Efficiency Ventilation (lit 6).

Table 3. Development of market penetration

	1997	1998	1999	2000	2001	2002	2003	2004	2005
number of new dwellings	97000	90000	85000	78000	70000	66500	?	?	?
EPC	1.4	1.2	1.2	1.0	1.0	1.0	1.0	?	?
number of MVHR	2900	5400	8500	12500	17500	20000	?	?	?
market % MVHR	3	6	10	16	25	30	35	40	?
absolute saving MVHR HRwtw referred to nat. supply/mech. exhaust (TJ)	25.6	47.5	74.8	110.0	154.0	176.0			
	monitored				prognosis				

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First Draft

The PV-Covenant in the Netherlands

Case Study for the IEA/CERT project on

"Lessons learned and best practices in energy technology deployment"

I. Introduction

In this case study the *PV Covenant in The Netherlands* [1] will be illustrated. The technology involved is *photovoltaic solar energy* (PV) *for the built environment*. The formal starting date of the Dutch PV Covenant was the 14th of April 1997 and it will be closed in December 2000.

This Dutch PV Covenant is an interesting program because:

1. It is a joint approach by the demand- and supply side of the Dutch PV market in co-operation with the government and Novem, The Netherlands Agency for Energy and the Environment. All partners in the PV Covenant deliver a specific fixed contribution.
2. The Covenant is based on consensus on joint efforts towards price reduction in relation to goals for phased installation of grid connected PV power.
3. The implementation of PV systems in the built environment is tuned on National PV programme executed by Novem, also partner in the Covenant.
4. The goals of the PV Covenant are based on a solid plan: *"PV Introduction plan"*; annex of the Covenant.

II. Objectives of the PV Covenant

Policy objective:

The aim of the PV-Covenant is: *"To direct and guide the initial market introduction of PV-systems in the built environment."* The quantitative target is to realise **7,7 MWp** of cumulative grid connected solar PV in the built environment in the year 2000[15].

Strategic goals:

To deliver an effective contribution to the development of PV as sustainable energy source for the large scale application in the Dutch energy supply of the next century. More specific:

[15] This goal has already been reached

a. Realisation of the number of PV systems in the built environment is necessary, according to the PV introduction Plan, to build up the needed experience for a sound future

b. A phased development of the installed PV power, according to the *"PV Introduction Plan"* [2]

c. To contribute to the improvement of the price performance ratio of grid connected PV systems and to build on the competitiveness of PV as energy source in the Dutch energy supply

d. To improve and widen the awareness of PV of industry, institutions and the society, enabling future large scale introduction of PV in The Netherlands, using the common vision of *The PV Introduction Plan*.

Specific Goals:

The specific goals of the PV Covenant are related to the contributions of the partners which signed the Covenant.
The **Ministry of Economic affairs** will do its best to make available in the period 1997-2000:

A. an average amount of 13 million Dutch Guilders per year for:

   1) research and development of solar cells;
   2) R&D of components for grid-connected application
   3) Product and market development of autonomous PV systems in The Netherlands and for export.

B. an average amount of 20 million Dutch Guilders per year (including personnel) for:

   1) realisation of pilot projects to fill in Dutch PV Programme "PV in the built environment"

The **Energy Distribution Companies** (EDC) will strive for the realisation of 7,7 MWp cumulative installed grid connected PV power in 2000. This matches with 0,1 PJ of saved fossil energy. Each EDC will strive to realise her share of this goal related to her market share of the nation wide electricity sales.

The PV companies, **manufacturers of PV** cells and modules will strive to substantially reduce the price of PV systems in accordance with the figures of *The PV Introduction Plan*, which are based on expected market volumes.

The **building industry** will strive to take all necessary actions to realise the 7,7 MWp on roofs and buildings, possibly constructional adjustments, cost savings for roof tiles and supporting 'green financing schemes'. Each building company will strive to contribute to the 7,7 MWp at least according to their related market share.

R&D institutions (ECN) will bring in their expertise and facilities to support the realisation of the targets for price reduction and reliability by implementation of R&D results and evaluation of realised projects. Her own R&D program will be matched with the goals of the PV Covenant.

Novem will execute the National Research Program for PV and will take all necessary actions for realisation of the goal of 7,7 MWp in 2000. Furthermore Novem will initiate

publicity campaigns with the partners for further PV stimulation, monitor the development and execute the secretariat of the Covenant.

What specific barrier(s) to technology diffusion was addressed ?

In order to achieve the goals for PV set by the Ministry, a commonly shared strategy needed to be developed and important parties needed to be committed to this plan. Only a joint strategy of the supply and demand side of the market could guarantee the market volume needed for the required cost reductions. Furthermore the Covenant intended to create sufficient awareness and commitment for grid connected building integrated PV by the large market players and emphasise the opportunities as stakeholder related to the inevitable development of PV in The Netherlands and world wide.

III. Process of Definition/Design of the Program

In the initial phase towards the covenant the Ministry of Economic Affairs initiated the so called PV-Platform, consisting of key players in the pv area. This Platform developed the concept covenant starting in 1994.

Meetings of the Platform were organised regularly on a bimonthly basis besides bilateral meetings. On April 14th of 1997 the PV Covenant was officially signed by 15 organisations.

The Covenant is aiming for PV application in the built environment and preparing the way for large scale application. The PV Covenant is based on a detailed strategy report "PV Introduction Plan", written in co-operation by ECN (as R&D institute) and the Dutch PV industry (Shell Solar). ECN is one of the main executors of the Dutch R&D activities in the field of PV.

IV. Main Actors Involved in the Implementation of the policy

The PV-Covenant was signed in 1997 by 15 parties: ECN, R&S (the later Shell Solar Energy), the Ministry of Economic Affairs, several Energy Utilities (Energy Distribution Companies) and their branch organisation (EnergieNed), several project developers (building industry), and Novem. In the course of 1998 and 1999, 13 more parties co-signed the Covenant, (more utilities, other PV-manufacturers and suppliers, and municipalities). The chairperson of the PV Platform is an independent person, which turned out te bean important binding factor .

Main actors:

- **Novem** is executing the Dutch National PV Programme “NOZ-PV” on behalf of the Ministry of Economic Affairs. Therefor Novem is a ‘spider in the web’ of activities in the field of PV. Novem provides subsidies for PV (demonstration) projects.
- The **Ministry of Economic Affairs** is providing the funds for the execution of the NOZ-PV programme and sets the goals for PV introduction in The Netherlands.
- The **Energy Distribution Compa**nies (EDC’s) played a leading role initiating PV-projects at the time the Covenant started, due to their position in the energy market. They have investment subsidies available for PV projects in their ‘B-MAP programme’. At present EDC’s are focused more on the aspects of market liberalisation. Initiatives with the development of new products and services including ‘green energy’ products have started. Some of the EDC’s have build PV-systems to cover a small part of the needed green electricity by PV power. Furthermore all Dutch EDC’s have agreed on the production of 3,2% Renewable Energy by the year 2000.
- **ECN** with over 30 PV experts in different R&D areas played an important role in the support of the development and up scaling of the Dutch Shell Solar production lines for cells and modules.
- The **Building industry (mainly project developers)** evaluated PV-application opportunities in many new housing projects. The large scale new housing programme in The Netherlands (500.000 new houses till 2007) offers good opportunities for (smaller) PV systems. Their interest in PV was stimulated by the prosperous market situation with large demand and good economic circumstances and the growing awareness for sustainable building.
- **Shell Solar** as cell and module manufacturer increased their production capacity and started initiatives in product development (‘Sunpower’). As market leader the played a leading role in the targeted cost price reduction. Most of their initiatives were taken in co-operation with other Covenant partners such as an inverter manufacturer, EDC’s and the building industry. Furthermore Shell Solar and above mentioned and other organisations contributed to the initiatives for large scale projects like the 1 MWp housing project in Amersfoort.
- Due to his former experience (as a politician) and position, the **independent chairman** with his extensive network was able to bind the heterogeneous group of Covenant partners, each with their own interests. In co-operation with the secretary (the independent and experienced PV consultant) they form a team which is able to operate independently.

V. Policy mechanism used

Right after signature the PV Platform was reformed to a forum with all the organisations which signed the PV Covenant. From this forum of 28 people a smaller PV Steering Group was formed with representatives of each line of business. The PV Steering Group, which meets every two months is represented by one person of the Energy Distribution Companies, two on behalf of the Manufacturers, one on behalf of the building industry, one on behalf of

the knowledge institutes, a representative on behalf of Novem, one of the Ministry and the independent chairman assisted by an independent consultant for the secretariat.

Tasks of the Steering Group were to control and monitor the execution of the PV Covenant and the expansion with new organisations.

Furthermore, since 1999, the Steering Group plays an initiating role in formulating and preparing a new PV Covenant for the period after 2000.

The Covenant was and still is a basis for the National PV Program (NOZ PV) executed by Novem and funded by the Ministry of Economic Affairs. The **subsidy programme (NOZ PV)** is therefor tuned to the goals of the Covenant. During the Covenant subsidies were available for demonstration projects in the built environment, for more experimental projects where new (technical) issues were demonstrated, for market introduction projects and for R&D projects on cells, modules or BOS/components. Also a specified budget is available for autonomous and export projects. The total amount of money of this program directly related to the Covenant is about 35 million Dutch Guilders per year.

The ministry furthermore stimulated PV financially by adding PV on the list of environmental measures and equipment were tax paying companies can get **fiscal advantages** like the option to depreciate an investment in one year (in stead of the usual more years) and extra tax deductions on the investment.

In the mean time the **Energy Distribution Companies** (EDC's) which signed the Covenant also made some additional **generic subsidies** (average: 3 NLG/Wp) for PV projects available. These investment subsidies were financed by their Environmental Action Plan ("B-MAP"), which is financed by a small environmental tax all consumers are due to pay till 2000 on every kWh and every cubic meter of gas.

In the "PV introduction Plan", annex of the Covenant, expected **cost schemes** were formulated based on the expected market volumes per year and cumulative during the Covenant period. These cost schemes served as a reference for the judgement of project proposals submitted for subsidy in the Novem NOZ-PV program. Only with good reason higher prices were accepted in projects. The cost schemes therefor served also as reference in the market.

Tasks of Novem's NOZ PV program is also the execution of an PR and **information campaign**. Some special brochures and flyers were made specifically for the development and progress of the PV Covenant. For all the specific activities related to the PV Covenant as mentioned above Novem has a budget available. From this budget also the secretary (an independent PV consultant) and the chairman were paid (together some 30.000 EURO per year), as well as costs for meetings (rooms).

As a result of the PV Covenant some additional **voluntary agreements** were put up for specific projects by some of the partners. For instance one of the EDC's based in Rotterdam, made and signed a 'Solar electricity Covenant' with some near municipalities: Den Haag and Rotterdam. The last city also signed the PV Covenant, while in Den Haag the headquarters of the EDC is located. Aim of this specific Covenant is the realisation and installation of small and larger PV systems in order to fulfil their obligation of the PV Covenant. Also in other large projects more forms of co-operation like a Covenant can been seen. The last years

Covenants have proven to be an effective instrument achieving various environmental targets in The Netherlands.

VI. Monitoring and evaluation process

The main actors monitoring the progress of the implementation of the PV Covenant, are the PV Steering Group, the PV Platform and Novem.

PV Platform

At least twice a year the PV platform meets and discusses the latest topics by having presentations by its own members or specialists on other fields (for example marketing). Furthermore presentations with data are given on the progress made with the Covenant targets. Some market figures are gathered or available at Novem, other are collected by a simple questionnaire between all partners by the secretary. The agenda of a meeting is made by the secretary in co-operation with the chairman. Being an independent PV consultant the secretary has a good overview over the (international) market developments.

PV Steering Group

The PV steering group meets about every two months. News, new developments from partners and projects and (international) market developments etc. are discussed. The independent secretary and chairman play an important role in judging the relevance of topics for the meetings.
Since the Steering Group contains the most experienced people in the field of PV in The Netherlands, discussions take place at a very high level. Difficult matters are prepared in the Steering Group and subsequently proposed to the PV Platform. Of all PV Steering Group meetings a report is being made, which after correction by the Steering Group is spread also towards the partners in the PV platform.

Monitoring report

In a Monitoring Procedure, annex of the PV Covenant, is written how the monitoring should be executed. An overview of aspects to be addressed in the (yearly) report is also provided.

Novem is executing a market survey every year in order to create a market overview of PV systems. Based on the market data Novem will interpret trends and developments. The data are being collected by questionnaires send to all manufacturers and suppliers of PV systems and components. Novem is purposed to produce a report every year, which then can be spread towards the partners of the Covenant. Since 1997 one monitoring report has been produced and it seems that additional reports are not being missed, due to the overkill of information partner organisations are receiving.

The monitoring report covers all items addressed in the monitoring procedure, which is based on the international guidelines of the IEA PVPS program [5].It is the intention of the PV Steering Group to produce at least one final evaluation report on the ending PV Covenant.

New PV Covenant

In the middle of 1999 the PV steering Group was urged to start with the preparation of a new PV Covenant for the period after 2000, since the present Covenant is ending per 31st of December. The experiences with the present Covenant and the increased goal (parties talk about 250 MWp in 2007!) make it preferable to attract new organisations to join a new PV Covenant. An example is the National Association of Installers (VNI), since (the PV experience of) installers are becoming more and more crucial for large scale market introduction. Other important organisations are associations of various consumer groups such as housing associations and the National Business Association.

VII Discussion of results

Overall evaluation of objectives

The acceptance of grid connected PV-systems as a part of both the built environment and of the national energy supply has developed in a very positive way in the Netherlands. Many parties consider building integrated PV-systems as an attractive and viable option and are actively participating in demonstration projects and market developments. A wealth of experience has been built up with the application of PV-systems as a building product in many different types of buildings and new housing projects. New products have been developed (Sunpower) and forms of co-operation between various partners have been started in order to manage larger building integrated PV projects, such as an one MegaWatt project in Amersfoort and the currently under preparation 5 MWp project in the province of the North of Holland.

The market for PV-systems is developing well, and the aim of 7.7 MWp by the end of 2000 will most probably be achieved. In relation to this the targeted price development mentioned in the “PV Introduction Plan” [2] has been realised.

The PV Steering Group, as representation of the PV-Platform, is working hard on an updated strategy document and a new PV Covenant for the years 2001-2007, with the aim to contribute effectively to the realisation of around 250 MWp (cumulative) by the year 2007.

It is difficult to specify the role and importance of the PV Covenant in this process. However, several parties involved in the PV-Platform claim that it is not only the actual signing of the Covenant which is important, but also that the process of writing and discussing the PV-Covenant and the underlying Introduction plan stimulates discussion on important, sometimes controversial subjects. Also, it is a good way of getting the actual expectations and aims of parties out in the open. Moreover, the PV-Platform constitutes an important network, in which parties can meet and exchange information and have an opportunity to state their case and try to influence national policy. Also, considering the eagerness of parties to co-sign the Covenant (14 additional partners of various background signed after the initial 15 in two shifts during last one and a half year), being part of the PV-Platform is important for all parties who feel they have something at stake in the development of PV-systems in the Netherlands.

Which were the key elements of success ?

Important elements of success are the fact that quantified goals in terms of installed power were formulated, and that there was a budget for realising projects. The PV Platform

constitutes an important platform for open discussions and exchange of opinions, thus enlarging the support by organisations involved in the government goals . Furthermore the PV platform turns out to be an excellent forum to exchange the latest information and newest developments from key note persons from the Dutch PV market, the government and Novem. Although the participants all have very few time available, the attendance of the meetings was very good which underlines the importance.

The status and image of the Covenant increased the added value for organisations to join. The grown common interest of large scale PV application has a positive influence on politics. The signed agreement is used in several ways for extra publicity and status in obtaining projects and sales activities.

Also important is the strategy document 'PV Introduction Plan' [2], because it outlines a vision and strategy which is also supported by the central authorities. All partners can refer to it and justify internally according to the development of their own company strategy. Finally, the PV Steering Group as representation of the PV Platform, and with the national experts around the table, greatly enhances efficiency of operations and the level of discussions.

Which were the main sources of problems ?

In the initial phase, large efforts had to be made to create a Covenant text that was acceptable to the important players. Parties involved felt that they were in the platform in order to state and protect their particular positions and not to help the development of the PV market in general.

For long term strategy implementation it can be recommended to monitor closely the harmonisation of a (new) national PV program with the Covenant goals.

With the growing importance of strategic subjects discussed in the PV steering Group some Platform partners wanted to get more information. A conflict of interest can occur between the Steering Group wanting to discuss freely, without getting confidential information in reports 'out on the street', and partners in the PV Platform aiming for more details. This is more specific the case when the market is growing and partners are becoming more and more competitive. Therefor in the last meeting of the PV Platform it was agreed that an extra representative of another module manufacturer would take part in the PV steering Group.

Important and hard to maintain is the detailed monitoring of the PV Covenant. Checking and controlling if the efforts by partners are related to their market share and specified contributions in the Covenant needs continuous attention by a specialised organisation.

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Deployment of Renewable Energy in a liberalised energy market by Fiscal Instruments in the Netherlands

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Introduction

To achieve a place for renewable energy the Government of the Netherlands has followed a *supply oriented* policy approach during the past decade. In view of the rapidly emerging liberalized energy market government is changing its focus from support to producers to a demand-driven approach.

Key elements of the Dutch policy for the promotion of renewable energy over the past decade were:

- the energy tax on the use of electricity and natural gas
- fiscal instruments to lower investment costs
- voluntary agreements with the energy sector and industry (based on tradable Greenlabels)
- various subsidy schemes to increase the attractiveness of new initiatives.

In view of the upcoming, liberalized energy market 2 major instruments will be added in 2001: (i) a fully liberalized market for green electricity with free consumer choice; (ii) a legally based tradable certificate for renewable energy. The lay-out of the Dutch policy for renewable energy, with its focus on the demand side, has a rather unique position within Europe. Firstly, because of its focus on the demand side, and, secondly, because of its emphasis on voluntary action.

This paper evaluates the market development over the last 4 years and for the future.

Objectives

Renewable energy policies are driven by the well-recognised need for a sustainable society. Within Dutch government policies, targets for renewable energy are addressed in environmental programmes, white papers on energy and on climate change.

The Dutch government aims in its Third White Paper on Energy (1995) at 2 major goals for 2020:

- 33% improvement of the efficiency with which energy is used by continuing energy savings and use of more efficient technologies (with this efficiency target total energy consumption should remain effectively at the 1990 level despite economic growth)
- 10% of all energy used should be provided from renewable sources.

Currently, around 35 PJ (1.2 %) of the Netherlands energy consumption is delivered from renewable sources. For 2020, the target of 10% renewable energy represents a supply of 380 PJ based on the most recent projections of long-term economic growth and energy consumption.

In the Energy Report from 1999 the governments presents its policies in view of a liberalised market:

- A consumer driven approach in the renewable energy market
- Voluntary agreements with specific sectors in the market
- Greening the fiscal system by increasing the energy tax
- Encouraging research and development through specific programs.

Recently, our government published its Action Plan on Climate Policy. This plan contains the actions which are required to comply with the reduction targets of the Kyoto Protocol. By the end of the Kyoto budget period, the emissions of greenhouse gases should be 6% lower than in 1990 (according to the EU agreement on the burden sharing of the Kyoto target over its member states).

Based on projections of greenhouse emissions a reduction of about 50 million tons of CO_2 is required. Domestic measures should cover 25 million tons of the total reduction (the remaining 25 million tons will come from Joint Implementation, CDM-projects and emission trading). Renewable energy forms part of the domestic measures to reduce CO_2. To implement this reduction, a firm target for 2010 has been set at a share of 5% by renewables to the total energy consumption (180 PJ). In terms of CO_2 reduction, this target should reduce 4 million tons of CO_2.

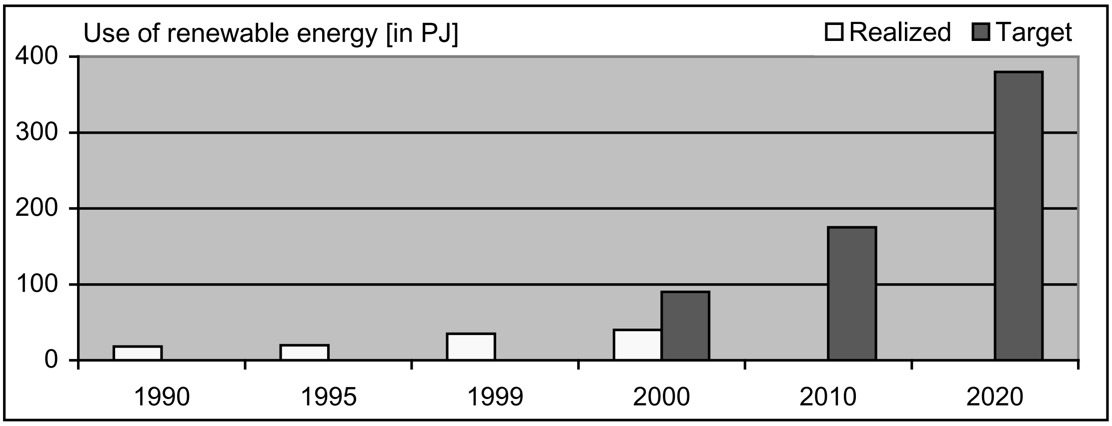


Figure 1 Targets for renewable energy in the Netherlands according to government policy

Policy design

Following the publication of the Third White Paper on Energy Policy in 1995, Government recognized that its subsidy schemes and fiscal instruments to decrease investment costs of renewables were insufficient to achieve its intermediate target for 2000. Also, the level of investment and subsidies from the energy distribution sector up to 1995 would be inadequate to reach this target. The actions of the energy sector formed part of a voluntary agreement with the Minister of Economic Affairs on the implementation of an environmental action plan *(Milieu Actie Plan, MAP)*. This agreement was up for renewal in 1996. Considering the intermediate target for renewables in 2000, government and the energy sector agreed on including a specific goal for renewable energy as part of the new voluntary agreement. During the negotiations this goal was finally set at 1.700 GWh of renewable electricity which the distributors would supply to their customers in 2000.

The new target created a significant challenge for the energy distribution sector. In 1996, approximately 2.300 GWh of renewable electricity was produced, of which about 1.600 GWh was from waste incineration or from auto-producers and not delivered to the public grid. However, both sources are excluded from the agreement. The objective was to specifically increase the deployment of “new” renewables, such as wind energy and biomass. Achieving the target of 1.700 GWh required major investments in the service areas of each distributor, by either the companies themselves or by private investors. However, the opportunities and possibilites for implementing for instance wind energy vary widely between these service areas.

The sector realized that if they maintained their usual policy of subsidizing in their own service area only, the costs of reaching the target would vary substantially between the distributors. For customers this would mean that environmental levies they paid as part of the energy tariffs to cover the environmental action plans would also vary. To overcome these differences, the energy sector investigated the possibilities of burden sharing systems. Mid 1997 the energy sector concluded that a tradable certificate system for renewable energy would be the best option. Subsequently, two decisions were taken by EnergieNed, the branch organisation: (i) a binding set of targets for each electricity distribution company with a penalty for not complying, and (ii) the introduction of a tradable certificate for renewable

energy, the so-called Greenlabel. The system was fully implemented and operational by January 1998.

The Greenlabel represents a tradable certificate which is issued for each unit of 10.000 kWh of renewable energy which has been delivered to the grid. Producers of renewable energy receive this Greenlabel in addition to a regular price for their electricity and the benefits provided by the government. By selling Greenlabels the producer can achieve a profitable exploitation of his installation.

The Greenlabel system brings benefits to both buyers and sellers of renewable energy:

- lower costs for distribution companies in comparison with the usual subsidy system, because they are able to buy from outside their own service area on a larger market
- a better price for producers of renewables, because they are able to search for the highest bid and not bound anymore to the distribution company in the service area where their installation is connected to the public grid.

Following the introduction of the energy tax in 1996, one distribution company (PNEM, now part of Essent) started with selling green electricity *("Groene Stroom")* to its customers. The exemption of the energy tax for green electricity helped to lower the higher price of this product (see section 5.2). Although still more expensive than "regular" electricity, a niche market appeared to exist with customers willing to pay extra for a green product. Given the success of the first product, other distributors followed with their own products.

In 1999 the Minister of Economic Affairs evaluated the position of renewable energy in a liberalized market. The energy sector had made it clear, in a position paper called Energy and Enviroment in the 21st Century, that it wasn't prepared to renew any voluntary agreement after 2000. The sector feared that if they would take on voluntary agreements, new entrants in the market would not follow this example, but instead go for market share and lower price. According to the position paper, energy saving and renewable energy are considered important, but only at the specific request of customers. The further introduction of renewable energy should, in the opinion of the energy sector, be based on selling products like green electricity.

Government recognized the implications of the liberalized energy market. In the Energy Report of 1999, the Minister of Economic Affairs lays down the approach for the coming years. The most crucial step is opening a fully competitive green market in 2001. This market opening with free consumer choice is ahead of the market opening for mid-sized and small consumers (in 2002 and 2004 respectively). To facilitate the market, a legally based certificate system will be put in place. These certificates are issued for renewable production and receive their value on the market place as they are eligible for tax exemption when used to sell green electricity to consumers. As a third step, the tariffs of the energy tax are increased substantially, while the exemption for green electricity remains in tact. With the tax

levels of 2001, green products can become cheaper in price than regular electricity despite the extra costs of renewable energy.

Main actors and their role

The changes in policy from more or less a supply based support over the past decade to a demand side based approach in the coming years will change the involvement and roles of the main actors. New actors (such as traders and brokers) will step in the field, while producers, retailers and consumers will operate in different settings. New actors and major changes in the role of existing actors are highlighted in the table below.

actor	role	
	past decade	future (from 2001)
Ministry of Economic Affairs	develop policies close voluntary agreements	develop policies set rules free green energy market close voluntary agreements
Tax Service	approve tax credits approve exemption energy tax	approve tax credits approve exemption energy tax
Energy distribution sector	provide subsidy to producers (upto 1997) buy for voluntary agreement (through Greenlabels from 1998)	retail selling green energy
Issuing Body	did not exist officially	issue certificates monitor & oversee market
Traders & brokers	no role	buy & sell green energy (mainly wholesale market)
Consumers	pay levy to distributors	buy green energy
Producers	invest on subsidy	invest on market based demand
Novem Senter	support implementation provide subsidies	support implementation provide subsidies

Policy Mechanisms

The shift to a sustainable and prosperous society can be supported by "greening" the fiscal system. Within this context, in the Netherlands the Regulated Energy Tax was introduced since 1996. The energy tax encourages energy conservation and the use of renewable energy by making fossil energy much more expensive. The reduction in the energy tax and the zero tariff for 'green' electricity, provide a strong incentive to use renewable energy. In addition the tax system focuses on supporting investments with specific fiscal instruments.

Support for Investments

Investment support in the Netherlands is entirely based on fiscal measures. The following schemes to improve the profitability of renewable energy are available:

a) *Green Funds:* Investors in "green projects" (such as renewable energy) can obtain loans at a lower interest rate (about 1.5 percentage point) from Green Funds. These Funds are created by savings

by private persons, who are exempted from paying income tax on the interest received. About 2.000 million Dutch guilders are available in green funds.

b) *Accelerated Depreciation*: The VAMIL scheme offers entrepreneurs a financial advantage because accelerated depreciation is permitted on equipment which is included in the VAMIL list. The accelerated depreciation reduces tax payments on company profit

c) *Tax Credit*: The EIA scheme makes it possible that investments in technologies on the EIA list may be offset against taxable profit. The tax credit offered varies from 52.5% to 40% (depending on the size of the investment).

From these three instruments EIA provides the strongest investment support. The combination of Green funds, Vamil and EIA equals a subsidy on the investment of about 25 - 35 %, depending on the profit and fiscal situation of the company. Banks now offer lease constructions on renewable energy equipment where these fiscal measures are incorporated, making financing easy and also available to parties who are not fully able to use these instruments.

Higher payment for electricity from renewables

Households and Small and Middle-sized Enterprises (SMEs) pay an energy tax on electricity and natural gas. These consumers pay their energy tax –as part of the energy bill– to their supplier, who in turn pass the revenues on to the taxation authorities (Ministry of Finance).

The Environmental Taxes Law which forms the basis of the energy tax includes two special provisions on renewable energy:

– producers from renewable energy which is delivered to the public grid are eligible for a support payment from the proceeds of the energy tax
– consumers who buy “green energy” under a contract with a supplier are exempted from paying the energy tax.

The following sources qualify as “renewable” according to the energy tax: wind energy, small hydro, biomass[16], biogas and PV. Other sources (in particular energy from municipal waste incineration) does not qualify as renewable or green energy according to the definitions of the energy tax.

Since the introduction in 1996, the energy tax has been increased substantially for small consumers (see Table 2). By January 1999, the government introduced a tax exemption for green energy. This exemption of the energy tax has created a strong incentive to buy green for the group of small end-users. The level of support payment to renewable producers follows the tariff for mid-sized end-users. Since the introduction of the energy tax, these

[16] Only energy from 100% biomass qualifies as renewable. Mixtures with plastics or other materials from fossil resources do not qualify.

tariffs have increased as well, but not as progressive as for small consumers. The total payment from the energy tax to producers will reach about 23 million Euro in 2000, which is less than 1% of the total revenues collected. In addition, about 25 million Euro will flow to renewable producers from green tariffs (enabled by the tax exemption of green energy).

Table 2 Tariffs of the Energy Tax in the Netherlands (in €ct / kWh)

Year	1996	1997	1998	1999	2000	2001
Electricity use						
0 – 10.000 kWh	1.34	1.34	1.34	2.25	3.72	5.83
10.000 – 50.000 kWh (*)	1.34	1.34	1.34	1.47	1.61	1.94
50.000 – 10.000.000 kWh	-	-	-	0.1	0.22	0.59
above 10.000.000 kWh	-	-	-	-	-	-
Natural gas						
0 – 5.000 m³	1.45	2.9	4.32	7.25	9.45	12.03
5.000 – 170.000 m³ (*)	1.45	2.9	4.32	4.74	5.19	5.62
170.000 – 1.000.000 m³	-	-	-	0.32	0.7	1.04
above 1.000.000 m^3	-	-	-	-	-	-

(*) Producers of renewable energy receive a support payment from the proceeds of the Energy Tax according to this tariff rate

Agreement with utilities on a mandated share for renewables

In the Netherlands the government has made an agreement with the energy sector in 1996 concerning CO_2 reduction and market introduction of renewable energy, with a specific target for the end of the year 2000 (Environmental Action Plan 2000). Within this agreement the energy distribution companies will have to sell a quantified amount renewable electricity of 1.700 GWhe by the end of year 2000.

To cover the expenditures of the Environmental Action Plans, distributors charge consumers a levy as part of energy tariffs for gas and electricity. The maximum rate allowed by the *Energy Distribution Act* is 2.5%; in practice, environmental levies are lower. Rates are approximately 0.2 €ct per kWh. In total the revenue received for the Environmental Action Plans is around 100 million Euro a year. A significant part of these revenues (approx. 40 million Euro) is used for investing in renewable energy or buying Greenlabels.

To fulfill the target of 1.700 GWh in an economically efficient way, the energy sector introduced in 1998 the Greenlabel system of tradable certificates. Producers receive such a certificate for each unit of 10.000 kWh delivered to the public grid. They can sell the certificate on the market which consists mainly of energy distribution companies. Since the

start of the system in 1998, prices for Greenlabels have increased, from around 2.5 €ct / kWh to 3.0 €ct / kWh for recent contracts. The price rise is caused by a shortage of certificates on the market to cover the target of 1.700 GWh.

Free consumers of green energy

In addition to the supply based approach, another part of the Dutch energy policy focuses on increasing the demand side. Consumers can choose for the green electricity programme of their energy supplier. They pay an additional tariff when they buy "green electricity", but in return are exempted from paying the energy tax. Currently, tariffs vary between 2.7 and 4.5 €ct / kWh (see table below). Depending on the supplier, green electricity is cheaper or about as expensive as regular electricity (for which the tariff includes the energy tax). On average, green electricity is sold at a premium rate of about 3.6 €ct (excl. VAT) above the normal price. The additional tariff is used to pay the producers of renewable electricity about 2.7 €ct, and the remaining 1 €ct is used for administration, marketing and profit.

supplier	tariff * [in ? ct/kWh]	indication of share in green market	indication households reached in service area
Essent	2.7	✻✻✻	✰✰✰
Eneco	3.7	✻	✰
NRE	3.9	✻✻	✰✰✰✰
Delta	4.3	✻	✰
Delfland	4.5	✻	✰✰
REMU	4.5	✻	✰
NUON	4.5	✻✻	✰✰

* Excluding VAT and energy tax exemption
(3.7 ? ct/kWh for use up to 10,000 kWh in 2000)
(5,87 ? ct/kWh for use up to 10,000 kWh in 2000)

Legend market share	
✻	0 - 5%
✻✻	5 - 30%
✻✻✻	> 30%

Legend households reached	
✰	0 - 1%
✰✰	1 - 2%
✰✰✰	2 - 4%
✰✰✰✰	> 10%

The conditions and composition of "green electricity" vary between suppliers. In 2000, about 650 GWh of green electricity will be sold to households, services and industry (total renewable production –electricity from municipal waste not included- was around 1.150 GWh in 1999). Due to the structure of the green pricing programmes and its short history, it is difficult to estimate how much new capacity has been or will be installed through these programmes. In participation, they are, however, a success. Some active suppliers have succeeded last year in achieving more than 10% of their customer base (the average is around 3%).

The number of consumers has increased considerably over the last 4 years (fig. 5) and reaches around 155.000 at the moment. The largest difficulty encountered by suppliers is not to attract customers for their programmes. Some have even opted to stop their marketing. The largest obstacle at the moment is the increase the generation of renewables and installation of new capacity due to a whole range of difficulties in obtaining permits.

Reducing cost price and increasing green payment

The mixture of Dutch policy instruments to strengthen the competitiveness of renewables works in two directions: (i) reducing the cost price of producers and (ii) increasing the ability to pay for renewables by end-users. A schematic representation how all instruments work together is given in fig. 2.

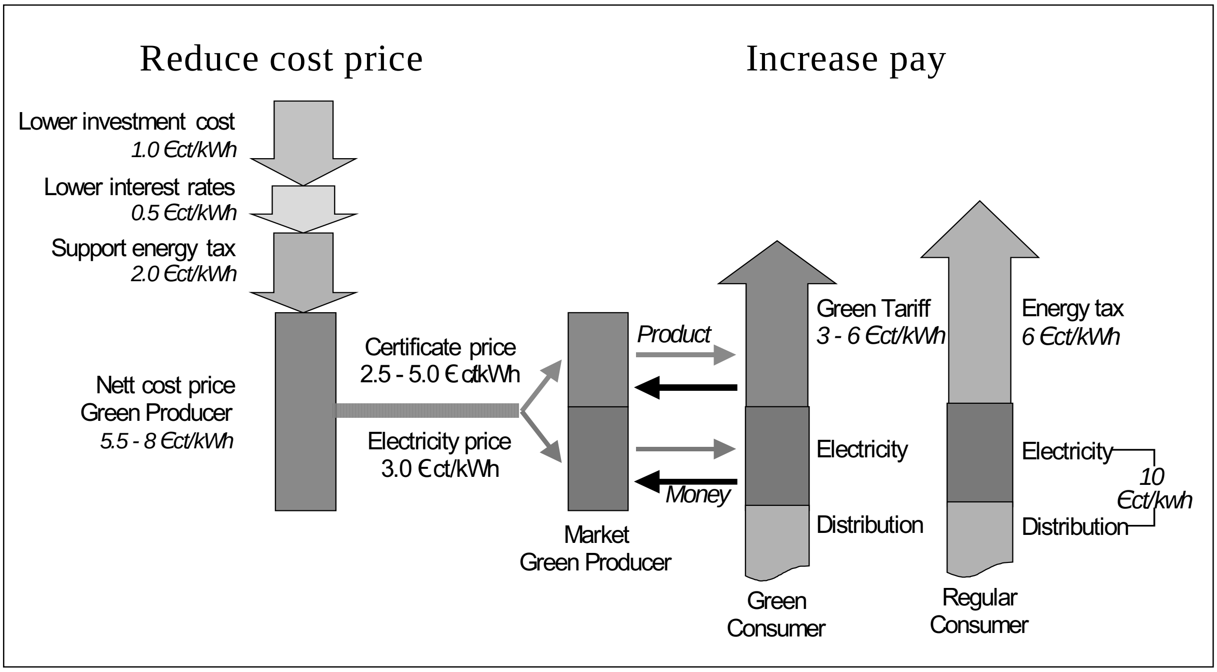


Figure 2 A schematic diagram how Dutch policy instruments achieve competing prices for renewable energy. On the supply side, instruments help to lower the cost price of renewables and allow competitive prices for electricity. The tradable certificate a producer receives can be sold on a separate market. Fair prices are possible through the demand side instrument of green tariffs and the energy tax.

Money flows in the following way in the system:

– *cost price reduction by 2.5 – 4 Eurocents per kWh*
  - all fiscal instruments relating to the investment lower the production costs of an installation with about 1 – 2 Eurocents per kWh
  - the support payment from the energy tax for each renewable kWh produced lowers the cost price with 1.5 – 2 Eurocents per kWh

competitive prices on electricity and certificate markets
  - the producer can now offer his electricity for regular prices on the “fossil” electricity market
  - in addition, he receives a tradable certificate which can be sold on a separate market

increase the ability to pay for green by 6 Eurocents per kWh
  - the exemption of the energy tax for small consumers allows a tariff of around 6 Eurocents per kWh for “green electricity” which is competitive with “regular” electricity
  - with these revenues suppliers can buy green certificates on the market from producers or traders.

Monitoring and evaluation of policy instruments

The success of Dutch policy instruments in the deployment of renewable energy sources can be measured in several respects:

- the market penetration of renewables
- the competitiveness of renewables with fossil based generation
- the use of financial resources provided by government instruments
- the market share of green pricing programmes and consumer involvement
- the "user-friendlyness" of policy instruments for investors.

The monitoring of the deployment of renewables is carried out by a number of organisations. Novem monitors for the government together with the Central Bureau of Statistics (CBS) the market penetration of renewable energy. The issuing and use of the tradable Greenlabels is registered and monitored by KEMA on behalf of EnergieNed[17]. EnergieNed also monitors the market share of green pricing programmes. The Ministries of Finance and of Economic Affairs undertake regular evaluations how financial resources from government instruments are used. These evaluations also consider the efficiency and success of these instruments.

Market penetration of renewables

During the last 4 years, the production of renewable electricity increased from around 600 GWh in 1996 to an expected amount of 1.400 GWh in 2000. In relative terms this represents a a large increase. However, despite the doubling in volume, market penetration is still well below government targets. In comparison with other countries (such as Denmark and Germany), the introduction of "new" renewables proceeds substantially slower. In this respect, current policies fail in promoting the market share of renewables.

The main reason for not meeting targets (and a slower increase than in neighbouring countries) is the shortfall in wind energy projects which come online. Although surveys of investment plans show a large volume of potential production, difficulties in obtaining planning approvals and building permits prevent a rapid implementation. The current portfolio of investment plans covers around 4.000 GWh of wind capacity; however, the annual increase is in the order of approximately 100 GWh.

A promising signal, however, is that the renewable energy market reacts to the delays which wind projects encounter. Because of the lack of wind energy deployment, investors switch to bio-energy and this source takes over in the free market.

[17] For the legally based tradable Green Certificate System which will start in 2001, this task will reside with the Issuing Body for these certificates.

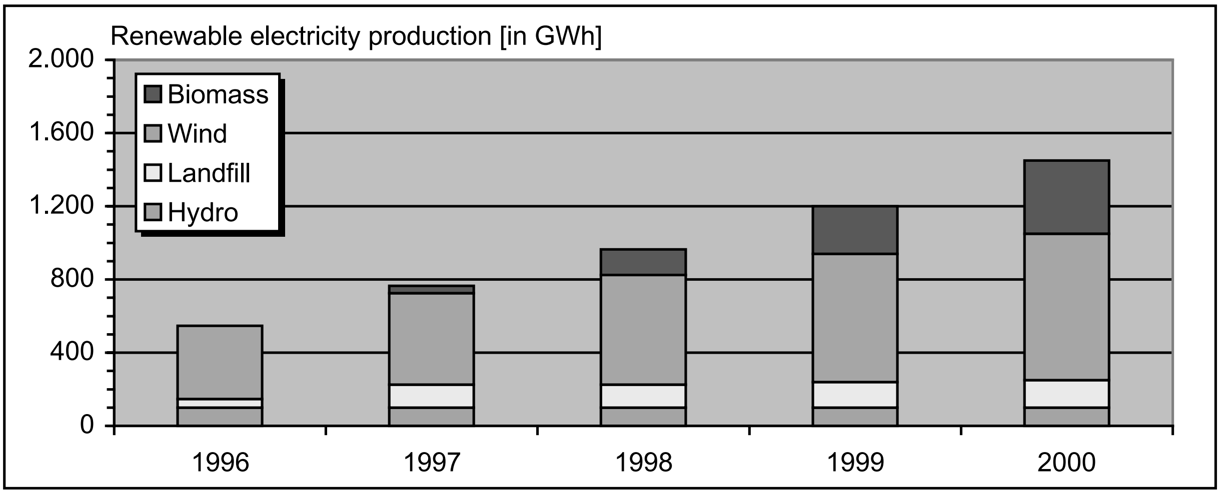


Figure 3 The increase of renewable electricity production in the Netherlands. Due to a lack of wind energy deployment, bio-energy is taking over the lead in the market.

Competitiveness with fossil based generation

Government support of producers with direct fiscal measures is for some options only sufficient to make them competitive with fossil based generation. The sales price for sources like wind energy is slightly above current market prices for electricity when these direct support measures are taken into account (see Table 3). To achieve market penetration of these sources, additional measures are required.

Until 2000, this additional support is given either through the purchase of “Greenlabels” or by revenues from green pricing programmes. From 2001 onwards, sales revenues from green pricing programmes will be the main source of support. For sources such as wind energy and biomass CHP, certificate prices of around 0.5 – 3.5 €ct/kWh are required to achieve competitive market prices. Taking the exemption of the energy tax as a benchmark for the maximum certificate price, retailers can offer up to 5.8 €ct/kWh to producers (in addition to the regular electricity price and other fiscal support of the government).

The combination of direct support to producers and the revenues of green pricing (enabled by the exemption of the energy tax) create competitive prices with fossil based generation for nearly all Dutch renewable energy sources.

The total financial value of the Dutch renewable energy market amounts to 130 million Euro in 2000. Approximately, 75% of this money flow is covered by support mechanisms for renewables (see fig. 4).

Table 3 An indication how competetive renewables on the “fossil” and “green” electricity markets based on sales prices (including government support)

	electricity sales price (in €ct/kWh)			green tariff price (in €ct/kWh)		
	without support	after direct government support *	competitive with fossil electricity (~ 3.5 €ct/kWh)	indicative price for a green certificate	competitive with energy tax exemption	
					tax 2000 (3.5 €ct/kWh)	tax 2001 (5.8 €ct/kWh)
hydro	12-15	8-12	no	4-8	no	some
wind	6-8	4-6	no	1-2	yes	yes
landfill	3-4	1-2	yes	< 0	yes	yes
biomass cofiring	5-6	3-4	yes	< 0	yes	yes
biomass CHP	8-10	5-8	no	2-4	some	yes

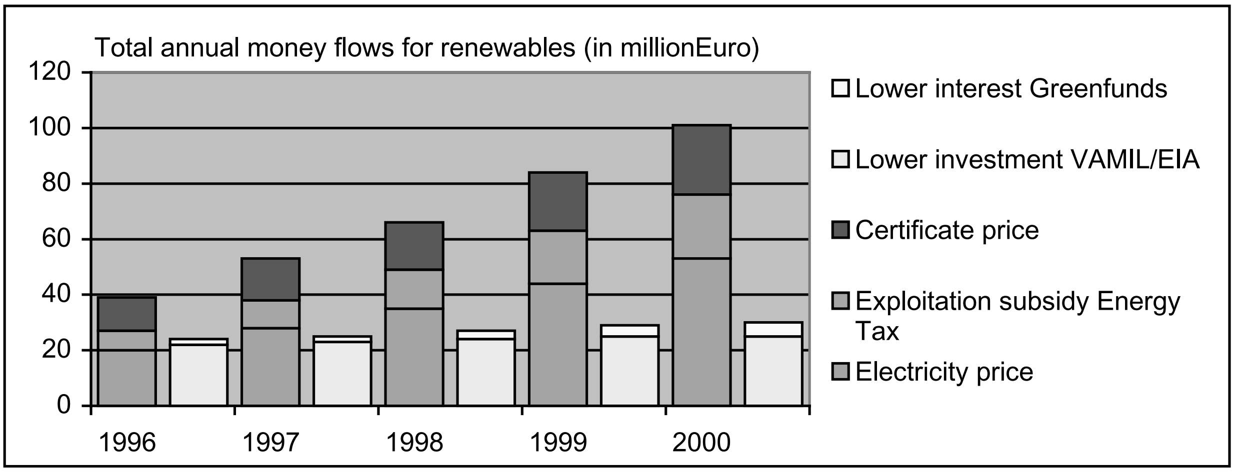


Figure 4 Total annual flow of money to renewable energy in the Netherlands from electricity sales and support instruments. The left column for each year shows the payment which are based on electricity output. The right column shows the support based on investment costs.

Market share of green pricing programmes and consumer involvement

Dutch Green Pricing schemes have attracted within a short period of time on average 3.5% of all households. Some active suppliers have succeeded last year in achieving more than 10% of their customer base. The number of consumers has increased considerably over the last 4 years and reaches around 155.000 at the moment. As a result, a significant portion of all renewables produced is now sold under green pricing programmes to househoulds, services and industry.

Suppliers find a large interest among customers for their programmes even with little marketing efforts. The largest obstacle they face at the moment is the increase the generation of renewables and installation of new capacity due to a whole range of difficulties in obtaining permits. Some have therefore even opted to stop their marketing of green energy, because supply is limited.

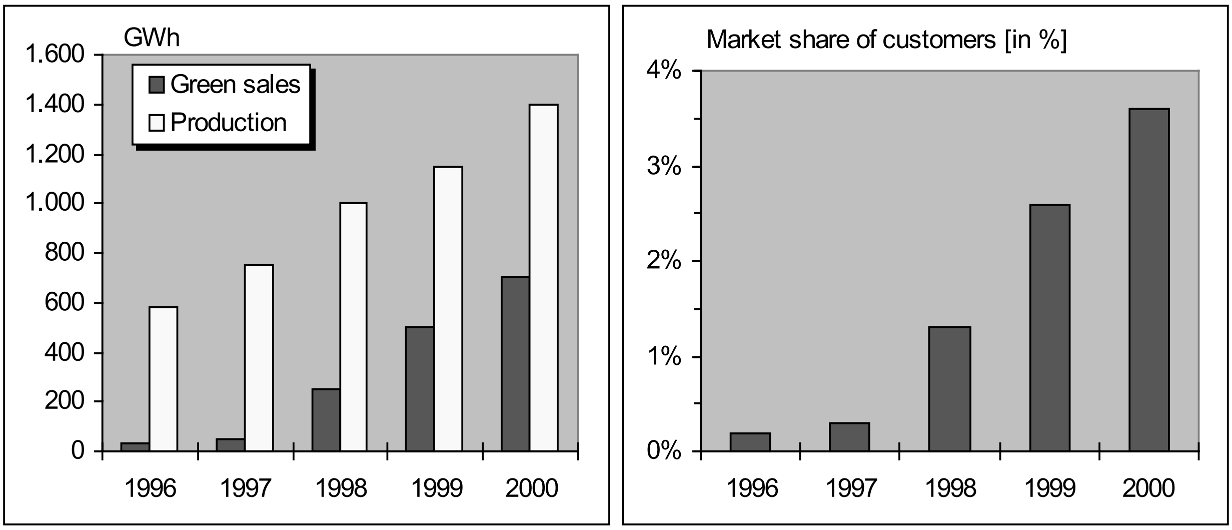


Figure 5 Annual sales and production of “green” electricity in the Netherlands (left) and market share reached by green pricing programmes of the total customer base (right)

“User-friendlyness” of policy instruments for investors

In comparison with other European countries, the Netherlands have the broadest and most diverse use of support mechanisms for renewable energy (see Table 4).

Having the broadest range of policy instruments does not necessarily mean it creates the most effective approach. For instance, countries as Denmark, Spain and Germany reach faster growing levels of renewables than the Netherlands through their policies of feed-in tariffs[18]. The Netherlands have decided not to use this approach for 2 reasons:

– fixed buying rates for grid operators do not fit well within the structure of a liberalised energy market

– fixed rates do not provide an incentive for innovation, competition and reduction of production prices of renewable energy.

The lay-out of the Dutch policy for renewable energy has a rather unique position within Europe: it focuses on strengthening the demand side and places a strong emphasis on voluntary action. The advantages of this approach are a better “fit” with the new setting of the liberalised market with full competition and free consumer choice. On the other hand, the approach is vulnerable. The deployment of renewable energy strongly depends on market conditions and reactions. There are no guarentees that targets will be met.

From the perspective of the investor, the current Dutch policy instruments are complex and sometimes confusing. To overcome these complexities, investors usually need (and use) consultants and financial advisors to assess the implications for their investment case.

[18] A feed-in tariff is an obliged, fixed (high) tariff for which grid operators have to buy electricity from specific sources, such as renewable energy or combined heat and power production.

Table 4 Use of policy instruments for deploying renewable energy in EU member states

	Belgium	Denmark	Germany	Netherlands	France	Finland	Greece	Ireland	Italy	Austria	Portugal	Spain	U.K.	Sweden
energy tax on fossil fuel		■		■		■				■			■	■
investment subsidies	■	■	■	■		■	■		■	■	■	■		■
fiscal investment benefits		■	■	■			■		■	■	■	■		■
feed-in tariffs electricity	■	×	×	▒	▒		×	■	■	▒	▒	×	■	
exploitation subsidies		■		■										
voluntary agreements				■	■									
obligation		▨		▨						■				
tradable certificates	▨	▨		■					▨				▨	
tax advantage green pricing				■										
competition through tenders					■			■					■	

explanation:

■ applied; × (high) rates obliged; ▒ for certain sources; ▨ under development

LESSONS FROM THE DUTCH APPROACH

We draw the following lessons from the Dutch policy approach to deploy more renewable energy:

- a trading system based on certificates provides a market based solution for the deployment of renewable energy and fits within the liberalised market:
  - the Ducth market has shown that is capable to react rapidly to changing market conditions (e.g. the lack of wind energy deployment is countered by more investments in bio-energy)
  - trading promotes the deployment of the most cost-effective options
  - the system provides the opportunity for a transparent market of green energy with consumer choice and full accountability (because products can be verified independently)
- this trading scheme can work with several demand policies such as an obligation or voluntary demand by consumers through green pricing programmes;
  - when green pricing is the main drive for demand, the price difference between renewable and “regular” energy plays a dominant role to achieve sufficient demand
  - an energy tax on “regular” electricity (in combination with a lower or absent tax on renewables) provides a market based solution to support the switch to green energy
- current policy approaches to support the market introduction of renewables are usually complex and diverse (not only in the Netherlands, but other countries as well);

  - the complex situation regarding support mechanisms provides sometimes a barrier for investors; simpler mechanisms could be more effective and would certainly be more transparent
  - when an open, internal European market for renewables emerges, differences in support mechanisms between countries may distort market development
- the rapid market penetration of green energy in the Netherlands (and some other countries as well) suffers from long lead times in project development
  - financial support instruments cannot solve these issues; other policy instruments and actions are required to shorten these lead times.

Market Transformation on Lighting (Sweden)

Introduction

Technology procurement of high-frequency (HF) electronic ballasts was carried out in 1991 and 1992. The competition was announced in September 1991 and concluded in March 1992. The purchaser group guaranteed a direct purchase of 26 000 HF electronic ballasts, with an option on a further 26 000. In comparison with the sales of HF lighting in Sweden prior to 1992, which had amounted to about 5 000 units, this represented a significant marketing opportunity for the manufacturers.

HF electronic ballasts replace the traditional mains-frequency iron-cored choke ballasts in fluorescent lights. HF lighting has many advantages: an improved light quality, better controllability and longer life. Taken together, these mean that lighting fittings designed for use with HF ballasts can result in electricity savings of 20-25%, with a 20% longer life. Savings of up to 70% can be expected if HF lighting systems are combined with other lighting improvements such as new luminaire designs and effective control.

Objectives of the program

As the installation of HF lighting systems is generally linked to the replacement of the luminaires, NUTEK's incentive agreements have specified a maximum specific installed lighting power of 10 W/square metre, which should be compared with the typical present-day value of 20-25 W/square metre.

The performance specifications for HF lighting systems that were drafted in 1991 were successful, considering not only the present-day market but also future requirements. Today, several manufacturers offer products in this field.

The market for HF lighting systems has grown rapidly during the last four years, so that it today accounts for about 60-70% of new luminaires. Over 600 000 were sold in 1995, and HF lighting can be said to have become a standard. The rate of take-up seems to be close to that estimated by NUTEK. In comparison with the situation prior to NUTEK's involvement, annual sales of HF lighting systems are now 20 times higher.

Based on the assumption that each HF lighting fitting saves 19.6 kW/year (1 700 hours x 14 W per lighting fitting = 19.6 kWh/year), the total energy saving to date is assessed to amount to over 71 GWh, of which 33 GWh were saved in 1995. Of this, NUTEK's share amounts to at least 80%. As the installation of such systems is generally associated with the replacement of older lighting systems and can often account for savings of up to 70% in terms of the nominal lighting power per square metre, the upper limit for energy saving, resulting from the lighting fittings themselves, lower lighting power and improved control systems, amounts to over 200 GWh in total, or 100 GWh during 1995 alone.

Process of definition/design of the program

The ballast manufacturers' commitment was established by the technology procurement programme through the buyers' groups order of 26 000 HF-ballasts, which was approximately five time greater than the yearly sales of the HF-ballasts prior to the procurement. The winning manufacturer was the one with the best solution for future product development (Stillesjö 1991). The buyers' group was

composed of the leading purchasers whose choice of technology strongly affects other purchasers and actors on the market, that is, opinion leaders. In order to increase the level of knowledge about HF-ballast among the purchasers/buyers and

the influential actors, several actions were taken. The concurrent demonstration project "Light Corridors" was carried out in several phases and thereby had several additional goals. The project demonstrated installations with a wide geographic coverage. The local utilities were given the option of

obtaining a demonstration installation featuring HF-lighting for office rooms and a corridor (Ottosson& Wibom 1997; Pertola & Bångens 1995).

The most important results from this demonstration project were the development of programme requirements for lighting power density. These requirements are 10 W/sqm installed in office rooms and 5 W/sqm in corridors. The programme requirements do not only involve energy efficiency, they also

contain requirements for visual comfort. After some time they became the common standards among many lighting consultants and electrical installation contractors. (NUTEK programkrav ("program design requirement") 1994; Ottosson & Wibom 1997; Pertola & Bångens 1995)

The other result from the "Light Corridors" demonstration project was the development of a testing method for the program requirements, which enabled all manufactures to test their product. Studies on HF-lighting's effects on health and visual comfort were also included in the "Light Corridors project." Moreover, this project also showed the economical results obtained when the initial investment

costs were compared to the lifetime operating and maintenance cost. Life-cycle costing information was introduced as part of the lighting programme.

Eventually, the lighting luminaire manufacturers began to show a considerable commitment to this. The first published collection of examples of high quality, energy-efficient office lighting with luminaires and installation that met the requirements included 34 examples from 15 different manufacturers (NUTEK 1994-11). The latest edition from October 1997 had 61 examples, 15 of them with new,

high-efficiency fluorescent strip lighting, T5's. A total of 14 manufacturers had their products tested. (NUTEK 1997-10).

All the information produced by the “Light Corridors project” was widely disseminated by targeted informational material and education, as well as by the participants in the project installations. However, these efforts were not enough to get the property owners and administrators to invest in HF-lighting, partly because of the severe recession in the economy in the early 1990s, which had a large effect on the building sector. To tackle this obstacle, NUTEK created incentive agreements whereby the property owners were given a subsidy of SEK 1,5 (~US$ 0.2) per each kWh saved in the first year. This money covered only a part of the incremental cost involved when investing in energy-efficient lighting. In order to get this subsidy, the programme requirements of 10 and 5 W/sqm installed had to be met, which was achievable only when HF-lighting was installed. About one hundred incentive agreements were signed. A survey three years later among those who have had incentive agreements showed that 72% continued to adhere to the programme requirements and thereby the HF-lighting systems.

The luminaires with HF-ballast are generally more efficient and give a higher lumen output from the luminaire. Consequently, the number of luminaires per room can be diminished. The HF-lighting is most cost effective when the reduction in operating and maintenance costs is taken into account. This information is not always easy to communicate convincingly if the operating costs and the investment cost are not assessed to the same budget, i.e., those who pay for the efficiency don’t benefit from the operational savings. A guidebook and seminars, ENEU 94, on how to succeed in purchasing energy-efficient technology was created in co-operation with the Association of Swedish Engineering Industries. The key information for success is to gather at an early stage all those who might be affected by both the technology and the resultant decision, and to jointly derive the required specifications. Later, when the bids come in, they are to be compared according to life-cycle analyses (ENEU 94).

The buyers’ group for the technology procurement programme for HF-ballast was composed of industry leading purchasers, whose choice of technology strongly affects other purchasers and actors on the market. In 1991, NUTEK’s lighting programme, consisting of buyers’ groups and incentive agreements, had reached 30% of the total floor area in commercial premises. This high level of commitment among the property owners and purchasers was achieved through networking, active and dedicated project management at NUTEK.

The yearly energy savings by 2010 from the NUTEK’s lighting programme are approximately 390 GWh.(Figure 2). The direct effects are those from the incentive agreements. The saving from these are only 8.6 GWh yearly, beginning from 1992. and represent only 2.2% of the total effect over the time span considered. (Lighting installations have a 20-year life span, and are included in Figure 2 under the heading ”incentive agreements indirect” as a part of each year’s saving distributed over 20 years time.), The most important effects of the incentive agreements and the “Light Corridors ” project are however the four ripple effects that they have resulted:

- an indirect effect among those involved in the agreements

- a ripple effect among those who have heard about the programme requirements and the agreements
- a ripple effect resulting from electrical consultants (in Figure2: “Spin-off 2”) who have been in direct contact with the incentive agreement parties or who have themselves been involved in the 'Light Corridors' project. The ripple effect is due to their continuing to recommend new lighting technology while working for other clients
- a ripple effect resulting from electrical installation contractors (in Figure 2: “Spin-off 3”) who have been in direct contact with the incentive agreement parties or who have themselves been involved in the 'Light Corridors' project. The ripple effect is due to their continuing to re-commend new lighting technology when working for other clients.

The aggregated, the direct, indirect and ripple effects of the incentive agreements amount to an annual electrical saving of 390 GWh over 20 years. This corresponds to a market penetration rate of approximately 40% each year after 1998. (NUTEK 1996; Suvilehto, Alopaeus Sandberg, Nilsson, and Persson 1997).

The total cost for the NUTEK’s lighting programme is estimated at SEK 37 M (~US$ 5.3 M) NUTEK’s cost per saved kWh is however only SEK 0.008 (~US$ 0.0011). (NUTEK 1996). This price per saved kWh was arrived at by dividing the cost equally for the 20 years over the equipment’s life-time using the fixed annual instalment method, with a 6% interest rate.

Main actors and Policy mechanisms used

The early energy-efficiency programmes within the public and commercial sectors have focused on two main end-uses, lighting and ventilation. The lighting programme started with a technology procurement for electronic high frequency ballast (HF) for fluorescent lighting. It began by understanding the market and its participants, figure 1. Purchases in this market are made by relatively few professional buyers and/or decision makers. The main influential actors on the market are electric consultants and electric installation contractors. The more cautious actors in the early stages of the programme were the lighting luminaire manufacturers.

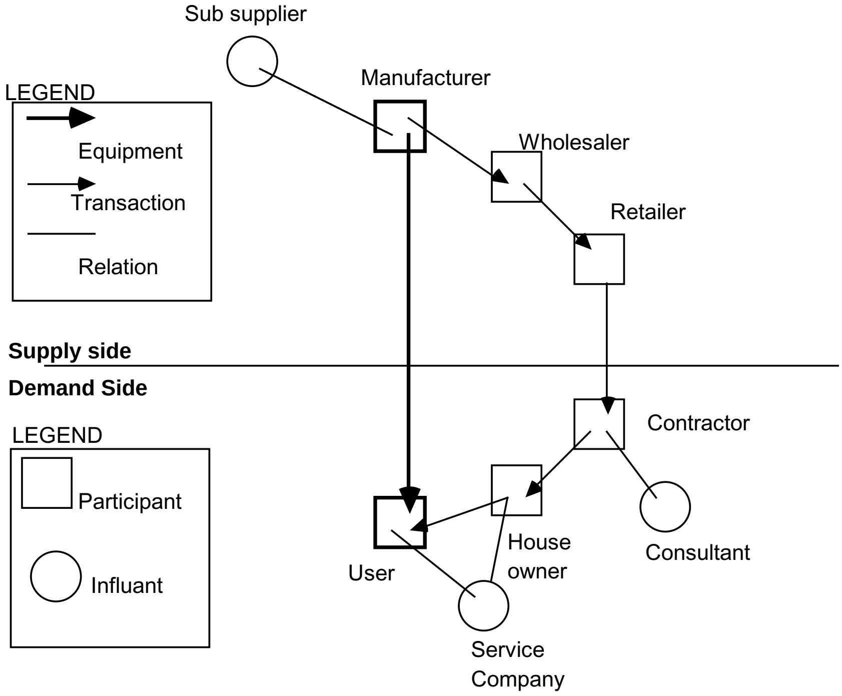


Figure 1. Market Structure for The Procured Products. Source Nilsson 1996.

A technology procurement (or co-ordinated procurement) scheme was used, in the following way: the buyers group ordered 26 000 pieces of electronic ballast which was approximately five times greater than the yearly sales prior to the procurement. This first trail batch was given a subsidy. The procurement was combined with several co-ordinated market activities. There was e.g. a concurrent demonstration project “Light corridors” were the local utilities were given an option to demonstrate the technology in practice whereby the programme was given a wide geographical spread. 0

The market transformation programme for lighting focused also on the design phase of the lighting installation. The programme developed design requirements for lighting power density together with visual requirements . The leading words for the programme were good performance with less energy. Power density levels were 10W/sqm in an office room and 5 W/sqm in corridors. These levels have become a standard among the lighting consultants and electrical installations contractors. However before developing such a levels a testing method for lighting was needed and developed as one of main phases in the project. The tested lighting systems were made known for the market with separate collections of good examples. Programme was also combined with education of the market actors e.g. designer and electric installations contractors as well as luminaire manufacturers. The programme tested and informed about how the the energy efficient lighting systems effected peoples health. . Today main focus is on the purchasing process. The efforts are set on the economical evaluations used in purchasing. STEM provides market with a tool to purchase according to the installations life cycle costs.

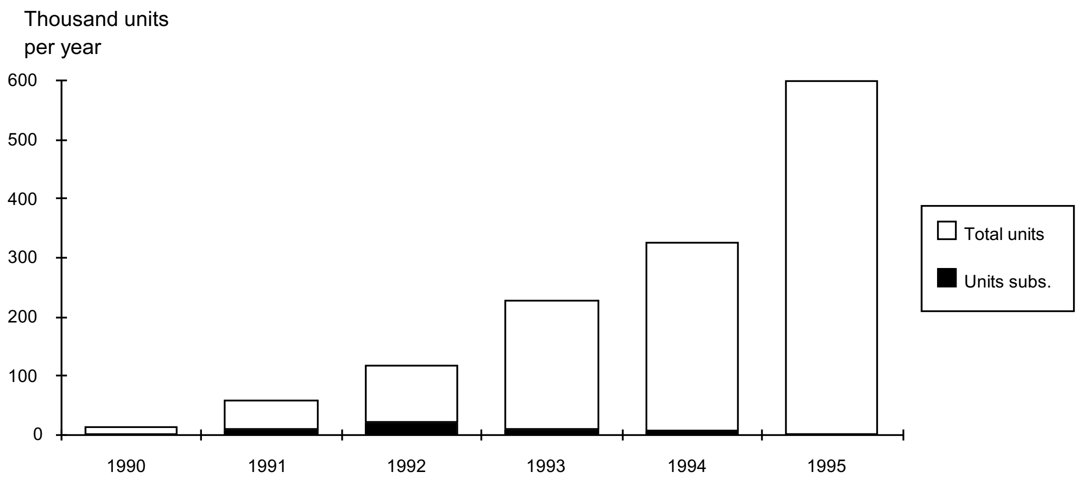
Monitoring and evaluation process

HF lighting pays best when it can be installed from the start in a new building project or for renovation projects when an existing lighting system is replaced by HF lighting in its entirety.

Profitability depends on investment costs, maintenance costs and product value. HF lighting has many benefits that are not shown in Table 4.3. When assessing profitability, it is impossible to give an average figure as it is always the user who sets the values to be assigned to the product characteristics.

The payoff time for HF lighting varies widely, depending on the installed lighting system. It is used mostly in schools, shops, swimming baths, offices, industries and the health care sector. It can also be used as outdoor lighting or lighting of parking places: in Hässleholm, Kristianstad, Perstorp, Östra Göringe and Simrishamn, for example, it has been used in various commercial premises. A straight payoff time varies between 3.6 and 12 years. However, a 12-year payoff time is unusually long: this is because it was the first major installation in the town (Energy efficiency improvement measures in Kristianstad, 1995).

The energy savings justify installation of HF lighting. However, energy saving is not the only reason: there are many other, and perhaps more important, benefits such as flicker-free lighting, reduction in power demand, the use of occupation sensing control, daylight control etc.



The effects of the programme on energy use consist of the direct effects, the indirect effects and the take-up effect. The direct effect resulting from the participation of the purchaser group amounts to about 1 %, the indirect effect resulting from incentive agreements amounts to about 15 %, and the remaining proportion of the 80 % is due to spontaneous take-up. We are of the opinion that HF lighting systems have entered the self-sustaining take-up phase, and that energy savings resulting from this take-up will increase relative to the other market influence mechanisms over the coming years.

At the present rate of growth, HF lighting systems will entirely take over the relevant market segment by the end of the century, which also indicates that the energy savings will be permanent and will increase in the future (see also Chapter 7). Several empirical investigations indicate that 'behavioural' changes, to the benefit of HF lighting systems, are significant among relevant target groups who influence purchasing, as shown in Table (Dovelius, 1996). It is interesting to note that the market share of HF lighting (60-70 %) is in good agreement with the shares indicated by installation contractors (68 %) and purchasers (71 %) when interviewed on the use of HF lighting.

Awareness changes in respect of HF lighting

Target group	1994	1996	Capacity
Installation contractors	39 %	68 %	Install the systems
Electrical consultants	64 %	94 %	Recommend the systems
Purchasers	25 %	71 %	Purchase the systems

There are, in other words, clear learning effects which, as a result of significant market growth, have resulted in the price fall as shown in Figure 3.6. The price of HF lighting units has fallen by about 25 % between 1992 and 1995, and is expected to fall further. After, and as a result of, NUTEK's technology procurement programme, the European market has also grown, particularly in countries having higher electricity prices. This growing foreign market has a beneficial effect on prices. The overall Swedish lighting market has also improved as a result of the project and of other lighting projects.

The replacement of entire luminaires by HF luminaires involves system costs that vary from case to case, although the price of the actual HF lighting unit is the same. A recent survey (Dovelius, 1996) shows that installation of HF lighting involves an additional cost of about SEK 200-300 per luminaire. Nevertheless, despite this additional cost, the market for HF lighting systems is growing rapidly, which indicates that a high value is attached to their benefits in the form of lower running costs, reduced energy bills, flicker-free lighting etc. This is a case in which the market is prepared to pay an additional cost for the benefits of the technology.

Factors that affect the economy: HF lighting

	Positive effect	Negative effect	Reported
Investment:			
1. Cost increase due to the equipment		1	*
2. Cost increase due to associated measures		2	
3. Cost savings in other measures	3		*
4. Maintenance costs (not energy)	4		*
Energy saving:			
5. In the lighting equipment itself.	5		*
6. Elsewhere, as a result of use of the equipment.	6		*
7. Higher energy use elsewhere.		7	*
8. Energy price changes.	8		*
9. Reduction in power demand.	9		*
10. Life time	10		*
11. Real rate of interest			
Value factors:			
12. Thermal comfort.	12		*
13. Indoor climate quality.			*
14. Appearance	14		*
15. Noise.			
16. Risks	16		*
17. Safety of use.			
18. Maintenance-free	18		*
19. Health	19		*
20. Environmental aspects			

1: HF lighting costs approximately SEK 200 more per luminaire. It is best to replace the entire lighting system in order to obtain full benefit of HF lighting.

2: Additional costs for occupation sensing and daylight control.

3: There are various potentials for saving if the entire lighting system is replaced. The energy saving amounts to about 20-25 %.

4: Reduction in the number of light sources.

5: Most efficient lamp operation and limitation of the ON time.

6: Reduced heat load, reduced cooling requirements, ability to provide occupation and daylight control.

9: Reduced power demand.

10: 90 000 hours (15-25 years?) per ballast, with extended tube life.

12: Flicker-free lighting.

18: Reduction in the number of light sources.

19: Reduced risk of accidents, better working conditions, good occupational hygiene and good work environment.

Discussion of results

Discussions with HF lighting manufacturers indicate that NUTEK's action has played a considerable part in introducing HF lighting to the market. It is estimated that development has been brought forward by five to seven years, and has also encouraged development of improved products. Based on manufacturers' data, NUTEK's contribution today accounts for at least 80% of the market.

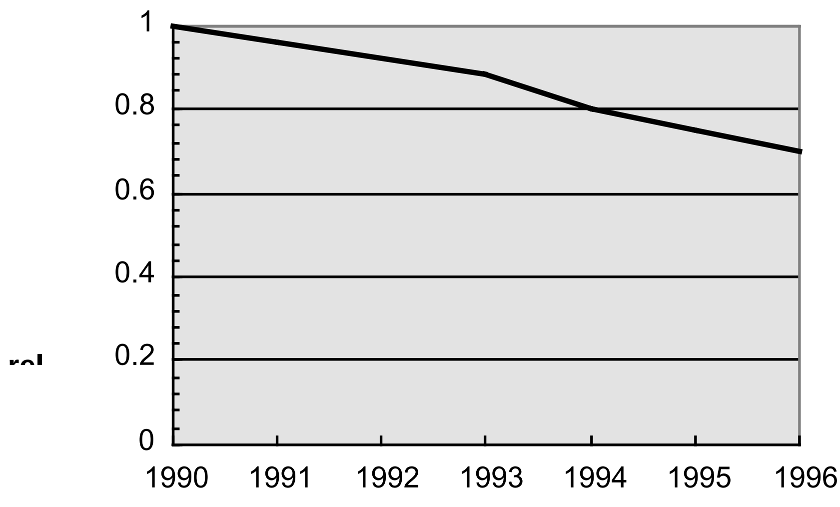
The HF lighting technology procurement project has been very successful. Several factors and events have assisted this: perhaps the most important were the right choice of time and an understanding of the market's current, hidden and future needs. Incentive agreements, the programme requirements, performance requirements and plentiful information on lighting have all been the correct operative instruments.

The HF lighting technology procurement project has been highly successful, resulting in rapid take-up of HF lighting systems and an improved quality of lighting. Several factors and events have assisted this: perhaps the most important were the right choice of time and an understanding of the market's current, hidden and future needs. Incentive agreements, the programme requirements, performance requirements and plentiful information on lighting have all been the correct operative instruments.

HF electronic ballasts as such are of less interest, although they are the key technological component in larger lighting renovation schemes. NUTEK was successful in concentrating attention on the greater whole of lighting and sparking improvements in the lighting environment. The effects would probably have been less impressive if NUTEK had concentrated its efforts on HF electronic ballasts alone, simply because the name is less comprehensible than is lighting. In addition, NUTEK also considered users' requirements, and not simply the energy savings, when disseminating information on HF lighting.

It could be claimed that the market was ready for change. At the same time, the concept of 'lighting culture' was growing in Sweden, accompanied by an unconscious acceptance of light. The fact that the market for these types of lighting systems consists almost exclusively of commercial premises, and that purchasing decisions are made by companies and not by individual consumers, is by no means unimportant. During the 1990s, companies have attached increasing importance to the productivity of their employees and have, for example, attempted to improve working conditions. There is a clear link between the quality of lighting and productivity, i.e. better lighting often results in higher productivity. The wages costs of those working in the premises is one of the major cost items, while energy as such is not. A few days' increase in productivity (e.g. through reduced absence, improved working conditions and general satisfaction) pays for the additional costs of better lighting.

Through its incentive agreements, NUTEK succeeded in creating sufficient demand for this lighting to encourage the manufacturers to take the competition seriously. The competition was important for the winning manufacturer, as its main business is in lighting technology and lighting control systems. The company had been developing this technology since the beginning of the 1980s, but had not commercialised it as the market was too small. At the same time, the competition and its after-effects presented a substantial business opportunity, as HF lighting was strategically close to the company's main business areas. One of the effects of winning the competition was that the manufacturer strongly stepped up further development. This, together with growth of the market, has resulted in noticeable price reductions.



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CS 13

Market Transformation on Heat pumps (Sweden)

Introduction

NUTEK has arranged three technology procurement projects in the heat pump sector. The first two, which were more in the nature of market surveys and smaller demonstration projects, were operated between 1990 and the beginning of 1993, but were not particularly successful in market terms. The third project ran from December 1993 until September 1995. Its objective was to encourage the development of reliable, cheaper and improved heat pumps for detached houses. The purchaser group consisted of a mixture of potential buyers, which also included members from the other Nordic countries. In addition to helping to draft the performance specification, the purchaser group guaranteed purchase of at least 2 000 units of the winning model.

The new heat pumps have now been on the market since the end of 1995. In less than a year, sales have exceeded the target of 2 000 units, and appear to have reached 4 000-5 000 units at the end of 1996. In addition, there has been a significant growth in interest in the Swedish heat pumps from other countries, with about 30% of the output of the larger manufacturers being exported to Europe.

Objectives of the program

The NUTEK technology procurement was finished in 1996. It provided an energy-efficient heatpump (efficiency factor 2.8 to 3.8) for a low cost (30% cheaper) for the small power classes. The heating

energy savings from the heat pump was at least 8 000 kWh per year. All proposed systems were tested and market pricing, as well as pump efficiency, was carefully followed.

Market characterisation: Fifteen manufacturers have a combined market share of approximately 90% of the market for heat pumps in the small power class suitable for single family homes. The other actors in the market are the utilities, heating, water and sanitary consultants, and installation companies. The purchasers are single-family house owners. Approximately 1/3 of all the single-family houses have direct electric heating, and a total of 250 000 houses were built in the 1970s, and should be renovated soon.

Process of definition/design of the program

The technology procurement in 1993 for small, brine-water heat pumps was started as a market transformation programme for domestic heating. The heat pumps are a fairly well known product in Sweden. Unfortunately, there were some poorly performing pumps in the mid 1980s and these low-quality pumps and peoples' bad experiences with them made the total market for heat pumps collapse.

In the beginning of the 1990s there were very few heat pumps for small single family houses with a floor area of 140 sqm, and an electricity need for both heating and hot water in the range of 20 000 kWh.

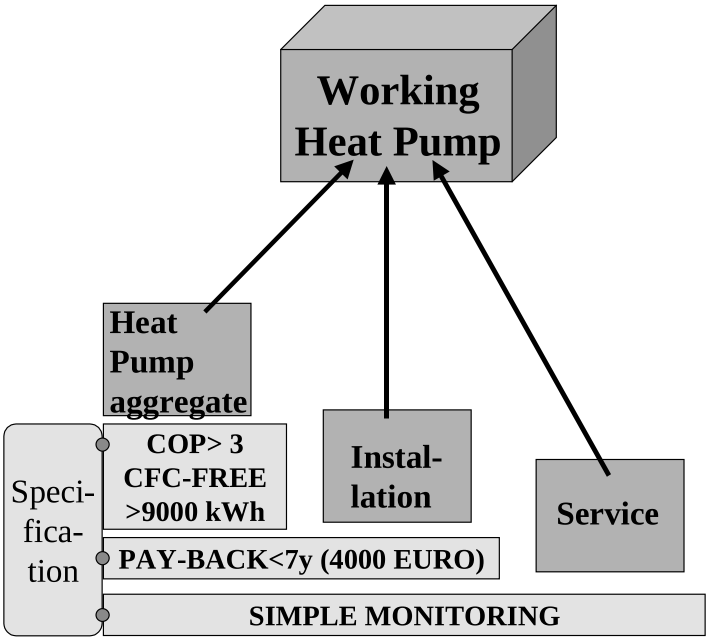
As far as the manufacturers were concerned, the performance specification was demanding. Manufacturers who produced prototypes had them tested cost-free. Six manufacturers met the performance requirements. The two winning heat pumps were over 30% more efficient and 30% cheaper than heat pumps prior to the competition. In practice, NUTEK's efforts succeeded in bringing forward a new generation of heat pumps.

Main actors and Policy mechanisms used

A technology procurement scheme was used, in the following way: potential purchasers of heat pumps were put together with energy experts in a working group to draft the required energy efficient performance parameters together with the other requirements for the heat pumps to be developed and a competition for heat pumps with those characteristics was announced to manufacturers willing to participate. In addition to helping to draft the performance specification, the purchaser group guaranteed the purchase of at least 2 000 units of the winning model.

Procurement demands

- Module size (3*600)
- Installations should faciltate service
- Specialist competence for service not required
- Chlorine-free refrigerants
- Low noise level
- COP > 3
- Electricity use to be lowered > 8 MWh per year
- Price for complete installation
- Pay-back < 7 years for installation
- Pay-back < 3 years for pump module



The procurement programme was combined with a "package" of activities supporting the market penetration of the winning models. Methods used were subsidy for the first trial batch, positive labelling, campaigns on national, regional and local level, education of professionals as well of consumers by telephone consumer advice, information material and trade exhibitions [19].

NUTEK's package of activities supporting the market penetration consists of regional and local campaigns involving targeted informational folders for consumers, positive labelling for identification of products that met the requirements, telephone consumer advice (a consumer hot-line), education, trade exhibitions, and subsidies for the first trial batch. The most essential elements for the improvement in market position have been the highly committed procurement winner and the trade association for heat pumps. The active and committed project leadership at NUTEK and the consumer hot line were also important.

An important reason for the success to date has been the sound knowledge of the heat pump sector within NUTEK and long-term consolidation of knowledge within the sector. These two factors have enabled the right arguments to be found for activating the latent technology and getting out on to the market. NUTEK has also provided by no means insignificant technical support.

NUTEK also made a considerable effort to stimulate the heat pump market. Important signals have been given, and the reputation of the heat pump, which was perhaps one of the most critical factors against it, was restored and even improved.

The size of the initial guaranteed purchase was equivalent to about a whole year's sales in Sweden, which must also have encouraged the manufacturers to participate. This is a sector in which heat pumps are often manufacturers' main product, which gives them a greater

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[19] Swedish Procurement and Market Activities. American Council for Energy Efficient Economy, ACEEE Summer study 1998, 7.317, Heini-Marja Suvilehto & Egil Öfverholm

incentive to bring out improved products. The new heat pump does not directly compete with existing products: instead, its superior performance simply replaces the older range.

Increased sales on the domestic market, and favourable export prospects, have resulted in significant optimism and openness among the manufacturers, thus strongly powering further development. Although it now seems unlikely that much additional procurement incentives will be required for small waterborne heat pumps, NUTEK should continue to monitor the trend and be ready to take steps to ensure that they favourable market continues and any impediments are eliminated.

If we compare the price and performance of heat pumps in the European market, it can justifiably be claimed that, after this technology procurement project, Sweden is the leading country in respect of small liquid/water heat pumps.

Monitoring and evaluation process

The total sales of the heat pumps with a brine-water system have increased heavily after the NUTEK's technology procurement programme (Figure 3). According to the heat pump manufacturers' trade association, NUTEK's procurement programme restored the credibility of heat pumps in the market and established heat pumps among the options for home owners (Lund et al. 1996).

The increased sales volume has meant that economies of scale are beginning to appear in production, thus opening the way to reducing the prices. In addition, economies of distribution and reduced sub-contractor prices have also occurred. Together, the manufacturers estimate that these factors should enable the price of heat pumps to be reduced by about 25 % over the next few years.

One year after conclusion of the programme, the energy savings resulting from it are estimated as amounting to about 30-40 GWh/year. The market is growing and also includes increased exports to the other Nordic countries, to Switzerland and to Holland. Some manufacturers have reported an increase of over 100 % in turnover, with even the smallest increase amounting to 30 %. This has resulted in new investment in additional production capacity and a substantial increase in employment within the companies concerned.

There are many different arrangements for heat pump systems, depending on where the heat source is, how the heat is distributed in the house and how the maximum output power of the heat pump compares with the maximum power demand of the house. A heat pump either saves electricity or replaces the use of other energy carriers by electricity.

An earth heat pump affects the profitability of all conservation measures intended to save heating energy in the house. It is therefore not sufficient merely to investigate the heat

pump; instead, the investigation/analysis should also cover any other conservation measures.

Factors that affect the economy Heat pumps for waterborne (previously electric) heating systems

	Positive effect	Negative effect	Reported
Investment:			
1. Cost increase due to the equipment		1	*
2. Cost increase due to associated measures		2	
3. Cost savings in other measures			
4. Maintenance costs (not energy)			
Energy saving:			
5. In the heat pump itself.	5		*
6. Elsewhere, as a result of use of the heat pump.			
7. Higher energy use elsewhere.			
8. Energy price changes.	8		*
9. Reduction in power demand.	9		
10. Life time	10		
11. Real rate of interest			
Value factors:			
12. Thermal comfort.			
13. Indoor climate quality.			
14. Appearance			
15. Noise.			
16. Risks			
17. Safety of use.			
18. Maintenance-free			
19. Health			
20. Environmental aspects	20	20	

1: The source publications have given costs for new heat pumps: the price of the heat pump (SEK 15 440 - SEK 20 800) + the cost of the collector + installation; total, SEK 35 700 - SEK 40 000. There are major differences in the costs of the piping system for the collector.

2: Laying the pipes causes damage to gardens (of existing houses), and can give rise to extra costs and value losses.

5: In general, the energy savings resulting from new heat pumps have been estimated as amounting to about 9000 kWh/year. The heat distribution system affects .... ? .... ? .... ? .... In a low-temperature heating system, the savings are greater than when heating with conventional radiators.

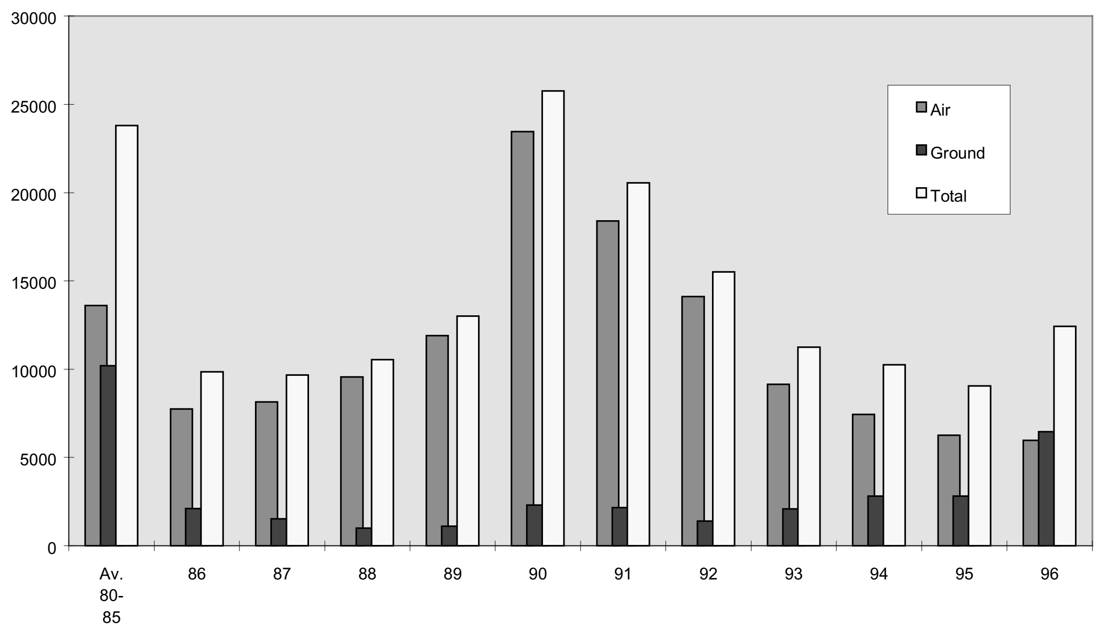
8: The energy price depends on the electricity tariffs, which can vary widely in Sweden.

9: The power saving, relative to the energy saving, is small in the case of a heat pump, amounting roughly to about 30 % of the house's power demand. However, this enables the supply fuse rating to be reduced, thus reducing the standing charge for electricity. (One of the factors determining the fixed charge element of Swedish electricity tariffs is the supply fuse rating.)

10: A 20-year life has been used as a basis for the budget calculations.

20: Installing a heat pump increases the taxable value of the house. On the other hand, the value of the house-owner's capital increases.

Figure: Heat pump sales in Sweden.



The technology procurement programme has succeeded in transforming the heat pump market. The total yearly sales of heat pumps are approximately 25 000 pieces, before 1995 the yearly sales were approximately 12 000 pieces. The sales are now focused on the ground coupled heat pumps which are more efficient and suit better the Swedish climate. The same efficiency level as in the procurement can today be provided by most of the producers. More over 75 percentage of the new residential buildings today, both multifamily houses and detached houses, are equipped with a heat pump[20].

Discussion of results

Several reasons can be identified for the rapid success and market spread. Heat pumps were already relatively well known in Sweden, although they had acquired a poor reputation during the 1980s with regard to quality. In the 1990s, it was price and lack of confidence in them that were the main problems for the heat pump market. NUTEK’s competition forced the manufacturers to produce a marketable product and played a central part in re-establishing the reputation of heat pumps on the market. In combination with good products, this resulted in rapid take-up.

One year after conclusion of the programme, the energy savings resulting from it were estimated at about 30-40 GWh/year. The market is growing and also includes increased exports to the other Nordic countries, to Switzerland and the Netherlands. Some manufacturers have reported an increase of over 100% in turnover with even the smallest increase amounting to 30%. This has resulted in new investment in additional production capacity and a substantial increase in employment within the companies concerned.

To control costs one must first of all bear in mind that we are not talking about “overnight“ potentials but a release over a certain time when the situation changes and can be changed.

1. Timing is important. Changes should not be forced but opportunities for a change not be lost. Most energy using equipment will be changed during the next 25 years. If all those opportunities are used there will be tremendous change. Policy target is education and routines for design and purchasing.
2. Technology use has to be directed towards improvement and implementation of the improved products. Policy target is the redirection of the purchasing power and the dialogue between important customers and manufacturers.
3. Volumes for the technology have to be enlarged to ensure that costs for improvements can be distributed and that competition bring forward new solutions. The effects are mostly captured in the “learning curve“. A forced growth in volume will make these effects arrive sooner. Such force is at hand when procurement is made by central purchasers or by a group of co-operating local purchasers.
4. Actors will have to develop improved concepts as the business environment changes. Utilities might adopt the energy service concept on the deregulated market. Third party financing might be more common. Energy Service Companies (ESCOs) might turn global etc etc. The more the interest is turned to the service and the lesson the “raw“ kWh the better.

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[20] Peter Rohlin, Swedish National Energy Administration, July 2000.

5. Distributional evolution is necessary. Retailers and consultants will be more important as advisers to sustain the trends towards improvements. Promotional systems, labelling, improved design instruments, new routines for purchasing etc, are all instruments to develop in order to guide customers better and to ensure profits for the actors taking part in distribution of goods.
6. Systems design that takes better care of multiple aspects of technology shifts, as described earlier.

	POTENTIAL	ACCEPTANCE
TIMING	+	
TECHNOLOGY	+	
VOLUME	+	+
ACTORS		+
DISTRIBUTION		+
SYSTEMS DESIGN	+	+

CS 14

The Swedish Government Programme for an Environmentally Adapted Energy System (EAES)

Introduction

1. During late autumn 1992 and spring 1993 the Swedish Government, in connection with the ratification of the UN Framework Convention on Climate Change, initiated an international climate related programme, which is mostly known as the EAES Programme, the Swedish Programme for an Environmentally Adapted Energy System. This programme is primarily directed towards projects in Baltic Region and Eastern Europe (Estonia, Latvia, Lithuania, Poland and Russia). It is aiming at an improvement of energy systems through energy efficiency measures and increased use of renewable energy sources for energy.

2. In June 1997 all the implemented and ongoing projects in the Baltic States were reported to the UN Climate Secretariat in Bonn in accordance with the Uniform Reporting Format which was finally adopted by the COP working groups at their meeting in March 1997. The reports had the form of joint reports endorsed by Sweden and the respective Baltic country.

3. The Baltic Sea Region has been one of the supreme testing grounds for the AIJ process. On the UNFCCC AIJ-list there are 96 projects of which 76 concern Energy Efficiency and Renewable Energy. Out of these 76 there are 52 registered in the Baltic Sea Region. That means that an overwhelming majority of the knowledge that the AIJ projects where supposed to create, in terms of how barriers can be overcome, is first-hand knowledge in this particular region.[21]

4. The energy systems built up during the earlier planned economy systems in Central and Eastern Europe were almost totally based on fossil fuels, mainly oil and coal and to some extent natural gas. Usually these fuels were imported at prices far below those on the world market or there were correspondingly low internal prices for domestic fossil fuels. Energy efficient technology and technology for environment protection were not particularly called for in this context and were not a natural choice at any phase in the production or the consumption of energy. The low energy prices simply did not motivate the application of such technologies.

5. The main activities are directed towards a reduction of emissions, hazardous to the climate and the environment, from oil or coal-fired energy production plants.

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[21] See also *Activities Implemented Jointly. Partnerships for Climate and Development*. IEA/OECD, Paris 1997 p.57 ff

- **Conversion of heat production plants to the use of biofuels:**

  The existing boilers have been equipped with a prefurnace and simple fuel, ash and flue gas systems in order to keep costs down.

- **Reduction of heat losses in district heating systems**:

  The district heating systems have been complemented with water treatment facilities and substations in order to stop corrosion an to improve temperature control in the houses. In some cases pipes have been added or replaced and small, inefficient boiler houses closed down. Labour intensive methods have been used to keep investment costs at a minimum.

- **Energy efficiency in buildings**

  The windows have been weather-stripped, the attics insulated and the internal heat distribution systems adjusted to adapt to the best practices of the 70s

6. The cases are typical for the potential in Markets in Transition and development all over the world. The success in finding and releasing such projects as done in the EAES project could be copied widely.

Objectives of the program

7. Studies have shown that around 90 % of the energy systems in the Baltic States and Eastern Europe are based on fossil fuels, in particular in the district heating systems which are relatively well developed but often in a very bad shape due to lack of maintenance etc. All the more important in this context was of course the introduction of world market prices for oil and other fossil fuels, which for the Baltic States meant drastic price increases. Increased fuel prices have heavily affected heating costs in all parts of the system and have resulted in stronger demands for subsidies from the state budget and/or municipal budgets and a worsened financial situation for the production plants and distribution companies. As for consumers, at present their heating costs represent 50 % or more of their total housing costs.

8. The annual emission of CO_2 per capita in 1989 in Central and Eastern Europe was 16.8 tonnes, which was almost twice that in the EFTA/EU countries, 8.5 tonnes. The corresponding figure for Sweden in 1989 was 7.3 tonnes. Besides CO_2 emissions from the energy sector it has been stated that the sulphur emissions, which adversely affect the southern parts of Sweden in particular, emanate to a very large extent from Eastern Europe. Since 1990 a decrease in sulphur dioxide emissions has been observed, however, the degree of pollution is still considerable and there are signs that these emissions are beginning to increase once again.

9. The situation in the Baltic Sea Region is a “microcosm” of the development trends on the energy markets and the prerequisites for creating sustainable systems. The development in the energy sector in the 1990´s in the Baltic States is partly of a similar nature, partly following different paths. Two of the countries Estonia and Lithuania are net exporters of electricity, in the case of Estonia electricity production is mainly based on domestic oil-shale and in the case of Lithuania based on nuclear power, while Latvia imports a large part of its main supply of electricity. In all the countries natural gas plays an increasing role for heat production. At the same time all the countries have vast and still un-exploited domestic energy resources of biomass mainly from forest wastes, which is a highly suitable fuel for district heating, and in the future also for co-generation. Other possible renewable sources are biogas and wind. The Russian Federation and Poland both have domestic fossil resources but also, in particular the Russian Federation, vast possibilities

of using biofuels. There is now a growing interest in both these countries for the use of biofuels for heat production.

10. During the last 5-6 years the use of domestic biofuels has increased, in particular in the Baltic States. Starting from a rather low part of the total energy balance of 2-3 % the increase sometimes has been 100-200 %, but still biofuels does not contribute to more than 8-10 % of the total energy supply. In this context it can also be noted that during this period an export market for biofuels has been developed in these countries and now represents an important part of income from exports. Increased export opportunities have, however, resulted in increased prices of biofuels on the domestic market. Although increased access to, and competition from, natural gas as a result of extended networks there is still an interest for using biofuels where the prices for biofuels have a competitive advantage. This is of particular interest in areas where natural gas is not accessible. There is also an interest for diversification as regards fuels for heat and electricity production both for increased security of supply and sometimes for competitive procurement reasons.

11. As regards energy efficiency the situation is similar in all the countries and is characterised by low technical and performance standards in production plants, distribution and end-use, due to lack of contemporary know-how and inadequate legislative and institutional framework. The often unclear legal status as regards ownership of residential buildings is an obstacle for obtaining financing for energy efficiency measures.

12. Another barrier is lack of financial resources for investment in the energy sector and insufficient capabilities in preparation and implementation of new investment projects.

13. Still, in some cases, due to lack of financial resources, municipal heating companies which have possibilities to use biofuels are forced to buy imported fossil fuel from the big local or international oil and gas companies which can offer deliveries on long-term credits, rather than the more cheap domestic biofuels which often are provided by small local companies.

14. There is still also a lack of policies for environmental protection measures directed towards the energy sector which is one of the most important sources of emission hazardous to climate and environment. There are no, or still too few, incentives from environmental point of view to promote increased use of renewable energy sources. The ongoing process in many of the countries towards adaptation and adjustment to the EU policies of the respective national policies as regards environment and energy and the increased regional co-operation in the Baltic Region will be of great importance for the future development.

Process of definition/design of the program

15. The point of departure for the EAES Programme was to make use of the good experiences of the improvements of the climate and the environmental conditions in Sweden, which are the results of the programmes for energy efficiency and increased use of renewable fuels, not least in the district heating sector, during the years since the international oil crises in the 1970's. A decisive factor was also that the preconditions for the use of waste from forestry works and wood-working industries in all the countries concerned were of the same magnitude as in Sweden. The programme was primarily directed towards small and medium-sized projects which until then had generally been considered as administratively too cost-demanding for implementation within programmes introduced by international financing institutions. The direction towards municipalities and municipal heating companies was also an area where the barriers for obtaining financing at reasonable conditions were the greatest.

16. In the more detailed conditions for the projects elaborated by the programme management there were no explicit demand for state guarantees in other cases but when the plant in question was owned by a state entity. To begin with the guarantees for the loans often were provided and decided upon by municipal authorities, later on when the municipal companies were included in the legislation for private companies in the respective Baltic states the securities usually have the form of registered mortgages or pledge agreements. Only in a very few cases state guarantees have been provided. The loans are mostly provided with a maturity period of 10 years including a grace period of 2 years and at a rate that is low but market-adapted (STIBOR+). The idea was furthermore that the projects to be implemented generally should have a pay-off period of less than 10 years.

17. The basic strategies for the projects are defined by the following key words/phrases:
    - **Quick** implementation, standard solutions
    - **Affordable** investments on favourable, but commercial, terms
    - **Reliable**, proven and sustainable technology

18. The fact that the financing of the projects were to be provided though loans a clear combination of cost-efficiency and substantial results in the form of climate and environmental improvements and clear economic advantage were imperative. Furthermore it was important to be able to offer implementation solutions which were based on well-established and sustainable technology and a short implementation time. Thus, there was no incentive for implementing projects that were not profitable within a reasonable time-frame. The main direction was therefore on. projects which otherwise were not to be implemented due to barriers such as scarcity of capital, high capital costs, lack of information, inadequate access to economic or technical expertise etc.

19. At the beginning of the programme the loans from the EAES Programme very often were the very first any of the municipalities or the municipal heating companies had ever been engaged in. Therefore, it has always been a special assignment for the Swedish side to explain thoroughly the conditions for the loans and the economy of the projects. An important role in this context is played by the local legal advisers that are assisting the management of the EAES Programme and the borrowers in the process of arranging loan agreements and securities for the loans so that these documents are always in line with the legislation in each country and that they follow the rules set out by the respective governments for loans from abroad. This work is all the more important as the EAES Programme has a possibility to provide loans without guarantees from the respective governments.

20. Already before the EAES Programme started there were a good knowledge on the high technical skills in the countries in Central and Eastern Europe within the Swedish agencies dealing with energy, industrial and technical cooperation both on a bilateral basis as wells in international cooperation activities. However, for obvious reasons, the acquaintance with market economic principles was weak in these countries. It was therefore important that the plant-owner and the local project manager were to be directly involved in all parts of the implementation process in what could be characterised as a "learning-by-doing" process. Swedish consultants was assigned to assist the local management in this process until the project was commissioned. In addition, local technical experts were assigned as advisers and to follow the implementation and commissioning and making independent evaluations of the projects.

21. Partly this process was chosen as the resources for a more extensive and comprehensive training activities was not foreseen in the programme. Looking back, it can be said that this working method has been beneficial for both sides as it has provided the local partner with knowledge of market economy including i.a. experience of procurement in open competition, loan handling etc. The Swedish side in turn has gained in-depth and detailed knowledge of the specific problems and the possibilities in each country and has also created a good environment for long-standing cooperation and relations. Over the years this experience and knowledge have contributed to a refinement of the programme and the implementation process. The success of this working method has also been verified in a number of local, Swedish and international evaluations.

Main actors and policy mechanisms used

22. As a result of the Government Bill on Energy adopted by the Riksdag (Parliament) in June 1997 a new Government agency, the Swedish National Energy Administration (Statens Energimyndighet, STEM) entered into operation as of 1 January, 1998. The main part of the new agency consists of the departments dealing with energy matter which were transferred from NUTEK. The Swedish National Energy Administration has the central role of implementing the Government's policy aiming at transforming the Swedish energy sector to sustainability and to be less dependent of both fossil fuels and nuclear energy, where emphasis is laid on energy efficiency and further increased use of renewable fuels for both heat and electricity production.

23. The loan is given by the Swedish Administration. The loans are mostly provided with a maturity period of 10 years including a grace period of 2 years during which the interest accumulates. The interest rate is set to STIBOR + x% where x is depending on the type of project and the borrower. Security is given by local municipality guarantees or by mortgage.

24. Implementation

Projects are normally divided into the following stages:

- Expression of interest from a municipality
- Visit and assessment by NUTEK representatives
- Letter of intent
- Small feasibility study, Business plan
- Design of a simple call for tender
- Loan contract, Guarantee, Security, Mortgage
- Open competition
- Evaluation of tenders
- Signing of main contract
- Project management, On-site meetings, Support and Supervision
- Commissioning, Final inspection
- Operation and maintenance
- Emission measurements
- Follow-up programme

The project management is done by the local staff, having a local budget and using local labour and material as much as practically possible. Therefore, the local management is one of the main factors to be evaluated before a project is initiated. The local project management is, however, guided through the entire process by NUTEK representatives.

25. One important assignment for the Swedish consultants when a potential project was located, either through direct search activities or through proposals from central authorities, was to get an overview of the real costs and the consumption of fuels, production demand etc. In the earlier situation fuel was provided for a central supply facility, salaries to the staff from another budget and the settling of tariffs and collection fees for the heat by other authorities and organisations. There was no clear demand for total cost coverage and very often over-capacity was installed and - at the same time - the losses in distribution and end-use were, and are still, often considerable. Another important issue was to find out about the real base-load requirement, i.e. in practice, the status quo (or ex-ante) baseline. In the calculations of the cost-efficiency of a boiler conversion project the base-load was a decisive factor for the new capacity to be installed in order to avoid installation of over-capacity.

26. An important feature of the EAES Programme is the fact that all procurement are made in open competition where Swedish companies, companies in the other Nordic countries as well as local companies in the respective recipient countries can participate provided they can offer equipment and services of the required technical standard.

27. Through the projects Swedish companies have gained experiences of the working conditions in the respective countries and a fruitful long-standing cooperation have been developed between Swedish and local companies of benefit for both sides. Local companies get increased possibilities to adapt their technological standards to international requirements and thereby improved export possibilities. Swedish companies increase their competitiveness, including on third markets, through such cooperation. In this context the special small boiler production project in Latvia could be mentioned. In short this project was based on Swedish technology procurement experiences and resulted in local production of small biofuel boilers in the size of 1.5-2 MW following a technical concept elaborated by Swedish consultants. A number of such boilers have been installed in EAES projects in Latvia and in neighbouring countries.

28. It has many times been verified from the participating Swedish companies, which often are small or medium-sized, that the EAES Programme has opened up market possibilities which they otherwise had not been able to exploit due to lack of knowledge and/or that such activities would have been considered too risky. Through the EAES Programme these companies, together with their local partners, have got good reference plants which have rendered them a number of other customers in the respective countries, i.a. forest industries and wood-working industries.

29. For the plant-owners and local suppliers the projects have provided a possibility to get practical learning-by-doing experience of market economic conditions. It often happens nowadays that the local Baltic company takes the role of main contractor and the Swedish company participates as sub-contractor. Over the years an increasing cooperation between local experts and consultants and Swedish consultants have been developed. Today, very often local consultants are engaged as sub-consultants to the Swedish firms engaged.

Monitoring and evaluation process (see also appendix)

30. Today the programme comprises around 60 projects, some 50 of which have been fully implemented or are in their very final stages of implementation, and another 10 are ongoing. About half of the projects concern boiler conversions, where environmental effects are more obvious and directly measurable. However, to increase the efficiency of a boiler conversion it is often advisable to implement efficiency measures in the distribution network. This may, for example, include water treatment for the system as well as measures affecting buildings thereby also increasing the efficiency in the entire heat supply system. Improvements to the distribution networks can thus result in the closing down of fossil fuel fired boilers, while measures in buildings result in higher comfort. Besides energy savings of some 20-25 % in heat consumption, further savings can be obtained as the residents no longer have to use electric radiators to compensate for unsatisfactory heat and hot water deliveries. The indirect merits of energy efficiency measures in distribution and end-use are also that they might mean savings in the form of avoided costs in respect of new heat production plants.

31. The investments, financed by loans to the plant owners for a total of more than 60 projects, (see appendix) represent about SEK 225 million (approx. US$ 25 million). In addition to these costs, NUTEK has provided consultancy support for around SEK 40 million (US$ 4.3 million). Additional costs for the projects consist of administration, evaluation and follow-up activities, as well as information and seminars The directly measurable reductions in environmentally hazardous emissions resulting from the implementation of the projects in the enclosed list, are estimated at:
    - CO_2 300,000 tonnes/year
    - SO_2 3,100 tonnes/year
    - NO_x 170 tonnes/year

32. Results from implemented conversion projects that have operational experience from 1-3 heating seasons show that the fuel costs for heat production in the converted boilers have been reduced by an average of 40 % compared with the costs for the same production level based on fossil fuels. At the same time, job opportunities have been created in the extraction and production of biofuels sector and it has been possible to make use of waste from wood-working industries that otherwise is subject to dumping fees. The low prices for e.g. sawdust contribute to the reduction in the total biofuel price.

33. The average investment costs per installed MW in boiler conversion projects are less than SEK 1 million, including civil works. In the small boiler projects in Latvia, where the boilers have been produced locally, based on a Swedish concept, the average cost per installed MW is around SEK 0.65 million. However, such figures are less important than the annual plant production figures. So far those plants which have been in operation for two or more heating seasons show good capacity utilisation records. The investments for boiler conversions, counted as per tonne of reduced CO_2 emissions, are around SEK 545 (US$ 57), counted over one year only, while the lifetime of a converted boiler is estimated to be 15-20 years.[22] The specific investment cost for other types of projects is highly variable. The grant part, including administration, evaluations etc. is estimated at around SEK 80/tonne CO_2. International expertise recommends the accounting of a risk cost of 20 % for defaults in loan repayments. NUTEK has estimated this cost factor to be equal to the grant part, i.e. SEK 80/tonne CO_2.

34. It should also be noted that in some cases the borrowers have refrained from making full use of the offered two year grace period and have already started their repayments on

[22] See also paragraph 36 below. The investments are recovered fully in the profitable projects.

the loans. So far no real defaults in repayments have been registered although in one case a delay has occurred. In general, the borrowers show great concern in honouring their obligations under the loan agreements. Up to the end of 1996, repayments, interest and instalments of around SEK 6 million (US$ 0.850 million) have been made. For 1997 the expected repayments are estimated to amount to some SEK 11 million (US$ 1,5 million). The repayments are reallocated to the Programme for financing further projects.

Discussion of results

35. The EAES Programme has provided Sweden with at lot of knowledge on the particular problems in the respective countries where projects are implemented. The working method - close contacts and cooperation with local experts during the whole implementation phase, during commissioning and in the follow-up activities - have created an ever increasing and widespread network which now includes central authorities, universities, energy institutes, municipalities, energy companies etc. This network plays an important role for transfer of knowledge, for preparation, translation and adaptation of information to be disseminated in the different countries and for contributions and participation in other projects, i.a. in different twinning projects initiated by the European Union and international organisations.

36. Due to the fact that the projects are financed through loans to the plant owner the major part of the EAES are of "no-regret" character, i.e. projects that are attractive to the host mainly on the basis of economic profitability but they do often go un-exploited due to a number of different barriers, such as scarcity of capital, too high capital costs and availability of long-term borrowing on the local market, lack of information, inadequate access to technical expertise. As joint implementation projects, such activities require a foreign partner to make relatively small investments in order to reduce such market barriers that enable the local partners to take actions that are already cost-effective, as is described in the report by IEA, 1997 "Activities Implemented Jointly - Partnerships for Climate and Development". Such small projects are usually difficult to finance through international financing organisations as the incremental costs often are too high and the bureaucracy too time consuming. It has also been stated that the strategy chosen by the EAES Programme recognises that there is a great potential for lowering barriers to existing no-regret options and that it initiates a process of market transformation for further activities of climate improvements beyond the joint implementation project.

EAES Programme - Projects implemented and ongoing in terms of year of commissioning, country and project types

Year of comissioning	Number of	Invest-ment[23]	Consult-ancy[24]	Total	Saved/ converted	CO_2 reductions		Cost for reduction of CO_2, öre/kg					
Country	projects	Costs	Costs	Costs	Energy	Annually	Accumulated	Investment		Consultancy		Total	
Type of projects		MSEK	MSEK	MSEK	MWh/år	tonnes	tonnes		accum.		accum.		accum.
1993	3	11	3	14	72 000	25 600	384 000	42	3	12	1	55	4
1994	7	30	5	35	134 800	48 120	891 800	221	12	54	3	275	15
1995	7	20	4	23	86 700	30 400	436 500	87	6	26	2	113	8
1996	17	63	12	75	273 450	90 345	1 381 175	194	13	51	4	245	17
1997	13	28	6	35	73 070	26 090	481 350	130	8	40	3	170	11
1998	13	35	7	41	105 810	36 575	741 625	215	13	89	6	304	18
Ongoing	6	36	4	41	72 700	25 800	520 350	167	9	23	1	190	11
Estonia	21	75	13	87	302 770	100 260	1 635 900	182	12	48	3	230	15
Latvia	22	63	11	74	246 850	85 875	1 567 125	186	11	38	2	223	13

[23] Loan to the project

[24] Covered by grant

Lithuania	9	44	6	50	191 000	62 750	1 016 250	103	6	18	1	122	7
Russian Federation	13	42	11	53	77 910	34 045	617 525	155	10	90	6	245	16
Poland	1	2	1	3	500	2 200	55 000	88	4	34	1	122	5
Boiler conversion projects	27	105	18	123	562 500	192 270	3 128 550	65	4	16	1	80	6
Distric Heating Distribution	15	30	6	36	58 270	21 990	350 200	189	11	46	3	235	13
Energy Eff. in end-use	11	17	6	23	13 860	4 840	72 600	431	29	164	11	595	40
Combined projects	13	74	12	85	184 400	66 030	1 340 450	124	6	22	1	147	8
Total resp.	**66**	**225**	**42**	**267**	**819 030**	**285 130**	**4 891 800**						
Average CO_2 cost/invest.								**79**	**5**	**15**	**1**	**94**	**2**
Total resp.	**66**	**225**	**42**	**267**	**819 030**	**285 130**	**4 891 800**						
Average CO_2 cost/project								**166**	**10**	**49**	**3**	**214**	**14**

1 SEK = 100 öre = 0.11 Euro

CS 15

Energy Efficiency Best Practice Programme Case Study

Introduction

The UK Energy Efficiency Best Practice Programme (EEBPP) was launched in April 1989, to stimulate energy savings in industry, buildings and the business use of transport energy. The Programme involves an integrated set of activities to develop & research current best practice, disseminate relevant, impartial information and support the development of new energy efficient technologies and techniques. To ensure sufficient programme coverage, the EEBPP comprises two components, industrial (including transport use) and buildings, that run in parallel, but with appropriate knowledge-sharing.

Since its launch, the Programme has evolved, working with the various business, commercial and public sectors to meet its objectives. The Programme uses input from relevant trade and professional associations and industry experts, together with feedback from impact assessment, to direct changes and set strategies. As a key Department of the Environment, Transport and the Regions (DETR) initiative, the Programme gives priority to major departmental policy concerns. Under the Kyoto Protocol, the UK is committed to reducing greenhouse gas emissions to 12.5% below the 1990 levels by 2008-1012; in addition, the Government has set a domestic goal to reduce carbon dioxide emissions to 20% below 1990 levels by 2010. The Programme plays an important role in UK Government programme of action to deliver these emission reduction targets, working in synergy with other policies and measures. It also features strongly in the DETR's efforts to promote sustainable development. The EEBPP continues to evolve as a major player in the Climate Change Strategy set by the UK Government's and the Devolved Administrations.

The EEBPP is a comprehensive technology transfer information dissemination programme that has successfully and cost-effectively addressed the information/market barrier. The achievements of the Programme have been quantified and the targets set have been met. Indeed, the target for savings by the year 2000 was increased when it became clear that the original one would be exceeded.

Objectives of the programme

In the UK, industry and buildings account for some two-thirds of total energy consumption, making a substantial contribution to national carbon dioxide emissions. Energy use in these areas could be reduced by some 20-30% using currently available, proven cost-effective energy efficient technologies and management practices. The EEBPP sets out to address gap between what is currently achieved and what could be achieved with best practice, by promoting technology and management practices. The Programme works alongside other policies and measures to encourage energy efficiency. For example, consultants under the Site Specific Advice initiative have access to all EEBPP information, and the Climate Change Levy has had much help from the EEBPP to enable businesses to meet their Negotiated Agreements, or simply to reduce their energy bills.

Targets for the EEBPP are set with the overall strategic goals of lessening the climate change impact of UK industry and the national building stock, improving industrial competitiveness and promoting energy security. The overall objective of the EEBPP is to

stimulate energy savings worth £800 million/year (1990 prices), equivalent to carbon savings of about 5 million tonnes/year.

Energy savings must also be made cost-effectively. The Programme is designed to help organisations cut energy bills by 10-20%, by providing the independent advice and assistance needed to persuade them to use cost-effective technologies and management techniques. It must provide a cost benefit of at least £5/year of energy savings for every £1 of tax payer's money used to fund the Programme. Further details on the objectives of the EEBPP can be found in the Climate Change Strategy[25].

The EEBPP continues to address significant barriers to the take up of energy efficient technologies and techniques. The Programme offers impartial information and advice, targeted to individual queries, tackling the seemingly conflicting barriers of too much information and insufficient unbiased information. Through promotion of results from successful demonstration projects, the Programme aims to stimulate senior management commitment, and to overcome resistance arising from the perceived risk of investment in new technology. Training initiatives aim to involve all the workforce, overcoming the human barrier to improving energy efficiency, mainly resulting from a fear of change. It also offers support for research and development of new energy efficient technologies and techniques, and uses the considerable management and technical skills within the Programme to identify and address gaps in knowledge.

Process of definition/design of the programme

As a strategy-based programme, the EEBPP is managed for the benefit of business, with its direction decided in consultation with business. Strategies are evolved in close collaboration with representative bodies, trade and professional associations and other relevant parties.

Sectoral and cross-sectoral strategies are set up in response to perceived needs or changes within particular areas. Each strategy defines a coherent set of issues, identifies the actors concerned and outlines the ways in which the issues will be addressed. The Programme's management teams have established close working relationships with relevant sectoral and cross-sectoral organisations, and these links are exploited as part of the information gathering process for each proposed new strategy. The strategy development process involves identifying barriers to energy efficiency, prioritising areas for action, and generating a portfolio of possible project and promotional activities. The process is designed to identify the most cost-effective areas for action.

Draft strategy documents are then presented to the Energy Efficiency Programme Committee (EEPC), which advises the DETR on the potential savings, cost-effectiveness and so on. The EEPC comprises up to 12 independent members drawn from industry, commerce, the buildings sector and academia, and as such offers valuable, expert advice and makes a significant contribution to the content and direction of the programme.

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25 The UK Government's Climate Change Strategy, published in November 2000, is available on the Department of the Environment, Transport and the Regions (DETR) web site, at www.detr.gov.uk/climatechange.

Main actors and their roles

At the time of writing, the EEBPP is managed on behalf of the DETR by two contractors, ETSU (part of AEA Technology plc) and BRECSU (part of BRE Ltd), who act in agency roles. After 1 April 2001, the Programme will be run through Carbon Trust[26].and subsequently management of the different Programme elements will be put out to tender.

The industrial component is managed by ETSU and currently covers all the main industry sectors, the industrial utilities and commercial and fleet transport. It also encompasses cross-sectoral areas like compressed air, small and medium-sized enterprises (SMEs), combined heat and power (CHP) and management techniques. The buildings component is managed by BRECSU and addresses domestic housing, public sector buildings and commercial and industrial premises. Again, this component also encompasses cross-sectoral areas like insulation, lighting, SMEs, CHP and management techniques. Where there is a potential overlap in areas of responsibility, ETSU and BRECSU consciously work together to co-ordinate their activities, sharing knowledge to benefit the Programme. While recognising the need to work in different ways appropriate to the diverse energy use sectors, constant liaison and comparison of Programme management methodologies ensures maximum efficiency of the EEBPP.

Both contractors adopt the sector approach, with sector managers responsible for particular areas, such as chemicals, non-ferrous metals, housing and schools. On the technology side, sector managers work with equipment manufacturers and users to generate, collate and disseminate authoritative, information to relevant parties. Technical projects, such as New Practice and Good Practice Case Studies, are monitored independently by contractors appointed by ETSU and BRECSU. With non-technology areas, such as management techniques, it is important to involve everyone in the workforce, so sector managers work with, for example, the Chartered Institute of Management and trades unions. Again, any results are verified independently by appointed contractors. The close working relationships with other relevant organisations are a cornerstone of the Programme's success.

The Energy Efficiency Programme Committee (EEPC) also plays a major role in the EEBPP. The 12 independent members mainly have industrial/commercial/building concerns, or come from academia. The committee also has also a representative from the Department of Trade and Industry (DTI) and an observer from the Energy Saving Trust. Through their review of each strategy, members of the EEPC make a significant contribution to the quality and success of the Programme, and to ensuring value for money.

Policy mechanisms used

As the UK Government's principal energy efficiency information, advice and research programme for organisations in the public and private sectors, the EEBPP works in synergy with other Government policy measures, particularly negotiated agreements.

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[26] The Carbon Trust is the provisional name assigned to a UK governmental body, being set up to run an integrated programme to accelerate the take up of existing low carbon technologies and other measures that support a low carbon economy.

The core output of the Programme is a portfolio of descriptive or prescriptive publications, which range from detailed technical reports to simple leaflets. The majority of publications fall into four categories:

- Energy Consumption Guides that benchmark energy performance in specific sectors of industry and building stock, and show patterns of energy consumption to enable readers to establish their relative energy efficiency performance, with suggestions of ways to improve it;
- Good Practice Case Studies and Guides that describe the application of proven energy-saving measures and techniques;
- New Practice Case Studies and Reports that detail independent monitoring of the first application of innovative energy efficiency techniques and practices;
- Future Practice Profiles and Reports that describe the R&D projects supported by the Programme, with the aim of developing tomorrow's solutions.

In addition, information is made available on CD-ROM and in other multimedia formats. Printed literature is distributed at events or by mail in direct response to specific requests.

Information and assistance available from international programmes, such as the International Energy Agency's (IEA) CADDET programme and the European Community (EC) SAVE and Framework R&D programmes, is also integrated into the EEBPP where it is cost-effective to do so. When the proposed European Best Practice Initiative (which draws on EEBPP experience) is launched, it will also be integrated into the Programme.

Increasingly, electronic dissemination techniques are being used, with much material now available on the Programme web site at http://www.energy-efficiency.gov.uk/eebpp. Relevant information is also disseminated via articles in the trade and technical press. All publications and independent advice can be obtained through the Environment and Energy Helpline, a freephone service available throughout the UK.

Under the EEBPP, ETSU and BRECSU have an extensive programme of events - workshops, site visits, seminars, conferences, exhibitions, and so on - for every sector that is active. All events are carefully tailored to specific audiences and energy efficiency messages. Many of the events are hosted or co-sponsored by other organisations, such as professional or trade associations, which not only shares the costs, but also encourages outside organisations to endorse the Programme message, thereby enhancing its credibility. Events prove an effective means of information dissemination, providing participants with well-targeted practical information and advice on energy efficiency as it relates to their situation.

Funding for the EEBPP comes from the DETR, as part of its research strategy. The DETR sets the level of funding and determines the Programme direction. The funding is split between the service costs for the principal agencies, ETSU and BRECSU, and for contracts let by these agencies for the independent monitoring of energy efficiency projects, the commissioning of scoping studies to develop sectoral and cross-sectoral strategies, marketing support services and so on. Regular reports are made to the DETR on both expenditure and progress towards energy saving targets. Funding for 2000/2001 is set at £19.804 million. Further details on funding can be found on the DETR web site at http://www.research.detr.gov.uk.

Monitoring and evaluation process

Impact assessment is an integral part of the EEBPP, with feedback playing an important role in the evolution of the Programme. Two types of impact assessment are used:

- **Follow-up studies**

These generally take the form of questionnaires, handed out at specific events for later completion. The questionnaires are designed to identify how EEBPP advice has been applied to make changes and whether these changes have resulted in energy savings. The responses are analysed by the relevant project team, with help from the ETSU or BRECSU impact assessment unit as appropriate. These studies enable the project teams to gauge the uptake of energy efficiency measures, which gives some indication of the effectiveness of the event, and the advice and literature handed out. These data are used to modify future Programme output as necessary. Following up an event also helps to build close working relationships between the Programme and its target audience.

- **Market research**

A top-down assessment, usually carried out by specialised market research contractors, is used to monitor the moves towards energy efficiency and the dynamics of energy efficiency practices, as well as the extent to which respondents have found the EEBPP useful. The relevant project teams, together with the ETSU and BRECSU impact assessment units, play a key role in deriving the study methodology and research plan. Data from these studies prove invaluable when revising or developing strategies. They also enable project teams to detect changes in sector benchmarks.

As part of an on-going improvement programme, advice on possible modifications to the assessment methodology is sought from external consultants and further work is planned to assess the extent to which energy savings are maintained over time.

The results of impact assessment enable the Programme managers and the DETR to identify new areas for activity and also areas in which work can be scaled down. For example, in recent years, the potential for major energy savings in business transport and in SMEs has been identified, and increased resources have been assigned to these areas. On the other hand, if a sector is identified where the rate of return on investment in promoting energy efficiency has reduced, it may indicate that work can be scaled down; a watching brief in the UK and abroad will reveal if, and when, the EEBPP should step up activity in such a sector.

While ETSU and BRECSU have developed monitoring and evaluation processes suited to their own areas, the processes themselves are subject to independent assessment by contractor appointed by the DETR. This verifies results and provides a platform for input to improve the methodologies used.

In addition, the performance of the Programme as a whole is also monitored independently of the agencies. For example, in 1995, the Policy Research in Engineering, Science and Technology (PREST) was appointed to carry out a comprehensive review of the programme, including its impact assessment techniques.[27] Studies of this kind enable the DETR to

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[27] A summary of the findings of the PREST review is available, and a copy can be ordered through the Energy Efficiency Best Practice Programme web site .

monitor value for money, modify Programme direction, expand research interests, develop links with other DETR research programmes, other Government initiatives and overseas programmes, and also to determine future research partners.

Discussion of results

Based on independent studies, by 1999 the Energy Efficiency Best Practice Programme had stimulated energy savings in excess of £650 million/year (where £ is the UK pound), equivalent to over 4 million tonnes/year of carbon savings. These savings are in line with those projected and agree with those derived from impact assessment studies, and show that the Programme is on line to achieve its overall target of £800 million/year, equivalent to 5 million tonnes/year of carbon savings. Indeed, savings resulting from the Programme have exceeded expectations, with the result that the target for the year 2000 was increased in 1994, when it became evident that the original one would be met with ease. Analysis shows that the EEBPP produces savings at a cost of around £20-30/tonne of carbon savings, making it a highly cost-effective programme.

The energy saving results are quantified through the results of follow-up studies and other impact assessment. The Programme repeats sector benchmarking, for example by collating data for Energy Consumption Guides, and uses the data to determine the shift in energy performance. To-date, each revisit has reported lower energy use, costs and therefore lower energy costs, improved competitiveness and reduced greenhouse gas emissions, showing that the messages are not only getting through, but being acted upon.

In recognition of the success of the EEBPP, it remains a key component of the UK Government's Climate Change Strategy, under which the Programme will broaden to help deliver the UK Government's emission reduction targets. In July 2000, the Environment Minister announced a new initiative, the Carbon Trust, in line with proposals from the Advisory Committee on Business and the Environment (ACBE) [28]. The Trust will take on the management and commercial development of the business (including business transport) elements of the EEBPP, enabling it to deliver tailored information and advice direct to business, carry out on-site energy audits and provide support to fund to development of low carbon technologies.

As the Programme has evolved, it has been increasingly important to develop and maintain links with other programmes, within the UK and overseas. These programmes form useful sources of information, as well as providing outlets for energy efficiency messages. Maintaining links has proved key to the success and evolution of the EEBPP, minimising duplication of effort and maximising spread of the messages. Partners include the IEA's CADDET programme and the EC SAVE and Framework R&D programmes. Where programme objectives coincide and there is scope for synergy, the EEBPP co-funds projects and encourages UK organisations to apply to these programmes for funding. Links have also been established with the UK Environment Agency on the energy efficiency aspects of the Integrated Pollution Prevention and Control Directive, and there is on-going liaison with the Energy Saving Trust. In addition, the Programme contractors liaise with the UK research

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[28] Details of the proposed Carbon Trust can be found through the DETR press release web page http://www.press.detr.gov.uk and through its environmental initiatives web page http://www.detr.gov.uk/environment.

councils, particularly the EPSRC (Engineering and Physical Sciences Research Council) and the Department of Trade and Industry (DTI) is kept informed of work relevant to its sectors.

The EEBPP has also been instrumental in promoting the use of CHP, working with the Government to help it achieve its target of 10,000 MWe installed by 2010. The EEBPP has setting up and running the CHP Club, designed to help CHP users exploit the new, positive opportunities to develop CHP schemes. It is also closely involved with CHPQA, a self-assessment and certification scheme to help CHP users to capitalise on enhanced capital allowances and exemption from the Climate Change Levy, due to come into force in April 2001.

Independent evaluation of the EEBPP has proved very favourable, and has adjudged it to have a comprehensive coverage of UK industry and buildings. Where these evaluations have identified any weaknesses, the Programme has develop means of overcoming them. New approaches to information dissemination will continue to be exploited, to ensure the target audience is met and that energy efficiency information is readily available to all. As sectors become more energy efficient, Programme initiatives are held at a maintenance level until new issues arise that justify a greater level of activity. This maintenance ensures that energy consumption data remain current and evaluation techniques must be improved to enable monitoring of savings over time.

The Energy Efficiency Best Practice Programme is clearly effective in generating energy savings, and has proven good programme management skills that allow it to identify and exploit energy-saving opportunities within and across the various industry and buildings sectors. Key to its success have been organisational learning and experimentation, resulting in the use of initiatives derived for one area being applied elsewhere, increasing the energy-saving potential of individual sectoral activities. Regular review of strategies ensures that programme activities are continually refined and updated, and therefore remain appropriate. It also ensures that any market or technological changes are addressed by the programme.

The success of the EEBPP is well-documented, with the initiative being taken up in other countries, and by the European Community programmes.

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UNCONVENTIONAL NATURAL GAS E&P

EXECUTIVE SUMMARY

The gloomy, almost crisis-like outlook for the future of domestic natural gas in the late 1970's set in motion a set of national-level energy initiatives for adding new gas supplies. Two of the most valuable of these were: (1) the joint government/industry R&D programs in tight gas, gas shales and coalbed methane by the Department of Energy's Office of Fossil Energy (DOE/FE) and the Gas Research Institute (GRI) that established the essential exploration and production technology; and, (2) the unconventional gas economic incentives (Section 29 tax credits) that buffered the economic risks faced by the early set of unconventional gas developers and helped attract scarce investment capital to this emerging resource.

Now, twenty years later, unconventional gas offers one of the impressive technology success stories. A poorly understood, high cost energy resource is now providing major volumes of annual gas supplies and helping meet the growing domestic demand for natural gas.

- Unconventional natural gas provided 4,500 Bcf of supply in 1998, up threefold from about 1,500 Bcf twenty years ago.
- Proved reserves of unconventional gas are 52 Tcf, up from less than 20 Tcf when the R&D and incentive programs started.
- Assessed recoverable resources of unconventional gas are now estimated at 370 to 500 Tcf, providing confidence that with a continuing pace of technology progress the contribution of unconventional gas will continue to grow.

Behind these spectacular numbers are a host of dedicated activities, occasional failures and many successes, all underlain by substantial investments in R&D and technology. Tight gas, the flagship of unconventional gas, is now pursued routinely by independents and majors alike in over a dozen major domestic basins. Gas shales development has expanded from the Appalachian Basin to new basins in Michigan (Antrim) and North Texas (Barnett). Coalbed methane, a resource once labeled "moonbeam gas", has been converted from a mining hazard to a low cost source of new gas reserves. Ironically, geopressured methane, the resource holding "a 1,000 years of gas", came up short once the bright, hot light of serious scientific inquiring was turned on.

With the benefits of hindsight and history, it is also possible set forth key "lessons that have been learned" from this case study in energy technology development. While the "lessons learned" are many, four stand out:

- When rigorously planned and managed, joint government/industry R&D can be highly successful, providing significant benefits to the domestic economy.

- A critical mass of funding and sufficient time are essential for ensuring success, particularly for ambitious, break-through types of R&D initiatives.
- Special purpose performance based economic incentives can greatly accelerate industry's adoption of technology, by helping attract capital and rewarding success.
- Disseminating technology and building a base of support requires a comprehensive effort, ranging from publications for the informed layman to high visibility, "flagship" field demonstrations.

UNCONVENTIONAL NATURAL GAS E&P

INTRODUCTION

The topic of this case study in U.S. energy technology policy and deployment is *unconventional natural gas exploration and production.* The case study starts with two national-level initiatives established in 1978 -- a comprehensive, multi-year R&D program and a set of price and tax incentives for unconventional gas. While many of these technology policy initiatives ended in the early 1990's, some are still in effect, including a portion of the technology based Department of Energy R&D program in unconventional gas.

The case study provides a rich set of "lessons learned". These "lessons" demonstrate that combining a well managed joint government/industry R&D technology program with performance based incentives for early application of new technology can be highly successful, providing significant economic benefits to the U.S. economy.

<u>Historical Context.</u> After decades of plentiful supplies, low costs and public indifference, natural gas finally moved to the center of national attention. The winter of 1975-76 saw worrisome curtailments in natural gas supplies leading to closing of schools and public facilities. In the following winter the problems of supply curtailments grew worse, leading to Congressional hearings and a scramble for explanations.

While numerous reasons were posed for the cause of the problem, the one set of answers that gained broad public and political acceptance was that "the nation was rapidly running out of natural gas supplies." Prominent in the winning debate were two dominating figures, M. King Hubbert and the Federal Power Commission, both who saw a pessimistic, depleting future:

- King Hubbert, who had gained considerable credibility among energy policy and Congressional staff by correctly forecasting the peak and subsequent decline in domestic oil production, applied his same forecasting methods to natural gas. In widely followed Congressional testimony, he set forth a future of limited natural gas resources and a pending crisis in gas supplies. Hubbert viewed a low domestic natural gas resource base of 1,050 Tcf of which nearly one-half had already been produced. He predicted that the peak in natural gas productions would occur shortly (in 1977) followed by a dramatic decline.

- The Federal Power Commission, responsible for regulating the price and profitability of natural gas production, defended its stance for continued price controls by stating -- why deregulate natural gas when there is so little left to find?

<u>Search for New Resources.</u> The bleak, uncertain outlook for natural gas set the stage for ground breaking legislation -- phased removal of wellhead price controls, incentives

for new natural gas development, and restrictions on gas use for electric generation (NGPA, Public Law 95-621). The concern over future gas supplies also set in motion a search for new sources of natural gas, in settings that had been previously overlooked:

- A Federal Power Commissions task force identified that 600 Tcf of gas in place existed in three large Western basins. These gas resources were held in geologically complex, extremely low permeability ("tight") reservoirs where existing technologies were insufficient for ensuring economical production.

- The Bureau of Mines identified that considerable volumes of methane (pure natural gas) were being vented for safety reasons from coal mines, wasting a valuable resource.

- Gas bearing Devonian-age shales were judged to hold several thousand Tcf of gas in the Appalachian Basin, "one of the least defined domestic gas producing regions."

- And, public interest was stirred by major articles in Fortune and The Wall Street Journal that a new natural gas resource -- geopressured aquifers -- could provide gas for 1,000 years.

Numerous special purpose studies and narrowly focused R&D efforts were initiated to further understand and pursue these large, little understood natural gas resources.

Foundation for a Coordinated R&D Program. Faced with a growing body of new, sometimes promotional information on unconventional natural gas, the Energy Research and Development Administration (ERDA) commissioned a comprehensive study of these resources. Advanced Resources International, then called Lewin and Associates, with Mr. Vello Kuuskraa as Study Director, was contracted to perform this broadly scoped, landmark study. The introductory page of this study, "Enhanced Recovery of Unconventional Gas (Volumes I, II, and III)," February 1978, pointedly set forth the challenge:

"As conventional domestic natural gas supplies dwindle, the nation must seek ways to slow these trends and obtain new supplies. The choices faced are controversial, costly and risky. They entail difficult balancing among higher prices, accelerated development, reliance on imports and new technology. This study has been conducted to assist public decision-makers select among these many choices by addressing two questions:

- How severe is the need for additional future supplies of natural gas?

- What is the economic potential of providing a portion of future supply through enhanced recovery from unconventional natural gas resources?"

As important, the study set forth the framework for an aggressive, coordinated program of research and development on unconventional natural gas -- "Beyond the analysis of these two questions, the study serves to assist the Department of Energy (the successor to ERDA) design a cost-effective research and development program to stimulate industry to recover this unconventional gas and to produce it sooner."

OBJECTIVES, DESIGN AND IMPLEMENTATION OF THE PROGRAM

The Department of Energy's unconventional gas R&D/incentives program has had many political twists and policy turns during its twenty years of existence. The outline and objectives of the original Enhanced Gas Recovery Program, that responded to the supply crisis atmosphere of the late 1970's, was set forth in the FY 1978 Congressional Budget Request. Subsequent administrations, reflecting their own National priorities and energy strategies, shaped and modified this program continuously. The Gas Research Institute's R&D program in unconventional gas, formulated in 1982, faced a somewhat similar experience in its later years.

Original DOE R&D Program Objectives. The strategic policy goal was to develop and stimulate the deployment of advanced exploration, development and production technologies for recovering new gas supplies from the massive but complex unconventional gas resources -- tight gas, coalbed methane, gas shales and geopressured methane. The technical objectives were to increase per well gas recovery efficiencies and lower unit development costs while providing incentives (through tax credits) for prompt, orderly development of the nation's gas resources.

In addition, two quantitative, national-level natural gas supply goals were set forth for the Enhanced Gas Recovery Program:

- *Increase gas production by an incremental 3 billion cubic feet per day by 1986, and*
- *Add 10 Tcf of producible reserves by 1985.*

Changing Horses in Mid-Stream. Even before the results were in, the political winds and market conditions shifted. The Reagan administration, in 1980, first scaled back the R&D program and then pushed to eliminate government involvement in short-term gas supply R&D, citing (with little foundation) that "the private sector has the financial and technical resources to develop the technology needed for new unconventional gas resources." Congressional intervention maintained the program, although only at a life-support level.

In 1991/92, with the publication of the administration's National Energy Strategy and the growing R&D role of the Gas Research Institute in unconventional gas, much of the remaining DOE R&D program was eliminated, with only the low permeability ("tight sands") area surviving. When, in 1994, the Gas Research Institute also shifted its priorities, terminating its focus on unconventional gas in favor of a more generic technology-based R&D program, for all practical purposes public R&D on unconventional gas came to an end. With subsequent loss of focus and declining public and industry support, the Gas Research Institute's generic R&D program on gas supplies is now also being phased out.

Program Definition, Design and Implementation. The original DOE R&D program had its roots in Volume III of the study -- "Enhanced Recovery of Unconventional Gas (1978) -- and was shaped considerably by industry and outside technical input. Unfortunately, in subsequent years the political process rather than science and analysis shaped much of program design. In contrast, the GRI R&D program on unconventional gas was able to stay, at least during its formative years, outside the political process. The definition and design of the GRI program relied greatly on the priorities of industry-based advisory committees and a FERC imposed benefits calculation methodology. The two R&D programs complemented each other, with the DOE program often conducting the exploratory, fundamental science and the GRI program providing the applied science and technology transfer.

Each organization relied greatly on outside technical experts, research organizations and industry to perform and commercialize its R&D. This helped to bring valuable cost-efficiency and cost-sharing to the program, particularly during the field documentations stages. The

supporting Appendices to this paper provide additional details on the budgets and technical accomplishments of the DOE R&D program.

Supporting Policy Mechanisms

Two separate economic incentives were set forth in Congressional legislation to encourage the development of unconventional gas - - incentive pricing and tax credits.

Incentive Pricing Under NGPA. The first set of economic incentives for encouraging exploration and development of unconventional gas were set forth in the Natural Gas Policy Act of November, 1978. Section 107 of this act deregulated the well-head sales price of natural gas from Dervonian-age gas shales, coal seams and geopressured brines. Section 102 of this Act enabled tight gas to become eligible for the highest ceiling price within the NGPA regulated categories, providing this resource with modest economic incentives.

Section 29 Tax Credit. A separate set of economic incentives for unconventional gas were placed into The Crude Oil Windfall Profits Tax Act of 1980. Section 29 of this act provided tax credits to qualified unconventional gas wells and formations. While producers needed to select which set of incentives to use, the deregulation of natural gas in 1981 made this choice moot. With amendments, the Section 29 tax credit qualifying period for new unconventional gas wells lasted until the end of 1992, with tax credits provided for gas produced through 2002.

The incentive provisions of the Section 29 tax credit were designed to reward efficient unconventional gas development and performance. And they did. During a time when national average wellhead natural gas prices were between $1.50 and $2.50 per Mcf, the tax credit for tight gas was about $0.50 per Mcf and for gas shales and was on the order of $1.00 per Mcf for coalbed methane, adding considerable economic value to the efficient production of these resources.

Response to Incentives. Not surprisingly, industry's development and production of unconventional natural gas responded strongly to these incentives:

- The production of Section 29 "legally eligible" tight gas, a resource with many undeveloped basins and readily available technology, grew from 240 Bcf in 1980 to 1,180 Bcf in 1986, plateauing thereafter. Overall production from this resource, including "legally" and "geologically" defined tight gas, was considerably higher as numerous low permeability areas and pre-existing tight gas production remained unapproved by FERC or a FERC-designated State agency.

- Lacking a sufficient base of technology, coalbed methane had little opportunity to use the tax credits until the end of the 1980's. Even with this late start, by the end of the qualifying period over 5,000 CBM wells were drilled and completed before the tax credits expired.

- Drilling for gas shales increased substantially in the Appalachian Basin and with R&D opening up the Michigan Basin drilling boomed, averaging over 1,200 wells per year in the last six years of tax credits.

Post Tax Incentive Activity. A most significant outcome of the tax incentive program was that unconventional gas well drilling and completions stayed strong after the expiration of the tax credits:

- After a brief lull, tight gas well completions rebounded to 3,000 wells per year.
- Coalbed methane well completions slumped somewhat in the mid-1990's but now have reached new highs with the strong activity in the Powder River Basin.
- Gas shale well drilling has averaged 900 wells per year for the six years since the expiration of the tax credits, only somewhat less than the 1,200 wells per year prior.

The reason for the strong post tax incentive activity was that unconventional gas exploration and development technology had progressed sufficiently such that the industry remained economic and could attract capital without the need for further incentives or subsidies.

MONITORING AND EVALUATION

The initial DOE and GRI unconventional gas R&D programs placed considerable effort toward establishing reliable, efficient monitoring and evaluation systems. Explicit supply enhancement goals, detailed R&D program plans, annual budget justifications and benefit to cost analyses were used. However, as the gas supply conditions moved from shortage to surplus and the political support for public R&D waned, the rules of the game and the measures of success changed.

The DOE R&D Program. The initial DOE R&D program's monitoring and evaluation process, involving independent outside technical experts, served the program well. As new information was collected and compared with expectations, a series of significant shifts in the program occurred. For example, the geopressured methane program, having found to be geologically flawed, was terminated. At the same time, other priorities and budget shifts occurred with increases for tight gas and coalbed methane and decreases for gas shales, bringing the individual technology area budgets into closer line with their resource potential.

However after a few years, as the gas shortage turned into a gas surplus, much of the national level evaluations and mid-course adjustments became politically driven rather than analytically founded. The coalbed methane R&D program was essentially shut down. The gas shale R&D program stayed on life support only due to Appalachian Basin political support. Subsequently the program was terminated in 1992. Tight gas R&D survived, but at a dramatically reduced level.

In recent years, DOE's R&D monitoring and evaluation process has again become much more analytical and rigorous. While no sense of urgency has yet emerged for using R&D or incentives to stimulate additional natural gas production (even though natural gas prices are at an all time high and concerns exist again about winter gas curtailments), several important management steps have been taken. A Strategic Center for Natural Gas has been established at the National Energy Technology Laboratory and a National Research Council/National Academy of Sciences evaluation of the accomplishments and benefits of each of the unconventional gas technology areas is underway.

The GRI R&D Program. From its inception, the Gas Research Institute was mandated by the Federal Energy Regulatory Administration (FERC) to perform extensive cost-benefit analyses, set forth rigorous budget justifications, and hold several levels of advisory board review. This process and clear focus on unconventional gas served GRI and its R&D program well. In 1994, however, GRI switched from a resource based program addressing unconventional gas to a generic E&P technology based program. At that point, GRI began to look like any other industrial R&D shop, lost its national gas supply mandate, and found difficulties justifying its program costs and benefits to industry.

DISCUSSION OF RESULTS

Unconventional gas offers one of the great success stories of national benefits and progress in technology. A poorly understood, high cost energy resource, one that the U.S. Geological Survey had not even included in its national appraisals of future gas resources (until their most recent 1995 assessment), is now providing major volumes of annual gas supplies and helping meet growing domestic natural gas demand.

- Unconventional natural gas provided 4,500 Bcf of supply in 1998, up from 1,500 Bcf twenty years ago.
- Proved reserves of unconventional gas are 52 Tcf, up from less than 20 Tcf twenty years ago; remaining recoverable resources of unconventional gas are estimated at 370 Tcf to 500 Tcf.

Looking ahead, based on projections by DOE/EIA's National Energy Modeling System (in AEO 2000), considerable further development of this resource base is expected, assuming a continuing strong pace of technology progress. By 2010, annual unconventional gas production is expected to reach 5,700 Bcf. The recent National Petroleum Council (NPC) Natural Gas Study expects even more from unconventional gas, estimating 6,800 Bcf of supply in 2010 from these resources. (The NPC tight gas study includes certain gas plays, such as the Austin Chalk with 400 Bcf of annual production, that are counted as conventional gas in the DOE/EIA model.)

The NPC study explicitly states, "This study assumes that technology improvements will continue at an aggressive pace." Recent cutbacks in industrial R&D, the small size of DOE's gas supply program, and the termination of the Gas Research Institute's public R&D on unconventional gas raise serious concerns on the future pace of technology progress. The NPC Study highlights its concerns by stating, "However, recent (declining) trends in research and development spending raises concerns regarding this (aggressive pace of technology improvement) assumption."

1. Tight Gas Sands. By the mid-1970's, industry knew that large quantities of natural gas resources existed in tight (low permeability) formations. However, the flow and production of gas from most of these tight formations was too low to support economic recovery. A handful of independents explored for areas where nature had sufficiently fractured this tight rock to make it productive, but generally with a poor record of success.

At the start of the R&D and incentives program, annual production from tight gas sands was low, with most of the naturally fractured "sweet spots" in these tight gas basins having been deemed found and developed. Significant advances in exploration, well drilling and stimulation technology were required to further pursue this large, complex gas resource.

The combined DOE, GRI and industry R&D programs, plus a set of modest tax incentives, unlocked the gas resource held in these tight rocks. The gas play, born in the Appalachian and San Juan basins, expanded rapidly into the major Rocky Mountain gas basins and more recently into Texas and the Mid-continent. By 1998, annual tight gas production was 2,920 Bcf, up from 1,400 Bcf in the mid 1970's. Proved tight gas reserves were 35 Tcf from a cumulative of 46,000 producing wells (not including the numerous older low producing tight gas wells in the Appalachian Basin), with nearly 48 Tcf of tight gas having been produced since the initiating of the R&D program.

2. Gas Shales. At the start of the R&D Program, the Appalachian Basin gas shales were a small, declining resource providing 70 Bcf per year. Annual new well drilling averaged only 200 wells and proved reserves were about 1 Tcf. Wells were being completed open hole, with little definition of productive pay zones, and were being stimulated with nitroglycerine (a remnant of early 1900's technology). Much of the activity was centered in the Big Sandy area of eastern Kentucky. Little understanding existed on key gas storage and production mechanisms nor about geologically similar gas shale plays in other parts of the country.

By 1998, annual gas shale production had reached 360 Bcf. Proved reserves were 5 Tcf, with another 4 Tcf having been produced in the twenty years from 1978 to 1998. Stimulated by Section 29 tax credits and the expansion into new gas shale basins in Michigan and North Texas, well drilling climbed sharply. Over 16,000 productive gas shales wells were drilled from 1978 to 1998 with a peak of 1,700 gas shale wells completed in 1992, the last year wells could qualify for tax credits.

3. Coalbed Methane. The combination of building a scientific base of knowledge, fostering appropriate technology and providing economic incentives launched the birth of a new natural gas industry -- coalbed methane -- now with nearly $10 billion of capital investment. Much of the early development was by independent production companies such as Devon Energy, Meridian Oil and Taurus Energy, who saw their gas production, reserve holdings and market capitalization rise sharply.

Coalbed methane production climbed from essentially zero at the start of the R&D program to 1,200 Bcf in 1998, from three significant basins. Proved reserves were 12 Tcf from over 6,000 producing wells, with another 7 Tcf having already been produced. The introduction and continuing adaptation of technology enabled the industry to remain profitable and vigorous, even after the 1992 expiration of Section 29 tax credits. Today, several new coalbed methane basins and plays are being actively developed, including the Powder River (Wyoming), Raton (Colorado), and Uinta (Utah), providing a base for continued growth.

4. Geopressured Methane. While considerable geologic and reservoir knowledge was gained, no commercial natural gas production was established for this resource. Still, the R&D program in geopressured methane helped bring a strong dose of reality and understanding on the viability, or lack of, for this gas resource and helped dispel the speculation that “a 1,000 years of natural gas” was at hand.

LESSONS LEARNED

Twenty years have passed since the DOE R&D and incentive programs were launched in unconventional natural gas. What lessons and insights might one be able to draw from this rich base of experience that would be relevant to other existing and emerging R&D programs such as Carbon Sequestration? Among the many “lessons learned,” ten stand out:

1. When rigorously planned and managed, government supported R&D can be highly successful, providing significant benefits to the domestic economy. The DOE and GRI R&D programs introduced knowledge and hardware that turned a low productivity, high cost resource into a reliable source of new natural gas reserves and supply. Using a value of $0.50 per Mcf of additional natural gas production and reserves due to advances in technology and economic incentives, the national economic benefits of unconventional gas are $46 billion, not counting future development.

2. Establishing a scientifically-based knowledge base “the intellectual foundation,” is an essential first step. Much of the negative outlook and low R&D support for coalbed methane stemmed from an ill-advised and unsuccessful “drill and hope” field demonstration project (separate from DOE’s R&D program) before a scientific foundation had been established. The series of dry holes that followed severely set back and almost condemned what is now a vigorous industry.

3. Joint industry/government partnerships and implementation help leverage R&D resources and bring commercial practicality to the program. The GRI unconventional gas program regularly benefited from industry cost share and advice. DOE began to realize similar values when it increasingly turned to industry/government partnerships rather than relying solely on the internal R&D programs of its National Laboratories for implementing tight gas and gas shales R&D.

4. A critical mass of funding and sufficient time are essential for achieving success, particularly for ambition, breakthrough efforts. The timely and efficient development of the coalbed methane resource had a major setback when it was prematurely terminated. Fortunately, GRI picked up the R&D on this resource and made it one of its high priorities, enabling the technology to mature, to be rigorously field tested and to achieve success.

5. Independent evaluation of fundamental assumptions, data and results, while often unwelcomed by research investigations and proponents, is essential for avoiding wasting scarce R&D resources. The independent review of the geology and science of geopressured methane (while initially roundly criticized by its proponents) helped close down a large R&D program targeting this geologically flawed and economically non-viable resource.

6. Cost reductions and efficiency improvements in geologically based technologies rely as much on adapting the technology to the geologic setting as on fundamental breakthroughs. Successful results in the various coalbed methane and gas shale basins required substantially adapting technology rather than blindly applying methods that worked in other geologic settings or requiring totally new technology. As such, reliable and accessible geologic and reservoir data on the high potential basins need to be a priority for R&D.

7. Efficiently disseminating technology to industry requires a comprehensive program of technology transfer ranging from publications for the informed layman to high visibility "flagship" field demonstrations. GRI's publication of the "Quarterly Review of Methane from Coal Seams Technology," the numerous articles prepared by its technical contractors and the major field laboratory at Rock Creek greatly reduced the time for technology penetration and use by industry.

8. Economic and tax incentives can greatly accelerate industry's adoption of technology by helping assemble capital, by lowering economic risk and by challenging the financial community's imagination. The tremendous boost in new investment and well drilling, seen by all three of the unconventional gas resources, is a testament to the power of properly structured economic and tax incentives.

9. Special purpose "performance based" rather than broadly structured or "input based" economic incentives are a key to success. The highly focused Section 29 tax credits available to the unconventional gas industry had considerably larger impacts than the general purpose R&D tax credit available to all industry.

10. For maximum effectiveness, the incentives need to be sufficiently attractive and long lasting but also have a "sunset provision." Section 29 tax credits significantly improved project economics during the initial risky phase of unconventional gas development. As the technology and resource understanding matured, these risk premiums became less, enabling the unconventional gas industry to compete for project approval and capital without the need for continued incentives.

TECHNOLOGY DEPLOYMENT CASE STUDY
U.S. DEPARTMENT OF ENERGY'S SUB-CFL PROGRAM

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Introduction

In early 1998 the U.S. Department of Energy (DOE) launched a program designed to speed the market introduction in the United States of a new generation of smaller, brighter, and less expensive compact fluorescent lamps (CFLs). The program, called the DOE Sub-CFL Program, emphasized the small size of the lamps, intending to overcome one of the primary market barriers to wider market acceptance of this technology. CFLs often do not fit into lighting fixtures designed for typical incandescent lamps. It was developed primarily in cooperation with the multi-family housing industry, the primary target market sector, but also encouraged participation by other high volume buyers and market intermediaries, such as electric utilities, universities, government agencies, lighting retailers, public housing authorities, and hotel/motel companies.

The program used a technology procurement to induce manufacturers to develop and sell new products meeting technical specifications developed in cooperation with the multi-family housing industry. After extensive interaction with the multi-family housing industry, DOE's Pacific Northwest National Laboratory (PNNL) issued a request for proposals (RFP) to lighting suppliers, soliciting bids to supply sub-CFLs meeting minimum technical specifications. Winning suppliers were selected based on price, the extent to which bid product was smaller than the maximum size requirements, and the quality of the warranty offered.

The program offers an interesting case study for three primary reasons: 1) it successfully introduced 16 new lamp models into the U.S. market; 2) it achieved this aggressive response from the lighting industry without advanced guaranteed purchases, which are typical in technology procurement programs, and; 3) it exceeded its program sales goal of one million lamps by more than 50%.

Program Objectives

The Sub-CFL Program was developed in response to the Energy Policy Act of 1992, Sections 127 and 128 which required DOE to study and propose plans for developing and commercialising more efficient appliances (including lighting equipment). The legislation did not contain specific goals other than the general goal, "to improve energy efficiency." No specific energy use or carbon emission reduction goals were stated in the legislation, nor were any specific energy efficiency goals described.

In addition to the Energy Policy Act goal of improving energy efficiency, the Sub-CFL Program had several specific goals and objectives. The long-term goal of the program was to expand the market for CFLs by inducing manufacturers to develop and sell new CFLs that are shorter and lower cost than most CFLs then in the market. The medium term objectives of the program were to:

1) induce at least two manufacturers to commercialise new, smaller CFLs;
2) induce the commercialisation of a low-cost, 15 W integral CFL less than 5 inches (127mm) in length;
3) implement a program that offered CFLs at prices substantially below the then prevailing market price of $15-$22, and;
4) achieve sales of at least one million units.

These goals were based on the results of market research aimed at identifying the market barriers to wider use of CFLs in the multi-family housing sector. That research identified several barriers, by far the most important were price and size. Less important market barriers identified were low levels of luminous flux (light output), and ability to start in cold temperatures (for outdoor use). Accordingly, a program was designed addressing these barriers. Technical specifications were developed for the procurement setting maximum size requirements for each lamp wattage category in the program, minimum luminous efficacy, and a minimum starting temperature.

Process of Definition/Design of the Program

Based on its experience in working with the public multi-family housing sector on the Super-Efficient Apartment Size Refrigerator Program[29], DOE began working with private multi-family

[29] The Super-Efficient Apartment Size Refrigerator Program was a technology procurement jointly developed and implemented by U.S. DOE, the New York Power Authority, and the Consortium for Energy Efficiency. It led to the market introduction and substantial sales of a refrigerator exceeding U.S. DOE minimum refrigerator standards by 30%.

housing owners and operators, seeking opportunities to help them purchase more energy-efficient appliances, including dishwashers, refrigerators and clothes washers. DOE engaged a wide range of companies throughout the U.S., both large and small, in an effort to more fully understand their business and the decisions that affect the energy use of their multi-family buildings. In addition, DOE engaged several national and regional trade associations representing multi-family owners and operators.

Multi-family housing companies initially expressed strong interest in the idea of organizing projects to test the rental market response to the use of more efficient appliances. But the very substantial incremental cost of efficient appliances, relative to the cost of appliances that were typically installed by the companies, proved to be a formidable obstacle. The multi-family owners and operators were unwilling to stray from their long-run practice of purchasing the lowest cost appliances available, regardless of their energy consumption.

As a result, DOE began to explore technology improvements requiring less capital outlay and suggested a program to encourage owner/operators to consider purchase of Energy Star® lighting fixtures, specifically, dedicated CFL fixtures (lighting fixtures using pin-based CFLs) for outdoor and common areas. The owner/operators, however, stated that the expense of retrofitting fixtures in existing buildings made them an unattractive candidate for a joint project with DOE. The investment conservatism of the industry proved to be an even more formidable obstacle to the organization of a collaborative project than DOE had previously estimated.

DOE then proposed integral CFLs, a low-cost technology, hoping that successful completion of a low-cost, low-risk project would help make the industry more comfortable working with DOE and make possible future projects involving higher capital outlays by the industry. The suggestion was well received, but the discussions with the industry identified two major market barriers to widespread use of CFLs: price and size. Multi-family owners and operators emphasized most CFLs were too expensive and too long to fit into most of the existing lighting fixtures in their buildings.

After consideration of the substantial amount of information and feedback received from the multi-family industry, DOE decided a technology procurement, aimed at bringing low-cost, very small CFLs into the market was an appropriate means of engaging the multi-family housing sector in an effort to use more efficient technology. A technology procurement program was thus developed.

The decision to use a technology procurement approach was based on several factors:

1) New products were needed in the marketplace to address the identified market need.

2) Aggressive pricing was needed to make the new products attractive to the identified market. Technology procurement offered an opportunity to use competition among bidders to drive prices down.
3) The technical change needed in CFLs to meet the size requirements developed with the multi-family housing industry was modest; a common trait for products brought to market through successful technology procurements.
4) The multi-family industry expressed strong interest in the proposed approach.

A technology procurement program was designed to maximize the chance of success. The key design elements, and a short justification for each follow.

1) *Two-phase approach*

   The program was implemented in two phases, with the first lasting five months, and the second lasting 24 months. The purpose of the first phase was to test the logistical operation of the program and to test the market reaction to products offered. Furthermore, the first phase was designed to attract bids based on products already available in the market, while the second phase was designed to attract newly developed products. The time consumed by phase I was intended to allow manufacturers more time to develop the new-to-market products expected in the second phase.

2) *Web-based ordering*

   To keep implementation costs down, a newly developed web site was used as the primary channel for distributing information about the program, as well as for ordering products made available through the program

3) *Strong warranty*

   Knowing of the multi-family industry's dissatisfaction with previously available CFLs, and of their hesitancy to purchase products with which they were not familiar, the program required manufacturers to offer an unconditional one-year warranty, which essentially eliminated risks of participation by multi-family owners and operators.

4) *Cold start capability*

   Most lighting costs in multi-family property are billed directly to tenants. However, common area lighting, a large fraction of which is located outdoors in climates that experience low winter temperatures, is billed to the property owners. Since the program was targeting the property owners/operators, a specification was adopted which required bidders to offer products that would start and produce acceptable lighting levels in very cold temperatures.

5) *Emphasis on size*

Recognizing the importance of small size in overcoming market resistance to purchase CFLs, the program emphasized size reductions by not only setting difficult-to-meet size requirements[30], but by also awarding extra evaluation points to bidders by the extent to which they reduced size beyond the minimum requirements.

6) *Multiple suppliers*

Given DOE's previous experience with technology procurement, the program was designed to increase the chance that more than one bidder would be awarded an agreement to supply products through the program. Multiple suppliers allow program implementers to drop suppliers for performance or product quality reasons without having to suspend the program or issue a new RFP because other suppliers are available to continue supplying products.

7) *Participation by buyers outside of the multi-family housing sector*

While the target market sector was the multi-family housing industry, the program was designed to allow participation by utilities, government agencies, schools, and retailers. Program designers believed potential product demand by these other sectors would increase the number and aggressiveness of bids submitted by CFL manufacturers, without appreciably increasing program costs or complexity (since no subsidies were involved).

Main Actors and Their Roles

The main actors involved in the implementation of this program and their roles were:

1) *Private multi-family housing owners and operators*

As described previously, these companies were heavily consulted in the development and design of the program. They were used to identify the key market barriers to wider spread use of CFLs, and their guidance was used to design a program that met their needs. This sector was also the primary market target for the program.

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[2] The program's technical specifications restricted participation to those lamps meeting the following maximum length requirements: 15-16W (133mm); 18-20W (140mm); 23-28W (152mm); 30+W (178mm). A typical general service incandescent lamp of 60 - 100W is 113mm long.

2) *Multi-family housing trade associations*

During program design, discussions were held with several trade associations for the purpose of soliciting their guidance and their assistance in communicating and promoting the program to their members. At a national level, both the National Multi-Family Housing Council and the National Apartment Association were engaged. Both provided valuable guidance and agreed to alert their membership to the program opportunity.

3) *CFL manufacturers*

Extensive discussions were held with a large number of CFL manufacturers that were considered to be potential bidders. Meetings were held in the corporate offices of all three major lighting manufacturers (GE, Osram, and Philips), as well as a substantial number of smaller manufacturers and manufacturers' representatives (TCP, Lights of America, Link USA, Sun Park, Planet Mirth, Duro-Test and others). These meetings were used to alert the manufacturers to the program, to solicit their interest, and to seek their review and critique of both the program design and technical specifications. These meetings proved invaluable in shaping the technical specifications and in building interest in bid submission.

4) *Utilities*

While individual utilities were not engaged in the development and design of the program, program designers believe this was an oversight. Given the important role they've played in using and promoting the program, their involvement at an earlier stage would probably have produced a program better suited to their use. Nonetheless, a number of utilities -- especially large California-based utilities – have either directly purchased large number of lamps for use in their programs, or promoted use of the lamps to their customers. And interestingly, publicly-owned utilities, such as the Los Angeles Department of Water and Power, found the program especially useful given it had used government purchasing procedures to arrange the ordering agreements with the winning program CFL suppliers. That allowed publicly owned utilities to purchase the lamps without having to implement their own government-regulated procurements, which tend to be expensive and time consuming.

Utilities designed a number of programs around the sub-CFL program, including a low-income weatherization program providing the sub-CFLs free of charge to low-income customers, a green power program giving sub-CFLs to customers willing to sign up for green power, a multi-family housing program promoting volume purchases of sub-CFLs by multi-family owners and operators, and a program that signed up retailers to purchase and resell sub-CFLs in exchange for utility-paid advertising directing customers to participating retailers.

5) *Consortium for Energy Efficiency (CEE) and Northwest Energy Efficiency Alliance (NEEA)*

   Both of these organizations are market transformation organizations[31]. CEE is a national organization, whose membership is primarily energy utilities engaged in market transformation programs. CEE played an important role in regularly communicating program information to its membership during the program's implementation. NEEA is a regional organization whose members include utilities, companies and other organizations involved in market transformation programs in the Pacific Northwest. NEEA not only modified their existing CFL program to promote use of sub-CFLs available through the DOE program, they voted in the Spring of 2000 to assume leadership of the Sub-CFL program (with co-funding from DOE), and to launch a special effort aimed at increasing the presence of sub-CFLs in Northwest retail stores.

6) *Retailers*

   Based on the assumption that the majority of program sub-CFL sales would be sales directly from manufacturers to large volume buyers, such as multi-family housing companies, retailers were not asked to participate in program design. However, once sub-CFLs were made available through the program, the new products and prices were attractive enough to spur significant involvement by retailers, particularly cooperatives that buy products for the thousands of small, independently owned hardware stores in the U.S.

Policy Mechanisms Used

The policy mechanism used for this program is a technology procurement. Technology procurement is a method to pull new technologies and products into the marketplace through competitive procurements backed by large volume buyers. Generally, it involves a multi-step process requiring:

- Organization of target large volume buyers and market influencers (such as utilities);
- Interaction with those buyers to understand their business and technology needs in detail;

[3] Market transformation program is a term used in the U.S. to describe a new generation of conservation programs that are more carefully designed to exploit market forces than the previous generation of utility-sponsored conservation programs, and that are designed to have their market effects be self sustaining after cessation of the programs.

- Definition of their technology needs in the form of technical specifications, and acquisition of their commitments or intentions to purchase new products meeting those specifications;
- Dissemination of those specifications for expert appraisal by potential manufacturers of the newly defined product;
- Issuance of a competitive solicitation to potential suppliers, requesting bids for new products meetings those specifications, as well as the price at which they are willing to offer the products;
- Selection of one or more winners from those bids;
- Completion of agreements with the winning bidders establishing the terms and prices by which third party purchasers might purchase of the target products;
- Implementation of promotion/ marketing programs to maximize the purchase of the newly available products.

By working closely with potential buyers, technology procurement greatly increases the likelihood that products brought to market will be well received by buyers. And by organizing large volume buyers for new products, technology procurement reduces the risks to manufacturers of new product introduction, and allows them to introduce products at more competitive prices.

The Sub-CFL technology procurement followed the steps described above, with few exceptions. The key exception was that utilities were not significantly involved in the development of the program, more by oversight than by design. However, after the program was developed, utilities became important program partners by helping their customers purchase the newly available lamps.

The RFP attracted bids from seven companies in Phase I, from which three were awarded basic ordering agreements (BOAs). The Phase II RFP brought in eight bids, from which five were awarded BOAs. DOE did not subsidize the lamps, yet because the lamps could be purchased in large quantities directly from manufacturers or their representatives, prices of the new products were kept very low, ranging from a delivered price of $4.95 to $8.30 each, depending on order quantity and destination.

The program then launched a modest effort to announce the availability of the lamps. A website was developed to provide information on the program and products (www.pnl.gov/cfl). Other popular energy and multi-family housing websites were contacted and requests were made to install links to the program on their websites. Program staff made presentations at conferences, wrote articles for multi-family housing newsletters and other publications, and encouraged utilities to develop programs to take advantage of the new lamps.

As of October of 2000, the program is entering a new stage, in which DOE will be relinquishing its leadership of the program, and turning it over to the Northwest Energy Efficiency Alliance (NEEA). DOE's role was focused on market introduction of sub-CFLs,

and given its success in achieving that goal, it sought to transition the program to another organization interested in continuing promotional efforts for the lamps. In agreeing to assume leadership for the program, NEEA declared its intention to focus its efforts on getting sub-CFLs into the retail market sector in the Pacific Northwest, particularly independently owned retail stores that generally do not have the resources to easily access new products. To promote the new products, NEEA's program will use a combination of a completely redesigned website, with special features of value to retail store purchasing, and circuit riders, specially trained individuals who make site visits to hundreds of retail stores and offer information and assistance in purchasing new energy-efficient products for resale. NEEA has committed to operate the program in such a way as to allow utilities and purchasers outside of the Pacific Northwest to continue accessing program information and products in the same way they previously had (although no effort will be made to promote the products outside of the Northwest). Furthermore, they plan to sponsor issuance of new RFPs that will expand the range of Sub-CFL lamps included in the program, such as adding dimmable and reflector-type lamps.

For the 2-½ year operation of the program, total DOE expenditures amounted to $342,000. This budget covered technical research, market research, interaction with potential buyers and manufacturers, development of technical specifications, RFP development and issuance, award evaluation, CFL performance testing, promotion, and other miscellaneous program tasks. Expenditures by utilities who have operated programs to promote use of sub-CFLs are unknown, but are believed to exceed $1 million. Planned expenditures by utilities are also unknown, but are estimated to exceed $3 million.

Monitoring and Evaluation Process

DOE did not adopt a third party monitoring and evaluation process. However, DOE implemented a modest internal monitoring and evaluation process, using one contractor directly involved in the program's implementation, and one contractor who was not.

Approximately nine months after products were first made available to buyers through the program, buyers were surveyed on a range of issues, including:

- Reason for purchase
- Satisfaction with purchase
- Problems with performance
- Speed and accuracy of order fulfillment
- Warranty claims
- Where installed

Results from the survey revealed a high level of satisfaction, insignificant problems with performance, limited order fulfillment problems, and prompt handling of warranty claims. In addition to this survey, program staff regularly solicited and received customer feedback on the above issues. This feedback identified problems with two suppliers, both of which were subsequently disqualified from the program.

In addition to this type of program monitoring, DOE had program suppliers provide monthly sales reports. Those reports showed a steady upward trend in lamp sales.

DOE also implemented an effort to measure market impact from the program, relying on its implementation contractor for this information. Pre-program baseline observation measurements were made for a number of market impact indicators, including:

- Number of sub-CFLs introduced to the market
- Number of retailers selling sub-CFLs
- Evidence of influence on standards or specification setting organizations
- Sub-CFL prices
- Sub-CFL sizes
- Sub-CFL sales
- Number of utilities specifically promoting sub-CFLs

Measurements and observations for each of these indicators were taken in August and September of 2000, indicating significant market impact, several of which are discussed in the following section on results.[32]

Discussion of Results

Information collected in the above-described measurement of market impact, as well as other available program information, indicated the program achieved all of its medium-term objectives. It is still too soon to judge whether it has met its long-term goal of expanding the market for CFLs, but there is substantial evidence indicating the program has had an important market impact.

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[4] Readers should note these measurements and observations were not conducted within a rigorous, externally reviewed evaluation framework. They were collected as part of a modest effort intended to serve internal program management needs, and thus should not be interpreted or used in the same way a third party, more rigorous evaluation would.

The medium-term program objectives are repeated here, followed by a brief discussion of observed or measured results:

1) *induce at least two manufacturers to commercialize new, smaller CFLs*

   The program induced five manufacturers to commercialize new products. Lights of America (LOA), Sunpark Electronics, Link USA, JKRL, and Surya/PMI all developed and introduced new products in the U.S. market in response to the program. LOA introduced two products (15 and 20 watts); Sunpark six products (15, 20 and 23 watts, each in a mid- or high-power factor versions); Link three products (15, 20 and 26 watts); JKRL four products (15, 20, 23 and 26 watts); and Surya/PMI one product (15 watts). Some of these products reflected modest changes in what the manufacturer had previously offered, such as small size reductions, increased luminous efficacy, and better cold temperature starting and operation (Sunpark, Link, and JKRL); while others reflected all new lamp designs (LOA and Surya/PMI).

2) *induce the commercialization of a low-cost 15 W integral CFL less than 5 inches (127mm) in length*

   The program succeeded in inducing commercialization of two 15 watt, low-cost products that were less than five inches (127mm) in length. LOA introduced model # 2415, a spiral tube lamp whose tubes are attached to the base at an acute angle (as opposed to the right angles typically used by spiral lamp manufacturers). The lamp is 4.69 inches (119 mm) in length, and sold through the program for $6.75 to $7.25, depending on order quantity. Surya/PMI introduced model # PMIET15, which uses four u-tubes mounted in a compact base. The lamp is 4.56 inches long (116 mm), and sold through the program for $4.95 to $6.25, depending on order quantity and destination.

3) *implement a program that offered CFLs at prices substantially below the then prevailing market price of $15-$22*

   Products offered through the program were priced aggressively. As of September 2000, delivered prices for the various products ranged from $4.95 to a high of $8.20, depending on lamp model, order size, and destination.

4) *achieve sales of at least one million units*

   Reported sales in the program surpassed 1.5 million units in August 2000..

In addition to the results associated with the program objectives, the following results were observed:

1) The number of retailers offering sub-CFLs appeared to increase. Prior to launch of the program, the only lamps known to meet sub-CFL size requirements, and known to have significant retail presence, were Philips Earthlight Universals. As of August 2000, there are now numerous sub-CFL models widely available in the retail sector, including lamps sold through the program, and sub-CFLs brought to market by other

manufacturers. Numerous national, regional, and independent retailers now offer sub-CFLs.

2) The program had an observed impact on specifications setting organizations, most noticeably with regard to power quality specifications. The program's draft specifications on power quality touched off an intensive set of discussions among utilities, EPA Energy Star staff, and manufacturers over the high-power quality requirements that utilities and EPA had imposed on CFLs and residential lighting fixture programs. In less than a year, these programs had almost universally backed off on these requirements, and adopted the power quality requirements of the sub-CFL program.[33]

3) CFLs meeting the sub-CFL size requirements continued to enter the market after the launch of the program. In addition to the many lamps introduced by small manufacturers, GE brought two new models to market meeting sub-CFL size requirements, including a spiral lamp that is selling for as low as $6.67 at a major regional retailer. A sales-weighted average size of CFLs sold in the U.S. is unavailable, but a growing selection of sub-CFL lamps is now clearly available.

4) Prior to launch of the sub-CFL program, no utilities were promoting sub-CFLs. (Numerous utilities were promoting CFLs, but they had no size requirements or efforts aimed at sub-CFLs.) As of August 2000, numerous utilities were promoting sub-CFLs, all of which are in the western region of the U.S. Almost all of the major California utilities are specifically promoting sub-CFLs, and as discussed before, the Northwest Energy Efficiency Alliance, in cooperation with northwest utilities, is implementing a new region-wide program to promote sub-CFLs.

Key Elements of Success

The single most important element contributing to the success of the program was the careful evaluation of a market sector that led to the discovery of a very important market barrier to CFLs (size) which had been overlooked by previous CFL programs. The second most important element of success was the careful evaluation and identification of technical means for overcoming this barrier. Together, these elements positioned this program to develop a good technical solution for a prominent market problem.

Another key contribution to program success was selection of the right policy tool, technology procurement, for the set of circumstances faced by DOE. A clearly defined and widespread need that could be addressed with modest technical improvements in existing technology made technology procurement an attractive candidate. Making it all the more attractive was its ability to use competitive processes to drive down prices (another important market barrier) without the use of subsidies.

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[5] The Sub-CFL Program specified a power factor of 0.5, and had no requirement on total harmonic distortion (THD) for current. These specifications were in marked contrast to power quality specifications in widespread use at the time, which required a power factor of at least 0.9, and THD of no more than 33%. Most companies and organizations sponsoring programs with these specifications were finally persuaded that the high power quality requirements offered little or no benefit to their electric systems, and unnecessarily made the cost of CFLs higher. They subsequently dropped the THD requirement, and adopted the 0.5 power factor requirement.

Selection of multiple winners, which prevented absolute dependence on a single supplier, and utility involvement, which proved to be very important partners for moving product into the marketplace, were also key contributors to success.

Main Sources of Problems and Failures

A significant source of problems was the program's decision to work with small manufacturers (and their representatives). While these small companies proved willing to challenge the status quo, and willing to price their product very aggressively, several nonetheless suffered from their logistical ability to handle large volume orders. Substantial time and effort were expended to resolve these problems.

A second important source of problems was the perception by some companies in the retail and wholesale lighting business that DOE was attempting to compete with them. They saw DOE operating a website directing potential buyers to a select group of suppliers, and interpreted that as an inappropriate use of government funds. Almost all of these problems were resolved by explaining that DOE's purpose for operating this program was to introduce new products to the market, and then provide *short-term* assistance in getting those products established in the market.

Another program shortcoming was its oversight of the important role utilities could play in helping bring these products to market. As described earlier, utility partnerships were not developed until after the program was underway. While they nonetheless became very important partners, the extent of their role and the effectiveness of the program probably would have been greatly enhanced had they been involved in early program design.

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Lessons Learned
The United States Clean Coal Technology Demonstration Program

Introduction

Launched in 1985, the Clean Coal Technology Demonstration Program (CCT Program) is an ongoing unique, cost-shared, technology development effort supported jointly by the United States Department of Energy (DOE) and the private sector. In its implementation, many precedent setting actions were taken and a sense of mutual responsibility for the end product was developed. The program's success to date is a tribute to the innovations used by both the public and private sectors to overcome procedural issues, create new management systems and controls, and move toward accomplishing shared objectives. The program has an exceptional success record. Over half of the 40 projects in 18 states have reached successful completion.

The technological successes are evident. SO_2 and NO_x control technologies emerging from the CCT Program have moved into the utility and industrial marketplace and now provide cost effective regulatory compliance. A new generation of advanced coal-based power systems has been placed in commercial service that represents an enormous leap forward in terms of efficiency and environmental performance. These advanced power system projects will provide a springboard for widespread, global deployment. This in turn will contribute greatly to reductions in greenhouse gas emissions.

The principles of the CCT Program evolved from many of the experiences - positive and negative of earlier U.S. DOE demonstration programs. As a result, the program has accommodated changing political and economic environments. The CCT program serves as a model for other government programs aimed at introducing new technologies into the commercial marketplace.

Objectives

The CCT Program was established to demonstrate the commercial feasibility of CCTs to respond to a growing demand for a new generation of advanced coal-based technologies characterized by enhanced operational, economic, and environmental performance. Clean coal technologies being demonstrated under the CCT Program are establishing a technology base that will enable the U.S. to meet more stringent energy and environmental goals.

Coal Technologies for Environmental Performance

The CCT Program is cognizant of concerns about global climate change. Clean coal technologies (such as IGCC) being demonstrated in the CCT Program offer utilities an option to reduce greenhouse gases (GHG) by as much as 25 percent with first generation systems through enhanced efficiency. Commercialization of atmospheric fluidized-bed (AFBC) and pressurized fluidized-bed combustion will also serve to reduce GHGs.

Coal Technologies for Competitive Performance

As the electric generation market moves from a regulated industry to a free market, the CCT Program has kept pace with the changes. Whether the changes are brought about by the federal government through existing or new legislation or by state governments, the CCT Program is demonstrating the first generation of many technologies that will be needed in a competitive power generation market. These new technologies will be far more efficient than existing plants and environmentally benign.

Coal Technologies to Sustain Economic Growth

The CCT Program is contributing to the maintenance of a diverse energy mix in the U.S. by developing and deploying a technology that enhances the efficient use of the United States' abundant coal resource while simultaneously achieving important environmental goals. The advancements in coal use technology resulting from the CCT Program will reduce dependence on foreign energy resources and create an international market for these new technologies. The Worldwide market for power generation technologies could be as high as $80 billion between 1995 and 2020.

Process of Definition/Design of the Program

The projects are selected via a competitive solicitation process administered by the U.S. DOE. The U.S. Congress sets the goals for each solicitation. The Department of Energy translates the congressional guidance into performance-based criteria and developed approaches to address "lessons learned" from previous solicitations. The criteria and solicitation procedures are offered for public comment and presented at pre-proposal conferences.

The CCT Program implementation principles are:

Strong and stable financial commitment for the life of the project, including full funding of the government's share of the costs;

Multiple solicitations spread over a number of years, enabling the CCT Program to address a broad range of national needs with a portfolio of evolving technologies;

Demonstrations conducted at commercial scale in actual user environments, allowing clear assessment of the technology's commercial potential;

A technical agenda established by industry, not the government, enhancing commercialization potential;

Clearly defined roles of government and industry, reflecting the degree of cost-sharing required;

A requirement for at least 50 percent cost-sharing throughout all project phases, enhancing participant's commitment;

An allowance for cost growth, but with a ceiling and cost-sharing, recognizing demonstration risk providing an important check-and-balance to the program;

Industry retention of real and intellectual property rights, enhancing commercialization potential;

A requirement for industry to commit to commercialize the technology, reflecting commercialization goals; and

A requirement for repayment up to the government's cost-share upon successful commercialization of the technology being demonstrated.

Main Actors and Their Roles

Public and private sector involvement is integral to the CCT Program process and is crucial to the program's success. The CCT Program was created as a joint government-industry initiative. It is a partnership in which the federal government sets performance objectives, founded in national environmental concerns, and asks industry to respond with technical solutions. After the U.S. DOE selects the projects most suited to accomplish solicitation objectives and establishes performance measures, industry takes the lead in project management and assumes responsibility for commercialization. In this cooperative effort, industry retains its rights to the real and intellectual property generated through the development and commercialization of the technology in return for assuming at least 50 percent of the project costs.

To date CCT Program participants include:

ABB Combustion Engineering, Inc., and CQ Inc.

ABB Environmental Systems

Air Products Liquid Phase Conversion Company, L.P.

AirPol, Inc.

Alaska Industrial Development and Export Authority

Arthur D. Little, Inc.

Babcock & Wilcox Company

Bechtel Corporation

Bethlehem Steel Corporation

Coal Tech Corporation

CPICOR™ Management Company, L.L.C.

Custom Coals International

ENCOAL Corporation

Energy and Environmental Research Corporation

JEA

Kentucky Pioneer Energy, L.L.C.

Lakeland Electric, City of Lakeland

LIFAC-North America

McDermott Technology, Inc.

New York State Electric & Gas Corporation

NOXSO Corporation

Ohio Power Company

Passamaquoddy Tribe

Public Service Company of Colorado

Pure Air on the Lake, L.P.

Sierra Pacific Power Company

Southern Company Services, Inc.

Tampa Electric Company

ThermoChem, Inc.

Tri-State Generation and Transmission Association, Inc.

Wabash River Coal Gasification Repowering Project Joint Venture

Western SynCoal, LLP

Policy Mechanisms Used

The CCT Program is implemented through competitive solicitations. Five competitive solicitations sponsored by the U.S. Department of Energy resulted in selection of the most advanced coal-based technology concepts available anywhere in the world. Federal funding was leveraged twofold through partnerships encompassing utilities, state governments, technology developers, and research organizations. To date more than $5.6 billion has been expended, with industry and states investing two dollars for every one from the federal government.

The first solicitation (CCT-I) for clean coal projects resulted in a broad range of projects being selected in four major product markets:

I. Advanced electric power generation

II. Environmental control devices

III. Coal processing for clean fuels

IV. Industrial applications.

The second round of solicitations (CCT-II) became the centerpiece for satisfying the recommendations contained in the Joint Report of the Special Envoys on Acid Rain (1986). The goal was to demonstrate technologies that could achieve significant reductions in the emissions of precursors of acid rain, namely SO_2 and NO_x. The third round of solicitations (CCT-III) furthered the goal of the CCT-II and added technologies that could produce clean fuel from run-of-mine coal.

The fourth and fifth solicitations (CCT-IV and CCT-V, respectively) recognized emerging energy and environmental issues, such as global climate change and capping SO_2 emissions, and thus focused on technologies that were capable of addressing these issues. CCT-IV called for energy efficient, economically competitive technologies capable of retrofitting, repowering, or replacing existing facilities, while at the same time significantly reducing SO_2 and NO_x emissions. CCT-V focused on technologies applicable to new or existing facilities that could significantly improve efficiency and environmental performance.

Monitoring and Evaluation Process

In 1989, the Secretary of Energy issued directives to establish a Clean Coal Technology Executive Board to be chaired by the U.S. DOE Assistant Secretary for Fossil Energy (ASFE) and to establish a CCT Review Panel. The purpose of the directives was to streamline the review and approval process for clean coal technology projects. The Executive Board responsibilities include:

Monitor progress on each project negotiation and implementation against an agreed upon schedule, and report to the Secretary of Energy on the overall progress of the CCT Program on a regular basis

Resolve issues referred to the executive Board by the Review Panel(s), or for which the ASFE's office desires the viewpoint of the Executive Board members.

Approve and forward to the Secretary of Energy Comprehensive Reports to congress on negotiated projects that have been accepted by the Review Panel and forwarded to the Executive Board by the ASFE.

Provide a final control, where necessary, on the timeliness and quality of documents generated and actions taken by U.S. DOE staff to comply with the Clean Coal Program management objectives.

However, projects are managed by the participants, not the government. To protect the public interest, safeguards are implemented to track and monitor project progress and direction. The U.S. DOE interacts with the project at key negotiated decision points (budget periods) to approve or disapprove continuance of the project. Also, any changes to cost or other major project changes require U.S. DOE approval. In addition to formal project reporting requirements, an outreach program was instituted to make project information available to customers and stakeholders.

List of References and Documentation

Public Law 98-473; Initiation of CCT Program; informational solicitation

World Wide Web Home Page: (http://www.fe.doe.gov)

Fossil Energy TechLine: +01 202-586-4300

Computer Bulletin Board via modem: +01 202-586-6495

CCT Compendium: (http://www.lanl.cov/projects/cctc)

The following documents are available through the U.S. DOE, Office of Coal and Power Systems, Washington, DC 20585, +01 301-903-2624.

Clean Coal Technology: The New Coal Era

Clean Coal Technology Demonstration Program: Program Update

Clean Coal Technology Demonstration Program: Project Fact Sheets

Clean Coal Today

Topical Reports

Project Performance Summaries

Annual Clean Coal Technology Conference

CCT Program Bibliography of Publications, Papers and Presentations

Clean Coal Technology Program: Lessons Learned

Clean Coal Technology Export Markets and Financing Mechanisms

Foreign Markets for U.S. Clean Coal Technologies

Discussion of Results

The number and magnitude of demonstration projects put in place by the CCT Program is unprecedented, as is the extent of industry cost-sharing. The investment has resulted in 40 projects in 18 states. Over half of the projects have already reached successful completion. Now almost a decade-and-a half after the CCT program's inception and within its original Federal funding target, the program has achieved and expanded its objectives.

Below are listed several success stories of the DOE Coal R&D and Clean Coal Technology (CCT) programs. The CCT successes -- mostly demonstrations of pre-commercial, new technologies -- could not have occurred without earlier DOE R&D. R&D successes that culminated in CCT demonstrations include:

I. Low NO_x burners: Far less expensive than preceding technology for removing NO_x (oxides of nitrogen, precursors of smog) emissions, about ½ of US coal-fired capacity today has these burners. Sales to date are about $1.5 billion.

II. Atmospheric Fluidized Bed (AFBC) power plants: DOE/industry investments in this clean technology have resulted to date in at least $9 billion in domestic and foreign sales ($6.2 B domestic, $2.8 foreign) and 75,000 domestic jobs.

III. Advanced Scrubbers: Three advanced scrubbers have been demonstrated by DOE, one of which earned *Power* magazine's *1993 Power Plant of the Year* award.

IV. Tomorrow's Power Plants (*Integrated Gasification Combined Cycle*, or IGCC and *Pressurized Fluidized Bed*, or PFBC): These pre-commercial, virtually pollution-free plants have the potential of far higher efficiencies (thus 20% to 40% lower CO_2 levels).

V. The Rosebud SynCoal ™ and Encoal ™ processes are two different ways to upgrade low-rank coals to cleaner, more efficient fuels. Both processes are being marketed worldwide.

The success of the CCT Program is attributable, in part, to lessons learned from prior experiences and early involvement of the private sector in shaping the program. DOE has learned from its experiences during the program's implementation and has been able to make improvements. A feature of the CCT Program is that there been a series of procurement actions, spread over a number of years. Allowing time between solicitations has made it possible to meet changing national needs, to make adjustments in program implementation, and to allow time for private sector to develop projects.

Coal for the Future

The investment in the CCT Program is forming a solid foundation upon which to build a responsible future for fossil energy while addressing growing global and regional environmental concerns and providing low cost energy. The U.S. DOE's Office of Coal & Power Systems (OC&PS) has identified specific program areas to build upon the success of the CCT Program and provide a solid foundation upon which to progress toward Vision 21. Vision 21 is a long-term strategic concept which integrates OC&PS program goals to develop the full potential of the nation's abundant fossil fuel resources while addressing regional and global environmental concerns. Vision 21 plants would comprise a portfolio of fuel-flexible systems and modules capable of producing a varied slate of high value commodities, such as clean fuels, chemical, and electricity, tailored to meet market demands in the 2010-2015 time frame.

Country expert on this deployment program/policy:

Expert's name: Mrs. Barbara N. McKee

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Industrial Assessment Centers Program: Deployment Policy Case-Study

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Filename: IEA_IAC(FD)

Introduction

The Industrial Assessment Center Program (IAC) is run by the Office of Industrial Technologies within the United States Department of Energy's Office of Renewable Energy and Energy Efficiency. The IAC program (formerly called the Energy Analysis and Diagnostic Centers (EADC) program) has been training university engineering students in energy efficiency practices for small and medium-sized manufacturing plants (SICs 20 – 39) since 1976. The name of the program was changed to reflect the broader range of the services offered which now include a waste and productivity assessment along with the traditional energy audit. The primary teaching mechanism has been a paper analysis of a plant's energy bills, physical layout, and short description of operations followed by a one-day hands-on walk-through of the plant. Students are taught to ask analytical questions and make first-hand observations that will aid them in preparing a written summary of recommendations for improvement. The program offers students a unique opportunity to gain actual plant floor experience which has translated into better job offers and has established a cadre of engineers loyal to their energy efficiency roots who continue to espouse energy efficiency practices and technologies throughout their careers. Plants managers typically implement 50% of the recommendations for immediate savings, and adopt an awareness of energy, material, and labor inefficiencies that allows them to continue to make similar improvements, over time, both at the original plant where the assessment took place, as well as at other company locations.

Objectives of the program

The strategic goals of the IAC program reflect the strategic goals of the Office of Industrial Technologies (OIT). The following is the goal statement of OIT:

"By partnering with the industry, OIT will motivate and will assist industry develop technology solutions to critical energy and environmental challenges that will produce important national

benefits per unit of Gross National Product. Major goals of the Office of Industrial Technologies are:

A 25 percent improvement in energy efficiency and 30 percent reduction in emissions for the vision industries by 2010. A 35 percent improvement in energy efficiency and 50 percent reduction in emissions for the vision industries by 2020.

The Office of Industrial Technologies, through partnerships with industry, government, and non-government organizations, develops and delivers advanced technologies and practices to assist industry in meeting challenging goals in the areas of energy efficiency, and global competitiveness."

Process of definition/design of the program

Legislation authorizing the creation of the federal energy administration was drafted soon after the United States felt the effects of OPEC's tightening of oil supply. In the United States of America, a considerable number of laws and regulations have been promulgated concerning energy policy, energy conservation policy and energy efficiency promotion. In terms of history of energy conservation laws, the "Energy Policy and Conservation Act of 1975" was the among the first laws which were established with a view to regulate and possibly curb energy consumption and limit the related dependence on imported oil. Over the past two decades, the initial act has been amended several times. The EADC program and the current IAC program are outgrowths of that original legislation.

Main actors and their roles

Teams of engineering faculty and students from the centers, currently located at 29 universities around the country, annually conduct roughly 25 energy audits or industrial assessments and provide recommendations to manufacturers to help them identify opportunities to improve productivity, reduce waste, and save energy. These teams of engineering students led by university professors form the core of the technology diffusion mechanism. There are two field managers who oversee 15 schools each. These field managers, also associated with universities, serve both an administrative and a supervisory function. The U.S. Department of Energy funds the program, oversees the field managers and conducts an annual "Directors' Meeting" where a cross-pollination of best practices takes place. The IAC program, the field managers, and many of the schools also maintain websites. Self-help material downloadable from these websites has also proved to be of great benefit for many industrial manufacturers and consultants who might not otherwise be eligible to receive an assessment.

Policy mechanisms used

The IAC program is fundamentally an information dissemination program. Congressional appropriations in recent years have been about eight million dollars U.S. annually. These funds cover all administrative expenses incurred both by DOE headquarters and its two field managers. In addition, each of the thirty universities receives a stipend to conduct in-house training of faculty and students in preparation for the in-plant assessments. Each of the students who conduct the assessments is paid by the IAC (with DOE funds) on an hourly basis for their involvement in the assessments. The Industrial Assessment Centers program enables eligible small and

medium-sized manufacturers to have comprehensive industrial assessments performed at no cost to the manufacturer. The manufacturers, however, do bear the cost of implementing any of the recommendations they decide to adopt. The free assessment serves an important contributory role (whether it be the initial raising of awareness, or the final input into a decision-making process already begun) in each plant's decision to implement energy savings recommendations.

Monitoring and evaluation process

There are at least four levels of monitoring and evaluation that help influence the self-correcting mechanism guiding the IAC program.

First, results of the assessments are quantified through phone interviews conducted by the engineering team six to nine months after the site visit. The results of these interviews are reported to the field manager at Rutgers University where plant specific information as well as recommendation and implementation results are housed in a database. Anyone with a computer and a modem can download these results over the internet. Once a year an annual report is compiled by Rutgers in which the assessment results are analyzed and discussed. The field managers are in regular communication with the DOE headquarters program manager who monitors performance results and discusses immediate concerns and long-term trends with the field managers who are expected to take corrective action when necessary.

Second, The U.S. Department of Energy conducts an annual "Directors' Meeting" where a cross-pollination of best practices takes place. This once a year three-day event is an opportunity for all 30 schools, two field managers, and DOE personnel to share thoughts and perspectives on goals and objectives...and which activities were most fruitful in helping to achieve those goals and objectives. The report of the annual Directors' Meeting is a major ingredient in helping to shape new program directions during the course of the next fiscal year.

Third, each year, each of the programs within OIT undergoes a program review. During these sessions, program managers are called upon to report program accomplishments in

the year gone by, and to develop future plans. These meetings are internal OIT meetings peer reviewed by other DOE program managers. From time to time a more intensive look at each program is conducted to ensure that program goals and objectives are coordinated with OIT goals and objectives...and that program is pursuing the right activities in the most efficient manner. This more intensive investigation is called a "critical program review." The IAC program is in the process of implementing some recommendations that were the result of a year-long "critical program review". The team that conducted the review consisted of DOE and National Laboratory employees. During the course of the year, the critical review team interviewed over 100 respondents, asking for opinions, observations, suggestions, criticism, and praise. These respondents included members of industry and consumer organizations, as well as universities and state energy offices. The full spectrum of stakeholders was consulted before the critical review team issued its final report with recommendations for program definition/design improvement. The annual program review and occasional "Critical Review" referred to above help gain an even broader outside perspective on program effectiveness and efficiency.

Finally, Oak Ridge National Laboratory is conducting an on-going evaluation of the assessments and various other pathways to energy savings. Some interesting preliminary findings suggest that, in addition to the documented direct initial effects of the assessments on the plants, alumni of the program continue to have a substantial long-term impact on energy savings throughout their careers. Also, we are just beginning to understand that the reach and result of technical assistance downloaded from IAC web sites is quite substantial. More definitive results will be announced when the evaluation is completed.

Discussion of results

According to the Industrial Assessment Center Program Impact Evaluation conducted by Oak Ridge National Laboratory, "It is concluded that appreciable energy and cost savings may be attributed to the IAC Program and that the IAC Program has resulted in more active and improved energy-efficiency decision making by industrial firms." The following discussion quantifies this assertion.

The program uses a well-established database (http://oipea-www.rutgers.edu/database/db_f.html) to track savings resulting from recommendations generated during IAC site assessments. As a result of the 734 assessments conducted in 1999, over 2.5 trillion btus are saved annually. Energy dollar savings of over $9.7 million annually are augmented by $6.6 million in waste savings and over $24 million in productivity savings. Total annual savings from 1999 assessments tallied $40,684,908, or $55,429 per assessment. Since the entire IAC budget was $8.3 million, these savings equate to a 4.9 to 1 benefit/cost ratio for year one alone. These savings will continue to accrue annually for many years to come.

This discussion does not include the cost of the implementations that is born by the plants themselves. This investment by industry can be seen as the leveraging effect of the IAC

investment. Since, historically, the average payback period has been about 1 year, it can be assumed that industry spent about $40 million to achieve the $40 million in cost savings in 1999. When the lifetime benefits of 1999 implementations are compared against the sum of federal and private sector outlay we see an aggregate benefit / cost ratio of 8.1 to 1 ($397,491,551 / $48,984,908).

These numbers do not tell the whole story since there are additional benefits that are not quantified in the current database. These include energy, waste, and productivity savings through: 1) replication of implementations at other plants, 2) implementation of recommendations that occur after the initial call-back (and are therefore not captured in the database), 3) the efforts of program alumni who find jobs in industry where they can continue to use their IAC training, 4) the dissemination of technical information found at the IAC headquarters', field managers' and IAC universities' websites. These other "pathways" to energy savings magnify the direct energy savings from the assessments themselves. The initial findings of the Oak Ridge National Laboratory program evaluation suggests that alumni savings are significantly larger than direct impacts from assessments.

From 1981 through the end of 1999, 9,075 assessments were performed by over 1,550 engineering students trained by the IACs. To put the total program effect into perspective consider that a cumulative federal investment of about $80 million dollars (in nominal dollars) has engendered activity that has saved industry over $2.4 billion (in constant 1998 dollars) from 1981 through the end of 1999. {Maria – please note that these numbers must undergo some additional scrutiny}

One example of the long-term effect of IAC alumni are the substantial number of program alumni who serve in positions of influence for Energy Service Companies that are dedicated to finding and implementing long-term energy savings solutions for industry. This subset of the alumni population accounts for trillions of btus saved per year. Substantial projects undertaken by these alumni include the building of co-generation facilities for energy-intensive industrial users that promise to save enormous amounts of energy for the next 20 to 30 years.

But, the intent of the program is not to gain a one-time quick fix, but rather to facilitate a long-term change in awareness, attitude and behavior that will ensure energy savings, waste savings, and productivity gains on a permanent basis. So it is the change in the human decision-makers and advisors that is perhaps the most interesting and long-lasting effect of the IAC program. As part of the IAC program evaluation, Oak Ridge National Laboratory conducted a study that modeled industrial energy-efficiency decision-making before and after one of three IAC interventions: direct energy assessment, the employment of an alumnus of the IAC program, or use of the information from an IAC Website. In all three cases, affected firms were seen to move toward permanently institutionalizing an energy-efficiency awareness and approach in their internal corporate investment strategy.

The key elements of the IAC program's success are: 1) well-trained faculty at the participating universities; 2) mentor/protégé relationship among students; 3) small team size (8 - 10 students); 4) real world hands-on approach to teaching; 5) polite and humble attitude of students toward their industrial hosts; and 6) practical solutions with proven payback (nothing exotic) to real problems. It was surprising to find that two indirect pathways to energy savings had such significant impacts: alumni influence on future decisions, and website dissemination of best practices, are also substantial key elements of the IAC's program success.

Some schools can fall into a "cookie-cutter" approach to problem solving, recommending the same solutions, even if more pressing problems with different possible solutions also exist. Other failures of the program that are now being addressed were the lack of student input and feedback to DOE headquarters to help program managers revamp less than adequate aspects of program delivery. A student forum website has been created to encourage students to communicate among the schools in the program and with DOE headquarters directly (if desired). Also, each student is given the opportunity to respond to an annual questionnaire regarding program performance. Finally, there was a danger that each IAC could operate as an island unto itself. Greater integration of the IACs with each other and with other beneficial programs and initiatives of the Office of Industrial Technologies is being sought. A committee comprised of four center directors has been formed to investigate channels for greater interaction and integration with other OIT programs. A number of initiatives have been started to incorporate IACs with the Industries of the Future approach that is the hallmark of OIT. That means that rather than concentrating exclusively on small and medium-sized facilities, IACs are now venturing into larger plants that are common to the nine energy-intensive "Vision Industries" that comprise the "Industries of the Future" (Agriculture, Aluminum, Chemicals, Forest Products, Glass, Metalcasting, Mining, Petroleum.

United States Department of Energy's Motor challenge and BestPractices Programs

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INTRODUCTION

Beginning in 1992, US DOE Office of Industrial Technologies (OIT) sought to design a program that promoted increased energy efficiency of motor systems and was responsive to industry needs. The Motor Challenge program began as the result of an industry roundtable discussion and evolved through a series of events that presented industrial end-users and the companies that serve them with a unique opportunity to share in and help shape the program. The result is a program "designed with industry for industry" that relies extensively on existing market forces to bring program messages to the industrial end-users

The program was initiated in 1993-94 with three initial offerings: showcase demonstrations, MotorMaster software, and the Information Clearinghouse. As additional program offerings were developed and the ongoing dialogue with industry matured, a program structure emerged to deliver the program message within existing market mechanisms.

By 1996, a primary feature of the Motor Challenge program model was its reliance on partnerships with industry both to develop new program materials and to deliver this information to industrial customers. Two additional programs, Compressed Air Challenge and Steam Challenge, subsequently emerged based on elements of this program design.

By 1999, other sectors, such as process heating, had expressed interest in developing their own program initiatives. Rather than continuing to create separate new programs, OIT moved to integrate all existing and proposed program initiatives of this type under the program heading of BestPractices. Like Motor Challenge, BestPractices offers tools to improve a plant's energy efficiency, enhance its environmental performance, and increase its

productivity. The BestPractices team is comprised of all the resources, tools, and expertise that previously made up the OITs' Challenge programs - Motor Challenge, Steam Challenge, Compressed Air Challenge, and the Industrial Assessment Centers. The team applies a plant-wide systems approach in identifying opportunities to help industries increase energy efficiency, reduce waste, and boost productivity.

The BestPractices Program provides technical assistance by delivering energy-saving products, services, and technologies to the nine Industries of the Future (IOF): agriculture, aluminum, chemicals, forest products, glass, metalcasting, mining, petroleum, and steel industries. Plant-wide assessments, Showcase Demonstrations, technical assistance, and workshops all occur within the United States. Self-help tools and information are downloaded internationally from the program's website at http://www.oit.doe.gov/bestpractices/.

This case study will focus primarily on the experience with the Motor Challenge Program because it is the most mature and has been the subject of a formal evaluation.

PROGRAM OBJECTIVES & BARRIERS

The policy objective of the BestPractices program is to facilitate a transformation in the way the nine IOF energy-intensive manufacturing industries consider and manage their power demand from motors, steam, compressed air, and process heat systems plant wide. Through BestPractices, OIT aims to provide industry with better near-term and long-term technological solutions to improve energy efficiency, enhance environmental performance, and improve productivity for their total manufacturing plant operations. BestPractices takes an integrated systems approach to analyzing ways in which energy needs can be minimized.

Existing industrial equipment and services markets (both supply and demand) traditionally focus on components rather than systems. This piecemeal approach to industrial motor-driven and steam systems in the US typically results in less than optimal system operation, reliability, and efficiency. Motor Challenge, and now BestPractices, pursues an objective to develop best practice information and tools in cooperation with industry associations and energy efficiency organizations. These information and tools are then distributed either directly by the Programs, or through Allied Partners (vendors, utility companies, and others) to end users of motor systems to promote a systems approach in the way these systems are managed, maintained, upgraded and improved. The program goal has been and continues to be improving awareness of the benefits of a systems approach in US industry.

The main barrier to the program has been the industry's failure to focus on energy efficiency, since energy is relatively cheap. Furthermore, manufacturers are reluctant to tamper with tried and true production systems to pursue what they believe to be small percentages of energy savings. Management has tended to emphasize production quotas as opposed to efficiency gains. This program seeks to underscore the positive effect on the bottom line from addressing energy inefficiency in a systematic way. Through printed materials, software decision-making tools, training, Showcase Demonstrations, case studies, and third-party

independent performance validations, BestPractices removes the perceived financial and technical risk of undertaking major energy savings projects. From the start, the program faced the challenge of changing ingrained business and engineering practices among end-users and vendors without the use grants, rebates or other direct financial incentives.

PROGRAM DESIGN AND STRUCTURE

The BestPractices program has used an approach that can be described as "*developed by industry for industry.*" The overall program design evolved over several years with substantial input from the industrial community. Throughout the development of the BestPractices program, program managers have been guided by the following technical and program design principles:

- Promote a "systems" approach
  Industrial engineers have long known that careful matching of the elements of a plant system (in the case of motor systems – motors, controls, couplings, and process machinery) to the work to be performed yields far more savings than upgrading just the individual components. The Motor System Market Assessment found that over 71 percent of total potential savings came from systems-level measures such as improving the configuration and control schemes in pump, fan, and compressor systems. The practical procedures and the benefits of the system approach are stressed in program tools, publications, and case studies.

- Harness the business motivations of end-users, manufacturers, and vendors in disseminating technical information and promoting energy efficiency

  The BestPractices program has and continues to emphasize not only the energy savings associated with improved system efficiency, but other benefits of efficiency improvements such as increased control over production processes, reduced waste, and an improved production environment for workers. BestPractices also works with manufacturers and vendors to identify and exploit competitive advantages associated with promoting efficient systems and the benefits of life cycle costing. A recent evaluation of the Motor Challenge program found that 67% of all savings resulting from program activities during the period from program inception through 1998 could be attributed to the actions of Allied Partners- equipment vendors, utilities, equipment manufacturers, state governments and others who partnered with Motor Challenge to deliver the systems message to their industrial customers. This is particularly remarkable given that the Allied Partner activity was only launched in 1996.

MAIN ACTORS AND THEIR ROLES

The US DOE, OIT employees have formed the administrative backbone of the program, with technical support being provided by the Lawrence Berkeley National Laboratory, Oak Ridge National Laboratory, and the National Renewable Energy Laboratory. In addition, Washington State University provided technical support in development of software tools and staffing of the information clearinghouse.

As referenced above, the Motor Challenge program began developing partnerships with key industrial trade associations shortly after the program was launched. Partnerships were developed with the American Water Works Association, Compressed Air & Gas Institute,

Electrical Apparatus Service Association, Hydraulic Institute, Technical Association of the Pulp & Paper Industries (TAPPI), Consortium for Energy Efficiency, and several regional utility groups. These partnerships enabled the program to develop a very broad reach to industry with a modest level of support from USDOE.

The Motor Challenge program also established the Allied Partner initiative that includes over 225 companies and organizations nationwide. The Allied Partners cooperate with the program in promoting energy efficient motor systems through distribution of information materials, technical tools, and sponsoring technical training and workshop events. Allied Partners are companies and organizations that provide products and services to industry through the course of regular business contacts. Allied Partners are not paid to use program offerings or to promote more energy efficient motor-driven systems; they choose to participate based solely on sound business reasons.

POLICY MECHANISMS USED

The policy mechanisms used successfully by Motor Challenge to implement the program fall into two main categories: 1) information and decision-making tool development and dissemination, and 2) development of strategic partnership networks with industrial trade associations and industrial supplier companies.

n **Information and Decision-Making Tools**

Motor Challenge developed and offer a wide variety of information materials including decision-making software, training programs, case studies, showcase demonstrations, plant assessments, technical tips and fact sheets, and information services.

Decision-Making Software

1. *MotorMaster+ Motor Selection and Management Software.* MotorMaster+ contains a database of efficiency, price, and other catalog information for more than 25,000 three phase, integral horsepower electric motors produced by major manufacturers. Using this database, the algorithms contained in the program, and information on motors currently in use, vendors and end-users can identify specific models which will provide the most cost-effective replacement for failed motors. The program can also be used to analyze the benefits of replacing versus repairing a failed motor. Other modules support motor inventory management. To date, over 23,000 copies of MotorMaster+ have been distributed to end-users and vendors.
2. *Pump System Assessment Tool - PSAT*. PSAT estimates pump system efficiency based on a limited number of on-site measurements. It can be used to assess the overall efficiency of a pump system relative to its optimal

performance. It can be used to determine if further engineering analysis is justified to improve the pump itself and its system components and controls.

3. *ASDMaster*. ASDMaster is a software program that assesses the feasibility and cost-effectiveness of adding Adjustable Speed Drive controls to a motor system. This product was developed under the auspices of the Electric Power Research Institute (EPRI). Motor Challenge licensed this software from EPRI and sponsors training in its use and distributes the software to trainees.
4. *AirMaster*. AirMaster provides an assessment of a compressed air system. Its primary purpose is to estimate compressed air system energy use and load profile based on a guided set of on-site observations and measurements.

Training Programs

Motor Challenge technical training sessions cover a wide range of plant system topics including: use of MotorMaster+ and motor selection; basic pump system efficiency topics and use of PSAT software; basic Adjustable Speed Drive operations and use of ASDMaster.

4,536 individuals representing an estimated 2,923 establishments have registered for these courses. Additionally, an estimated 2,500 to 5,000 individuals have received training through participating Allied Partners (suppliers and others) but have not registered with the Program.

Showcase Demonstration Case Studies

Showcase Demonstration Case Studies develop information on the field performance of energy efficient motor systems and design practices. In exchange for technical assistance from the Program's technical experts, customers arrange for monitoring and verification of energy savings associated with various system efficiency measures. Motor Challenge used the documentation of the Showcases to develop case studies which facility managers could use to assess the applicability of similar measures to their own facilities. To date, 16 technical case studies have been developed.

Technical Tip Sheets, Fact Sheets, Sourcebooks

Motor Challenge offers a wide range of technical information on motor system topics that identify industry best practices and key performance improvement opportunities.

Information Services

The Motor Challenge program Information Clearinghouse provided answers to technical questions over the phone, and compiles and disseminates technical information on a wide variety of topics. The program also developed and maintained a frequently visited internet web site and a bi-monthly newsletter (Energy Matters) distributed to over 25,000 individuals, and through an Allied Partner network (see below).

- **Strategic Partnerships with Trade Associations and Industrial Supply Companies**

As discussed earlier, Motor Challenge program pursued two approaches to deliver its message and its services. Each has its advantages and disadvantages, but it is clear that strategic partnership with industrial trade associations and industrial suppliers provided a significantly larger impact with less program resources than the direct contact approach.

Motor Challenge developed partnerships with trade associations representing important groups of end-users, manufacturers, and vendors in the industrial markets. The basic partnership approach has been to harness OIT's technical resources to address plant-related technical issues and opportunities that affect a broad range of the associations' members. These industry partnerships have also served as the main vehicle to develop new types of information, tools and training offerings. Examples of these partnerships include the following:

1. *The Compressed Air Challenge.* A focus on compressed air systems started with an industry partnership between Motor Challenge and the Compressed Air & Gas Institute (CAGI), a trade organization of 45 manufacturers of compressed air system equipment. The Compressed Air Challenge (CAC) developed from a dialogue with CAGI and 13 other organizations nationwide. The collaboration includes CAGI, DOE, equipment manufacturers and distributors, government agencies, non-government organizations, and utilities. In all the CAC counts 15 separate organizations as sponsoring members, all of which contribute both funding and time to the collaborative efforts. The CAC's first program initiative was to develop an introductory training program on compressed air system efficiency.

2. *Pump System Initiative*. The Hydraulic Institute (HI), a trade organization of approximately 70 pump manufacturers, has marketed a video training program entitled "Energy Reduction in Pumps and Pumping Systems" with student and instructor workbooks. HI has formed a "Life Cycle Costing" committee with DOE's facilitation assistance that will be developing products to assist end users address life cycle cost factors in managing and maintaining their pump systems.

3. *Pulp and Paper Industry Initiative.* TAPPI became an Allied Partner and distributed over 400 copies of MotorMaster+ to pulp and paper mills across the country. TAPPI has 33,000 members and provides Motor Challenge tools and information to them mostly free of charge.

4. *Electrical Apparatus Service Association (EASA) Initiative*. EASA became an Allied Partner and it has worked with the program to develop technical information materials that benefit its member service organizations and for the motor system end user. It also distributes the Energy Matters newsletter and other program materials to their members under the organization's auspices.

The Motor Challenge Allied Partnership also grew out of a need to more effectively reach industrial customers on a limited program budget. The Allied Partnership approach has since become a key delivery mechanism of Motor Challenge tools and services to the different actors in the targeted markets. It combines the concepts of "one to many" and "many to many" for maximizing the outreach with the limited resources available to the program. The purpose of Allied Partnership activities can be captured as follows:

- Create a broad network of program support;
- Highly leverage development and deployment activities;

- Provide opportunities for market players to work with each other in a neutral setting; and
- Create opportunities to spotlight other OIT-sponsored programs and technologies.

Motor Challenge has recruited a number of Allied Partner organizations (private, public, not-for-profit) to help disseminate its materials and services to end-users. Among vendors, Allied Partners are primarily manufacturers, equipment distributors, service providers, and industrial consultants who perceive a value in providing their own customers with information on how to increase the energy efficiency of their manufacturing facilities.

State government agencies and utilities with an interest in industrial energy efficiency also became Allied Partners. These organizations use the technical resources available from Motor Challenge to help structure their own programs to promote energy efficiency of industrial systems. They also distribute tools and information to vendors and end users that participate in state and local utility programs.

MONITORING AND EVALUATION PROCESS

The US DOE contracted Xenergy Inc. to independently conduct an evaluation of the Motor Challenge Program. The primary objective of the evaluation was to estimate the energy savings that can be attributed to the Motor Challenge activities. In the course of gathering and analyzing the data needed to estimate energy savings, Xenergy also compiled information on the program's effects on the markets for industrial motor systems and on participants' response to the various program offerings. Some energy savings estimates and selected findings on market impacts are presented below.

The evaluation research and analysis activities were designed to answer three basic questions:

- How many industrial facilities and vendors used Motor Challenge materials and tools to make changes in motor system purchase, management, and design practices?
- What portion of reported changes in motor system practices were attributable to Motor Challenge?
- How much energy did those changes save?

It is important to note that estimated savings associated with Motor Challenge participants upgrading the efficiency of replacement motors are incremental to savings realized as a result of the promulgation of regulations to implement new efficiency standards for some integral horsepower polyphase motors contained in the Energy Policy Act (EPAct) of 1992. In October 1997, federal regulations went into effect which required all general purpose integral horsepower motors up to 200 horsepower sold in the United States to meet efficiency standards developed by the National Electrical Manufacturers Association. In this evaluation, the program is only credited with savings associated with the purchase of new premium efficiency motors (higher efficiency than the EPAct standards), where the upgrade from EPAct standards can be attributed to the program. Also, the evaluation credits the Motor Challenge program influence on end users to replace a higher percentage of failed standard

motors rather than repairing them relative to what the users would have done in the absence of the program.

The primary objective of the evaluation was to estimate energy savings attributed to the Program. Therefore, it was decided to focus evaluation resources on program components that met the following criteria:

- Established energy program evaluation methods could be used to quantify energy savings; and,
- Established methods could be used to demonstrate a plausible link between program activities and actions taken by end users to save energy.

DISCUSSION OF RESULTS

The independent evaluation conducted in 1999 found that the Motor Challenge is responsible for US$24.9 million in annual energy savings, is highly cost-effective, and has just begun to reach US industrial end users. The evaluation attributed approximately 67% of program savings to the Allied Partnerships and 33% to direct program efforts. Training produced the greatest benefit, followed by use of MotorMaster+ software.

Given below are some of the results of the evaluation:

- The energy savings attributable to the program totaled 498 GWh per year. Table 1 shows the distribution of these energy savings attributable to different program components. The monetary value of these savings is estimated at $24.5million as of end of FY1998.

Table 1
Summary of Energy Savings
Attributable to the Motor Challenge Program (as of end of FY1998)

Component	**Net Program Energy Savings (MWh/year)**	**Net Program Energy Savings ($/year)**
End-Users		
MM+	246,112	11,813,362
Showcase Demos.	22,861	1,630,073
Training Attendees		
ASD Training	24,758	1,188,375
Pump Training	30,199	1,445,695
Allied Partners		
Vendor & Consultants	80,597	3,868,639
Utilities & Government	59,674	2,864,323
Subtotal	*464,121*	*22,810,467*
Other		
Energy Matters (newsletter)	27,284	1,309,620
Teleconference	6,857	329,143
Total	***498,262***	***24,449,230***

- On average, the registered MotorMaster+ users are large industrial facilities. Xenergy estimated that they use roughly 20 times as much motor system energy as the average manufacturing plant. Altogether, MotorMaster+ users consumed 155,000 GWh/year in electricity versus 1.1 million GWh/year for industrial users as a whole. Thus, even though registered MotorMaster+ users represent less than one percent of all industrial facilities, they account for 14 percent of total industrial electricity use and a comparable portion of motor system energy.

- Between 5,600 and 9,500 end-user facilities received information materials, tools, and training directly from the program. 3,510 of the facilities are registered MotorMaster+ users. An additional 10,000 end-users received Motor Challenge tools and materials from vendor and utility Allied Partners. It is not clear how much these end-users overlap with those that received materials directly from the program.

- Among registered MotorMaster+ users, between 10 and 15 percent undertook changes to motor system design, purchase, and maintenance practices that they said would not have been made in the absence of the program. These changes included upgrading efficiency of replacement motors; opting to replace rather than repair failed motors; improvements in motor system maintenance practices; and installation of ASDs.

- At least 3,000 motor system vendors and consultants received information, tools, and training from the program.

- Among a group of the 104 vendors and consultants participating in the program as Allied Partners, about half reported that they had used Motor Challenge materials to influence customers to purchase energy efficient motor equipment and to make changes in their practices regarding motor system design, specification.

- 96 electric utilities, industry associations, and government agencies used MC materials and tools to structure or enhance their own programs to increase motor system efficiency for their customers and constituents. Over 10,000 customers were reached through these programs.

Some other evaluation results in context include:

- *Over the life of the program, Motor Challenge has established communication channels with technical and management decision-makers that represent a large portion of US motor system consumption.*

  At a minimum, Motor Challenge has identified technical and management personnel (registered MotorMaster+ users) in 3,510 facilities that account for 14 percent of total industrial motor system energy use, or roughly 95,000 GWh per year. In addition to these end-users, the program has identified potential decision-makers in 2,000 to 4,000 facilities through its Information Clearinghouse, and training activities. The customer identification records that support these operations are a key resource in advancing the mission of the program.

The results can also be understood in the context of the market for motors.

- MotorMaster+ users attributed the purchase of 10,170 premium efficient motors to the influence of the program (instead of purchasing EPACT qualifying motors). This is roughly 6 percent of the number of units of all premium efficient motors sold in 1998 to the industrial sector.

- MotorMaster+ users reported that they replaced 20,500 failed motors, instead of repairing them. Those 20,500 motors were almost entirely in the 5 horsepower and over range, and have a retail value of about $38 million. They account for over 4 percent of the number and dollar sales, respectively, of all polyphase induction motor sold in those horsepower categories in 1998. Based on the results of the end-user survey, Xenergy concludes that facilities that use Motor Challenge tools have used them extensively to guide decisions regarding replacement versus repair of failed motors.

To summarize, Motor Challenge has barely scratched the surface in terms of helping end-users realize system-level energy savings. Between MotorMaster+ users, training session attendees, and users of various information services, Motor Challenge can account for about 6,000 to 8,000 end-use facilities. As mentioned above, MotorMaster+ users are very large facilities in terms of motor energy usage. For purposes of this analysis, it was assumed that Motor Challenge participants who are *not* MotorMaster+ users are significantly smaller, that is, closer in size to the average industrial facility. Using this assumption, it was estimated that all end-users that have participated in Motor Challenge use between 110,000 and 150,000 GWh per year in motor system energy. Applying the *Market Assessment* finding that system-level improvements can reduce motor system energy use by 10.5 percent, potential savings from system related measures for these firms' ranges from 11,000 to 16,000 GWh per year. Xenergy's best estimate suggests that end-users represented in the various evaluation surveys undertook projects that yielded a maximum of 550 GWh per year in savings. This is no more than 5 percent of the potential savings.

Motor Challenge changed and adapted over the years. Some of the problems or weaknesses that led to the modifications are mentioned below. These were endemic to the "Challenge" programs that preceded the BestPractices Program:

- Initial attempts to sign up Partners were met with some resistance. Reporting data on energy consumption and production was seen as one possible explanation.
- There was more demand for inclusion in the Allied Partner program than DOE resources allocated could support. Therefore, an effort to broaden the reach of the Allied Partner program by signing hundreds of new companies and organizations was curtailed. The Allied Partnership remains open to any interested domestic company or organization. However, current program strategies now favor strategic Allied Partnerships with key national and regional trade associations, national equipment manufacturers and distributors, industrial consulting firms, utilities with large industrial loads, along with state agencies and non-government organizations who work directly with industry.
- Separate "Challenge" programs were set up to specialize in different technology areas. This was not the most efficient way to work with or deliver a broad range of information and assistance to industry. As a result, OIT initiated BestPractices, which integrates all of the previous "Challenge" programs.

<u>BestPractices Program</u>

The BestPractices program is building on the successes and lessons learned from Motor Challenge and the other Challenge programs, while expanding new efforts into the area of emerging technologies. BestPractices is integrating the delivery of energy-saving products, services, and technologies to the nine OIT, Industries of the Future: agriculture, aluminum, chemicals, forest products, glass, metalcasting, mining, petroleum, and steel industries. In

coordination with the industry-specific and industry-wide programs of OIT, BestPractices continues to provide technical assistance to help these industries increase energy efficiency, reduce waste, and boost productivity. The BestPractices team includes representatives of the IOF partnerships, Industrial Assessment Centers (IACs), and OIT's former Challenge programs for motors, steam, and compressed air. The team promotes a plant-wide systems approach in identifying immediate cost-saving opportunities, productivity improvements, and opportunities for application of emerging technologies.

BestPractice offers the same types of information and services as were offered through the Challenge programs such as information materials and services on industrial equipment and systems, decision-making tools, technical training, and other resources. In addition, BestPractices now offers assistance for assessing plant operations, including:

- Free, one-day assessments of small- to mid-sized plants by university-based OIT Industrial Assessment Centers
- Cost shared plant-wide assessments to help IOF manufacturing plants develop a comprehensive strategy to increase efficiency, reduce emissions, and boost productivity. Up to $100,000 in matching funds are available to IOF plants through a competitive solicitation process.

Advanced technologies developed with OIT support are regularly emerging from research and development and are ready for demonstration and use. BestPractices offers expanded support to help deliver these solutions to industry through showcase demonstrations and technology implementation.

- Showcase Demonstrations held at manufacturing sites; provide the public opportunities to understand the benefits of emerging technologies by seeing them applied in real-use conditions. The effort includes an independent third party to validate technology performance and costs in comparison to baseline practice; each technology with validated performance benefits will receive an OIT Certificate of Recognition.

- To validate performance and reduce the perceived risks associated with emerging technologies, BestPractices offers cost-sharing support to facilitate technology adoption. OIT Technologies eligible for implementation assistance must have completed the full-scale demonstration phase.

<u>References:</u>

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Energy + - a pan-European procurement project for refrigerator-freezers

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Introduction

The pilot project named *energy* + ran from January 1999 until June 2001 and sought to facilitate an increased market penetration of energy efficient refrigerator-freezers on the European market by making the best existing units (by the time of the project's start) available from more manufacturers throughout the Union, and by making these models the choice of more customers. The project *also* intended to contribute to earlier commercialisation of units that are even *more energy efficient* than the best existing ones through a technology competition.

Ten European countries participated in the project (Austria, Finland, France, Germany, Italy, the Netherlands, Norway, Portugal Sweden, and the U.K), which used a method often referred to as procurement. It is simple in principle: The project group gathered strong, influential purchasers from the whole Union and, together with them, drew up specifications for a refrigerator-freezer with good energy and environmental qualities that is also user friendly. These specifications were then presented to manufacturers to show them that there is a market for these highly efficient products and to point out what features the buyers are looking for. By doing so the project intended to spur manufacturers to develop or make such units available on a larger scale.

The first pan-European procurement project

Before the start of the project, processes of this kind had only to a limited extent been used in the European Union and in other international co-operations. Those initiatives had shown that such aggregation of buyers is possible and also effective within one country, or among a limited number of countries. The Energy + project is interesting to study since it extended the concept by embracing the whole European Union and Norway. By working on a pan-European scale a strong market pull could be created which enabled a market transformation where a buyer group from one country alone would not have been strong enough. However, extending the concept also meant new challenges since the countries in Europe are rather different not only in terms of climate and culture (with different product preferences and

usage patterns as the consequence), but also in terms of market structures and political aspects, making the process complex.

Objectives of the program

The project was preceded by a one-year study[34] investigating the possibilities and the potential for procurement activities at European level. The study concluded that the instrument is feasible as well as promising for common European actions. One of the main barriers at European level was identified as the lack of experience and therefore confidence in the process as such. To gain such experience was one of the main objectives of the project. Refrigerator-freezers were found to meet the criteria necessary for such an activity as they are fairly standardised products sold on a highly international market. Being the most common cold appliance sold in Europe, with approx. 45% of total annual cold appliance sales of 18-19 million units, they also represent a significant energy saving potential. Further, production of such highly efficient units was not considered to imply any major technical problem for manufacturers. The main barrier to the large diffusion of already existing efficient units seemed to be the high sales price, which appeared to be the result more of branding and marketing policies than expensive technical components.

The action was timed in line with the political agenda at European level: It was built upon the well established energy labelling system and plays an important role to help identify efficient cold products during the period between the introduction of the minimum energy performance standards (September 1999) and the up-coming revision of the energy label thresholds. When the European Union introduced its labelling scheme for refrigerator-freezers only a few appliances qualified for the most stringent level "A". A quick evolution of the energy efficiency of products available on the market has, however, made it necessary to revise the criteria (the levels and principles for which has been proposed by the *Cold II* study presented in Spring 2001). Since it will take a few years for the new requirements to come into force, the e*nergy+* project has had and continues to have an important role in giving visibility to the most efficient products available and helping the manufacturers and buyers distinguish them from the "normal" A-rated units.

The project further constitutes a good means for the European countries to work together towards the common green house gas (GHG) reduction commitments under the Kyoto Protocol35, as domestic refrigerators and freezers are responsible for and 6% of Europe's final electricity use meaning about 2% of Europe's GHG emissions related to human activities.

Process of definition/design of the program

The project was based on a previous one-year study carried out under the SAVE programme (see earlier reference). Nine countries participated in the study under which national teams

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[34] "Procurement for Market Transformation for Energy-Efficient Products – a study under the SAVE programme", 1998, Swedish National Energy Administration (STEM) report ER 15:1998

[35] "Kyoto Protocol to the United Nations Frame work Convention on Climate Change", 1997 FCCC/CP/L.7/Add.1

carried out a total of 36 market studies regarding four different products: electric motors, solar-energy systems for water heating, office lighting systems, and refrigerator-freezers. These market studies included interviews and discussions with a wide range of market actors and policy makers. Refrigerator-freezers were found to be the best candidate for a pilot action.

Once the broad product category – refrigerator-freezers – had been decided upon, the pilot project undertook a more detailed feasibility study on this specific market. This study set out to investigate a number of questions, such as market relevance, market structure, supply chain patterns (e.g., the paths from supplier to end-user), how retailers market their products, pricing structures, the distribution of products on the market according to the European energy label classification in various countries, and the technical scope for improvements. All relevant market actors including retailers, manufacturers, trade unions, consumer associations, policy makers and research institutes were consulted. During the whole project a close contact has been kept with these actors who have been actively involved at all stages.

Main actors

Buyers and supporters

The term "buyer group" has been defined in a broad sense, since the role of the *energy+* buyer group was different from similar groups used in more traditional procurement projects. This was mainly due to the important role of retailers in a European context. Thus, the "buyer group" included retailers, institutional buyers (such as housing companies and holiday resorts), and supporters (such as national and regional energy agencies, and environmental NGOs who in their daily work inform about and push for energy efficient products). These actors were important collaborators when defining the technical and functional specifications presented to manufacturers.

All of the buyers and supporters have signed a declaration where they state their intent to buy and/or promote e*nergy+* appliances. The declaration is non-binding, but it nevertheless represents an effort on behalf of the signatory to penetrate and acknowledge the technical requirements, and an important moral commitment to the process.

Manufacturers

Manufacturers were invited to present products that would qualify to enter the *energy+* lists by meeting a set of strict but simple technical and functional specifications defined by the buyers and supporters in co-operation with the project management. The specifications did not prescribe any technical solution: manufacturers were free to present any solution as long as its performance and functions met the specifications.

Consumer associations and recognised testing institutes

These actors where involved to test the performance of the appliances presented by the manufacturers.

Policy mechanisms used

The policy mechanism used, often referred to as procurement, is simple in principle: The project group gathered strong, influential purchasers from the whole Union and, together with them, drew up specifications for a refrigerator-freezer with good energy and environmental qualities. These specifications were then presented to manufacturers to show them that there is a market for these highly efficient products and to point out what features the buyers are looking for. By doing so the project intended to spur manufacturers to develop or make such units available on a larger scale.

Energy+ contained the following five main phases of work:

Phase 1 Feasibility study (more detailed studies focusing on refrigerator-freezers and their market specifics).

Phase 2 Definition of process (i.e. letter of intent, *energy+* lists, updates), aggregation of buyers, development of mandatory specifications and optional requirements.

Phase 3 Results and follow up of Round 1, Publication of Round 2 specifications, publication of requirements for the *energy+* award competition.

Phase 4 Tender/development period, aggregation of additional buyers and supporters for Round 2.

Phase 5 Evaluation and selection of *European energy+ Award* winners, additional marketing, testing and follow up of the project.

Dissemination activities were part of all the five phases above.

It is not possible to draw clear cuts between these steps or phases of the *energy+* project, or of any procurement activity. The whole process requires a great deal of flexibility and openness to adjust to new inputs and experiences during the course of the project. For instance, the feasibility study was not only an activity that served to verify a given, planned procedure; it also played a role in starting to build up important relations with market actors who would eventually come to participate in the project's buyer group. During the feasibility study, important experience was achieved and used as input when the technical requirements for the products were developed. Thus, the feasibility study itself also served as an initial step of the market transformation activity for the project.

Similarly to the feasibility study, it is also difficult to draw clear division lines between the phases of building up a buyer group and developing the technical requirements. The buyer group's views on the requirements were actively solicited, and the requirements were amended several times based on input from buyers, technical experts and the project team's views before they were finalised.

A project was carried out in two rounds.

For the first round, a list of units that met the *energy+* mandatory specifications and that were available on the market by December 2000 was compiled and published. This first round list was updated once in September 2000 to include new entrants.

The second round was dedicated to *energy+* appliances available in 2001 when new lists of units were compiled and promoted. The publication of the second round lists was also co-ordinated with the announcement of the winners of the *energy+* award competition

The European energy+ Award competition

As an additional incentive for innovation and increased energy efficiency, the *European energy+ Award* competition was launched in February 2000 when the results of the first round were presented. The competition was based on the mandatory specifications, together with optional requirements of importance to the buyers. The mandatory specifications and the optional requirements together may best be described as set of specifications aimed at guiding the manufacturers in the development of products. These optional requirements include even better energy efficiency (than the mandatory specifications), refrigerants and foaming agents with low environmental impact, low noise, clear (external) temperature displays, reasonable price, and user friendliness. A formula based on the relative importance of the various optional requirements was developed to guide manufacturers in developing their submissions, and to help evaluate the entries. (Mandatory specifications as well as optional requirements are available from the project's web site, www.energy-plus.org.)

The competition was open to units in three separate classes: one-door models, two-door models and prototypes. The winning products were presented at a public award ceremony at Domotechnica trade fair in Cologne, Germany, in March 2001.

Cost and funding

The total budget of the project amounted to approx. one million Euro of which the SAVE programme's share was 35%. The rest came from the participating organisations, often national agencies or research institutes and universities in co-operation with such. Considering the impact of the project and the fact that it involved ten countries during 2,5 years the project does not appear expensive.

As for the direct *project-related* costs and impacts it should be noted that part of the costs are to be seen as investments that will lower the costs of continued *energy+* project(s) (costs for logo, web site and network build-up are to a large extent investments).

Monitoring and evaluation process

In what respects the technical results of the project an independent jury composed of internationally recognised experts in the fields of energy efficiency, technological aspects and consumer issues evaluated and selected the winner of the award competition. To verify the information in the testing protocols sent in by manufacturers, random testing of the appliances in all classes was performed at the internationally recognised TNO testing laboratory in The Netherlands using standardised testing methods.

An evaluation of the actual project and its impacts is included in the project programme. In the beginning of the project information was gathered on a number of key factors like market availability of efficient units, price, sales data and also an evaluation of attitudes and awareness. Some of these key factors were evaluated once again after the finalisation of the

project, and some of them are still to be evaluated. It is for example far too early to observe real market impacts as the project just came to its end. The already tight budget does not admit any third party evaluation, that would have been desirable.

Discussion of results

The contents of the lists or qualifying units and participating demand side actors far exceed the project team's expectations by the time of the project start. Approximately 100 organisations joined as institutional buyers, retailers or supporters. These organisations together represent more than 15.000 retail outlets and manage a total of more than one million dwellings. By the time of the last update of the lists (April 2001) four manufacturers had submitted 16 qualifying products to be included in the lists. Two of these products were *European energy+ Award* winners. These units are the most energy efficient on the European market today and have values believed to come close to, if not conform with, the most stringent minimum level for class A under the revised European cold appliance energy label. One can thus draw the conclusion the project has contributed to an earlier introduction of highly efficient units on the European market.

The project has contributed to rise the awareness of energy efficient refrigerators among actors within each country, and it established a contact network that did not exist before the project implementation and that can be used in future projects.

In the light of the successes in terms of listed energy+ products, manufacturers enthusiasm and overall positive feedback from retailers, it is sometimes easy to forget that an important aim of the project was to test the methodology. Does co-operative procurement on a pan-European basis work? The results were not the results of a traditional policy instrument simply scaled up to a European level. They were the results of a new approach to market transformation never tried before on a pan-European level. The methodology was tried and found to function.

Key factors of success

The strong demand side with retailers, institutional buyers and numerous supporters φρομ αλλ οϖερ Ευροπε ωασ α κεψ φαχτορ φορ συχχεσσ. Τηε χονχεντρατιον ον μαρκετινγ issues and recognition for the participants by the creation of a graphical profile, a logotype, a promotion CD-rom for the participants, a web-site and the production of promotion material is believed to have played a major role for the actor's interest to participate.

Main sources of problems

The main problem was the difficulty to match the administrative rigidity of the energy agencies and public bodies involved in the project with the flexibility demanded in different phases of a procurement program. Another problem, that was to some extent overcome, was the fact that the biggest buyers were not end-users but retailers who have an interest in high range products with a high mark-up, something that hampers diffusion and therefore is in contradiction with the aim of the project.

Another important problem is related to the difficulties and limitations to work with limited funding which is insecure in the long-term. To provide continuity and security for the market actors a long-term budget must be secured if this kind of actions are to continue.

More information about the project and its results is available on the project website www.energy-plus.org**.**

The IEA-SOLARPACES START Missions a deployment policy case-study

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Introduction to the START Mission Instrument of IEA SolarPACES

Since 1977, IEA/SolarPACES has pursued a focused program of research and development in the field of concentrating solar power and chemical energy systems. Systematic development of three concentrating solar power (CSP) technologies—troughs, towers, and dishes—has led to the ever-increasing ability of these technologies to concentrate and harness solar energy for electricity production and other uses with efficiency, reliability, and cost effectiveness. Our vision within the IEA/SolarPACES community is that by 2010, CSP technologies will be making a significant contribution to the delivery of clean, sustainable energy services in the world's sunbelt.

The goal of the SolarPACES START Missions (Solar Thermal Analysis, Review and Training) is to help nations and their power sector to develop a rational approach to the deployment of solar thermal electric systems and to improve the competitiveness of solar thermal technologies. The objectives shall be achieved by supporting the market development and expand the awareness of the potential of solar thermal to address the energy and environmental problems that the world faces. Each Mission means the concentrated joint effort of an international team of SolarPACES experts and representatives from their respective country, and may include analyses of appropriate solar thermal power technologies, review of specific sites for solar thermal power projects, review of the terms of reference for detailed feasibility studies, development of a concept of financial engineering based on the applicable law, identification of potential funding sources and options for specific projects, comparison of power generation costs in the country.

The first step in realizing grand market-introduction plans is to develop initial project opportunities. SolarPACES is helping identify the most promising projects by sending experts to selected sunbelt countries. To date, START teams and other SolarPACES experts have been instrumental in launching and/or supporting project feasibility studies for India [6d], Egypt, Spain [9a,9b], Crete [9c], Morocco, South Africa, Mexico, Australia [6a,6e], and Brazil. IPP-type projects employing solar trough and tower technology are in an advanced stage of development in at least 6 countries.

How the START Mission has become a uniquely successful tool of deployment policy will be shown here on the example of the first START Mission to Egypt, which has culminated now in the implementation of the 130MW Hybrid Fossil Solar Thermal (HFST) Power plant project at Kuraymat with private participation and a 50Mio USD support grant of the Global Environmental Facility (GEF)

Objectives of the IEA SolarPACES program

Our vision within the IEA/SolarPACES community is that by 2010, solar thermal power technologies will make a significant contribution to the delivery of clean, sustainable energy services in the world's sun-belt.

Recognizing both the environmental and climatic hazards we face in the coming years and the continued depletion of the world's most valuable fossil energy resources, high temperature solar thermal technologies can provide crucial solutions to energy problems within a short time-frame.

Electric power production from solar thermal plants is nearing cost-effectiveness and will be among the early opportunities for the technology to enter the market place. We expect that success in entering this market will reduce costs and help pave the way for more advanced solar thermal technologies and processes capable of producing gaseous and liquid fuels and chemicals to penetrate a much broader range of markets, including the transportation and chemical sectors of the world economy.

The following three objectives to help us achieve those objectives, are planned to expand our IEA/SolarPACES role from one which has been focused largely on technology development to one addressing the full range of activities necessary to overcome barriers to large-scale adoption of solar thermal technology.

1. Support TECHNOLOGY development by leveraging national resources for research and development through international cooperation.These core SolarPACES activities remain of utmost importance to improving the competitiveness of solar thermal technologies.
2. Support MARKET development to reduce financial, political, market and institutional hurdles to commercialization of solar thermal technology.
3. Expand AWARENESS of the potential of solar thermal technologies (including long term fuel supply and the potential for solar chemistry) to address the energy and environmental problems that the world faces.

In addition to the technical hurdles we have focused on for the past two decades, we are facing numerous non-technology-related barriers to solar thermal's achieving wide spread contributions to sustainable energy and a cleaner environment. To achieve our vision we must overcome obstacles and threats, and we must meet a number of critical challenges.

Obstacles and threats:

- Energy market deregulation and low energy prices, including a market-push toward use of the least-cost power option, while ignoring the cost of external environmental impacts of competing technologies.
- Uncertainty about cost, performance, and reliability.
- Perceived risks of high capital-cost projects.
- Intellectual property protection issues.
- Funding decreases in national solar thermal R&D programs.

Challenges:

- Establishing appropriate market entry incentives, including equitable taxation relative to conventional energy products, carbon taxes or renewable energy tax credits
- Removing legislative and regulatory barriers to the supply of CSP to the grid.

- Increasing support for the development of effective tools for assessing the true value of renewable technologies including externalities.
- Improving the attractiveness of investment opportunities in CSP technologies

Process of Definition/Design of the START Mission Instrument

In October, 1995, the concept of the START Mission was developed. The goal of these Missions is to help nations in the above mentioned regions develop a rational approach to the deployment of solar thermal electric systems within their country.

Each Mission means the concentrated joint effort of an international team of SolarPACES experts and representatives of the respective country, and may include

- analysis of appropriate solar thermal power technologies
- review of specific sites for solar thermal power projects
- review of the terms of reference for detailed feasibility and implementation studies
- development of a concept of financial engineering based on the applicable law
- identification of potential funding sources and options for specific projects
- comparison of power generation costs in the country.

The START missions have proven to be instrumental in linking the various national solar thermal R&D policies of the fourteen SolarPACES member states represented by the SolarPACES Executive Committee with the needs of the host countries, the capacity of the involved industry and the financial support schemes of multilateral development agencies.

The Roles of the START Mission Team and its Host

The main actors of the START missions and their roles are discribed in detail in the START Mission Procedures endorsed by the SolarPACES Executive Committee and included in the Annex A to this case study. A summary is given here:

Organization's from a country's energy and electricity sector, interested in the development of solar thermal projects may formulate a proposal to host a SolarPACES START Mission to the SolarPACES Executive Committee via its Secretariate. Such proposal must discribe

- the host organization's interest and expectations in the field of solar thermal technologies
- the host organization's role in the host country's energy policy making and energy project implementation process
- the specific solar thermal project opportunities, that the host organization would like to analyze and review in a START mission
- the solar thermal technologies, in which the host organization would like to receive information and training

In case the proposal is accepted by the SolarPACES Executive Committee, the host organization will be requested to fill out a preparatory START Mission Questionaire for efficient execution of the missions as included in the Annex B to this case study.

The START Mission experts are selected by the START Mission Coordinator and the interested host organization according to the expertise profiles required for the respective mission from an expert shortlist. Funding of the expert's time spent in the preparation, conduction and reporting of the Mission will be provided in kind by the SolarPACES member

that has nominated the expert. The participation of additional experts from industry, electric utilities and financing institutions may be decided by the START Mission Coordinator on a case by case basis. The final report of each START Mission will be edited by the Mission Head with the active support of the participating experts in English language. It will include the information provided by the host organization in the host country questionaires, the findings of the mission and an executive summary.

Policy Mechanisms used in the START Missions

As part of the preparatory phase of a START mission, the START Mission Head identifies together with the Host the policy mechanisms and support instruments for which the host country may be eligible and reviews such policies and instruments during the mission itself for applicability to the identified solar thermal project opportunities.

The conducted START missions to Egypt, Jordan, Brazil and Mexico have identified the Operational Programs of the Global Environmental Facility (GEF) as the principal support instrument for the market deployment of solar thermal technologies in these developing countries within the sunbelt.

As the objective of the solar thermal project opportunities identified and analyzed by the START Mission Team is to reduce GHG emissions, they falls into the main area of the GEF's Climate Change Operational Programs, which are:

Operational Program No.5 (GEF-OP5)	Removing barriers to energy conservation and energy efficiency
Operational Program No.6 (GEF-OP6)	Promoting the adoption of renewable energy by removing barriers and reducing implementation costs
Operational Program No.7 (GEF-OP7)	Reducing the long-term costs of low greenhouse gas-emitting energy technologies

During the START missions, it must be determined to what extent the project opportunities in the Host country fulfill the eligibility criteria and terms of reference of GEF Operational Programs 6 and 7. GEF-OP6 seeks to reduce GHG emissions associated with energy consumption and production through increased use of already commercially viable Renewable Energy Technologies (RET). The objectives of GEF-OP6 are to:

- remove the barriers to the use of commercial or nearly commercial RETs; and
- reduce any additional implementation costs for RETs that result from a lack of practical experience, initial low volume markets, or from the dispersed nature of applications, such that profitable "win-win" transactions and activities increase from the deployment of RET's

The program, however, will be flexible in the consideration of new applications as the range of commercial applications increases with time and the technologies become more economical. A successful result is one in which a particular least-cost, win-win renewable technology has become financially sustainable in the market of a recipient country. The output of a GEF-OP6 project is the removal of a barrier to a particular renewable energy application, possibly a barrier resulting from high cost of implementation.

The objective of GEF-OP7 is to reduce anthropogenic greenhouse gas emissions by increasing the market share of those low GHG energy technologies for specific applications

which are not yet widespread least-cost alternatives in the recipient countries. Meeting this objective depends on two assumptions:

1. that the assisted technologies will be implemented once their cost has become competitive with fossil-fuel technologies and
2. many of the promising renewable energy technologies will achieve successful results

Technologies “graduating” from GEF-OP7 may need some additional support from GEF-OP6 in countries with barriers.

GEF-OP7 activities would initially focus on those technologies that have been commercially proven or demonstrated, but have not impacted significantly on the market because of the high costs of technology transfer and replication, or associated commercial risks in new operating environments. For cost effectiveness, the scope of GEF-OP7 should be limited to those technologies which are expected to become more economical with the economies of scale of manufacturing and widespread application.

There are two main types of project results:

1. the direct results of the low GHG emitting technology project are the amount of energy generated, the amount of GHG emissions avoided, etc.
2. The indirect result, of greater interest to the program, is the reduction in cost of future procurement

There are three key assumptions for cost reduction leading to increased competitiveness and market share, i.e. that

1. cost reduction will in fact be passed on
2. cost reduction is industry-wide and not limited to the businesses receiving GEF financing
3. there are no countervailing reductions in international prices of competing fossil fuels and alternative technologies

GEF-OP7 will finance activities, including project preparation, on an incremental cost basis. The types of activities that can be financed include targeted activities in research, capacity buildup, technical assistance and investments.

Preparing, Monitoring and Reporting START Missions

The most important ex-ante evaluation tool of the START missions is the START Mission Questionaire as included in the Annex B to this case study, that has to be filled out by the Host country before the START mission. The data provided in this Questionaire are the basis for preliminary screening of suitable solar thermal project concepts- For this purpose, the experts of the START mission team design suitable technology configurations, estimate their annual performance with the provided solar resource data, estimate the levelized electricity cost with the provided economic data and estimate financial feasibility on the basis of the provided revenue schemes. With such preparation, the START team experts focus during their mission on the independent presentation of the technologies, the review of the resource data, the inspection of the proposed project sites and the discussion of the eco-financial assumptions. In an final conclusion round table, a consensus recommendation to the Host country on the further implementation plan of the identified solar thermal project opportunities is elaborated jointly between the START experts and the involved Host country decision makers. These START Mission findings are documented together with the results of the preparaqtory analysis in a final START mission report.

Best “checkpoints” or feedback systems for monitoring or evaluating the successful implementation of the solar thermal projects proposed jointly by the START Team and the Host country are the common milestones of power project implementation:

- Conceptual Design Completed and Technical Feasibility Proven
- Project Site Identified and Secured
- Financing Concept Completed and Ecomic Feasibility Proven
- Consultancy for Preparing the Projects Request for Proposal Contracted
- RFP Published
- Winning Bid Selected
- BOOx or EPC Contract Assigned
- Plant Committed and Start of Operation

Discussion of START Mission Results

The tangible results of the IEA SolarPACES START missions to Egypt, Jordan, Brazil and Mexico can be summarized as follows:

START Mission to Egypt in February 1996:

In Egypt, the START Mission was requested by the hosting New and Renewable Energy Agency (NREA) and the Egyptian Electric Authority (EEA) of the Government of Egypt, to

provide information exchange by independent experts on solar thermal technologies applicable in Egypt

1. review three specific sites planned and previously evaluated by the NREA
2. discuss the Terms of Reference (TOR) for detailed feasibility and implementation study: Bulk Renewable Electricity and Energy Production (BREEP)

The START Mission recommendations served as the information basis and independent expert evaluation for Egypt’s subsequent application to the Global Environmental Facility, to support the identified 130MW Hybrid Fossil Solar Thermal (HFST) Power plant project at Kuraymat with private participation with a 50Mio USD support grant under GEF-OP7. The milestones of success have been:

- NREA’s submission of a longterm solar thermal implementation program to the Egyptian cabinet and parliament, aiming at the implementation of … MW of CSP plants until 2020; this program has been fully endorsed by cabinet and parliament in 1997.
- Award of a 1000kUSD GEF grant to NREA for project identification and feasibility analysis and preparation of the terms of reference for international project bidding in 1998.
- Request for Pre-Qualification of private developer consortia, interested in implementing the 130MW HSFT Kuraymat plant as a BOOT project. Over twenty international prime developers submitted their statement of interest by May 2000.

Publication of the RFP for Kuraymat is scheduled for early 2000; award of BOOT contract for end 2000; after a 18-24 month construction period, the Kuraymat hybrid fossil solar power

plant shall start operation in 2004. Planning of two subsequent 300MW hybrid fossil solar thermal power plants has just started to be on grid in 2007 and 2009 respectively.

Basic key to this success was the absolute engagement of NREA and the support of EEA and the Egyptian Ministry for Energy for this project: Prior to this first START Mission to Egypt, NREA had very successfully conducted a series of activities investigating the national solar thermal potential, national technological capacity and industrial resources and their implications for the national energy plan, as a means of gaining the support of the Egyptian Electrical Energy Agency and Ministry of Energy as well as international development agencies. In this case, through a series of preliminary studies and selection processes, the host organization, NREA, had already focused its prime interest on natural-gas-fired hybrid fossil-solar power plants with proven parabolic-trough collector technology, particularly gas and steam turbine combined-cycle plants. While GEF-OP7 is an excellent instrument for the support of such projects, the application procedures and negotiation interfaces have still be designed in the era of public utilities with government owned power projects in mind and can hardly keep pace with the dynamics of modern private sector power project development.

START Mission to Jordan in March 1997:

In March 1997 a START team composed of IEA/SolarPACES representatives from Egypt, Germany, Israel, Spain, Switzerland and the US, with guest observers from the European Union, visited Jordan. The Mission host was the Jordanian National Electric Power Company, NEPCO, located in Amman. The purpose of the START mission was to brief NEPCO, the Ministry of Energy and Mineral Resources and the Royal Scientific Society on the current techno-economic status of solar thermal technologies and discuss the next steps in building Jordan’s first large solar thermal power plant.

Jordan’s solar potential and land resources are optimal for the implementation of solar thermal power technologies. Most regions in Jordan offer direct normal insolation above 2000 kWh/m²yr. The best sites, in the southern part of the country, exceed 2500 kWh/m²yr. It is estimated that within 50 km from required infrastructure (roads, grid) accessible sites have huge potential far in excess of present consumption. The START team recommended that the collection of direct radiation data be continued and that more direct normal radiation stations be setup.

For a first solar thermal IPP, the START team recommended the integration of a parabolic trough or solar tower system in a base-load 130-MW fuel-oil-fired steam plant as a booster or fuel saver be considered. Further progress towards implementation of a solar thermal project lost focus and priority in NEPCO, who was entirely absorbed by the new challenges imposed by the privatization and deregulation of the Jordanian power market. Now, that a series of conventional private IPP’s have been successfully bidded and implemented in Jordan, newly emerged “green” investment funds and project developers have revived the solar thermal proposals of the START mission team and resumed recently negotiations with NEPCO and the Jordanian Ministry of Energy on a solar thermal BOOT project.

START Mission to Brazil in May 1997:

During the week of May 5th, 1997, a START Team composed of IEA/SolarPACES representatives from the US, Germany, Spain and Israel visited Brazil. The host of the mission was Centro de Pesquisas de Energia Elétrica (CEPEL) located in Rio de Janeiro, an

institution similar to USA's Electric Power Research Institute. The purpose of the team's visit was to brief research centers, electric utilities, and the energy ministry regarding the techno-economic status of solar thermal technologies and to explore the possibility of building a solar thermal power plant.

The START Team visited two proposed solar sites, reviewed the associated insolation data, and performed a first-cut systems analysis based on this data. CEPEL organized an International Solar Thermal Workshop to take place during the START Mission, which included START Team presentations on technology, economics, proposed plants, and the analyses of Brazilian meteorological data, and possible solar sites. Brazilian researchers and officials presented information on energy demand, financing, private and government markets, and past studies of solar thermal development. The team met with CEMIG (the electric company of the state of Minas Gerais who historically has expressed the greatest interest among Brazilian utilities in developing solar thermal electric power) to exchange information on energy resources and options, and demonstrated various software tools to researchers at CEPEL's laboratories in Rio de Janeiro.

Brazil's aggressive power sector expansion program seeks to increase the installed generating capacity by building natural gas pipelines and power plants, since many restrictions have been placed on tapping the remaining hydro potential. CEPEL and others in Brazil have studied the CO2 avoidance impact of concentrating solar power. The greatest success of this START Mission has been in providing IEA's support for CEPEL's efforts at reducing the long-term costs of greenhouse gas-reducing solar electric generating stations. Without IEA's participation, the Brazilian Government might not have continued this particular greenhouse gas reduction effort.

The START Mission was able to bring expertise and tools to Brazil for studying and designing solar power plants. The ability to exchange information is invaluable: Brazil needs access to the current status of the technology, while the international concentrating solar power community needs to understand the policy and cultural barriers facing the technologies.

Perhaps a weakness of the START Mission was its lack of outreach to international development organizations, such as The US Agency for International Development (USAID) and The Interamerican Development Bank (BID). Concentrating solar power rarely surfaces on these organizations' vistas, leaving a broad gap in medium- to large-scale renewable power options for developing countries.

Prior to this START Mission, Brazil had applied for a grant from the GEF for the purpose of building a solar power tower with methane reforming storage technology. The GEF requested that Brazil first prepare an assessment of the available concentrating solar power (CSP) technologies in order to show the merit of the proposed system. Funding for this technology assessment has been granted through the GEF and the study will soon begin under the direction of CEPEL. The current plan of work, in addition to the technology evaluation, includes market analyses, further international technical collaborations, and formulation of cost-reduction strategies. IEA/SolarPACES assistance has been requested for all phases of the study.

Dissemination Mission to Mexico in October 1998:

A solar thermal dissemination mission was conducted in October 1998 in Mexico City on "Solar Thermal Concentrating Technologies", at the Technology Museum in Mexico City and cosponsored by IEA SolarPACES and Institute for Electrical Investigations of the Comisión Federal de Electricidad (CFE-IIE).

The dissemination mission was attended by 31 experts from Europe, Mexico and the United States. CFE had invited high level representatives from the Mexican Energy Ministry, CFE, industrial firms and the Mexican solar energy research community.

The North Western part of Mexico offers excellent solar radiation potential (2500kWh/m² and higher) and the load demand curves are similar to the load demand curves in California with peaks in summer afternoons due to the increasing load of air conditioning. The radiation values were mostly estimated from satellite cloud coverage data; the ground data base is rather poor. There are various research groups active in solar thermal covering the subjects of parabolic trough technology, direct steam generation, dish technology and solar chemistry. Such activities, however, have been conducted in a rather isolated manner without the interchange with the solar thermal work carried out in Europe. It was agreed to establish a closer working relationship with the European and U.S. solar thermal research community.

The Mexican Ministry for Energy reported about the successful implementation of gas fired independent power projects in the North of Mexico and expressed the interest of the Mexican government in the presented solar thermal technologies and the will of the ministry, to support CFE and private developers in obtaining a Worldbank/GEF grant for the realization of a privately financed solar thermal power project. The Ministry also affirmed, that the national law for independent power producers would allow private developers to implement a solar thermal plant at Mexico's border with the US and to export solar electricity to the US, where it may be sold for green power tariffs.

CFE reported that it had reestablished negotiations with the Worldbank/GEF on the funding of a solar thermal feasibility study and the obtainment of a grant for a solar thermal project in the order of 50 million USD. A mission of the Worldbank was expected for the week after our mission to Mexico, where the next steps should be clarified.

Since this mission in 1998, CFE has received a grant from GEF to complete the feasibility study on the economic viability and technical feasibility of integrating a solar parabolic trough systems with a Combined Cycle Gas Turbine (CCGT) at the Cerro Prieto, Baja Norte site owned by CFE with world class solar insolation at 2665 kWh/m²-year. CFE is committed to complete the terms of reference for bidding this solar thermal project by the end of 2000. The recent change of the Mexican government, however, may also imply changes in composition and structure of the governmentally owned CFE, which actually may delay project progress. The dependence of governmentally owned national utilities on changes in government is a common weakness of many projects in developing countries and has paralized the progress of a similar solar thermal project in India for more than a decade.

Conclusions from the START Missions

The SolarPACES START missions have proven to become an extremely time and cost effective instrument of the SolarPACES community, to help achieve the objectives of supporting MARKET deployment of solar thermal technologies and of expanding

AWARENESS of the potential of solar thermal technologies. Their major success so far has been the support of the 130MW Hybrid Solar Thermal Plant at Kuraymat in Egypt, that has been promised a 50Mio USD grant by the GEF and for which over 21 international consortia have stated their interest, to develop, finance and operate it as a BOOT project.

While the cost of the START missions have been minimal (a few thousand USD travel budget provided by SolarPACES and a few person months of inkind expert contributions from the participating SolarPACES member organizations) the real ingredients for success may be summarized as follows:

- High interest and local pushers in the host countries, including an excellent, voluntary preparation of the START mission by the involved host organizations
- Informal approval of the START Mission Requests by the SolarPACES ExCo and informal agreement on the objectives and agenda of the START Missions between SolarPACES and the Host organizations
- High personal motivation and dedication of all experts from the START Mission team and the Host countries to achieve the objectives with their inkind contribution without any buraucratic or administrative hurdles.

In this way, the START mission serves as a catalyst for condensing available transnational expertise, industrial technologies, international financing support elements and an existing political will in the host countries into a feasible solar thermal project proposal.