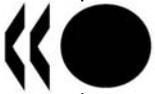


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Abstract

This report examines the links between environmental innovation and globalisation from two perspectives. It explores, on the one hand, how firms are adapting their environmental innovation strategies to the challenges and opportunities of global markets, and on the other, ways in which governments are promoting environmentally-related innovation in the context of a globalising economy. The report draws on interviews with representatives from governments and companies. The case studies resulting from the interviews with company representatives provide insights into how firms' strategies are evolving in response to new opportunities and challenges in environmentally-related sectors, and global markets. The focus of the report and the case studies is on innovation in the fields of energy efficiency and renewable energy.

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EXECUTIVE SUMMARY

Environmental innovation and global markets

This report examines the links between environmental innovation and globalisation from two perspectives. It explores, on the one hand, how firms are adapting their environmental innovation strategies to the challenges and opportunities of global markets, and on the other, ways in which governments are promoting environmentally-related innovation in the context of a globalising economy. The report draws on interviews with representatives from governments and companies. The case studies resulting from the interviews with company representatives provide insights into how firms' strategies are evolving in response to new opportunities and challenges in environmentally-related sectors, and global markets. The focus of the report and the case studies is on innovation in the fields of energy efficiency and renewable energy.

The innovation process

Innovation has been defined as the introduction of new products, processes, or services into the market. The innovation process is commonly divided into three stages: invention, innovation, and diffusion, though, in practice, the process is not linear. Two models dominate the academic technology innovation literature. According to the "technology push" view, technological change occurs mostly as the result of autonomous trends and public policy. The proponents of this view emphasise the need for governmental support for the development of technologies, most commonly through publicly-funded R&D programmes. The "market-pull" view holds that technological change comes primarily from the business sector and depends mostly on corporate investments in response to demand. This view emphasises the importance of government policies such as technology-based regulatory limitations, emission caps, or charges. The recent literature and the case studies developed in this report lend support to the idea that, in practice, both push and pull factors affect technology development.

The internationalisation of environmental R&D

One of the features of the internationalisation of R&D is the increasing relocation and outsourcing of R&D activities, in order to, *inter alia*, bring R&D activities closer to new markets and tap knowledge sources abroad. This also happens in the field of environmentally-related R&D. However, what is outsourced is mostly development, whereas basic research is still mainly done at headquarters.

Globalisation facilitates outsourcing of production, and supply chains are becoming increasingly globalised. Many companies outsource R&D and innovation activities to suppliers, often small enterprises, which in turn must meet their clients' own environmental policies, in addition to or beyond regulatory requirements. This dynamic can stimulate environmental innovation and lead to positive spillovers, but it also constitutes a challenge for suppliers, often small and medium-sized enterprises (SMEs), who have to comply with environmental standards and regulations of many countries, and meet the internal environmental requirements of their clients.

The growth of international markets for environmental technologies

Globalisation is creating wider markets for environmental technology, as large opportunities exist for producers and exporters of environmental goods and technologies. Many companies are expanding their operations, including environmentally-related R&D and innovation, to new markets. Much of the expansion is occurring in emerging economies, especially in China, India, and Brazil.

For environmental technologies to penetrate and succeed in global markets, it is important that they succeed domestically. Thus, well-designed environmental policies that spur innovation, and government measures that contribute to creating and consolidating domestic markets for environmental technologies constitute a basis for success in global markets. Gaining market experience at home is especially important in the case for small and medium-size enterprises.

Long-term, stable regulation and market conditions are essential for technologies to access markets and to gain a solid position. Governments can contribute to these by adopting – and keeping in place over a sufficient period of time – policies that take account of the length of the innovation process for various technologies and their successful market penetration.

Internationalising environmental innovation policies

Globalisation poses new challenges for governments' environmental innovation policies. National R&D programmes may result in support for foreign firms, and need to take account of the more open patterns of innovation developing with globalisation. Equally, environmental policies can provide incentives for innovations that are more domestically-oriented, while policies that are more internationally-oriented can help promote economies of scale and the diffusion of the new, cleaner technologies.

Many governments are internationalising their national environmental innovation policies in order to scale up the development and diffusion of environmental technologies. Measures include targeting R&D support in order to make domestic companies more competitive in global markets; enhancing export capacity; supporting the “internationalisation” of SMEs; increasing consumer demand for environmentally preferable products; and enhancing co-ordination and information sharing among government agencies involved in environmental innovation. Governments are also adopting international co-operation approaches that can help them to, *inter alia*, share costs and risks of projects that no country would undertake alone.

Domestic co-ordination between ministries of environment and ministries of industry and other innovation policy makers is necessary to promote a consistent and effective environmental innovation strategy that also allows environmental innovations to be competitive in global markets. Environmentally-related R&D, and especially, R&D in the areas of energy efficiency and renewable energy, is often the competence of several ministries, which have different objectives and priorities. Closer inter-ministerial co-ordination is a precondition for integrating competitiveness and environmental considerations in innovation policies.

The role of governments in promoting environmental innovation in global markets

Government policies and regulation continues to be a key driver for environmental innovation, though other factors are gaining importance, including the market opportunities that some companies see in environmentally-related sectors. For large companies operating globally, regulation in all their potential markets, not only in their home country, is increasingly important. Companies operating globally aim at conforming to environmental standards in their key potential markets, even if they are stricter than those of their home country or other, less promising markets.

Many companies operating in global markets call for greater harmonisation of standards and product standards. On the one hand, diverging, country-specific product requirements can work against the economies of scale that are needed to make clean technologies more competitive. On the other hand, however, harmonising environmental requirements constitutes a challenge for governments wishing to retain sovereignty over domestic environmental standard setting.

Long-term, stable market conditions are essential for environmental innovations to mature, become marketable, and succeed in the marketplace, whether it be national or international. Governments can contribute to these by adopting, and keeping in place for the necessary time, regulations and policies that take account of the length of the innovation process for the various technologies and their successful market penetration.

In order to allow for open innovation, policy measures should avoid focussing on specific technologies, but rather be “technology-neutral”. Otherwise, inefficiencies might occur, *e.g.* when subsidies encourage companies to produce technologies that might not be commercially viable, or where subsidies focus on few technologies (“winners”) and neglect others. Instead, a more effective role for governments would be to invest in creating a solid R&D infrastructure and to enhance technical and scientific education in order to promote a highly competitive and technically competent workforce.

Adequate enforcement is crucial to create a level playing field in the marketplace: regulatory requirements drive environmental innovation, but they need to apply to all participants. Weak or insufficient enforcement of environmental regulation creates undue advantages for producers and importers who do not comply and may not provide the incentives that domestic firms need in order to develop internationally-competitive environmentally-related innovations.

The importance of government support for environmental R&D varies by sector. Where there is strong demand for environmentally-related products or processes, government support is not likely to be important. In some areas, *e.g.* energy efficiency, the necessary technology is often already available, but its large-scale deployment requires government support. Measures such as feed-in tariffs introduced in support of renewable energies play a crucial role in scaling-up environmental technologies in global markets.

A range of measures could be used more efficiently to support markets for environmentally-related innovations. These include, *inter alia*: providing testing facilities and contributing to pilot projects; making better use of public procurement; encouraging consumers to purchase products that are more energy efficient and environmentally friendly; stimulating consumer demand for environmentally preferable products, through awareness raising, financial incentives and increasing the reliability in environmental technologies, *e.g.* by using technology verification and certification mechanisms; operating with local governments and municipalities; and helping access markets in developing countries. Governments are also increasingly engaging in partnerships with other governments and companies to promote environmental innovations and support their deployment in global markets. Some of these measures are being integrated in governments’ efforts to internationalise their environmental innovation policies.

1. INTRODUCTION

This report examines the links between environmental innovation and globalisation from two perspectives. It explores, on the one hand, how firms are adapting their environmental innovation strategies to the challenges and opportunities of global markets, and on the other, ways in which governments are promoting environmentally-related innovation in the context of a globalising economy.

While a substantive body of literature now exists on the links between innovation and globalisation, there is a dearth of information on how governments and business are tackling the effects of globalisation on environmental innovation strategies.

To fill this gap, a series of interviews with government and business representatives in eight OECD countries (Denmark, Finland, Germany, Japan, the Netherlands, Spain, the United Kingdom, and the United States) were carried out. This report builds on the outcomes of these interviews and on the recent literature on environmental innovation and globalisation. An OECD workshop held in Berlin on 20-21 September 2007 provided further first-hand information and insights from business, governments, and other key stakeholders.¹

The report is structured as follows: following this introduction, section 2 briefly describes key concepts linked to the innovation process, environmental innovation, and government measures to spur environmental innovation. Section 3, which constitutes the core of this study, looks at different links between environmental innovation and global markets, including how global markets serve as catalysts for environmental innovation. This section draws on, and is further illustrated by case studies based on interviews with companies. The case studies are included in the annex. Section 4 looks at the changing role of governments in promoting environmental innovation, and section 5 describes policies and measures put in place by governments to “internationalise” their environmental innovation strategies and approaches. This section reflects the interviews with government representatives. The report ends with a summary of key findings.

Key components of this report are the case studies, based on interviews with 14 companies. Most case studies include some additional material, drawn mainly from companies’ websites. The companies’ profiles and main areas of activity are provided in the annex. Table 1 lists the companies that have participated in this study and indicates the focus of their environmental innovation efforts.

¹ Information on the workshop, including the agenda and presentations, as well as speakers’ biographies are available at the workshop website www.oecd.org/environment/innovation/globalmarkets

Table 1. Overview of case studies

Company	Country	Website	Environmentally-related innovations in general	Energy efficiency	Renewable Energy
Endesa	Spain	www.endesa.es			X
General Electric	U.S.	www.ge.com	X	X	X
Ibiden	Japan	www.ibiden.com			X
Isotón	Spain	www.isofoton.com			X
Neste Oil	Finland	www.nesteoil.com			X
Nokia	Finland	www.nokia.com	X	X	
Philips Lighting	Netherlands	www.lighting.philips.com	X	X	
Sharp	Japan	www.sharp.com	X		X
Solarworld	Germany	www.solarworld.de		X	X
Toyota	Japan	www.toyota.com	X	X	
United Technologies Corporation	U.S.	www.utc.com		X	
Unilever	UK/Netherlands	www.unilever.com	X	X	
Vestas	Denmark	www.vestas.com			X
Viessmann	Germany	www.viessmann.de		X	X

The case studies look at a range of companies, and a variety of environmental technologies, products, and processes. Some companies produce renewable energy technologies (*e.g.* solar panels, wind turbines) and their innovation efforts are all somehow environmentally-related. Others produce cars, mobile phones, components for electronics, food, or personal care products. For these companies, environmentally-related innovation is part of their overall innovation strategy. While some companies see environmental regulation as contributing to creating new markets (*e.g.* for energy-efficient products or renewable energies), others consider that the same regulation leads, primarily, to increased costs and an obligation to change production methods.

All the interviewed companies have two key features in common: (1) environmental innovation is an important – if not the most important – part of their business strategy; and (2) they all operate in global markets, *i.e.*, they either have production plants and R&D centres in different parts of the world, or sell their products all over the world, or both. The focus of the case studies is on areas in which most of the interviewed companies are particularly active, namely energy efficiency and renewable energy.

The case studies reflect individual company strategies, personal opinions, or individual perceptions, which may not be shared by others. The findings of these studies therefore do not provide a sufficient basis to draw general conclusions applicable to all sectors. Instead, they should be seen as a rich source of information provided by key stakeholders and experts in the areas explored in this report, which helps to illustrate and support key findings emerging from recent work on innovation and globalisation.

Box 1 summarises the main themes covered in the interviews with the companies. The last part of the interviews, which focused on the role of government policies to support environmentally-related

innovation, was used to obtain feedback from companies on existing government policies, both in their home country and in other countries in which they operate.

It is important to mention that during the course of preparation of materials and interviews for this report, the scope of the research was expanded to include not only environmental R&D activities, as initially foreseen, but also other phases of technology innovation and deployment. One of the reasons for this was that companies, during interviews, tended to focus more on the ways in which globalisation affects their innovation activities (which are closer to the market) than on R&D activities, which take place at the very initial stages of the innovation process and are far removed from the commercialisation phase, and thus from the link to global markets. In general, the interviewed companies also considered that governments need to play a more active role in scaling up innovations in the global marketplace, and not only promoting or supporting companies' R&D efforts.

Box 1. Summary of questionnaire

I. Environmentally-related R&D activity within the company

General background
 Environmentally-related innovation and policies in the company
 Share of R&D with an environmental link

II. Drivers of environmentally-related innovation

What drives environmental innovation in the company?
 What role does regulation (in the home country and abroad) play?
 Is competition and access to new markets a key driver for environmentally-related R&D?

III. Motives to relocate and outsource environmentally-related R&D

Main source of company's environmental R&D, in the home country and abroad
 Drivers for doing environmentally-related R&D in the home country and abroad
 How does globalisation impact the company's environmentally-related R&D activities?

IV. Role of partnerships in environmentally-related innovation

Company's experience with R&D partnerships
 Role of environmentally-related R&D networks and criteria for success
 New challenges to environmental innovation due to globalisation

V. Role of government policies to support environmentally-related innovation

Feedback on existing environmentally-related innovation policies (home and abroad)
 Public incentives to environmentally-related innovation
 Is the existing framework useful? What is missing? What is working better elsewhere?

2. KEY ASPECTS OF THE INNOVATION PROCESS

While the business sector is the engine of technology development and innovation, public policy plays a central role in creating incentives for and reducing barriers to the creation of technology options that help society tackle environmental problems. In order to understand the implications of environmental innovation policies it is important to understand the nature of the innovation process more generally. Recent, comprehensive reviews of the literature are available at Foxon and Carbon Trust (2003), Stern (2006) and Foxon (2006).

The purpose of this section is not to offer an in-depth analysis of the literature but to review key terms associated with the innovation process, which may help better understand the relationship between environmental innovation and globalisation.

The innovation process

Innovation has been defined as “the introduction of new products, processes, or services into the market” (UNCTAD, 2005). The innovation process is commonly divided into three stages: invention, innovation, and diffusion. Invention is the initial conception of an idea. Innovation is the first application of the idea to actual practice by a firm or a consumer. Diffusion is the process by which additional firms or consumers adopt the new technology (Resetar *et al.*, 1999).²

More recently, other stages in the innovation chain have been added to bring more nuances to the discussion.³ Since this report focuses on energy-related innovations, it is useful to note stages proposed by some authors in energy technology development (Grubb, 2006; Foxon and Carbon Trust, 2003).

- **Basic research** aims at gaining a more comprehensive knowledge or understanding of the subject under study without specific applications in mind. In industry, basic research is defined as research that advances scientific knowledge but does not have specific immediate commercial objectives (UNCTAD, 2006).
- **Applied research** seeks to gain knowledge or understanding to meet a specific, recognised need. In industry, applied research includes investigations to discover new scientific knowledge that has specific commercial objectives with respect to products, processes, or services.

² The OECD Guidelines for Collecting and Interpreting Technological Innovation Data (Oslo Manual, OECD, 1997) further distinguish between technical and organisational innovations. Technical innovations are divided into product and process innovations: (a) Process innovations occur when a given amount of output (*i.e.* goods or services) can be produced with less input; (b) Product innovations require improvements to existing goods (or services) or the development of new goods. Product innovations in machinery in one firm are often process innovations in another firm; and (c) Organisational innovations include new forms of management, *e.g.* total quality management.

³ The concepts described in this section are provided for illustration only. The same terms are used differently by other authors. For example, some consider innovation to be limited to the adaptation of existing technologies - a more limited concept than the one used in this report.

- **Development** is the systematic use of the knowledge or understanding gained from research directed towards the production of useful materials, devices, systems, or methods, including the design and development of prototypes and processes (UNCTAD, 2006).
- **Market Demonstration** of technologies seeks to show, to potential purchasers and users, that the technology works in practice; it demonstrates its performance, viability, and potential markets.
- **Commercialisation** of the technology might include its adoption by established firms or the creation of firms around the technology. This phase includes market accumulation, which occurs when the technology expands in scale, often through the accumulation of niche or protected markets.
- **Diffusion** of the technology on a large scale entails the dissemination of the technology in different markets and the effort to do so at prices that allow the technology to compete against incumbent technologies.

The division of the innovation chain into several steps helps to organise the discussion, but in practice the process is not as linear as the steps above suggest. For example, the distinction between “research” and “development” is sometimes difficult, especially in technology-intensive industries. The reason for this is that much of the R&D work conducted involves close interaction between researchers in both the private and public sectors, often also including close collaboration with customers and suppliers (UNCTAD, 2006).

Moreover, technology development involves constant feedback and qualitative changes that are difficult to capture in the classifications proposed by scholars. As Grubb (2006) emphasises, innovation is the product of complex systems where the information and learning from the different stages of the chain and the ability to incorporate feedback from market experiences are critical.⁴ Additionally, innovation requires the co-evolution of technologies and institutions that support them. These developments may, in turn, favour certain technologies (known in the literature as “lock-in”) or keep new technologies from entering the market (“lock-out”).

What drives technology innovation? “Push” versus “pull” factors

Two economic views dominate the academic technology innovation literature leading to divergent economic explanations of what drives technology development: technology push, on the one hand, and market pull, on the other. It is beyond the scope of this paper to review the scholarly literature that has emerged around these views (for recent reviews, see Grubb, 2006; Stern, 2006; Foxon and Carbon Trust, 2003). Instead, this section summarises the rationale underpinning these “push” and “pull” arguments, as described by the above authors, to understand their impact on public policy approaches and to frame the case studies developed later in the report.

According to the “technology push” view, technological change occurs mostly as the result of autonomous trends and public policy. The proponents of this view emphasise the need for governmental action for the development of technologies, most commonly through publicly funded R&D programmes.

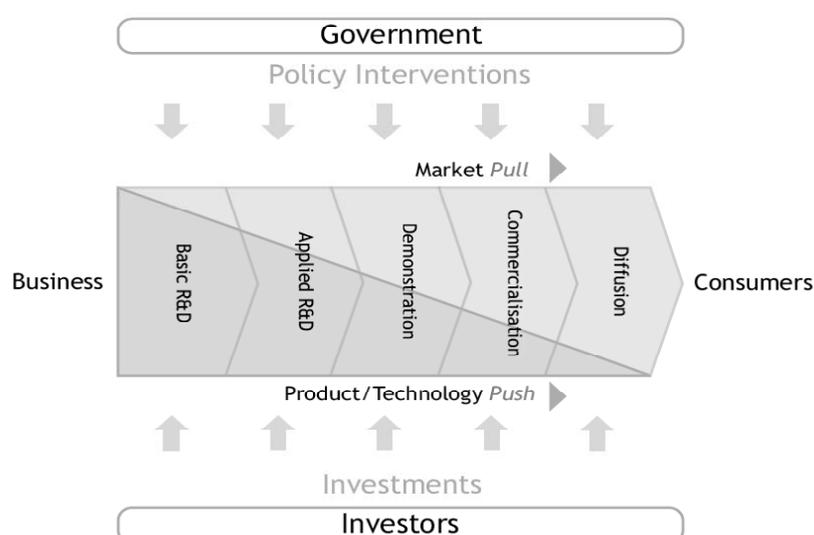
The “market-pull” argument, on the other hand, holds that technological change must come primarily from the business sector and depends mostly on corporate investments in response to economic incentives. This view gives priority to the adoption of regulatory measures such as technology-based regulatory limitations, emission caps, or charges. Companies will respond to these restrictions by producing

⁴ Grubb refers to the analysis by Shelton and Perlack (1996).

innovative technologies that reduce environmental impacts at a lower cost in order to gain competitive advantage. Proponents of this view recognise that business might lack incentives to invest in basic research because the commercial benefits might be too uncertain and companies might be unable to appropriate knowledge gained, but they tend to view public R&D policies as being sufficient to address these market failures.

In the areas of low-carbon technology development, both “technology push” and “market pull” affect the innovation cycle. “Supply” or “push” perspectives tend to operate during the early stages of R&D, at one end of the innovation chain, while “demand” or “pull” effects apply in later stages of that chain. The case studies developed in this report lend support to the idea that, in practice, both push and pull factors affect technology development. Figure 1 summarises the steps associated with the innovation chain.

Figure 1. The innovation process: a simplified version



Source: Foxon and Carbon Trust (2003)

Each sector of the economy presents different characteristics and dynamics, and some of the basic principles of innovation will vary accordingly. Some industries are far more innovative than others. Highly innovative industries, such as pharmaceuticals or electronics, face very high, often fierce, competition that rests on product differentiation. As a result, companies in these sectors have the incentive to innovate because it is precisely through technological investments that they might be able to receive significant pay-offs in the market place. In contrast, competition among companies in the power generation industry, for example, is based on price, and, thus market pull factors are weaker. The power generation sector operates today with fundamentally the same technology that was developed a century ago (Grubb, 2006; Stern, 2006; and WBCSD, 2006).

The greatest barriers to innovation accrue from market failures, and more particularly, the imperfectness of markets for new knowledge. Because of information spillovers, researchers (and those providing funding for research) are often unable to reap the full benefits of their innovations, and this can create disincentives to invest in R&D. In other words, innovation generates benefits above and beyond those that accrue to the innovator. This problem might be even more significant in the case of environmental innovations, where sharing new knowledge, either in the R&D process or after making an innovation publicly available, may lead to enhanced environmental conditions, and thus benefit society as a whole. Due to the “public good” character of environmental innovations, these benefits would accrue to

the public, and not to the innovator. Also, because of low volumes of technology manufactured, high production costs make products too expensive and therefore uncompetitive, at least in the first stages (OECD, 2006a).

Key features of environmental innovation

Environmental innovation can be defined as “new or modified processes, techniques, practices, systems, and products that avoid or reduce environmental harm” (OECD, 2006b). Environmental innovations may be developed with or without the explicit aim of reducing environmental harm. They also may be motivated by business goals such as profitability or enhanced product quality. Many environmental innovations combine an environmental benefit with a benefit for the firm or user.

An overview of the key features of the environmental industries sector, where a large part of environmental innovation takes place, is provided in Box 2. It draws on the views of the UK Environmental Innovations Advisory Group (EIAG, 2006).

Box 2. Key features of the environmental industry

The environmental industry sector covers activities ranging from pollution control through the development of cleaner processes and products to environmental services and consultancy.

Its core comprises companies that have been created specifically to help industry meet the requirements of environmental regulations, mainly so-called “end of pipe” techniques and clean-up. But with the drive towards sustainable consumption and production the coverage of the sector has expanded to embrace resources management and cleaner technologies.

While some companies, for example environmental consultancies, will readily identify with the environmental industry sector, others may not see themselves as part of the sector. There are also large overlaps with more established sectors including construction, manufacturing, energy, and biotechnology.

This makes the sector exceptionally difficult to define and its importance hard to measure. As a result the sector lacks visibility. Its contribution is often undervalued and it struggles to influence policy development.

This is a matter of concern because this is a sector whose products and services have value only because of the value society places on the environment. Governments must set and implement policies that create a value sufficient to justify investing in environmental innovations. This is what makes the environmental industries sector fundamentally different to other business sectors such as vehicles, where market forces drive demand and stimulate innovation. It is this that provides the unifying factor across the otherwise disparate sub-sectors that comprise the environmental industries.

Source: Based on EIAG, (2006), www.dti.gov.uk/sectors/environmental/index.html

Much environmental innovation occurs, not in the environmental industries sector, but in other parts of industry. In fact, environmental innovation is now an integral part of innovation efforts of many industries and companies as reflected in the case studies at the end of this report. When asked about whether they saw any difference between innovation in general and *environmental* innovation, many companies interviewed for the case studies in this report considered there were none. Most companies considered that all their innovations take environmental considerations into account, even when environmental improvements are not the main objective of their research and innovation efforts.

The automobile industry confirms this trend (see the case study of Toyota), but other industries, such as electronics (case studies of Nokia and Ibsen), food and health care (Unilever), as well as industries in the utilities and energy-related sector (case studies of Endesa, Isotón, Philips Lighting, Neste Oil, Sharp, Vestas, and Viessmann) are also investing in environmental R&D and developing environmental innovations that have significant environmental benefits, even if the companies do not consider them environmental innovations *per se*.

In many companies, environmental innovations are not limited to complying with regulation or measures related to the environmental performance of the companies' products: most of the interviewed companies have policies in place to improve their overall environmental performance and that of their products, even beyond regulation. One example (among many presented during the interviews with companies) is that of Sharp, which in addition to its aim to constantly improve the energy efficiency of its electronic products is also developing innovative, environmentally friendly components, such as the world's first plant-based paint applied to plastic parts of TV sets.

Governments' role in promoting innovation⁵

Governments have a key role to play across the innovation chain. Government measures to spur innovation differ depending on the part of the innovation cycle that is at stake. The appropriate extent of public involvement may also vary greatly between different sectors. Many government efforts focus on the initial part of the innovation chain, and provide support for basic and applied technology R&D, although increasingly, governments are also supporting the deployment and diffusion of innovations that have reached the commercialisation stage.

In the case of innovation oriented towards a "public good" like the environment, market pull is inoperable unless governments adopt regulation and put in place measures that increase the market value of environmental technologies. Cap and trade systems, for example, provide market-based incentives to underpin the diffusion of environmental technologies, such as low carbon technologies, and signal that innovation in this direction can ultimately expect some reward.

However, these measures alone do not guarantee that innovations will succeed in markets. As Grubb (2006) explains, for many sectors of the economy, public R&D support and regulatory measures may be adequate. In pharmaceuticals, for example, the "public good character of better medicines is automatically matched by the large-scale purchase of better drugs by national health authorities, private health practices, or direct private purchase; for information technologies, product differentiation built on a strong base of publicly-funded basic research provides a similarly strong combination. However, energy industries do not work like this. Public R&D cannot drive commercial uptake; market pull forces are weak, because product differentiation is not a key market driver; and the promise of emission controls does not form a credible long-term basis of sufficient security against which most firms could take substantial risks." Thus for a large, long-term problem like climate change, Grubb concludes, emission constraints need to combine with R&D and a range of targeted supports to promote technology investment through different stages of the innovation chain.

The above analysis by Grubb focuses on a specific sector, the energy sector, and a particular context – climate change mitigation. However, other authors also come to similar conclusions with regard to environmental technologies. For example, the Environmental Innovations Advisory Group's report (EAIG, 2006), when examining innovation in the UK's environmental industry's sector considers that "it is the lack of credible articulated demand that is at the root of the relative failure of innovation in the UK environmental goods and services sector, not any lack of research, invention, or innovative aspirations

⁵ This section is based on Grubb (2006).

(...). Going hand in hand with this lack of articulated demand is inevitably a failure to provide the right sort of support for innovation through to the market place. Government support for innovation is concentrated on the early stages of R&D, perhaps because this is regarded as furthest from the market and hence the most risky. If this is the rationale then it is wrong. R&D is relatively cheap and good research always succeeds in its primary purpose of increasing knowledge and has very little risk attached. The time of maximum risk is when much larger amounts of money are spent on demonstrations and on scaling up but before commercial sales prove that the market will buy the product.”

This view was also shared by many of the interviewed companies. Support for R&D is important, and this is especially the case for potential innovations for which no market is in sight, or not yet. However, this support is not enough to make environmental technologies succeed in the market, and therefore need to be combined with a range of other measures that operate before and around the commercialisation phase, where the risk to the company is biggest.

Overview of measures to spur environmental innovation

As discussed above, governments have a role to play in supporting environmental innovation throughout the innovation chain. These measures can be grouped under the following broad categories (Grubb, 2006; EAIG, 2006; and IEA, 2004): internalisation measures; support to technology research, development, and demonstration; market engagement programmes; barrier removal; and deployment policies. These different categories are briefly described below. The last category – deployment measures – is developed in some more detail, since this type of measures is key for the analysis of the links between environmental innovation and global markets in section 3 of this report.

- Internalisation measures: these include regulations such as emission controls that seek to address the damage caused by existing technologies (*e.g.* pollution created by conventional cars) and thereby improve the economics of the alternatives (*e.g.* low emission cars, such as hybrid vehicles). Policy measures such as emission taxes might also spur innovation as companies seek to reduce the cost of compliance
- Support to technology research, development, and demonstration: the main issues for public policy concern funding and management of publicly-financed R&D. The growth and direction of private R&D efforts will be a product of these incentives (as well as market forces). There is consensus around the idea that public R&D must complement, not compete, with private R&D.
- Market engagement programmes: once the technology is proven, the challenge for policy makers is to encourage and support the transition of trial technology from public R&D funding to engagement with the private sector. Examples of the tools used include: technology incubators (*i.e.* developing companies out of university-based ideas) and accelerator programmes of “field test” technologies (that, *inter alia*, increase the data on how the technology performs).
- Barrier removal: the way markets have become structured might create barriers to entry for new and promising environmental technologies. Some of these barriers include: subsidies, incumbent technology owner’s lobbying power, and regulations that discriminate (*e.g.* some short-term trading markets in liberalised electricity discriminate against the variable nature of wind production.) These barriers tend to be very market specific.
- Support for technology demonstration: Any “innovation strategy” has to be considered as a process which continues after the “research phase”, from a business as well as from a governmental perspective. One way for governments to help bring innovations into the market is to create programmes for first applications aiming to demonstrate their technical feasibility under

commercial conditions. The overall policy target is that such innovations reach “benchmark-level” in a mid- and long-term perspective. Germany launched one such programmes in the end of the 1970s and has won a rich experience in this field (see a description of the programme in chapter 5, sub-section on Germany).

- Deployment policies: These policies support the larger-scale deployment of emerging technologies because of the advantages that accrue from building up these industries and “buying down” the cost associated with them. The main empirical justification of these policies is found in the “experience curves”, the long-term reduction of costs associated with the technology as capacity increases and its growing competitiveness *vis-à-vis* incumbent technologies (see Grubb, 2006; and Foxon and Carbon Trust, 2003, for a detailed discussion). Many low-carbon technologies remain trapped in the cycle of small volume and high costs; hence public policy would tend to promote the adoption of such technologies to secure a learning-by-doing process that helps reduce costs as more field experience and scale is gained. Measures that have been used in particular to promote renewable energy deployment include (see more examples in Table 2):
 - **Feed-in tariffs** are mandates of a specific premium price to be paid for the electricity generated from renewable sources. A key example is Germany’s Renewable Energy Act. It guarantees renewable energy producers prices for electricity fed into the grid, which vary according to the technology and are progressively reduced. In Germany, the contribution of electricity from renewable energy sources to gross electricity consumption increased from about 4.7% in 1998 to 6.7% in 2000 and to about 10.2% in 2005. Related to total primary electricity consumption, the contribution from renewable energy sources increased to 4.6% in 2005 (German Government, 2006). The case study of Solarworld (see annex) explains this system in more detail.
 - **Renewable obligations (or portfolio standards in the U.S.)** require that utilities use a certain percentage of their electricity from renewable sources, usually through a tradable certificates system. Portfolio standards have been in place in Connecticut since 1998. Today they require that by 2010, 7% of power in the state be from renewable resources. Currently there are 20 States plus the District of Columbia that have put these policies into place amounting to 42% of electricity sales in the country (www.ctinnovations.com/funding/cccf/portfolio_standard.php).
 - **Technology mandates** require the adoption of particular technologies that have societal benefits. One example is from Brazil, where the ProAlcool policy required that passenger cars be built to run on ethanol and led to the installation of a nationwide distribution network, which supplies ethanol in all service stations. Supply was guaranteed via strict controls on planting of sugarcane and production of both sugar and ethanol (Philpott and Feller, 2006).

Table 2. Examples of deployment measures

Type of measure	Target technology
Fiscal	Biofuels (e.g., reduced taxes in the U.K., investment tax credits in the U.S.)
Capital grants	Clean coal development, solar energy (Germany, U.S., Japan)
Feed-in tariffs	Solar PV (Germany, Spain) Wind (Austria, Spain)
Quota-based schemes	Renewable energy (Portfolio standards in the U.S.)
Tradable quotas	Renewable Energy (U.K. Renewables Obligation; Renewable Transport Fuels Obligation)
Subsidies of infrastructure cost of connecting new technologies to the network	Solar, wind
Procurement policies of national and regional governments	Environmental goods and services (The Netherlands, Denmark).
Energy saving requirements in buildings	Renewable energy (Spain, new construction code)

Source: Adapted from Grubb (2006) and Stern (2006).

Recent work in the OECD on the impact of environmental policy and technological innovation based on patent data show that flexible instruments encourage investment in environmentally-related R&D to a greater extent than more prescriptive instruments. It also shows that environmental regulations – both domestic and foreign – affect innovation, and also, that innovative companies in different countries appear to be exploiting international market opportunities differently (see Box 3).

Box 3. Empirical work on the impact of environmental policy and technological innovation

The impact of public environmental policy on innovations in environmental technologies has been analysed empirically within the OECD. On the basis of work using patent data it has been concluded that:

- In the area of renewable energy, environmental policy has been a significant driver of environmental innovations, but the effects for different types of renewable energy varies by instrument type (such as support for R&D, guaranteed prices, tax incentives, tradable permits, etc.);
- For other areas, consumer pressure may be an equally important driver of innovations in environmental technologies, e.g. eco-labelling of paper products;
- The design of environmental policies can play an important role in ensuring that innovations take the form of integrated product or process changes rather than end-of-pipe solutions, e.g. the introduction of regulations encouraging on-board diagnostic systems for motor vehicles;
- Environmental innovation is affected by both national and foreign regulations, but innovative companies in different countries appear to be exploiting international market opportunities to a very different extent; and
- In addition, separate work undertaken drawing upon a database of 4 000 manufacturing facilities has found that the likelihood of having invested in environment-related R&D depends upon the nature of the environmental policy framework. In particular, flexible instruments (such as market-based instruments and performance standards) encourage such investments to a much greater extent than more prescriptive instruments. Moreover, the use of flexible instruments also encourages the introduction of integrated changes in production processes (“clean production”) rather than end-of-pipe abatement.

Source: Johnstone, N. (2007)

3. ENVIRONMENTAL INNOVATION AND GLOBAL MARKETS: KEY LINKS

Overview of links between environmental innovation and global markets

This section explores the links between environmental innovation and global markets, in particular the opportunities and challenges that emerge both for companies and governments. The analysis is based on the recent literature on environmental innovation, and the input received from governments and companies interviewed for this report.

Box 4. What is globalisation?

The term globalisation has been widely used to describe a process in which the structures of economic markets, technologies, and communication patterns become progressively more international over time. Higher levels of investment, deeper liberalisation of international trade regimes, intensified competition, and rapid technological change are some of the main drivers of this process.

While economic integration is a dominant feature of globalisation, other dimensions are also important, such as social, cultural, political, and institutional aspects. Changes in consumption patterns through easier access to goods and services, increased transport and energy needs, and global access to innovation and knowledge, all play a role in globalisation – and all have an impact on the environment. The growing extensity, intensity, and velocity of global interactions can be associated with their deepening impact such that the effects of distant events can be highly significant elsewhere. Local developments often go far beyond national boundaries and jurisdictions, and can have considerable global environmental consequences.

Source: based on OECD (forthcoming in 2008)

Several major studies have recently been undertaken to explore the links between innovation and globalisation. Examples include ongoing work by the OECD on globalisation of R&D and on open innovation, and UNCTAD's World Investment report 2005, which focused on the internationalisation of R&D by multinational enterprises. The links between *environmental* innovation and globalisation do not seem to have been explored in depth yet.

These links, however, are becoming more apparent, especially in light of the climate change debate, which has revealed the need to accelerate the pace of low-carbon technology development, not only through domestic measures, but also through the expansion of international markets for clean energy technologies and the promotion of international co-operation mechanisms to stimulate innovation and deployment of innovative technologies.

This section will focus on the following emerging factors and key issues:

- The growth of international markets for environmentally-related technologies
- The acceleration of the internationalisation of business R&D strategies, which manifests itself, in particular, through:

- Relocation and outsourcing of R&D activities to affiliates
- Globalisation of value chains
- New approaches to partnerships and co-operation

Growth of international markets for environmentally-related technologies

Simultaneous to the changes in the international innovation landscape, a transformation of the global market for environmental technologies is also occurring. Recent data about the size of this market reveal the large-scale opportunities that exist for companies. The global market for environmentally-related technologies has gone from approximately USD 450 billion in revenues in 1993 to USD 652 billion in 2005 (Environmental Business Journal, 2006).⁶

Within a decade, the market for clean energy technology alone is projected to reach USD 167 billion (Clean Edge, 2006) (See also Box 8 in section 4, which provides an overview of the growth of the eco-industry in the European Union). Most of the expansion of this global market of environmental technologies is expected to occur in emerging countries, especially in China, India, and Brazil. Globalisation is creating a fertile environment for investments in environmental technology, as investors channel funds to environmental sector, and in particular, low-carbon energy investment opportunities beyond their countries of origin.

Among the key factors driving growth in the global environmental market are the following (Environmental Business Journal, 2006):

- Economic growth and development in emerging markets is creating needs for infrastructure, especially water-related projects, and technological upgrades and know-how. As a result, the market is expected to increase 9-10% annually in emerging markets, mainly China, South Korea, Brazil, India, and Mexico, in contrast to 2-4% growth rates in developed countries, the main markets being the U.S., Japan, Germany, UK, and France;
- Environmental regulation and other government measures are having an effect on design and manufacturing operations beyond home countries (*e.g.* regulation such as California's "zero emission vehicle had an impact on vehicle manufacturers all over the world; the establishment of the EU Emission Trading Scheme has spurred action by states and cities in the U.S. aiming to develop similar opportunities for emissions trading);
- The global environmental market is growing in response to the needs of multinational enterprises that demand newer and better equipment and services to comply with environmental laws and to preserve a good reputation among communities in which they operate.

Acceleration of the internationalisation of R&D activities

A specific attribute of the globalisation of innovation is the internationalisation of business R&D activities (UNCTAD, 2006 and OECD, 2006b). While this process is not new, the pace at which it is occurring has increased in the recent past and its nature has changed involving more proactive foreign affiliates and emerging economy actors. A brief discussion is provided in Box 5.

⁶ Available figures on markets for environmental technologies, or eco-innovation markets, vary, since some include renewable energies; others only "end of pipe" technologies; some only include "hardware"; whereas others also include associated services; etc. The figures here are provided for illustration purposes only.

Box 5. Internationalisation of R&D

Growing internationalisation of R&D consists fundamentally of increased activities by foreign affiliates but also in the creation of international alliances. Three attributes characterise the internationalisation of R&D: (1) it is not a new phenomenon but it is happening at a much faster pace than ever before; (2) it is spreading to an increasing number of countries, including developing countries; and (3) it involves R&D activities that go beyond adapting technology to local conditions of markets abroad.

As regards the R&D activities of foreign affiliates, two shifts are occurring. The first one is quantitative. Most foreign affiliate R&D activities still occur in the so-called Triad (US, EU, and Japan) with developing countries capturing only a very small share of them. However, a growing share of foreign affiliate R&D is happening in developing countries and emerging economies — mostly in China and India. The second shift is qualitative. The nature of the activities that foreign affiliates are undertaking is changing, going from mainly adaptative R&D (known in the literature as “asset exploiting”) to more strategic options (“asset seeking”).

In practice, this analytical differentiation of tasks is not clearly cut. With an “asset exploiting” approach, key R&D activities are conducted at the headquarters and foreign affiliate activities aim at adapting technology and products to local conditions. The location chosen for these R&D activities abroad is demand-oriented, *i.e.* companies tend to choose proximity to market. Hence, if the key market is found in China, R&D will mainly focus on adapting the technology developed at the company’s headquarters to the needs of the Chinese market. The company will seek to be close to the lead users and adapt the products and processes to the local conditions.

With an “asset seeking” strategy, companies move more parts of the R&D activities abroad so that foreign affiliates play a more proactive role. In essence, the transfer of activities abroad allows the company to improve the existing base of technological assets and, ideally, to create new ones. Another goal is to seek new markets worldwide and to tap into local fields of expertise. Hence, the asset seeking approach to R&D leads to a more international structure of technology creation than in the case of asset exploiting strategies.

Locational factors also differ and, in the former case, key drivers for moving R&D activities abroad are the presence of scientific and technological skills as well as the presence of other firms and institutions in that location that might enable more technological spillovers. As mentioned above, most of the transfers of R&D activity still go from the headquarters to foreign affiliates in the Triad. But the small share that goes to developing countries is growing, driven by, among other factors, the lower cost of getting researchers as well as the large pool of researchers available in these countries. Cost alone is not the main driver for relocation of R&D to developing countries, but also the quality of the abundant pool of science and technology workers that has been improving in the past years.

Source : UNCTAD (2006) and OECD (2006a).

The internationalisation of R&D is an example of the broader changes that are occurring in the global innovation landscape, which is experiencing an acceleration of technological change that forces companies to innovate more quickly. Accordingly, companies and governments see a growing need for interactions between the science base and the business sector, and for the creation of international networking and business collaboration, more involvement of SMEs in developing and diffusing technologies, and the growing interdependence of countries’ innovation systems.

This sub-section will explore three key aspects of the internationalisation of environmental R&D: the outsourcing and relocation of R&D activities, the globalisation of R&D through supply chains, and new approaches to partnerships and co-operation. These three aspects are closely inter-related.

Relocation and outsourcing of R&D activities to affiliates

One of the key features of the internationalisation of R&D is the increasing outsourcing of R&D activities by multinational enterprises (MNEs) to foreign affiliates, to R&D centres abroad or to companies abroad (the latter is described in more detail in the next section). This process is driven by a combination of factors. These include intensifying competition, rising costs of R&D in developed countries, the scarcity of engineering and scientific manpower, and the increasing complexity of R&D, as well as the growing availability of scientific and engineering skills and manpower at competitive costs, the ongoing globalisation of manufacturing processes, and substantial and fast-growing markets in some developing countries, which increase their attractiveness as new locations (UNCTAD, 2006).

According to the recent literature, the internationalisation of R&D brings advantages to both home and host countries. For host countries, there are often positive impacts on the economy, as well as opportunities to access technology, build high value added products and services, develop new skills, and foster a culture of innovation through spillovers to local firms and institutions. The benefits for the home countries of companies outsourcing R&D are improved competitiveness by accessing strategic assets and new technologies, acquiring unique knowledge at competitive prices, increasing specialisation of their R&D, reducing costs, increasing flexibility and expanding their market shares (UNCTAD, 2006 and OECD 2006b).

According to most of the companies interviewed for this report, there is no significant distinction between drivers for the location of R&D “in general” and “environmentally-related” R&D. The reasons for outsourcing R&D activities or delocalising R&D centres are broadly the same for both. Most of these companies have their own R&D centres abroad or outsource R&D, for example, to their suppliers (see next sub-section). The main reasons for outsourcing R&D mentioned by several companies is to get closer to new markets and to access skilled workers. Reducing costs, on the other hand, was rarely mentioned as a factor for R&D outsourcing. Some details on R&D activities abroad are provided, in particular, in the case studies of Philips and Vestas.

As to the type of R&D done abroad, most companies mentioned that what is conducted abroad is the “development” portion of their R&D programmes, which is mainly the adaptation of technologies to other markets, whereas the “research” itself is hardly ever done abroad. In other words, outsourcing of R&D seems to refer to a rather small part of overall R&D activities and the largest part of R&D is still being done at headquarters. One of the reasons, especially regarding outsourcing to non-OECD countries, is the fear of knowledge spillovers, and valuable knowledge being “used by others” due to insufficient protection of intellectual property rights. Several interviewed companies considered that R&D was more efficient “if grouped in one location”, or developed “in-house”. One example is General Electric, which has four Global Research Centres (in the US, Germany, China, and India), which do practically all the R&D for the company’s activities worldwide.

Another, often-mentioned reason for delocalising R&D is to adapt abroad the technology that is generated at home. As markets for environmentally-related technologies become more globalised, the need to adapt those technologies to new markets also increases. The case study of Vestas, a company now heavily investing in R&D in Asia, where the potential market for wind turbines is enormous, clearly illustrates this situation.

One more reason why companies carry out R&D activities abroad is to benefit from R&D programmes in other countries. Since many governments are currently providing increased support for R&D in environmentally-related R&D, companies’ interest to benefit from such support may be a reason for increased delocalisation of such types of R&D, as compared to other areas where foreign R&D programmes are less tempting (because less easily accessible or less open to foreign companies.)

Several companies among those interviewed said that better R&D support than in the home country had been (or was soon to be) a key reason for carrying out R&D abroad. A range of companies mentioned the examples of R&D programmes in the EU being limited to 50% of the total investment, while in the United States and Japan, R&D support in energy-related R&D could go to up to 90 or even 100%. One interviewed company was envisaging moving some of its R&D activities to the United States, mainly to benefit from their more interesting support measures. Another company with activities in Latin America mentioned that certain countries provided a subsidy on the condition that R&D related to the supported activity was carried out in the country. On some occasion, this had been an important driver to carry out R&D in that country rather than in another one.

Outsourcing of R&D activities has started to raise concerns in some of the countries of origin of large corporations, especially due to the risk of “hollowing out” national industries and loss of jobs. Indeed, some of the most recent measures in innovation policies by OECD countries are partly driven by concerns related to growing outsourcing of R&D. For example, the German government explains that with its recent “High Tech Strategy” (see Box 6) it is “also reacting to the fact that investments in research and development on the part of industry are becoming increasingly dependent on economic trends. Experts have observed that companies are withdrawing from long-term research. Instead of taking advantage of strategic research to open up new markets, they are acquiring new competences by outsourcing research or buying in research results – including the results of publicly financed research.”⁷

Globalisation of value chains

Many companies do not outsource their R&D activities to affiliates or research centres, but leave R&D (or at least parts of it) to their suppliers. Indeed, one of the main characteristics of globalisation is the fragmentation of the value chain (Berger, 2005). The recent OECD study, “Staying Competitive in the Global Economy: Moving up the Value Chain” (OECD, 2007a) analyses this trend in detail.⁸ The following paragraphs are drawn from this study.

The globalisation of value chains is central to today’s rapid globalisation process. The phenomenon is also referred to in the literature as international production sharing, global production, and slicing up the value chain. The globalisation of value chains refers to the growing vertical integration of production and is closely linked to the growth of global production networks. It leads to the physical fragmentation of production, in which the various stages are located in different sites as firms find it advantageous to source inputs globally.

The globalisation of value chains is motivated by a number of factors. The first is the search for greater efficiency as growing competition in domestic and international markets forces firms to become more efficient and lower costs. One way of achieving that goal is to source inputs from low-cost or more efficient producers, either domestically or internationally, and either within or outside the boundaries of the firm.

The second major motivation is entry into new markets. Demographic shifts and rapid growth in several large non-OECD economies mean that an increasing part of global economic activity is taking place outside the OECD area. If firms wish to benefit from these growth centres, they need to be present in

⁷ Germany’s High Tech Strategy; BMBF, www.bmbf.de.

⁸ In the study, “Staying Competitive in the Global Economy: Moving up the Value Chain”, the concept of globalisation of the value chain includes outsourcing and offshoring of R&D activities to affiliates or third companies, whereas the present study has dealt with both aspects separately. This has been done mainly for reasons of clarity, but also because interviewed companies seemed to consider these two aspects of the globalisation of value chains to be quite distinct.

them. This does not necessarily involve the offshoring of existing production; in many cases, it involves expansion abroad.

Third, firms may move some activities offshore to gain access to so-called strategic assets, whether skilled workers, technological expertise, the presence of competitors and suppliers, or the possibility of learning from their experience. Tapping into foreign knowledge has become especially important in the internationalisation of R&D activities.

Notwithstanding these anticipated benefits, global value chains also involve costs and risks for firms. Starting up operations abroad and managing them efficiently in spite of differences in language, culture, and communication results directly in higher operating costs. Furthermore, there are potential risks, such as goods and services of inadequate quality, failure to meet delivery times, political instability, less reliable civil infrastructure, less developed legal and regulatory systems, and risks to intellectual property.

One particular feature of the globalisation of environmental R&D through the value chain is that many companies have internal environmental policies, which often include the obligation for suppliers to meet certain environmental requirements. These requirements are in many cases reflected in “green purchasing” guidelines, and include, for example, the obligation to meet environmental laws and regulations, to be certified, (*e.g.* ISO 14001 or EMAs), or in the absence of third party certification, to commit to certain environmental standards. They can also include the obligation for the supplier to provide environmental education to employees, and to have green procurement requirements itself. This is illustrated, for example, in the case study of Sharp, which describes the company’s recently updated “Green Procurement Guidelines”. Other case studies describing companies’ green purchasing policies are those of Endesa, General Electric, Toyota, and UTC.

With increasing outsourcing of R&D to suppliers, these requirements are thus also becoming more global, and better corporate environmental performance “spreads through” the supply chain. This can play a key role in promoting environmental innovation. By “pushing” the supplier to conform to certain environmental standards – which may not be prevalent in the suppliers’ country – environmental innovation (often coupled with enhanced environmental performance by suppliers) is being increasingly “globalised” through the supply chain.

For some heavily regulated products, such as automobiles, where emission standards have been gradually tightened, suppliers who typically only produce parts of the final product sometimes grapple with meeting increasing demands from their clients. These demands are linked, in many cases, with environmental standards applicable in the markets in which the clients operate. The problem of having to satisfy differing national standards (further discussed below), is therefore likely to particularly affect companies along the value chain. The case study of Ibiden, a Japanese producer of diesel particulate filters and components for mobile phones (whose clients, among the interviewed companies, include Toyota and Nokia), clearly illustrates this situation.

New approaches to partnerships and co-operation

It is generally agreed that many environmental problems require concerted action, international co-operation, and partnerships among countries, as the increasing number of multilateral environmental agreements and related initiatives show. It is also widely recognised that, in order to address global environmental problems, environmental innovation and technology development are required on a global scale, and this, in turn, calls for strengthened international co-operation.

The development and scaling up of environmental technologies require international co-operation among governments, between governments and industry, and within industry. Many of the efforts to spur

innovation and deploy promising products are organised around specific industries (e.g. the construction sector), and technologies (e.g. biofuels and fuel cells) regardless of their country of origin.

The scope of action of such initiatives is no longer within the country. While this might pose dilemmas for local regulators and policy makers (whose actions and constituencies are by definition bound by national borders), this reconfiguration of the innovation landscape and debate opens the door to an array of opportunities for joint technological development and diffusion that might bring tangible benefits for local industries and workers.

There are also challenges to implementing international co-operation arrangements. For example, there may be competitive trade-offs between the need to address environmental problems on the one hand, and to support and consolidate emerging domestic technologies on the other hand. Some governments might continue to fund environmental technology programmes domestically to boost its national industry even if other countries have already developed more innovative technological solutions. Governments may also fear that the benefits of their support will accrue to foreign companies. Examples of how governments are addressing these challenges are provided in section 4 of this report. These dilemmas might discourage collaborative approaches as countries try to promote the competitiveness of their own industries.

Similarly, companies entering into partnerships also need to balance their advantages with their costs and risks. Most of the companies interviewed for this report are engaged in R&D partnerships with research institutes and universities, other companies, or governments. The case study of Endesa, for example, describes co-operation between power plants in the framework of a “zero emission platform”; that of Toyota describes a “horizontal” R&D partnership with General Motors; and that of UTC the initiative among several large companies to develop energy-efficient buildings. While the interviewed companies see the need of partnerships and technical co-operation to, *inter alia*, share costs and risks linked to R&D, they also highlighted the trade-offs, such as the difficulties of managing such partnerships and ensuring adequate benefits for all. In some companies’ experience, how to allocate and share benefits and rights (such as intellectual property rights) is often a major problem in these partnerships. Some pointed out that cultural barriers might also work against the implementation of collaborative agendas between researchers from different countries.

At the Berlin workshop, several speakers highlighted the importance of co-operation among governments to develop and market innovative solutions to environmental problems – and the missed opportunities from lack of co-operation. This co-operation can be in the form of policy co-ordination. According to one speaker, “because of a lack of co-ordinated action, [EU] Member States and Europe as a whole are insufficiently able to take advantage of the potential of its leading role in eco-innovations. This harms both the environment and the economy.” He linked this to the concept of “lead markets”: innovative technologies developed following new environmental policies in one country can make the latter a “lead market, which then diffuses the technology and sets the global standards. One example is the introduction of a levy on waste in the 70s in the Netherlands, following which Dutch firms developed waste water treatment technologies to avoid paying the levy; these Dutch firms successfully export these technologies to those countries which adopted similar policies” (Duijnhouwer, F., 2007). The need for global co-operation to assess key technologies was also mentioned (Akaishi, K., 2007).

While policy co-operation in environmental innovation is still in its initial stages, collaboration in environmental and energy-related R&D is much more extended. A few specific examples of co-operative approaches between governments in the areas of energy efficiency and renewable energies are provided below. One example is the IEA’s Energy Technology Collaboration Agreements; the other two are recent initiatives involving individual countries.

The IEA's Energy Technology Collaboration Agreements

For 30 years, the International Energy Agency (IEA) has promoted technology collaboration among its members to facilitate progress of new or improved technologies (www.iea.org/Textbase/techno/index.asp). More recently, it has also encouraged the participation of non-member countries in these collaborative efforts. To support these efforts, the IEA has established technology collaboration contracts, known as “implementing agreements,” as a system of standard rules and regulations that allow interested member and non-member governments to pool resources and conduct joint R&D activities in areas of common interest.⁹

The benefits of having governments working together include: the improvement of the projects' definition; reduced costs and duplication of work; greater project scale; information sharing and networking; and enhanced international deployment prospects; as compared to the type of results achieved through national efforts alone: linking research, industry and policy; harmonised technical standards; and strengthened national research, development and demonstration capabilities.

The work and strategy of each implementation agreement must fit into the IEA goals of energy security, environmental protection, and economic growth. The work includes:

- Technology assessment, feasibility studies, environmental impact assessments, and policy implications;
- Research projects – from laboratory scale to pilot facility scale;
- Information exchange of programmes, policies, funding priorities, research, and modelling; and
- Dissemination of results and experiences acquired.

The IEA currently helps coordinate 40 implementing agreements with several thousand participants from 58 countries, working on key new technologies of energy supply and end-use. These agreements are open to IEA members and non-member countries and cover: fossil fuels (*e.g.* clean and advanced fossil fuel technologies including carbon capture and storage [CCS]), renewable energies (including biofuels) and hydrogen, end-use technologies (transport, buildings, and industry), fusion power, and cross-sectional activities. The participants include governmental or energy technology entities representing governments, research institutes, and universities; and energy technology companies. Each signatory designates a representative to an Executive Committee that governs and manages the work.

The projects are financed on a cost-shared or task-shared basis (or a combination thereof), as long as the signatories agree, as established in the implementation agreement. Cost sharing is more appropriate for funding a single joint activity or experiment; task sharing works well when participants are investigating different concepts in parallel.

⁹ The IEA Framework for International Technology Co-operation was adopted in 2003 (replacing the set of guiding principles that operated in the past years) to set forth the minimum legal and management requirements for implementing agreements (*e.g.* who can participate, and on which conditions).

*The Global Bioenergy Partnership*¹⁰

One recent international cooperative effort to induce environmental innovation occurred in the context of the Gleneagles Plan of Action established in 2005 by the G8 countries. As part of the agenda's energy commitments, a Global Bioenergy Partnership was launched in May 2006, with the goal to scale up the deployment of cost effective biomass and biofuels, particularly from developing countries where biomass use is prevalent.¹¹

The partners of this initiative are all G8 countries (Canada, France, Germany, Italy, Japan, Russia, UK, US), China, Mexico, the Food and Agriculture Organisation (FAO), the International Energy Agency (IEA), the United Nations Foundation, and the European Biomass Industry Association (EUBIA). One of the expectations is that this initiative will increase and facilitate an exchange of experiences and technologies not only North-South, but also South-South and South-North.

*Moving to a low carbon society – a UK and Japan joint research project*¹²

In February 2006, the UK and Japan started a joint research project, which will investigate how to achieve a low carbon society by 2050.¹³ The project will consider the necessity for action to reduce GHG emissions, share images of a low carbon society and investigate the technological and behavioural solutions that would be needed to achieve such a society. The outcomes of the project will feed into the Gleneagles Dialogue on Climate Change.¹⁴

The project reviews country level studies on greenhouse gas emissions, with the aim to develop and share the images of a low carbon society, and to investigate pathways to achieve a low carbon society through technological solutions, innovation, and behavioural change. It will also identify bottlenecks, barriers, and opportunities, and contribute to the development of international co-operation between researchers working in this area. The study will also consider the quality of life that people living in 2050 will require, covering energy supply, industry structure, city lifestyles, and transport networks.

What is noteworthy about this effort is the explicit inclusion of developing country needs in the discussions on transitions to a low-carbon economy. For example, the research project includes the revision of country-level GHG emission scenario studies in Brazil, China, India, Mexico, South Africa, and Thailand, as well as the revision of policy measures that tackle supply-side, demand-side, institutional, and financial aspects. This effort will also allow researchers to assess and quantify technological, institutional, and behavioural pathways, and to develop a set of options (including, technological and financial) to achieve the best outcomes.

¹⁰ See www2.minambiente.it/sito/settori_azione/pia/docs/roundtable_09_12_2005/chair_summary.pdf.

¹¹ See http://ec.europa.eu/environment/etap/pdfs/july06_global_bioenergy_partnership.pdf

¹² See www.env.go.jp/earth/suishini/index.htm and www.defra.gov.uk/news/2006/060216a.htm

¹³ The joint Japan-UK Research Project, "Developing visions for a Low Carbon Society through Sustainable Development", is a scientific study promoted by the Department for the Environment, Food, and Rural Affairs (UK) and the Ministry of the Environment (Japan). It will be supported by the Energy Research Centre (UKERC) and the Tyndall Centre in the UK, and the National Institute of Environmental Science (NIES) in Japan.

¹⁴ The Gleneagles Dialogue on Climate Change, launched at the G8 Gleneagles Summit in 2005, is made up of 20 countries, with the greatest energy needs, including the G8 and the major emerging economies, Brazil, China, India, Mexico and South Africa, as well as key international organisations, such as the World Bank. It allows them to informally discuss ideas and new measures to tackle climate change outside the formal negotiations under the UN Framework Convention on Climate Change.

4. GOVERNMENTS' ROLE IN PROMOTING ENVIRONMENTAL INNOVATION

The globalisation of markets and innovation strategies is creating new challenges for environmental regulation and government policies in promoting environmental innovation. On the one hand, environmental approaches limited to one country's jurisdiction – typically, national regulation and domestic environmental standards – may be an obstacle to the objective of promoting global markets for environmental technologies. On the other hand, environmental regulators might worry about the loss of regulatory autonomy and the disadvantages of creating environmental regulation that is consistent with that of other countries that have different economic, social, and environmental attributes.

The role of environmental policy, including regulation, standards, and economic instruments, as a driver for environmental innovation has been studied at length in the literature and will not be explored here. This section will therefore reflect the views of the government and company representatives interviewed for this report on the role that government policy plays in stimulating and framing environmental innovation in a context of globalisation.

While, on the one hand, globalisation is affecting, and to some extent, challenging, governments' traditional role, in particular in creating and framing markets through regulation, on the other hand it also creates opportunities for governments to develop new approaches to promote environmental innovation in both domestic and global markets. This section focuses on measures that interviewed companies and government representatives considered were the most important for opening up global markets for environmental innovations. It looks first at environmental regulation and environmental standards (the term "standards" is used here in a narrow sense, covering product and performance requirements established by governments, but not voluntary standards, *e.g.* those established to obtain non-governmental eco-labels). It also looks at government measures to support environmental R&D, and at measures to cross the so-called "technology valley of death" (Grubb, 2006), in other words, measures to help innovations access and succeed in the marketplace.

Environmental regulation as a driver of environmental innovation in global markets

Regulation was seen by most interviewed companies as an important driver for environmental innovation – or at least, as a catalyst to change their business strategy. For some companies, a shift in their approach to environmental matters has been driven by policies related to climate change mitigation, coupled with increased fossil fuel prices and concerns about energy security. In particular, GHG emission limits have been a catalyst for change for many companies. A clear example among the interviewed companies is Endesa, a large electricity producer, which was driven to major change by Spanish legislation adopted to comply with emission targets under the Kyoto Protocol. The company then rapidly adopted a more pro-active attitude towards environmental innovation and is in the process of improving its overall environmental performance in other areas (such as waste treatment and water use) even beyond regulation, and is heavily investing in renewable energy sources.

Most interviewed companies highlighted that stringency of domestic regulation (in the home country or in countries where they operate) is not the key problem – the absence of clear and predictable regulation is. Key factors of governments' role to stimulate innovation is "predictability and consistency of policies and (...) challenging and realistic target setting" (Turpeinen, H., 2007). Where a country does not set clear environment objectives and puts in place a regulatory framework to attain those objectives, companies are

unlikely to be motivated to innovate. On the contrary, one of the features of globalisation is that markets are much more dynamic, and companies do not focus on their home country markets, but can produce for other markets where clearer regulatory frameworks exist.

In many cases, regulation in one country has been a driver for innovation by companies in other countries. As described later, one of the characteristics of globalisation is the fragmentation of the supply chain, and regulation in one country or region therefore has direct effects throughout the whole supply chain. Several of the interviewed companies were investing in renewable energy solutions driven by regulation and market measures put in place, not in their home countries but in third countries. The case study of the Japanese company Iridium, which produces filters for diesel motors describes how European legislation on vehicle emissions has heavily stimulated research in that company to meet the requirements, and has spurred its sales to car makers producing for European markets.

Keeping abreast of regulatory changes in their clients' markets is one of the key preoccupations of suppliers, and requires close co-operation between both. Often the client is the main source of information on the requirements of new regulation, and thus takes the role of intermediary between the legislator in his country (or even in the countries where the client sells its products) and his suppliers. The increasing importance of close collaboration between clients and suppliers to meet regulatory requirements was highlighted by several of the interviewed companies and is reflected notably in the case studies of Iridium, Toyota, and Nokia. One recommendation in this context was that governments had a role to play in assisting small and medium-sized enterprises, which are part of the supply chain, to meet the environmental requirements of clients operating in global markets.

Many companies, as reflected for example, in the case studies of Nokia and Toyota, anticipate and act ahead of regulation in their key markets, which they regard as essential for obtaining a better competitive position. The case study of Neste Oil describes the "early bird strategy" adopted by the company to gain competitive advantage over much larger companies. These "frontrunner" companies prefer to act proactively on a voluntary basis, in order to foresee potential environmental legislation that could limit their flexibility.

With increasing pressure on emerging economies to take part in emission reduction commitments, companies in these countries are also preparing themselves for regulatory changes to come in the near future. According to a representative from Petrobras, a leading biofuels producer in Brazil, "Looking into the evolution of the climate change science, the potential impact of that change on the environment and on natural resources, as well as the role played by human activities, we believe that, despite current regulatory uncertainty, the new regulations will probably be more stringent and will demand some kind of commitment from countries not included today in Annex I to the Kyoto Protocol, like Brazil, China, and India. If Brazil, the country where Petrobras develops most of its activities, has to comply with some emission reduction targets, pressure will be put on Petrobras to reduce its GHG emissions as well, which may affect both our productive process and our products, posing threats to our business, like the following ones: additional costs to comply with more stringent environmental regulations; additional investments to upgrade the energy efficiency of processes and equipment or to implement fuel switching initiatives; additional technological efforts to improve processes; performance and implementation of alternative cleaner solutions; market share reduction of fossil fuels; additional investments to improve product quality and efficiency; reputation risks. Some good opportunities could be identified as well: expansion of the market for less carbon intensive fuels, like natural gas; and increasing demand for renewable fuels, like ethanol and biodiesel (Tadeu Furlan, L, 2007).

Most of the interviewed companies have their own internal environmental policies. In many cases, these go far beyond the commitment to comply with relevant laws and regulations. These internal environmental policies constitute strong drivers for environmental innovation, even more than domestic

legislation does. Good and constantly improved environmental performance – both of the final products and of production processes– is part of these companies’ brands and of their reputation. They also see better environmental performance as a way to be more competitive. The case studies of UTC, Nokia, Ibiden, and Unilever, in particular, describe in detail the relevance of internal environmental drivers for their innovation policies.

In general, companies apply these internal policies equally to all their plants, be they at home or abroad. These companies thus also “globalise” their environmental policies and contribute to the spreading of environmental standards and the development of environmental innovations deriving from the companies’ commitment to constantly improve their environmental performance.

Domestic environmental standards and product requirements

One of the most obvious dilemmas between domestic environmental standards and global markets is that the former can hamper the latter. Even in an increasingly globalised economy, domestic standards end at each country’s borders, although their effect can be felt beyond those borders. Even within the EU, where many environmental policies are harmonised, divergences of environmental standards, and the way in which they are implemented still exist.

Manufacturers prefer to face consistent requirements and technical requirements at least in key markets (namely, the EU, the United States - California in particular - and China) than country-specific ones. Such consistency facilitates manufacturing, reduces costs and contributes to establishing truly global markets. The difficulties of complying with diverging requirements in different countries for the same product are not new, but increasing globalisation of market risks is widening the gap between environmental and economic objectives. The difficulties of dealing with diverging environmental requirements was considered to be an obstacle to the creation of global markets by a range of companies (see for example the case study of Philips). For suppliers of parts, with customers in different countries, harmonisation of environmental standards, as well as of administrative procedures (*e.g.* patent registration), is particularly important (Ohno, K., 2007). Regulators tend to focus on domestic environmental conditions and are attached to autonomy in environmental policy-making. Hence one challenge for governments is to identify the trade-offs involved and to evaluate the costs and benefits, for the country and for the global environment, of maintaining national (or regional) product standards.

Another issue mentioned by a range of companies is the fact that certain environmental standards, *e.g.* those related to limits to the contents of certain substances, such as lead content in light bulbs, or the performance of certain products, are becoming increasingly stringent and complex, to the extent that governments cannot actually enforce them or verify compliance with them. While certain companies will do everything to comply with such requirements, including investing in R&D to develop the necessary innovations, others will put competing products on the market that may not entirely conform to the technical requirements, which unfortunately governments will not always have the means to verify this.

Insufficient enforcement can create a competitive advantage to non-complying firms. This is not a new problem, but it seems to be becoming a major barrier in the light of increasing competition from abroad. The problem was mentioned for example by Philips and Nokia, two companies whose internal policies, brand name, and reputation “would not allow them not to comply” even with the most stringent technical requirements, and who face competition from less compliant and brand-conscious companies.

Public financial support to innovation

A key issue when discussing environmental innovation is that of financing. Interviewed companies highlighted the importance of mobilising, identifying, and accessing funds in support of investments

towards environmental innovation. Similarly, during the Berlin workshop, participants considered that the private financial market is not yet sufficiently interested in, and reactive to, the opportunities offered by the environmental industry sector and that a “short-sighted global financial market sometimes hampers innovation” (Akaishi, K., 2007).

This report does not explore the issue of private financing sources for environmental innovation further. A recent OECD report on business contribution to the implementation of multilateral environmental agreements (OECD, 2007 b) describes in some detail the growing interest of the financial sector in the environmental technologies sector. There is also an extensive literature on measures put in place by governments to support innovation, in particular through R&D subsidies. This section will therefore only describe the ways in which interviewed companies regard the relevance of R&D subsidies for environmental innovation.

Few of the companies interviewed for this report considered public R&D support to be a key driver for their innovation strategies and, even less, for their efforts to access global markets. In fact, the majority of them did not rely on public R&D programmes but preferred to use their own resources for R&D. Their preference to use their own resources may be due, to a large extent, to the fact that the interviewed companies are very large and have enough funds to carry out their research programmes and focus on their own priorities. However, smaller companies interviewed for this report also did not seem to consider public R&D funds to be essential for their R&D activities.

The main reasons mentioned were that obtaining public R&D support is complicated, cumbersome, and time consuming. In addition, the amounts that can be obtained are relatively small, and require an important contribution of the company’s own resources (in the EU, at least 50%). For many companies, applying for public R&D was “not worth the effort” (and the related cost). Some company representatives said that if they believed that an idea was good, and would be successful in the market, they would make the necessary R&D investment. And, on the contrary, if they did not believe in it, even public funding of part of the cost would not justify investing to cover the remaining cost. Finally, global markets, increased market opportunities, but also increased competition, have accelerated the pace of innovation – and public R&D programmes are generally not designed to keep that pace.

In the view of some companies, R&D subsidies lead to inefficiencies by encouraging companies to produce technologies that might not be commercially viable. Instead of giving subsidies to producers of technology, companies find it more useful that governments improve their overall R&D infrastructure by, e.g. enhancing education to promote a highly-competitive and technically-competent workforce.

Some companies also mentioned that public R&D programmes were too short, as they considered that the actual time frames to develop innovations are often much longer. Japanese R&D programmes, which are designed over a ten (or more) year period, were mentioned as an example of offering a more appropriate time frame. Some government officials in charge of R&D programmes confirmed that the design of these programmes did not match the needs of many companies, but that other constraints made these shortcomings (especially long delays in verifying projects and releasing the funds) almost inevitable.

Measures to support markets for environmental innovation

For most companies to be able to perform successfully in global markets, they first have to succeed domestically. Gaining market experience at home is especially important in the case of SMEs. Even at a time where global markets are developing rapidly and offer major growth opportunities for companies, the domestic market plays a crucial role as it offers the main testing ground for new technologies and for obtaining feedback from clients, which, in turn, help them become more competitive. Therefore,

government measures that create and consolidate domestic markets for environmental innovations will, in most cases, also help companies to open the doors towards global markets.

One recurring plea by interviewed companies was that governments should contribute to creating demand for environmentally preferable products and ensure the stability of markets for such products. Long-term, stable market conditions are considered essential for technologies to access markets and to gain a solid position. Governments can contribute to these by adopting – and keeping in place – regulations and policies that take account of the length of the innovation process for various technologies and their successful market penetration. A few companies mentioned the absence of or uncertainty about, key regulation affecting their markets, as a major barrier to innovation efforts. One company, for example, considered that the government in its home country delayed for an excessively long period the adoption of clear measures in support of home owners installing energy-efficient heating systems. In the expectation of future measures, the domestic market stagnated, while it boomed in other countries. Another example is that of the recent derogation, in one country, of financial support for the use of renewable energies, which one of the affected companies considered contributed to instability, and therefore led to lack of investments in innovation in that sector.

A range of interviewed companies highlighted that government measures to support markets for environmental innovation should be technology-neutral. For these companies, the role of governments is to set clear environmental targets, and to provide the necessary framework conditions for companies to invest and innovate, both in domestic and global markets. However, in their view, governments should be “technology-neutral”, in other words, not impose the technology through which those targets should be reached. This view was also reiterated at the Berlin workshop.

Radical measures, such as bans on certain products, were viewed by some companies as a driver, and by others as an inhibitor of innovation. While bans may promote innovation in alternative products (which often already exist when the ban takes effects), they can also discourage innovation to explore potential improvements to the banned product or technology. The example used was that of incandescent light bulbs – while a ban on those would certainly promote the use of energy-efficient light bulbs, it would also stall any efforts to find improvements to the “banned” technology, even though these might, eventually, be viable. The first government to adopt such a measure (which, admittedly, is far more than a simple “encouragement” to consumers) is Australia. Its recent ban, which will phase out incandescent lamps, is described in Box 6.

Box 6. Australia's ban on incandescent light bulbs

In the area of energy efficiency, the challenge ahead is not technological (the technologies exist already), but large-scale development. Accordingly, the momentum for an international ban, or phase out, of incandescent lamps is growing, especially as a result of the actions by the lighting industry, public interest groups, and some regulators. Given that not all countries might agree to sign an international treaty banning these products, some have suggested that interested countries start working together to take voluntarily action. The interviews conducted for this study revealed that in absence of a ban or phase out, the market for energy efficiency light bulbs will not grow at the pace and scale that is necessary to tackle the problem of climate change. The International Energy Agency (IEA) has started a round of discussions with industry and policy makers to evaluate the best strategies to tackle this issue.

In a world first move, the Australian Government is taking action to phase out inefficient light bulbs. The step, announced in February 2007 by the Minister for the Environment and Water Resources, Malcolm Turnbull MP, should reduce Australia's greenhouse gas emissions by four million tonnes by 2012. The reduction in emissions will increase as the phase out progresses and the annual average reduction between 2008 and 2012 is estimated at around 800,000 tonnes. However, by 2015 the annual cut in emissions will have soared to an estimated four million tonnes per annum. Household lighting costs can be reduced by up to 66 per cent.

"The most effective and immediate way we can reduce greenhouse gas emissions is by using energy more efficiently," Mr Turnbull said. "Electric lighting is a vital part of our lives; globally it generates emissions equal to 70 per cent of those from all the world's passenger vehicles. But it is still very inefficient. We have been using incandescent light bulbs for 125 years and up to 90 per cent of the energy each light bulb uses is wasted, mainly as heat. A normal light bulb is too hot to hold – that heat is wasted and globally represents millions of tonnes of CO₂ that needn't have been emitted into the atmosphere if we had used more efficient forms of lighting.

These more efficient lights, such as the compact fluorescent light bulb, use around 20 per cent of the electricity to produce the same amount of light. A compact fluorescent light bulb can last between four and 10 times longer than the average incandescent light bulb, which can lead to major savings in household energy costs. While they may be more expensive to buy up front, they can pay for themselves in lower power bills within a year."

In Australia, lighting currently represents around 12 per cent of greenhouse gas emissions from households, and around 25 per cent of emissions from the commercial sector. Working with its state and territory counterparts, the Australian Government will gradually phase out all inefficient light bulbs and is aiming for full enforcement of new lighting standards legislation by 2009 to 2010. Special needs areas, such as medical lighting and oven lights, will be taken into consideration."

Source : Press release of 20 February 2007, Ministry for the Environment and Water Resources, Australia, www.environment.gov.au

Similarly, governments' choosing of "winners", *e.g.* a specific type of technology that would receive heavy government support was seen by some companies as a hamper to innovation and a barrier for the chances of success in global markets (see for example, Turpeinen, H., 2007). However, other companies recognised that their success in the market was largely due to targeted efforts by their governments to promote a specific technology or, for example, in the case of Vestas, a specific type of renewable energy. According to its representative, "while Vestas has shown the necessary business skills and determination in its past wind energy business development, changing Danish Governments have ensured long-term stable wind energy market conditions in Denmark, by adopting and keeping in place relevant regulation and policies. As a result of this, Vestas is today number one in modern energy, while Denmark has the world record of 20% wind energy in its national electric supply" (Backer, L., 2007).

The new German Renewable Energy Sources Act described in Box 31 was presented by several companies as a good example of a well-designed regulation that supports the creation of a stable market for

innovations in the renewable energy sector. According to one company representative, the Act establishes a simple, straightforward feed-in system, easy access to the grid, and a sufficiently long time period (20 years, with digressive support tariffs) that allows technologies “to mature”. He highlighted that because the system is open to all companies, both national and foreign, competition increases, thus helping mainstream new technologies and consolidating the markets. In addition, the fact that feed-in tariffs are digressive and limited in time puts pressure on companies to continue innovating, *e.g.* in ways that lower costs and enhance the performance of the products.

The following measures were highlighted as being particularly useful for scaling up environmental technologies and for helping innovations succeed – first in domestic markets, but also in global markets. These measures are in addition to those related to government regulation, discussed above:

Making better use of public procurement. Governments are major purchasers of goods and services for which, often, environmentally preferable alternatives exist. Many countries have put “green procurement policies” in place – but the majority of interviewed people, both companies and government officials, considered that they do not function to their full potential and, in particular, are not effective enough in scaling up markets for innovative environmental technologies and helping them mature. They considered that these programmes are not designed with a view to promoting innovations. Further, purchasers often lack the tools to assess which products are environmentally preferable. Cost is also a barrier, since environmental alternatives are often still niche products, and therefore more costly to produce, they tend to be more expensive than “traditional products”, and may not make their way up to a short-list in a public bid.

Some governments are making significant efforts to “green” government procurement, which can increase the market for environmentally-friendly products and technologies. In Finland, for instance, about 50% of the calls for tender of the largest public purchases involve environmental criteria. The Ministry of Environment has created an online database that facilitates green purchases by municipalities. A handbook on environmental considerations was completed in 2005 (Government of Finland, 2006). In the Netherlands, each year the government acquires approximately 30 billion EUR of goods and services. Since 2005, a directive has required authorities to increase the proportion of green procurement from 20% to 50% by 2010 (Government of the Netherlands, 2006). The EU also regards green procurement as a key instrument for intensifying demand, and has set, as a target, “to achieve, by 2010, an EU average level of green public procurement equal to that currently achieved by the best performing Member States.”

Encouraging consumers to purchase innovative products. Many companies consider that consumer pressure for environmental innovation remains weak. Therefore any measures that governments take to provide incentives to consumers are seen as helpful. Many governments are indeed developing and putting in place such measures. For example, in the EU, instruments to stimulate demand for environmental technologies include (in addition to green procurement), mobilising financial investments, technology verification, focussing on sectors with high gains, and building on promising Member State practice (Clark, I., 2007). Among innovative approaches, Toyota mentioned the recent example of California’s decision to reserve one highway lane to hybrid cars. Philips has been pursuing for years, that governments stimulate demand for energy saving light bulbs, *e.g.* by providing financial incentives for energy saving forms of street lighting, and restricting availability of high energy consuming products, *e.g.* a ban on incandescent light bulbs (Snijkers-Hendrickx, I., 2007).

For some industries, environmental improvements are difficult “to sell” to customers, and hardly influence their choice. Nokia, for example, considered that in the electronics industry, and more concretely, in the mobile phone sector, consumers do not pay particular attention to the environmental attributes of the product. Government efforts to raise citizen awareness about environmental issues and to promote more sustainable consumption patterns are can contribute to change this attitude.

Strengthening environmental technology verification (ETV) was mentioned by some company representatives as constituting a useful measure to support environmental innovation and strengthen competitiveness in global markets. Originating in North America in the mid-90s, ETV programmes seek to accelerate market acceptance of innovative technologies by providing users with information about their performance, thereby substantially reducing the uncertainty for purchasers. Several countries have put in place, or are developing, environmental technology verification programmes, including Canada (www.etvcanada.com), the United States (www.epa.gov/etv), and the EU (www.eu-etv-strategy.eu). Box 7 provides an overview of the United States' ETV Programme. These countries regard the programmes as having an important role in strengthening competitiveness for technology developers. The EU also highlights the importance of its programme "for faster market introduction of new and novel technologies" and for small and medium-size enterprises.

Box 7. The US Environmental Technology Verification Programme

The ETV Programme was initiated in 1995 to verify the performance of innovative technologies that have the potential to improve human health and the environment. The programme operates, in large part, as a public-private partnership through competitive cooperative agreements between the Environmental Protection Agency (EPA) and five non-profit research institutes, although some verifications are performed under contracts.

The project was initiated to speed the introduction of new technologies to the US and international marketplaces by providing a platform for evaluating the performance of new environmental sampling and monitoring methods.

The ETV Programme, through its cooperative agreement recipients, develops testing protocols and publishes detailed performance results in the form of verification reports and statements, which can be found at www.epa.gov/etv/verifications/verification-index.html. EPA technical and quality assurance staff review the protocols, test plans, verification reports, and verification statements to ensure that the verification data have been collected, analysed, and presented in a manner that is consistent with the EPA's quality assurance guidelines. By providing credible performance information about new and improved commercially ready environmental technologies, ETV verification can help vendors sell their technologies and help users to make purchasing decisions.

The purpose of ETV is to provide objective and quality assured performance data on environmental technologies, so that users, developers, regulators, and consultants can make informed decisions about these technologies." ETV verification does not imply approval, certification, or designation by EPA, but rather provides a quantitative assessment of the performance of a technology under the specified test conditions.

Source: EPA, www.epa.gov/etv/pdfs.

Co-operating with local governments and municipalities. Some companies suggested governments could work more closely with municipalities to encourage the use of innovative environmental technologies. Examples offered by the interviewed companies included using energy-efficient street lighting or low emission public vehicles.

Helping access markets in developing countries. Global markets also increasingly include developing countries, but for many companies these are very difficult to access. At the same time, developing countries could enormously benefit from environmental technologies, and in particular, renewable energies. An example of government co-operation with a company to deploy renewable energy technology is the Japanese government's co-operation with Sharp to install solar panels in Mongolia.

Obviously, not all measures work for all types of products and technologies, and approaches that succeed in one country or context may not be suitable elsewhere. Many governments are still grappling with the challenges of globalisation for innovation policies and are exploring ways to seize the opportunities of global markets for environmentally-related innovation. Exchange of experience among governments, companies, and other stakeholders, and feedback from companies on government measures can contribute to assessing the effects of government policies and approaches and identifying successful policy mixes.

Providing testing facilities and contributing to pilot projects. A range of companies mentioned this as a key area in which governments could contribute. This was also one of the main conclusions of a recent study carried out by the Danish government (see Box 9), which interviewed over 400 companies in the environmental industries sector.

Developing environmental policies: enhanced co-operation and consultation. From the discussions with government officials interviewed for this project, it emerged that officials from environment ministries and those of industry or other ministries in charge of innovation policies often have different views on the links between environmental innovation and the opportunities of global markets. Normally, environment ministry officials tend to focus on the environmental benefits of “their” regulations and the environmental impacts of industry (and on how to reduce them). Innovation is treated as a means to an end; technologies are promoted if their environmental benefits are large enough to justify the costs of supporting the technology. Ministries of industry or those in charge of technology have a different approach toward innovation: often the overarching goal is to increase competitiveness, and to contribute to economic growth and to job creation.

For this reason, the use of global markets as an opportunity for environmental innovation is often more the result of initiatives undertaken by ministries of industry and technology than by ministries of environment. As one environmental official stated, “our mission is to protect the environment, not to create international market opportunities for companies.” While this position is understandable, it might delay the expansion of environmental innovations, especially where the size of the domestic market is too small to provide the necessary economies of scale that are required to reduce costs and encourage the development of new technologies. This is particularly true in the case of some renewable energy.¹⁵

Co-ordination and concerted action between ministries therefore is an important step for governments in ensuring that environmental innovation policies adequately respond to the challenges of global markets, and in developing strategies that can contribute both to achieving the country’s environmental objectives and to strengthening the capacity of domestic innovators to compete in global markets. Some interviewed companies considered that, in the light of increasing globalisation, government policies should also be developed in a more inclusive manner, including, *inter alia*, consultations with companies operating globally – even if they are not established in the country in question.

The next section explores the efforts by some governments to make their environmental innovation policies more “international” in order to stand up to the challenges of globalisation. It includes some examples of more inclusive ways of developing policies.

¹⁵ See Neuhoff and Sellers (2005) for a discussion of the barriers to the mainstreaming of renewable energy technologies.

5. INTERNATIONALISING ENVIRONMENTAL INNOVATION POLICIES

According to the latest OECD Science, Technology, and Industry Outlook (OECD 2006b), “most OECD governments recognise that the best way to benefit from global innovation networks is to strengthen domestic innovation capabilities and develop local talent. At the same time, countries have put in place targeted policies to respond to specific challenges posed by globalisation. Examples of such measures include R&D tax incentives to attract and retain foreign R&D investment, helping firms to identify foreign partners or fostering international collaboration in research, measures to encourage greater mobility of researchers, or encourage expatriate researchers to return”. As yet, however, the Outlook points out, “few countries have determined how best to adapt national policy frameworks to a more global innovation system, but some countries are leading the way”.

Given this report’s focus on linkages between innovation and globalisation, this section looks at how governments are “internationalising” their environmental innovation strategies. It offers examples of measures that several OECD governments are taking to use the global market as a catalyst for environmental innovation and to increase the opportunities for international co-operation to promote environmentally-related innovations.

This review focuses on the following areas of national environmental innovation policies:

- **International co-operation** measures: the establishment of formal or informal international, regional, or bilateral partnerships to promote R&D activities and accelerate the deployment of environmental technologies; and
- **International market** measures: leveraging international or regional markets, for example through export promotion programmes to scale up the deployment of environmental technologies outside the country of origin.

The environmental innovation strategies of the following eight countries were reviewed: Denmark, Finland, Germany, Japan, the Netherlands, the UK, the US, and Spain.¹⁶ This selection corresponds to the country of origin of the companies that were interviewed for the report. Given the formal connection between EC directives and policies on the domestic strategies of six of the countries, recent initiatives by the EU are also described. The descriptions concentrate on efforts to develop and deploy low-carbon technologies that seek mainly energy efficiency, as well as renewable energy, which is also the focus of the case studies.

The European Union

Since 2004, the Environmental Technology Action Programme (ETAP) promotes eco-innovation in the EU through a range of activities that fall under three core clusters: going from research to markets, improving market conditions, and acting globally (http://ec.europa.eu/environment/etap/index_en.htm). The programme seeks to consolidate an EU-wide market for environmental technologies that offers opportunities for growth for companies whose internal markets are too small. ETAP is part of a broader initiative to increase EU competitiveness (the Lisbon Agenda, http://europa.eu/scadplus/glossary/lisbon_strategy_en.htm).

¹⁶ These reviews are based on information available on the web for EU countries in particular, the ETAP webpage http://ec.europa.eu/environment/etap/linklist_en.htm, as well as on material and input obtained during interviews with government officials.

In the context of ETAP, a crucial step to creating a regional market for environmental innovation is the EU decision to develop an Environmental Technology Verification (ETV) programme (see also Box 7 above). Vendor-generated data have been viewed with scepticism and, consequently, high performing innovative technologies that have the potential to protect the environment have faced substantial market barriers. It has therefore been considered necessary to establish a market-based verification process in co-operation with the private sector in order to overcome those market barriers and assure that data can be accessible, understandable, and credible. Verification must not be confused with certification. The former involves the independent assessment of a technology's performance without any judgment of it, while certification normally goes one step further by guaranteeing that specific standards or performance criteria are met. It is important to remember that verification is a voluntary tool (http://ec.europa.eu/environment/etap/pdfs/overview_env techno_verification.pdf).

Another approach to promoting environmental technologies is the establishment of performance targets for all EU members that encourage industry to develop and take up environmental technologies. Among the main targets are those associated with the Integrated Product Policy, which seeks to minimise environmental degradations of products, the directive aiming at improving the environmental performance of energy-using products (EuP), as well as those arising from the directive dealing with Integrated Pollution Prevention Control (IPPC). Box 8 offers more details on the attributes of the European market for environmental technologies.

Box 8. The European market for environmental technologies

The European market for environmental goods and services was worth EUR 227 billion in 2004, representing 2.2% of the gross domestic product in the EU-25 area. The largest national eco-industry markets are France and Germany, followed by the United Kingdom, Italy, and the Netherlands. Environment technologies (or "eco-innovation") industries in the EU account for about one-third of the global market and employ over two million people. The turnover of the eco-industries grew around 7% between 1999 and 2004 (for the EU-15 area). In 2005 exports grew around 8% and there was a trade surplus of over EUR 600 million. Overall, the sector has enjoyed growth of around 5% a year since the mid-1990s.

The most important sectors in terms of revenue are by far water supply, wastewater treatment, and solid waste management. More recently created industries, such as renewable energy and eco-construction, are growing fast but remain essentially driven by investment needs generated by new environmental policy and legislation. Five crucial factors will affect the future growth of the European eco-industry and therefore affect the policy-making in this field:

- **Public policy:** Setting more ambitious environmental requirements and targets, as well as broadening the scope of existing legislation;
- **Harmonisation:** Establishing harmonised standards for environmental goods and services. For example, integrating environmental performance requirements in building standards can strongly develop markets for eco-construction;
- **Market-friendly measures:** Supporting price transparency and the internalisation of environmental costs in market prices. In addition, the establishment of market incentives such as tax credits, or trading schemes, could contribute to increasing the demand for environmental goods and services;
- **Consumer measures:** Increasing consumers' awareness of the nature and availability of services provided by the eco-industry; and
- **Funds:** Facilitating access to financial supports such as grants and loans to ensure the implementation of eco-industry projects.

Source : DG Environment and Ernst & Young (2006)

The EU's new Competitiveness and Innovation Framework Programme (CIP), has a budget of EUR 3.6 billion. This programme gives particular emphasis to environmental innovation as a pillar of the EU long-term competitiveness agenda. EUR 430 million were earmarked for eco-innovation exclusively, with efficient and renewable energy sources receiving significant attention.

Another example of internationalisation efforts by the EU is the launching of a risk capital fund of EUR 100 million to spur investment in energy efficiency and renewable energy projects in developing countries (http://ec.europa.eu/environment/etap/pdfs/dec06_geeref.pdf). Known as the "Global Energy Efficiency and Renewable Energy Fund," it will stimulate the creation of regional sub-funds tailored to meet regional needs and conditions, rather than investing in projects directly. Priority will be given to investments below the EUR 10-million mark for the deployment of environmentally-sound technologies that have a proven technical record.

The 2006 Action Plan for Energy Efficiency outlines a six-year framework of policies and measures to intensify the process of achieving the over 20% estimated savings potential in EU annual primary energy consumption by 2020. The largest cost-effective savings potential, according to the European Commission, lies in the residential (households) and commercial buildings sector (tertiary sector). Though the Plan focuses on local actions (*e.g.* "energy efficiency starts at home"), it also has an international dimension. To "foster energy efficiency worldwide" the Commission will aim to develop an "International Framework Agreement on Energy Efficiency" with key external trading partner countries and international organisations.

The agreement will focus on improving energy efficiency in end-use sectors and in energy transformation by using a number of policies and measures. The partners will include Brazil, China, India, Japan, Russia, and the United States and the collaboration will involve, *inter alia*, the United Nations, the International Energy Agency, the G8's Gleneagles Dialogue on Climate Change, the World Trade Organisation, the World Bank, and the European Bank for Reconstruction and Development. The goal is to develop closer co-operation on energy efficiency measurement and evaluation, minimum performance requirements for goods and services, labelling and certification, energy audits, stand-by losses, and codes of conduct. It should cover all end-use sectors, including transport, as well as energy transformation, where the global potential is large. The international partnerships action plan is expected to have the following milestones:

- Initiative for an International Framework Agreement on Energy Efficiency (2007);
- Voluntary agreements with export industries on information, minimum efficiency requirements, and labelling (2007-2012);
- Energy efficiency in energy and trade treaties, agreements, dialogues, and other co-operation frameworks (2007-2012);
- Co-operation on measurement methods for minimum efficiency requirements and labelling (2007-2012);
- International network for dissemination of information and advice on efficient technologies (2009).

Denmark¹⁷

The Danish Government promotes innovations that have an environmental component through several initiatives led by several ministries, consortia, and schemes. The Danish Council for Strategic Research and the Danish National Research Foundation play a central role in promoting environmentally-related R&D and allocated nearly DKK 180 million (more than EUR 20 million) to this effort in 2006.

The Danish Advanced Technology Foundation also offers environmentally-related R&D grants with 12 projects receiving over EUR 25 million. In 2006, the government made the commitment of putting more priority on more common research activities within the EU with special focus on climate change, the increasing pressure on the world's water resources, and the spread of toxic chemicals. The national environmental innovation strategy also mentions Danish participation in technology collaborative platforms within the European Union.

According to the government, “for a small, specialised country like Denmark a strategy for environmentally-friendly technologies has to be international in approach.” Hence, a central aspect of the strategy is exports promotion complemented by increased collaboration between Danish companies with institutions and companies abroad. Thus far, circa 420 Danish enterprises involving 60 000 employees consider themselves to be environmental technology providers with a majority of their production dedicated to exports. A concrete and representative example of this industry's international potential are wind energy providers: in 2005, 99% of their turbines were sold outside Denmark.

In 2006, the Ministry of Environment launched its most recent “eco-innovation” strategy. Organised around those areas that the government sees as the most promising, the strategy aims to advance export opportunities to further promote the environmental technology sector. Initially, efforts will target markets in the US, Brazil, Russia, India, and China, and in particular will focus on energy efficiency, wind energy, biomass, and waste, as well as the aquatic environment. The strategy is described in more detail in Box 9.

The Danish Ministry of the Environment published two background reports in connection with this strategy. One is an analysis of the global market for eco-efficient technologies; the other an analysis of Danish strongholds in the area of eco-efficient technologies.¹⁸ The first analysis shows that at least 420 companies with 60 000 employees see themselves as environmental enterprises, along with 46 knowledge institutes focusing on eco-efficient technologies. This makes the environment cluster one of Denmark's largest business sectors. A majority of companies focus on (in this order) climate/energy, water, chemicals, air pollution, and waste. Five promising areas have been identified: wind energy from mega turbines, water purification, industrial biotechnology, biofuels, and fuel cells.

¹⁷ This section is based on Danish Government (2006).

¹⁸ The reports were prepared by COWI, an international consulting group specialised in engineering, environmental science, and economics, and FORA – a research and analysis division of the National Agency for Enterprise and Construction, respectively. See also Andersen, T. (2007)

Box 9. Danish Strategy on Promoting Eco-efficient Technology

In June 2006, the Danish Government published a strategy for promoting eco-efficient technology. The report is also an invitation to dialogue with the Danish parliament, companies, researchers, investors, etc. on how Denmark can accelerate eco-innovation, how it can achieve better cohesion between different policies, and how to improve the marketing of national environmental knowledge and expertise. In this strategy, the Danish Government presents nine specific initiatives for promoting eco-innovation. These include:

- **Partnerships for innovation.** The Government will enhance public-private co-operation between the state, companies, research institutions, and venture capital;
- **Targeted and enhanced export promotion.** The Government will enhance their efforts for exports of Danish eco-efficient technology. The overall goal is to improve the synergy between Danish national activities, participation in the global political scene, and exports of eco-efficient technologies. Initially, efforts will target markets in the US, Brazil, Russia, India, and China, and in particular they will focus on energy efficiency, wind energy, biomass, and waste, as well as the aquatic environment;
- **Research and technology development in the interests of the environment.** The Government will make special efforts to promote eco-efficient technology at universities and technological institutes. An active contribution to the Danish National Advanced Technology Foundation will also have priority, e.g. in work with partnerships for innovation;
- **Strengthened efforts to promote eco-efficient technology at the Ministry of the Environment.** The Ministry of the Environment will co-operate closely with other ministries and the private sector to strengthen the efforts to promote eco-efficient technology. The Ministry will allocate resources for more systematic work with eco-efficient technology to bridge the gaps between environmental authorities, the private sector, research, and various users and buyers of eco-efficient technology;
- **Targeted promotion of eco-efficient technology in the EU.** The Government will systematically encourage the EU to increase its support for development and use of eco-efficient technologies and products. The Government emphasises effective implementation of ETAP in the EU;
- **Climate and energy technology.** The Government will support the promotion of Danish strongholds within energy technology. A new energy technology development and demonstration programme will help meet the three central energy policy challenges in the Government's Energy Strategy 2025 regarding security of supply and global climate challenges, as well as growth and economic development;
- **Environmental impacts from livestock farms.** Among other initiatives, the Government will establish a new environmental approval scheme for livestock farms, which will simplify and harmonise the approvals system and require use of new eco-efficient technology;
- **A clean and unspoilt aquatic environment.** The Government will increase its focus on the development of eco-efficient technology that can help meet the environment objectives for water;
- **A healthy environment.** The Government will work to promote eco-efficient technology that reduces harmful pollution.

These initiatives build on ongoing and new initiatives across sectors and will be continuously developed in close interplay with Danish, European, and international regulations in the individual areas. In order to fund the proposed initiatives and further enhance current existing budgets, EUR 16 million will initially be appropriated in 2007-2009 to promote eco-efficient technology in Denmark.

The role of the government in these partnerships is to:

- Form the partnership: Bring competencies and knowledge together – companies, knowledge institutions, and government;
- Secure that research and demonstration projects are designed and carried out in accordance with current legislation;
- Act as mediator between the parties, keep up momentum, initiate relevant studies and analysis to support the research and development activities in the partnership; and
- Discuss the need for change of public regulation.

Source: based on: EC, http://ec.europa.eu/environment/etap/pdfs/nov06_dk_strategy_on_ecoefficiency.pdf, Government of Denmark www.ecoinnovation.dk, Andersen. T. (2007).

Finland¹⁹

In Finland, four funding institutions promote environmental R&D: the National Technology Agency (Tekes), the main public funding organisation for R&D in the country; the Academy of Finland with a focus on basic research; the Finnish Innovation Fund (Sitra); and the Finnish Environmental Cluster Research Programme whose theme for 2006-2008 is the “Eco-efficiency Society.” The funding institutions collaborate with two research organisations: the Technical Research Centre of Finland (VTT), a contract centre with technology and applied research expertise; and the Finnish Environment Institute. At the time of writing, the Finnish Government estimated that “within national technology programmes, more funding than ever is being allocated to the development of environmental technologies.” Within Tekes funding, circa 20% (*i.e.* EUR 81 million) of projects contain a significant environmental component.

In the field of bioenergy, and biomass in particular, VTT is one of the largest European centres conducting R&D. It has taken a proactive international approach by working with R&D institutes and industrial partners outside Finland to advance bioenergy technology. One concrete example is “Bioenergy NoE,” which brings together eight leading bioenergy institutes in Europe. This network seeks to build a Virtual Bioenergy R&D Centre that “can spearhead the development of a technologically and economically efficient biomass and bioindustry in Europe” (www.bioenergynoe.org).

With a budget of EUR 70 million between 2004 and 2008, the Technology Programme Business Opportunities in Mitigating Climate Change (or “ClimBus”) aims to identify and maximise opportunities for Finnish companies in the global market for mitigation technologies and services. The vision underlying ClimBus is that Finnish firms will be important suppliers of technology and services in international markets in areas related to climate change mitigation by 2010. It estimates that the net sales of the sector will grow from the present EUR 4.5 billion to EUR 7 billion (www.tekes.fi/climbus). The programme focuses on clean energy production and fuels, business service, energy efficiency technologies, and non-CO2 greenhouse gases. The programme also aims at identifying global market opportunities for technologies after 2010.

In its analysis of how its innovation strategy addresses environmentally-related technology development, the government points out that a central challenge is not the shortage of technologies but that “market and demand issues play too small a part in the technology development and programmes.”

¹⁹ This section is based on Finnish Government (2006).

Instead, they argue, the challenge ahead is to turn Finnish technologies “commercially and internationally marketable, and to develop and improve business skills needed for this.” A critical component is therefore to match international opportunities and Finnish expertise. One proposed action to promote this match is the coaching of participating companies in their final phase of technological programmes on how to turn their products into marketable products internationally.

Another example of the efforts to increase the international opportunities for growth for the environmental technology developers in Finland is the programme “Cleantech FinlandTM,” which aims to boost environmental innovations within small and medium-sized enterprises (SMEs). It identified nearly 300 environmental technology firms in the country that generated around EUR 2.1 billion in 2003. They are mostly small, recently created, and some of them are starting to “go international”. Hence, with the turnover from subsidiaries abroad, the Finnish environmental technology sector accounts for nearly EUR 3.4 billion excluding traditional “eco-industries” such as waste management and wastewater utilities that account for an additional EUR 1.3 billion. In Finland, 20 to 30 companies are considered environmental technology leaders and their strategy suggests that SMEs could benefit by acting, at least initially, as their subcontractors.

In order to support the internationalisation of these SME innovators, Cleantech FinlandTM promotes international company networks (mainly in the EU), launches market studies and pilot projects, and offers financing mechanisms to promote exports. The companies also work with Finpro, the governmental agency, in charge of promoting the internationalisation of Finnish companies (*e.g.* helping them identify the export countries with the greatest potential).²⁰

The Finnish environmental technology strategy also suggests that in order to increase the competitiveness of environmental technologies providers, these companies should offer comprehensive “solution” packages, and not simply a specific technology.

In 2005, Finland’s Innovation Fund (Sitra) launched a programme to build on Finland’s environmental technology know-how and turn it into a key area of growth in international markets (www.sitra.fi/en/Programmes/environment/environment.htm). One concern was that growth in Finnish environmental exports has been slower than the overall development of the markets. In Sitra’s view, only a few enterprises are international leaders and many small companies dominate the sector. In fact, the number of new businesses entering this industry has decreased in the past few years, and only a few medium-sized environmental technology enterprises are suited to international markets at the moment. Hence, with the Environmental Programme, Sitra seeks to stimulate exports of environmental technology by maximising the opportunities presented in the growing international market for such technologies. The aim of Sitra’s programme is to expedite the development, internationalisation, and integration of the environmental sector; promote investments in the field; create business networks and promote their internationalisation; and devise a national action programme to support the growth of environmental technology exports. One example was to launch a study of the Indian market for environmental technology (see Box 10).

²⁰

Finpro is an association founded by Finnish companies. They work with clients at different stages of internationalisation to guarantee that, especially, small and medium-size companies have access to high quality, comprehensive internationalisation services around the world (www.finpro.fi/en-US/About+Finpro).

Box 10. “Five roads to India”: internationalisation of Finland’s environmental technology strategy

In 2006, Finland's National Fund for R&D (Sitra) and an international business association examined the potential of the Indian Market for Finnish exports of environmental technologies. According to the report, “Opportunities for Finnish Environmental Technology in India”, the economic growth of India and its extensive markets are creating a growing demand for environmental technologies and know-how:

The report also describes why the emerging opportunities for Finnish companies are beneficial to India too. Additionally, the report provides information to help Finnish companies succeed when co-operating with Indian partners. At least five areas offer particularly high export potential:

- **Environmental monitoring:** India has a growing demand for the monitoring of water and air quality. The demand is targeted at the development and construction of monitoring systems as well as measuring stations and the equipment required by them;
- **Clean technologies for industry:** India’s strict legislation is steering industries towards adopting more modern technologies. Industrial companies in India are already investing in cleaner technologies, creating business opportunities particularly in water treatment processes; energy efficiency; and material utilisation in the chemical, paper, and steel industries. Prevention of industrial hazardous waste, as well as its utilisation and handling are also promising fields for business;
- **Climate change and carbon markets:** India offers excellent opportunities for emissions trading and for various technology producers that could help create emission reductions for India through the clean development mechanism;
- **Renewable energy:** India boasts one of the most extensive renewable energy source programmes. This creates opportunities for Finnish operators in wind power and biomass utilisation (e.g. “bagasse”, the biomass remaining after sugarcane stalks are crushed to extract their juice), as well as combined heat and power production. There is also demand for water power and biogas plants;
- **Waste management:** There is demand for waste management concepts and technology solutions, and for solutions that improve the profitability and efficiency of the sector. India’s large cities require more efficient waste collections and transportation systems, landfill technology, hazardous waste treatment, and consultation.

Source : Sitra (www.sitra.fi/en)

Proposed to last three years (2005-2008), the Programme entails investments in promising SMEs that are seeking to expand their presence in international markets, as well as expand their networks with other companies. Sitra publishes reports (e.g. exports prospects to Baltic countries, Russia, and Ukraine) and carries out pilot projects. In addition, together with other interested stakeholders, the Programme established an action plan to enhance the prerequisites for exporting environmental technology and know-how.

*Germany*²¹

Germany is engaged in several initiatives to draw the maximum benefits and opportunities from globalisation to address environmental problems while boosting its environmental industry sector.

The Federal Government created a programme to support market penetration of innovative environmental technologies in the late 1970ies. The “Environmental Innovation Programme” funds industrial-scale pilot projects in key environmental sectors such as climate protection, renewable energy and transport. These projects show how innovative technologies can be used in practice. The programme centres on projects that are promising both from an environmental and a commercial point of view, and are well suited for demonstration purposes. The projects can lead to further refinement both of the technologies involved and of the relevant environmental regulatory framework. Small and medium sized enterprises receive priority funding. While in the 1970ies mostly “end-of-pipe-technologies” were selected, current project selections focus on integrated technologies, including product and service facilities. The funding mechanism includes grants to reduce interests on loans and investment support (www.bmu.de/foerderprogramme/pilotprojekte_inland/doc/2330.php).

In 1992, the programme was extended to include the promotion of investments aimed at reducing environmental pollution abroad (“pilot projects abroad”). The purpose is to provide financial support for environmental pilot projects in EU accession countries. The programme has the objectives to support environmental pilot projects which will either have direct transboundary environmental effects in Germany or demonstrate effective climate protection by realizing cost-efficient model solutions (“lighthouse projects”). The overall goal is to encourage environmentally friendly investments in these countries (www.bmu.de/english/pilot_projects_abroad/doc/5684.php.)²². This programme has been very efficient and is considered to be a success.

Another recent initiative is the Memorandum for a “New Deal” for the economy, environment, and employment, issued in October 2006 by the Federal Ministry for the Environment, Nature Conservation, and Nuclear Safety (BMU). According to Germany’s Minister for Environment, this new ecological industrial policy for the future, “would serve to better position Germany and Europe in the global economy. Innovation is at the core of this policy. Box 11 summarises the guidelines contained in the Memorandum, considered necessary for the success of the policy.

²¹ This section is based on German Government (2006).

²² The recently published brochure “Innovative Technology for the Environment – Pilot Projects by the Federal Environment Ministry” provides further information about this programme and presents eleven examples including a “biomass combined heat and power plant using forest woodchips and sawmill leftovers”, the “Thousand Green Taxis for Berlin project, powered by natural gas” and “the Latvia housing energy rehabilitation initiative”; www.bmu.de/english/miscellaneous/current/doc/38094.php.

Box 11. Germany's "New Deal" for the economy, environment, and employment

According to the Memorandum for a "New Deal", the following guidelines must contribute to the success of ecological industrial policy and thus to the establishment of a true global efficiency revolution:

The state has to play a pioneering role

The state and its environmental policy are important innovation drivers. With state demand, the design of a regulatory framework and ambitious limit values that are announced in good time and with planning security, policy makers can instigate carefully targeted innovation incentives.

Set benchmarks as the basis for ecological industrial policy and action

The state, industry, and society must develop a political paradigm to counter ecological threats and global needs, which can be used to guide innovation policies. Joint objectives create acceptance for innovation – particularly if they make it clear that not everything that is technically feasible will actually be implemented. Concrete benchmarks help to structure the political agenda.

Develop an intelligent regulatory framework for ecological industrial policy

In the past, the "German model" drew its strength from an innovation strategy based on long-term investment cycles, particularly of small and medium-sized companies. Today they are often helpless in the face of global market dynamics. Despite the structural difficulties they face in the international context, something must be done to help long-term perspectives achieve a breakthrough. The regulatory hand of the state and the strategic view of policy-making must contribute to this.

Exploit export potentials more effectively

The export initiative for renewable energies has contributed to the success of this industry. We should use the experience gained here to promote the export of other environmental technologies in a more focused way. The range of environmental technologies must be expanded if they are to be disseminated more widely. But boosting international demand is equally important. Exporting successful policies plays an important role in this. The German Renewable Energy Sources Act is an example of how a successful instrument has become established internationally and how climate change policies have decisively contributed to the success of an entire industry.

Accelerate the market launch of innovative technologies

State procurement policy and intelligent market introduction programmes can help disseminate innovations. But companies must also shoulder responsibility and ensure that their product policies reflect state of the art developments. The top-runner approach has contributed to the strength of the Japanese consumer electronics industry. A European top-runner programme would be to help create a revolving innovation system in Europe.

Improve innovation financing for companies

The high costs associated with innovation projects and the lack of appropriate sources of financing prove to be central problems: small and medium-sized companies in particular can easily come up against their limitations. Lenders often impose restrictions due to uncertainties about the technological feasibility and market acceptance of ideas for innovations. If obstacles to financing could be overcome and financing for innovations improved, significant innovation potentials could be tapped. A mix of financing instruments that can respond adequately to companies' specific financing situations is needed.

Create lead markets and develop "man to the moon" projects

Technological development cannot be decreed "from above." But technological development does not take place in a vacuum. It is vital that the framework conditions centre on innovation. In addition, funding of

research and development that is strategic and focuses on lead markets can also make an important contribution.

Build new institutional structures for innovation

Innovation needs dialogue. But dialogue needs structure in order to permanently establish innovation as an issue to be tackled jointly by industry, society, and the political arena. One of the problems innovation strategies suffer is that they are fragmented in terms of financing, instruments used, and content. But crosscutting issues need crosscutting research and innovation strategies. An "industry cabinet" would force the major government departments to co-ordinate their policies at ministerial level. That would strengthen political impetus and is the prerequisite for a concerted strategy.

Source: Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (BMU), www.bmu.de/english/current_press_releases/pm/38146.php.

In the current legislative period (2005-2009), the government is focusing on stimulating research and technology in environment and energy technology. Under the aegis of the Federal Ministry of Education and Research it has recently developed a High-Tech Strategy, which bundles the Federal Government's strategies and actions into selected high-tech sectors to, *inter alia*, better face the challenges of globalisation. In the High-Tech Strategy, consideration is given to cross-cutting technologies like biotechnology and nanotechnology, but also to application fields such as energy and environmental technology. The aim of the Strategy is to build bridges between research and future markets. The focus will be on interlinking science and economics by means of modern cluster policies and new science and technology transfer tools. A selection of "lighthouse projects", *e.g.* on energy efficiency, finding new energy sources, or developing highly-efficient power stations with the aim of reducing CO₂ emissions to zero, are expected to help strengthen Germany's international competitiveness as a centre of technology.

With this initiative, the German government has developed, for the first time ever, a comprehensive national strategy for all its ministries with the aim of "putting [our] country at the top of the world's ranks in tomorrow's most important markets". Under this strategy, "all political sectors that affect research and development will be geared to a clearly defined goal".

According to the government, "We are feeling the effects of globalisation more than ever. There is no way Germany can compete with low-wage countries on a cost basis. As a result we will always need to try to keep a step ahead of the others. We can achieve competitive advantages and growth opportunities by developing new ideas, products, and system solutions. This will help create jobs and safeguard our standard of living as well as that of our children."

To implement the Strategy, the German government is investing an additional EUR six billion in research and development during the current legislative period. This represents the largest increase in research funding in the history of the Federal Republic of Germany. A total of some EUR15 billion will be allocated for cutting-edge technology through the year 2009. This will bring Germany's federal government, *Länder* (state) governments, and trade and industry closer to achieving their common goal: boosting research expenditure to 3% of gross domestic product by the year 2010.

The Strategy defines objectives for seventeen areas of innovation, creating a clear roadmap to be followed in each area. These include energy technologies: a comprehensive energy policy concept for Germany will bundle all measures being taken to ensure a sustainable energy supply. In addition to funding of high-tech developments in the indicated sectors there will also be strong support of intersectoral efforts.

Another recent initiative is the internet portal "Cleaner Production Germany" (www.cleaner-production.de), which provides information about the performance of German environmental technologies and environmental services. It contains professional summaries for quick orientation; detailed practical

examples of the state of the art; links to all key participants; comprehensive information about national and international promotion measures; and detailed information on energy, research and innovation, and environmental technology export.

The aim of the Internet portal is to make German and non-German stakeholders more aware of sustainable technologies, processes, and management strategies. It facilitates contact in the environmental technology field and in doing so fosters the development of business relations and co-operation. The project is promoted by the Environment Ministry and is constantly further developed under the aegis of the Federal Environment Agency.

The Renewable Energies Export Initiative (REEI, www.exportinitiative.de.) promotes the export of German renewable energy technologies. The aim is to establish a strategy that meets the needs of SMEs from the renewable energies sector, to disseminate German technologies internationally, and to implement specific actions to open up global markets. REEI supplies structured and sector-specific information on the most important international target markets, through publications and specialised events. It also arranges contacts with foreign business partners and customers. In addition, the REEI is involved in two climate protection funds intended to finance Joint Implementation and Clean Development Mechanism projects.

*Japan*²³

In March 2006 the Japanese Government launched a science and technology plan laying out the main goals and challenges for technological development in the coming years (Japanese Government, 2006a). Environmental issues are addressed in general terms (*e.g.* in terms of funding, a number of areas, including “environmental sciences,” will be a priority area). The strategy focuses on governmental measures and domestic objectives, and does not address the links to the business sector and international markets.

Japan’s new energy plan was released in May 2006 and placed energy security as its cornerstone objective (Japanese Government, 2006b). One of the three main pillars of the strategy is to establish a common, sustainable development foundation through a comprehensive approach for energy and environmental issues. The document also mentions the need to work “hand-in-hand” with the private sector. To achieve the strategy objectives, the Japanese government is seeking to raise energy efficiency and reduce oil dependence. Specific targets are to be met by 2030, of which the most prominent are: to improve energy efficiency at least another 30%; to reduce the ratio of oil dependence to a level below 40% and to reduce the ratio of oil dependence to 80% in the case of the transport sector. To achieve these goals, the government has established implementation plans that focus on specific themes, *inter alia*, transport innovation, “new energy”, and nuclear power.

To improve energy efficiency, the government relies on boosting innovation and on carrying out internal reforms to speed up the demand for innovative products and companies. Governmental measures to achieve this goal include the establishment of performance standards for specific sectors, such as housing. For example, financing and improved policies could help boost the demand for energy-efficient appliances in individual homes. The strategy also mentions, although in general terms, the need to encourage international efforts to promote “energy conservation standards and assessment systems by sector and aim for a full-scale international dialogue by 2008”, the year when the G8 summit will be held in Japan.

The activities to reduce oil dependence in the transport sector include: standards to promote fuel efficiency of passenger vehicles; new blending limit regulation of oxygenated compounds that contain ethanol by 2020; support for regional efforts leading to increased ethanol production; and dissemination of

²³ This section is based on Japanese Government (2006b).

electric and fuel cell vehicles including supporting the development of safe, efficient, low-cost hydrogen storage technology.

In the field of innovation in the development of “new energy” to reduce oil dependence, the plan offers the creation of support mechanisms, such as favourable taxation, to increase the market for solar, wind, and biomass energy technologies. The plan also mentions the need to promote demonstration projects where “people could view, touch, and understand the new energy supply.”

The implementation of the new national energy strategy rests on three types of activities:

- **Promoting the “creation of powerful enterprises”:** in addition to meeting domestic demands, Japanese companies are expected to strengthen their presence in international markets. To support these companies, the government will promote funding mechanisms, and technical and management capabilities by improving local market conditions;
- **Establishing efficient and effective use of policy tools:** these tools include budgetary and fiscal measures as well as the establishment of clear targets and progress assessment procedures; and
- **Implementing public hearings and public relations on energy and energy education:** the aim of these is to gain understanding of how users and the market respond to the energy measures in place and to promote awareness in the Japanese public opinion about the need to save energy.

One aspect highlighted by the strategy is the need for collaboration between the government and the private sector to meet the objectives of the strategy, an aspect that remains absent in the science and technology national strategy. Japan’s approach is clearly focused on the domestic market although some sections adopt an international dimension. For example, the government mentions the need to work “hand-in-hand” with the private sector to become “the world’s top runner in many of the energy-related technology sectors including energy-technology.”²⁴ The document, however, does not explain how this goal will be implemented.

In the area of co-operation, Japan seeks to establish a regional framework to save energy. The “Asia Energy and Environmental Co-operation Strategy” seeks to promote **energy conservation**, which Japan views as the country’s strength, by working with other countries in Asia mainly, China and India, given the rapid increase of their energy demand. Other candidates as “priority countries” are Thailand, Indonesia, and Vietnam (see Box 12).

The co-operation framework would tackle the following five areas:

- **Energy efficiency or conservation:** the activities include setting up energy efficiency standards and labelling systems (for the consumer, transport, and electricity sectors), and industry dialogues, as well as the use of international approaches, such as the clean development mechanism; assessing energy efficiency efforts using international benchmarks; and collaboration with the International Energy Agency;
- **Development of “new energy”:** the goal is to accelerate the adoption of new energies in the participating countries by promoting training, dispatch of experts throughout the region, and the development of new energy technologies;

²⁴ This relates to Japan’s “Top-runner programme” to spur innovation in energy efficiency. For more information, see: www.eccj.or.jp/top_runner/index.html

- **Clean coal:** the objective is to promote the dissemination of clean and safe coal technologies in Asia through training programmes, experts dispatching, and technological development and testing. Co-operation will be promoted in the area of coal liquefaction technology;
- **Stockpiling:** Japan proposes to build an effective stockpiling Asian scheme by developing a regional framework that facilitates co-operation and expertise exchange; and
- **Nuclear power:** the goal is to promote a common framework to safely develop this type of energy.

Box 12. NEDO's role in promoting R&D in Japan and overseas

The New Energy and Industrial Technology Development Organisation (NEDO) is the largest R&D management organisation in Japan. It promotes R&D projects that the private sector alone cannot implement. NEDO facilitates these activities by promoting collaboration between industry, universities, and public research organisations, and by providing public funding. Fields that receive NEDO support include: advanced industrial, environmental, new energy, and energy conservation technologies, as well as the dissemination of developed technologies.

Established in 1980, NEDO started to conduct energy R&D obtaining successful results in the development of photovoltaic power generation, among other areas. In the past years, the scope of activities has been expanded to include other technological fields such as environmental and advanced industrial technologies, e.g. electronics, nanotechnology, and medical technologies.

Recent projects include the following examples:

- **Energy conservation technology:** transformation of flat panel televisions by developing energy-saving screens;
- **Fuel-cell and hydrogen technologies:** establishment of codes and standards for a hydrogen economy that promote fuel cell vehicles that can be operated safely;
- **New energy technology:** development of new energy power storage technologies for next-generation vehicles, in particular the creation of new battery technology to be used by vehicles;
- **Introduction and dissemination of new energy:** promotion of R&D and dissemination of photovoltaic, wind energy, and biomass technologies.

NEDO is currently also promoting the adoption of advanced Japanese energy conservation and alternative energy technologies in Asia. One example is in China's cement industry. China has seen cement production increase rapidly because of the country's strong economic growth. To help reduce the environmental footprint of the cement plants in China, which are in many cases outdated, NEDO introduced, between 2002 and 2004, Japanese technology that allows Chinese cement plants to recover and use waste heat to generate power. This technology is incorporated in most Japanese cement plants already.

China's largest cement manufacturer began installing waste-recovery power generation systems in several of its complexes in 2006, to be completed by 2008. The power generated from these 11 Chinese plants will be almost equivalent to all the output generated in Japan with that technology. The benefits for China will be the energy savings of 1.31 million megawatts per hour and a reduction of CO₂ emissions of 1.07 million tones. To ensure that the waste heat recovery generation systems are adopted in China, reducing the cost of the equipment is necessary. To achieve this, NEDO's project required that, whenever possible, major equipment needed to introduce this technology (e.g. steam turbines and power generators) be procured from Chinese suppliers.

Source : NEDO, www.nedo.go.jp/english

*Netherlands*²⁵

The Dutch environmental innovation strategy does not have an explicit “internationalisation” component. The strategy, however, emphasises the need for regional collaboration on environmental R&D activities. One concrete step in that direction is Sustainable Enterprise or “Susprise”, an international initiative, led by the Dutch government and funded by the European Commission involving other environmental innovation organisations and ministries from Austria, Belgium, Denmark, Germany, Sweden, and the UK, as well as an entity from Spain’s Basque Country (www.susprise.net). Susprise is co-ordinated by SenterNovem, a specialised environmental innovation centre affiliated with the Dutch Ministry of Economic Affairs (www.senternovem.nl/English).

A key aim of Susprise members is to encourage synergies in R&D efforts to promote environmentally-related technologies. This consortium has allowed participating governments to exchange information on R&D programmes, priorities, funding systems, working methods, and experiences. Underlying this programme is the goal of turning the EU into “the most competitive region in the field of environmental innovation”. Some of the milestones of this international collaboration effort include the development of a database with R&D projects in the area of environmental innovation and examining best practices in programme design and implementation. The project was scheduled to end by December 2007 and to continue as part of a broader initiative to promote EU environmental innovation in the EU. The total cost for co-ordination during the four-year period is estimated to be EUR 2.7 million.

Another initiative, the “Dutch Energy Transition” strategy seeks, *inter alia*, to reduce the country’s dependence on foreign oil in the next 50 years (www.senternovem.nl/EnergyTransition/Index.asp). Seeking to develop a sustainable energy system and to increase the competitive position of Dutch business, the strategy targets six technology platforms (mobility, biobased-raw materials, efficiency, gas, electricity, and buildings). Companies are expected to contribute to the transition by saving energy in their production processes, but especially by introducing products and services to the global market that can lead to energy savings and greater use of sustainable energy sources.

Underlying the focus on market opportunities outside the Netherlands is the realisation that the space for energy innovation is “largely determined by international market and policy developments” and constantly “exploring the limits of what is possible nationally and internationally.” When national limits constrain the opportunities for innovation, the government will aim at promoting: (a) international co-operation to, *inter alia*, promote large-scale markets for specific products required to accelerate the learning curve of new energy technologies; and (b) collaboration on strategic R&D on sustainable energy with like-minded countries and companies in the EU context.

According to the government, technology development is beneficial for commerce in the Netherlands, “only where it also concerns technologies with a large potential outside the Netherlands and where there is a realistic possibility to develop a solid position in that market.” In the energy field, the argument goes, the realisation of this global market potential for energy technologies will be beneficial not only because it might increase the country’s competitiveness but also because it could help the Netherlands reduce its greenhouse gas emissions in line with its international commitments under the Kyoto Protocol.

The strategy recognises that the lack of a global market for sustainable energy technology poses “the chicken-or-egg” dilemma (“no demand means no supply, which means no demand”). Part of the solution, in the Dutch government’s view, lies in measures to increase consumer demand for energy-efficient cars and cleaner fuels. One proposal under the technology platform promoting sustainable mobility is to create a labelling strategy for the automobile market, not only in the Netherlands, but also internationally, that

²⁵ This section is based on Dutch Government (2006).

will help consumers choose a cleaner and more economical car. From a supply perspective, the platform calls for the creation of an international network that allows for experimentation.

Hence, some international opportunities for Dutch companies include the development and supply of clean gas, and of parts – both for hydrogen-powered cars and hybrid vehicles. Another potential benefit is in the transition toward “intelligent transport systems” (which allow for “predictable travel time and optimal route planning, comfortable and safe travel and low environmental burden per passenger-kilometre”).

*Spain*²⁶

In Spain, the government has established the following areas as top priorities for environmental innovation: climate change, urban sustainability, improvement of production processes, water management and conservation, energy, and transport. The Programme to Promote Technical Research was part of a broader national plan to promote innovation in 2004-2007. The goals include promoting Spanish business participation in international R&D collaborative efforts as well as the support of R&D activities that focus on renewable energy and the reduction of GHG emissions.

The Centre for Industrial Technology Development (CDTI) has financed over 50 environmental technology-related projects, with an average budget of around EUR 40 million and a financial contribution of EUR 20 million to environmental projects only (www.cdti.es). Approximately 10% of these projects are associated to international R&D initiatives: for example, Eureka (a European collaboration) and Iberoeka (a collaboration between Spain and Latin American countries). Another programme is Chineka, a “bilateral Spanish-Chinese programme for technological co-operation that promotes international technological co-operation between entities in Spain and China. It supports projects led by companies with the goal of promoting the competitiveness of Spanish and Chinese companies, and by supporting the execution of joint technological projects oriented towards the development and/or adaptation of new products, processes or services intended for international markets.” Environmental technology is an important component of these programmes, and normally comprises a third or a quarter of the total amount of funding.

Energy is a prominent theme throughout Spain’s environmental technology strategy. The country’s energy intensity is below the European average and the country has commitments to converge with its neighbours, which in turn translate into further investments in energy R&D. In particular, the Energy Saving and Efficiency Strategy calls for a reduction in primary energy consumption of 0.83% over four years (www.mityc.es). Moreover, the Renewable Energy Plan tightened its goals for the next years hoping to boost internal demand for wind energy, photovoltaic energy, thermoelectric solar energy, and biofuels. The latter are expected to provide 5.83% of fuel used for transport. Total investment under this plan is EUR 23 million.

In addition to R&D funds, environmental technologies are supported through market measures. For example, the Spanish government has launched an internationalisation plan to increase the technology content of the country’s exports. Some of the sectors in this plan are renewable energies and energy efficiency, environment, and waste management. The country’s Energy Plan further emphasises international opportunities for Spanish developers of renewable energy. The plan calls on Spanish companies to take advantage of its unique and advantageous position in certain markets, in particular those dealing with wind and solar energies.

²⁶ This section is based on Spanish Government (2006).

In the Energy Plan, the Spanish government acknowledges not only that the global market for renewable energy poses a unique opportunity for export growth but also expresses a sense of urgency as a number of competitors quickly enter these markets, in particular the wind energy sector. Thus, the government is furthering its support for R&D and deployment activities in these industries to, *inter alia*, help drive costs down, especially in the case of solar energy. However, the government is also aware of the fact that innovation coming from abroad is important for a relatively low-innovation country such as Spain, and support measures are therefore open to foreign companies and research institutes operating in the country.

United Kingdom²⁷

International markets, as a theme, are absent from the UK's environmental innovation action plan. This absence is partly because the core mission of the UK's Department for Environment, Food, and Rural Affairs (Defra) is, according to a Defra representative, to "protect the environment," not to promote innovation, *per se*, or to identify ways to increase the competitiveness of British environmental technology providers. Accordingly, other governmental agencies, in particular, the Department of Trade and Industry (DTI) have launched initiatives to increase the competitiveness of UK business through innovation — including renewable energy technologies. One of these initiatives, the creation of the Environmental Innovations Advisory Group (EIAG), was launched jointly by Defra and DTI (see Box 13).

Some of the measures focus on the domestic market but others look for market and collaboration opportunities beyond the UK. One example is the exploration of a partnership between the UK, Brazil, and South Africa to stimulate the production of bioethanol. One of the conclusions from a 2006 scoping study was that opportunities for collaboration exist in bioethanol production from sugar cane in a number of Southern African countries (www.dti.gov.uk/science/uk-intl-engagement/page34980.html).

The UK Technology Programme also supports relevant industry-led R&D, including emerging energy technologies. These include the Research Council's Energy Programme and several Department of Trade and Industry (DTI) capital grant demonstration programmes. Moreover, the DTI Global Watch Technology Partnering provides free expert support to UK SMEs seeking partnerships with world-leading organisations overseas. This programme intends to help companies: (a) identify overseas technology partners; (b) develop or transfer technologies, products, processes or management practices; and (c) gain entry to new industrial and geographical markets (www.globalwatchservice.com).

In terms of helping business deal in the development and deployment of low-carbon technologies, the Carbon Trust is an example of institutional innovation. By working directly with companies in technology development across a portfolio of technologies, the Carbon Trust has been playing a proactive role not only in accelerating the pace of innovation in energy technologies in the UK but also in commercialising them since 2001 (www.carbontrust.co.uk). Though the Trust was created by the government, it operates as an independent expert organisation.

More recently, the UK government also launched the Energy Technologies Institute to accelerate the development of secure, reliable, and cost-effective low-carbon energy technologies with the greatest commercial potential, including those that meet the energy needs of some developing countries (www.dti.gov.uk/science/science-funding/eti/index.html). The funding will be split fifty-fifty between the sectors — it is planned to invest GBP one billion in R&D over 10 years and to develop links with other countries. Some of the largest energy players are core partners of the Institute, *inter alia*, Shell, BP, EDF Energy, and E.ON, which will be operational in 2008.

²⁷ This section is based on UK Government (2006).

Box 13. The UK's Environmental Innovations Advisory Group

In 2003, the UK Government established the business-led Environmental Innovations Advisory Group (EIAG) and tasked it with identifying practical measures to tackle barriers to innovation in the environmental industries sector, and to mobilise key stakeholders to bring about change. One key purpose of this initiative is to “make the UK more successful in exploiting environmental technologies in the global market.”

EIAG members are drawn from a cross-section of environmental industries. Members are jointly appointed by the Department of Trade and Industry (DTI) and the Department for Environment, Food, and Rural Affairs (Defra), and serve in a personal capacity.

In November 2006, the EIAG published its first report “Environmental Innovation – Bridging the gap between environmental necessity and economic opportunity”. The report explores the opportunities for UK industry in global markets for environmental technology and services (worth USD548 billion, and forecast to grow by up to 30% by 2010), as well as the barriers that need to be overcome to face global competition.

Among the findings of the report are:

- The root of the relative failure of innovation in the UK environmental goods and services sector is not lack of research, but the lack of credibly articulated demand. The solution to this lies in the government taking action to mobilise the supply chain to deliver environmental innovations. This means moving from a focus on R&D and technology push, to a focus on intelligent supply chain management;
- Public procurement has the potential to drive markets for environmental innovations, but current practice fails badly. The EIAG developed a proposal for “forward commitment procurement” mirroring the way private sector companies manage their supply chain – namely by clearly articulating their future needs and providing a credible promise of future sales to provide the security that suppliers need in order to make the necessary investments;
- Government policy and regulation create the market for environmental goods and services; as such, governments can shape the market to get the outcome it wants by putting in place the right mix of policy measures. This requires, *inter alia*, progressive regulations with “stretch targets” to give business the incentive to look at new solutions; long lead times to give business time and confidence to invest in finding new solutions; clear objectives and focus on outcomes rather than prescriptive approaches; support measures such as procurement and fiscal measures.

Source: DTI, www.dti.gov.uk/sectors/environmental/EIAG/page10066.html.

United States

The US innovation system is uniquely decentralised leading to flexible approaches and a competitive spirit. Several federal agencies and departments manage their own programmes to spur environmental technology innovation. In the specific case of environmental R&D, most federal activities accrue from the Environmental Protection Agency (EPA) and the Department of Energy (DOE).

Having an open-ended approach to innovation has fostered multiple forms of collaboration within and across agencies, with industry, academia, and non-profit organisations. On the one hand, EPA has recently proposed a redesign of its R&D strategy moving from a traditional focus on “environmental protection” to the broader concept of environmental sustainability, paying particular attention to collaborative efforts. At

DOE, on the other hand, renewable energy, alternative fuels, and cleaner coal are receiving increased research attention and funding. Over the past years, the National Science Foundation has been a partner in many of the federal efforts to promote environmental R&D.

Together with Japan, the United States offers among the strongest public sector support for energy R&D. For example, the combined funding of US and Japanese governments is around 70% of the total energy R&D expenditure of all IEA member countries reaching USD 6.8 billion in 2004. Measured as a percentage of GDP, energy R&D investments in the United States rank fifth among IEA members while Japanese investments rank first (OECD, 2006b).

The US government also provides major support for R&D in renewable energy. According to 2002 data from the IEA, the United States allocated a peak of USD 700 million for solar energy, and approximately USD one billion for all renewable energies in the early 1980s. Since then funding for solar energy has stabilised at approximately USD 100 million per year for the past 20 years. Biomass support is at a comparable level and is increasing, especially for ethanol, while wind and geothermal energy R&D is supported at a level of approximately USD 40 million each year. A 20% tax credit is also available for “incremental” R&D for private companies. Some joint public-private cost sharing programmes exist as well (www.doe.gov).

The estimated budget authority for renewable energy programmes was nearly USD 349 million in 2003 (these programmes mostly address R&D). Two income tax preferences, a new technology credit, and exclusion of interest on facility bonds supported renewable energy at an estimated outlay of around USD 510 million in 2003 (General Accounting Office, 2005).

EPA’s public-private partnership programmes (www.epa.gov/partners) as well as other collaborative initiatives with industry aim to support, *inter alia*, environmental innovation efforts. These partnerships work throughout the innovation chain, from the research phase to the development, demonstration, verification and diffusion of innovations, including export and trade promotion.

Both EPA and the DOE have put in place public-private partnership programmes to promote innovation in energy efficiency and renewable energy development. One example is EPA’s “Climate Leaders Programme”, an industry-government partnership that provides guidance and recognition to companies developing long-term climate change strategies. According to the programme description, through their participation, companies “create a credible record of their accomplishments, reduce the impact on the global environment, and identify themselves as corporate climate leaders. Though not primarily internationally-oriented, it aims, *inter alia*, at increasing market opportunities for participants (www.epa.gov/climateleaders).

The Clean Energy Technology Export (CETE) programme is a public-private partnership under the DOE that addresses export barriers in global markets.²⁸ The programme does not deal with technology development, but with proven technologies. CETE’s activities fall into three categories:

²⁸ For information on the incentive programmes in place in the US for energy efficiency and renewable energy programmes see www.energy.gov/energyefficiency/index.htm and www1.eere.energy.gov/femp/. The most central collection of data is the Database for State Incentives for Renewables and Efficiency (DSIRE) or the DSIRE website at: www.dsireusa.org. A state-by-state summary of incentive programmes is available at: www.naseo.org/sep/default.htm. The DOE website with similar information is: www.eere.energy.gov/state_energy_program/search_projects.cfm

- **Outreach.** This effort consists mainly on information sharing and co-ordination among agencies. One recent example of this effort is the launching of a specialised website in March 2007 to “assist US companies in the deployment of clean energy technology in global markets”;
- **Tools.** These are programmes that are intended to help multiple vendors with multiple projects and address issues that no one company working alone could resolve; and
- **Partnerships.** These efforts serve to strengthen both efforts mentioned above — outreach and tools. The purpose is to institutionalise contacts and foster regular collaboration with the private sector, rather than encourage such arrangements on an *ad hoc* basis. One example of such a partnership is the effort by CETE to promote fora for venture capitalist and new technology companies where they can explore opportunities to create mutual benefits.

Summary of measures taken by governments to internationalise environmental innovation policies

Government efforts to promote the development and use of environmental technologies, including those aimed at energy efficiency and renewable energy still largely focus on domestic markets. However, this report shows that governments are adopting international co-operation approaches that help them, *inter alia*, share costs and risks of projects that no country alone would undertake entirely.

This approach is becoming increasingly common among European countries. Moreover, some countries, *e.g.* Finland, Denmark, Germany, and Spain are adopting explicit “internationalisation” strategies as part of their environmental innovation policy by encouraging their environmental and energy technology developers to tap into the emerging opportunities of international markets, and supporting them in doing so.

The key measures to internationalise environmental innovation in the EU and the eight countries studied for this report can be summarised as follows:

- **Improving co-ordination between ministries** to take into account the challenges and opportunities of globalisation when developing environmental policies. This includes devising comprehensive national innovation strategies in which all relevant ministries participate and where all political sectors that affect research and development are geared to the goals of supporting the quality and competitiveness of national innovations;
- **Targeting R&D support** by, *inter alia*, increasing and streamlining environmentally-related R&D subsidies to help domestic companies become more competitive in global markets; facilitating access to environmental R&D subsidies to domestic and foreign companies alike, to support that innovation be carried out domestically;
- **Enhancing export capacity:** through, *inter alia*, programmes for eco-industries to learn “how to export”; targeting support towards exports to emerging markets; improving synergies between national activities and participation in global markets, including exports of eco-efficient technologies; coaching companies in their final phase of technological programmes on how to turn their products into marketable products internationally; supporting companies’ presence in international markets, through, *inter alia*, funding mechanisms and supporting technical and management capabilities; promoting government-company partnerships, by, *inter alia*, institutionalising contacts and fostering regular collaboration with the private sector, rather than

encouraging such arrangements on an *ad hoc* basis; and promoting partnerships aimed at increasing market opportunities, domestically and abroad, for eco-innovators;

- **Supporting the “internationalisation” of SMEs**, through, *inter alia*, promoting international company networks; launching market studies and pilot projects; offering financing mechanisms to promote exports; creating programmes to support partnerships with world-leading organisations overseas, including how to identify overseas technology partners, developing or transferring technologies, products, processes or management practices, and gaining entry to new industrial and geographical markets;
- **Increasing consumer demand**, by raising consumers’ awareness of the nature and availability of services provided by the eco-industry and, *inter alia*, labelling strategies not only nationally, but also internationally, in order to help consumers in making better informed choices; and
- **Better co-ordination and information sharing among government agencies**, such as the launch of specialised websites to assist companies in the deployment of clean energy technology in global markets.

6. CONCLUSIONS

This report has explored the links between environmental innovation and global markets, drawing on a review of the recent literature and on a series of interviews with government officials and company representatives. The following preliminary findings emerge from this analysis:

- **Domestic policies shape global markets.** For environmental technologies to penetrate and succeed in global markets, it is important that they succeed domestically. Thus, well-designed environmental policies that spur innovation, and government measures that contribute to creating and consolidating domestic markets for environmental technologies constitute a basis for success in global markets. Gaining market experience at home is especially important in the case for small and medium-size enterprises.
- **The drivers for the internationalisation of environmental R&D do not differ significantly from those of R&D internationalisation in general.** One of the features of the internationalisation of R&D is the increasing relocation and outsourcing of R&D activities, in order to, *inter alia*, bring R&D activities closer to new markets and tap knowledge sources abroad. This also happens in the field of environmentally-related R&D, although in many cases, outsourcing concerns mainly “development” while research is often carried out in the home country.
- **Long-term, stable regulation and market conditions are essential for technologies to access markets and to gain a solid position.** Governments can contribute to these by adopting – and keeping in place over a sufficient period of time – policies that take account of the length of the innovation process for various technologies and their successful market penetration.
- **The diversity of environmental standards could hamper the development of global markets but it can also stimulate innovation.** Diverging environmental requirements could work against economies of scale that are needed to make clean technologies more competitive and could hamper the scaling-up of environmental technologies in global markets. On the other hand, the diversity of environmental requirements and standards could contribute to market dynamism and stimulate companies to innovate in order to satisfy different key markets.
- **Regulation in key markets drives environmentally-related innovation.** One of the main drivers for environmental innovation includes domestic regulation and standards, but those applicable in other countries are also of key importance. Companies operating globally aim at conforming to environmental standards in their key potential markets, even if they are stricter than those of their home country or other, less promising markets.
- **Effective enforcement is necessary to create a level playing field in the marketplace.** Regulatory requirements drive environmental innovation, but they need to apply to all participants. Insufficient enforcement of environmental regulation in one country creates undue advantages for producers and importers who do not comply and may not provide the incentives that domestic firms need to develop internationally-competitive environmentally-related innovations.

- **Government support and policy measures should be technology-neutral.** In order to allow for open innovation, policy measures should avoid focussing on specific technologies, but rather be “technology-neutral”. Otherwise, inefficiencies might occur, *e.g.* when subsidies encourage companies to produce technologies that might not be commercially viable, or where subsidies focus on few technologies (“winners”) and neglect others. Instead, a more effective role for governments would be to invest in creating a solid R&D infrastructure and to enhance technical and scientific education in order to promote a highly competitive and technically competent workforce.
- **Government support for environmental R&D is important but does not seem to be a key factor of environmentally-related innovation (at least for large companies).** The importance of government support for environmental R&D varies by sector. Where there is strong demand for environmentally-related products or processes, government support is not likely to be important. In some areas, *e.g.* energy efficiency, the necessary technology is often already available, but its large-scale deployment requires government support. Measures such as feed-in tariffs introduced in support of renewable energies play a crucial role in scaling-up environmental technologies in global markets.
- **Globalisation facilitates outsourcing of production, and supply chains are becoming increasingly globalised, creating challenges for suppliers to meet environmental requirements.** Many companies outsource R&D and innovation activities to suppliers, often small enterprises, which in turn must meet their clients’ own environmental policies, in addition to or beyond regulatory requirements. This dynamic can stimulate environmental innovation and lead to positive spillovers, but it can also pose a challenge for suppliers that may not have the technical and financial resources to upgrade their environmental practices.
- **Governments have a key role in encouraging consumer demand for environmental innovation.** Measures to encourage consumers to purchase products that are more energy efficient and environmentally friendly include information and awareness-raising, financial incentives; and operating with local governments and municipalities. Green public procurement is also an important measure in creating demand and providing an example to the public. It is also important to enhance the reliability of environmental technologies, through, *e.g.* technology verification and certification mechanisms.
- **A range of measures can contribute to support markets for environmentally-related innovations.** These include: providing testing facilities and contributing to pilot projects; making better use of public procurement; helping access markets in developing countries. Some of these measures are being integrated in governments’ efforts to internationalise their environmental innovation policies.
- **Domestic co-ordination between ministries is necessary to develop and promote consistent and effective innovation strategies.** Environmental innovation, and especially R&D in the areas of energy efficiency and renewable energy, is often the competence of several ministries, which have different objectives and priorities. For ministries of industry, fostering competitiveness of national industries is often the propriety of innovation policies, while that of ministries of environment is to promote innovation that contributes to achieving environmental objectives. Closer inter-agency co-ordination is a necessary precondition for integrating competitiveness and environmental considerations into R&D and innovation policies.

- **Increasingly, governments are adopting strategies to “internationalise” their environmental innovation policies in order to scale up the development and diffusion of environmental technologies.** Measures include targeting R&D support to make domestic companies more competitive in global markets; enhancing export capacity; supporting the “internationalisation” of SMEs; increasing consumer demand for environmentally preferable products; and enhancing co-ordination and information sharing among government agencies involved in environmental innovation.

ANNEX: COMPANY CASE STUDIES

This Annex contains 14 company case studies, which constitute a key component of this report. The case studies broadly aim to explore how globalisation influences environmental innovation by companies. They are based on interviews with company representatives and information volunteered by the companies. Factual information on each company (key activities, number of employees, main operations and locations, sales/assets etc.) has been drawn from the companies' annual reports and websites (unless otherwise indicated, data are from 2006).

The interviewed companies have two key features in common: (1) environmental innovation is an important – if not the most important – part of their business strategy; and (2) they all operate in global markets, *i.e.*, they either have production plants and R&D centres in different parts of the world, or sell their products all over the world, or both. The focus of the case studies is on areas in which most of the interviewed companies are particularly active, namely energy efficiency and renewable energy.

The case studies look at a range of companies, and a variety of environmental technologies, products, and processes. Some companies produce renewable energy technologies (*e.g.* solar panels, wind turbines) and their innovation efforts are all somehow environmentally-related. Others produce cars, mobile phones, components for electronics, food, or personal care products. For these companies, environmentally-related innovation is part of their overall innovation strategy. While for some companies, environmental regulation is seen mainly as contributing to creating new markets (*e.g.* for energy-efficient products or renewable energies), for others that same regulation produces, primarily, a cost factor and an obligation to change production methods.

Endesa

This case study illustrates how an electricity producer was led by legislation, first, to improve its environmental performance, and then adapted its business strategy to take full advantage of new business opportunities in the renewable energy sector. It also provides an example of a company's framework to actively involve suppliers in R&D activities.

Box 14. Endesa: company profile

- **Activities:** Endesa is the largest electricity company in Spain and Portugal in terms of installed capacity and market share in generation and distribution, with a significant presence in the Southern European electricity market, in particular in Italy. It is also one of the largest private sector multinational electricity companies in Latin America. Its core business is energy, including the supply of natural gas.
- **Headquarters:** Madrid, Spain.
- **Employees:** 27 204 employees, 53.2% of whom are located outside Spain and Portugal.
- **Operations:** in 2005, generated 185 264 GWh and sold 203 335 GWh, supplying electricity to approximately 23.2 million customers in 15 countries.
- **Sales and/or assets:** total assets amounted to approximately EUR 55 billion, 43.3% of which were located outside Spain and Portugal.
- **Website:** www.endesa.com.

“Pushed and pulled” into more efficient power production

Endesa is one of the ten largest electricity producers in the world. It is the largest in Spain, one of the five largest in Europe, and the largest private electricity company in Latin America. It has activities in several European countries, and operates plants in five Latin American countries.

For years, and still today, power plants have not had a reputation for being particularly active in environmental innovation, because, among other reasons, they have not had many incentives for it. Many power plants were often state-owned and of strategic importance for a country's economy, and governments were not keen to impose changes that could have caused major structural changes, costs, and in some cases, layoffs. Eventually, however, governments, in this case, the Spanish government, adopted regulation imposing emissions caps on power plants.

As has been the case for other utilities, in Endesa's case, one of the key factors that pushed the company to change was regulation, e.g. EU directives related to commitments under the Kyoto Protocol. This has been a fundamental driver for major investments in R&D. Endesa's representative considered this regulation especially constrictive since the emission quotas assigned to Spain were, in his view, very low as compared to the actual needs for Spain's economic growth and development, and cause a particularly heavy burden on Spanish producers. However, this situation has been a further driver to exploring alternative sources of energy.

Endesa's shift in policy towards increased energy efficiency, environmental improvement, and greater investments in renewable energy came from “being compelled to acting” to “greening its own activity and seizing new market opportunities”. Today, many of Endesa's plants are ISO 14001 certified, and over 87%

of the energy it produces comes from certified plants. Endesa has also made major investments in waste treatment and renewable energies. It reduced its CO₂ emissions by 22.7% between 1990 and 2005 and in accordance with its climate change strategy, plans to reduce them by a total of 35% by 2007.

According to its representatives and its sustainability report, Endesa's efforts toward environmental improvements now permeate its whole business activity (www.endesa.es/Portal/en/our_commitment/sustainability_2/Informes_publicaciones/default.htm). These efforts have been recognised, for example, through its inclusion in several sustainability indexes, such as the Dow Jones Sustainability Index (www.Sustainability-indexes.com), Storebrand Investments (www.storebrand.com), and the ASPI Eurozone (www.vigeo.fr).

Gearing up innovation through increased investment, innovation programmes and partnerships

Endesa sees technology and innovation as key drivers for growth of the sustainable energy market and as a lever for development of its assets. Its 2005 sustainability report highlights the increased efforts made by the company to spur innovation, including in the fields of environmental improvements, energy efficiency, and renewable energies, through a variety of means. These include a range of partnerships with other companies, research centres, and public authorities.

Currently, Endesa is engaged in a number of R&D projects in renewable energies, in particular, solar and wind energy, biomass, and bio-fuels. It is also a member of the "Zero Emissions European Platform", which aims at reaching zero greenhouse gas emissions for power plants in Europe by 2020 (see an overview in Box 15). The Spanish government is supporting Spanish companies in this initiative, which, in addition to its environmental benefits, can contribute to giving companies a competitive advantage.

Box 15. The European Technology Platform on Zero Emission Fossil Fuel Power Plants

The European Commission and the European energy industry, the research community, nongovernmental organisations, etc. have together established the European Technology Platform on Zero Emission Fossil Fuel Power Plants (ETP ZEP) that unites all key stakeholders in this field. ETP ZEP was officially launched on 1 December 2005 and aims to provide the way forward for the EU energy community by co-ordinating the development of the technology needed for zero emission fossil fuel power plants and the required CO₂ capture and storage (CCS).

ETP ZEP aims at coordinating the establishment and implementation of a strategic research agenda to meet the needs of European citizens and industry by 2020. The technology platform will identify and remove the obstacles to the creation of highly efficient power plants with near-zero emissions, which will drastically reduce the environmental impact of fossil fuel use, particularly coal. This will include CO₂ capture and storage, as well as clean conversion technologies leading to substantial improvements in plant efficiency, reliability, and costs. The platform is open and accessible, allowing the participation of all interested stakeholders.

Source : http://ec.europa.eu/research/energy/nn/nn_rt/nn_rt_co/article_2268_en.htm.

An important part of Endesa's business is in Latin America. Some R&D activities are carried out in those countries, but they are mostly development activities, the basic research being done in Spain. Drivers for carrying out R&D activities abroad vary. Colombia for example has a very favourable fiscal system linked to R&D activities. Other countries oblige foreign investors to invest a certain amount in R&D. Brazil, for example, requires an investment of 3-5% of income in local R&D. In general, R&D carried out abroad is mainly aimed at adapting existing technologies to local conditions.

In 2005, Endesa created the NOVARE R&D Energy Prizes, aimed at promoting the development of R&D projects in scientific areas of interest to the company. With these prizes, the company will fund projects that stand out for their contribution to technological innovation and social benefits. The company will become involved in the development of the winning projects by contributing its knowledge and through collaboration. In 2007, Endesa launched the second edition of the NOVARE Prizes, which are granted in four categories: clean combustion technologies; renewable energies and new energy sources; intelligent distribution networks; and energy efficiency.

Involving suppliers in innovation efforts

Endesa places special focus on involving its suppliers in its technology and innovation efforts. Suppliers must conform to certain environmental requirements, which include complying with all relevant applicable laws, as well as the supplying company's internal standards related to environment.

In 2006, the company established a special framework to organise supplier's involvement in innovation efforts. Through this collaborative framework, called CIDE (*Círculos de Innovación de Endesa* [Endesa's Innovation Circles], www.cide.endesa.es), Endesa transmits to its suppliers "its challenges and aspirations in technology applied to the electrical sector; in order that they find solutions and identify business opportunities." The platform revolves around three basic concepts: innovation internal forums, innovation circles, and R+D projects. The main objective of the initiative is value generation by focusing on the optimisation of the different Endesa's businesses.

General Electric

This case study describes a company's focus on environmental innovation as a key part of its business strategy.

Box 16. General Electric – company profile

- **Activities:** GE has six businesses: GE Commercial Finance, GE Healthcare, GE Industrial, GE Infrastructure, GE Money and NBC Universal. Industrial activities include appliances, lighting, factory automation systems, plastics, and security and sensing technology. Infrastructure activities include traditional and renewable energy systems, aircraft engines, oil and gas technology, locomotives, and water and process technologies.
- **Headquarters:** Fairfield (Connecticut, United States).
- **Employees:** 319 000 people worldwide, 2 500 employed in R&D centres.
- **Operations:** locations in more than 100 countries, R&D centres in New York (U.S.), Bangalore (India), Shanghai (China), Munich (Germany).
- **Sales and/or assets:** USD 163 billion in revenues in 2006. R&D budget in 2006: GE total – USD 5.7 billion; Global Research – USD500 million.
- **Other:** GE is the most widely held stock in the world with more than five million shareholders.
- **Website:** www.ge.com.

Drivers and obstacles for environmental innovation

General Electric (GE) is one of the largest companies in the world. One of the cornerstones of its activities is innovation, and it has one of the world's largest and most diverse industrial research laboratories, with R&D centres in the United States, India, China, and Germany.

Since 2005, environmental innovation at GE has been carried out under the umbrella of its "Ecomagination" strategy. This strategy, which builds on and consolidates past approaches to environmental innovation, aims at "meeting increasing demands for more energy-efficient and environmentally-friendly products, while ensuring economic growth for the company and investors" (www.ge.com/ecomagination). Environmental R&D is a key aspect of that strategy. Box 17 summarises GE's four key commitments under the Ecomagination strategy.

Box 17. GE's "Ecomagination" commitments

Ecomagination is a "business strategy to meet customer's demands for more energy-efficient, less emissive products and to drive reliable growth for GE. (...) Ecomagination also reflects GE's commitment to invest in a future that creates innovative solutions to environmental challenges and delivers valuable products and services to customers while generating profitable growth for the company."

Under Ecomagination, GE has made four key commitments:

- 1. Double its investment in cleaner R&D:** GE is increasing its research in such technologies from USD 700 million in 2005 to USD 1.5 billion in 2010;
- 2. Increase revenues from Ecomagination products:** GE will increase revenues from products and services that provide significant and measurable environmental performance advantages to customers – to at least USD 20 billion by 2020, with more progressive targets thereafter;
- 3. Reduce its greenhouse gas emissions and improve the energy efficiency of GE's operations:** GE is committed to reducing its GHG emissions by 1% by 2012, reducing the intensity of its GHG emissions by 30% by 2008, and improving energy efficiency by 30% by the end of 2012 (all compared to 2004); and
- 4. Keep the public informed:** to optimise the potential of its Ecomagination strategy, GE is engaging the public and customers in a free exchange of information, ideas, comments, and constructive criticism. This helps GE understand challenges and opportunities for improvement.

Source: GE (2007) "Delivering on Ecomagination, www.ge.com/ecomagination."

GE, which operates in most countries of the world, regards compliance with environmental regulations and standards as one of the key drivers for environmental innovation. It does not regard strict environmental standards or diversity of domestic regulations as a major problem. The company strives to meet the most demanding standards – or even goes beyond these in anticipation of stricter regulation to come. It offers high standard products in all markets, and will not produce lower-environmentally performing products for particular markets, even if in those markets' competition from lower-quality products is very high. In such cases – where competition is very high and margins very small - GE may simply choose not to enter these markets.

This does not mean that it sells the same products in all markets. There is no one single global market, but many markets, and each of them operates differently. The latest and most environmentally-friendly technologies may only find a market in certain countries, where environmental standards are high and

buyers are ready to pay higher prices. Previous models may have a market in other countries, for example, because environmental standards may be lower and the existing models may perfectly suit those standards and satisfy the domestic demand and capacity to pay. Still, the aim of GE is to meet the highest environmental standards, and its innovation strategy is driven by those high standards.

However, what puts a break on innovation is uncertainty about the applicable regulatory frameworks and standards. Absence of a clear framework and unstable or short-term regulation is an obstacle for a company to invest in innovation. Especially in new technologies for which there is still little demand from consumers, government regulation can have a crucial role in stimulating demand and creating new markets. Such regulation, however, needs to take into account the long time periods needed for a new technology to become viable in the markets – frequent changes or short-term support programmes can dampen a company's readiness to invest in innovation in such technologies.

Corporate image and reputation is also an important driver for GE to aim for high environmental performance and to keep innovating. Another relevant driver is innovation by key competitors – it is perceived as a signal that GE could innovate likewise or go beyond them. This is true also for others: according to GE, its Ecomagination strategy has also acted as a catalyst for other large companies in the United States to put greater emphasis on environmental innovation and put environmental issues into the mainstream of their business activities.

Outsourcing of R&D and supply chain management

GE does most of its R&D in-house, and has established its own R&D centres worldwide (see above). GE's view is that doing R&D in-house is more efficient and allows the company to keep control over the acquired knowledge and to maintain its rights (IPRs) on innovations.

Where GE outsources production, it is generally on commoditised products, where none or very little innovation is involved. If there is a way to improve those products, GE will normally get involved in the relevant developments.

All suppliers have to comply with GE's requirements, including environmental requirements. Box 18 provides details on supply chain due diligence.

Box 18. Supply chain due diligence at GE

GE sets high supply chain expectations for all its suppliers. GE's suppliers must comply with the laws that require them, *inter alia*, to protect environmental quality. To ensure continued compliance, GE carries out regular audits and inspections. In addition, GE helps suppliers in emerging markets improve their environmental, health, and safety (EHS) practices. This can take the form of training to increase awareness of citizenship issues, or the adoption of new systems to manage employee health and safety.

GE is committed to an "eyes always open" process to investigate issues raised from outside sources, such as press reports and ombudsperson complaints, as well as periodic on-site inspections. GE generally obtains contractual commitments from suppliers to comply with these standards, including audit and termination rights.

GE's supply chain expectations are enforced by GE global sourcing personnel trained in its supplier review programme. These teams inspect facilities around the world, review documents, and conduct interviews to identify substandard EHS conditions and encourage corrective action. A total of 2 248 sourcing personnel, globally, have been trained in the programme since it began.

All GE suppliers subject to an on-site assessment must be reassessed within three years, with those that have the most significant issues requiring annual audits. GE tracks the results in an automated database to assure all findings are addressed and closed in a reasonable period.

In 2006, GE conducted assessments at more than 2 450 suppliers, including over 1 600 reassessments. These identified 12 484 findings at approved suppliers, with more than 94% of all findings closed. While GE's experience is that most suppliers seek to meet GE's expectations, it terminated approximately 160 suppliers in 2006 for poor performance in the programme. GE retained their findings in its system in the event that these suppliers are reactivated in the future.

Source: based on GE, www.ge.com.

The role of governments in supporting environmental innovation in global markets

For GE, the key role for governments in promoting innovation is to set the ground rules, the frameworks for markets in which companies operate, and to enforce such rules. Ground rules that are too weak, unpredictable, or not enforced will act as a disincentive for companies to innovate and enter new markets.

Governments also have a key role in helping develop new markets. For example, if feed-in tariffs for solar and wind energy had not been created, these technologies would never have emerged, and even less, taken off successfully. For these markets to succeed, predictable and long-term measures have been crucial.

Green public procurement can be helpful in that it allows a country to lead by giving an example, but the importance of this measure should not be over-estimated. To be effective, it has also to be in line with taxpayers' wishes and priorities.

Bans to remove products or technologies from the market can stimulate innovation to produce alternative products. However, such a radical measure will prevent any possible innovations that might have improved the banned technology. For example, a ban in incandescent light bulbs will promote alternative options, but it will block any attempt to improve the technology used in such light bulbs, in

spite of there being a technological potential to do so. Measures that promote certain technologies without totally excluding others may therefore be preferable.

Governments generally hold consultations with businesses when developing new standards or rules that may affect their products. However, these consultations tend to be with national companies. With increasing globalisation, it would be desirable if government consultations also became more global, and involved globally operating companies. Such consultations should be at all levels, not only at the preliminary stages. This would allow companies to express their views and share their knowledge and experience (including that of operating in global markets) with governments, not only in their home countries, but also in those countries in which they operate.

As regards government financial support to R&D,- such support is very important for companies, even large ones such as GE, in order to take the step to invest in high-risk technologies for which there is no potential market to be seen yet. For the development of technologies in which the government has an interest, for example, technologies needed to achieve ambitious environmental objectives, governments should team up with companies, and not leave all the risk to them. While at further stages, government support is less crucial, at the initial stages, where the risk of failure is the highest, government support can make a real difference in a company's decision to invest in R&D in a specific technology, or not.

The level of such support and its accessibility can determine the decision of a company to choose one country or another. In this field, there are large divergences between countries: the United States government funds up to 80% of such high risk projects, whereas the EU limits its support to 50%. Moreover, acceding to EU support is very complicated, which can act as a disincentive to apply for it.

Ibiden

This case study explores the challenges and opportunities of globalisation, in particular, that of value chains for a supplier of multinationals. It focuses, in particular, on the challenges of complying with a range of different environmental requirements under national legislations and customer's own environmental policies.

Box 19. Ibiden: company profile

- **Activities:** Ibiden produces a range of products, mainly components for IT equipment (printed circuit boards, plastic package boards), special carbon products, ceramic fibre, fine ceramics, silicon carbide diesel particulate filters, catalytic converters, and sealants.
- **Headquarters:** Gifu, Japan.
- **Employees:** 10 115 people (consolidated).
- **Operations:** has plants in the Netherlands, Finland, France, the UK, Germany, Hungary, South Korea, China, Taiwan, Singapore, Malaysia, Hong Kong, the Philippines, and the U.S.
- **Sales/and or assets:** net income 2005, JPY 42 551 million.
- **Website:** www.ibiden.com.

Ibiden's R&D activities

Three per cent of Ibiden's budget is spent on R&D, of which 30% is specifically destined to environmental R&D. However, much of the R&D expenditure is more or less directly related to environmental improvements, either in the final products or in the production processes.

Ibiden uses very few subsidies for R&D activities. According to company representatives, to have access to subsidies in Japan is very cumbersome. The company is currently not using government R&D subsidies provided abroad, but intends to make efforts to tap into those sources of funding. However, for a relatively small company, allocating the resources to find out about subsidy programmes and apply for them is a constraint.

In the past five years, Ibiden's global activities have greatly expanded, and it now has 22 out of 40 subsidiaries abroad. Most of these do manufacturing, whereas R&D is mainly carried out at headquarters. An exception is the establishment of an R&D centre in California. Establishing R&D centres abroad has a very high cost, and the choice of the location is very important. In the case of the base in California, the purposes are to have direct access to leading edge-technology and to work with customers in effective product planning and development.

R&D collaboration

Ibiden is engaged in several R&D partnerships, including with its own customers and with universities, both within and outside Japan. One motivation for entering such partnerships is to speed up the process of new technical developments – a key business factor for suppliers operating in highly competitive industries. Advantages of partnerships include enhanced quality of the results and lowering of risks. Lowering costs was not ranked as a priority for entering partnerships.

However, partnerships also involve difficulties. It requires time and effort to find “win-win” outcomes out in a process that requires building up teams of people and entities with different policies and strategies. Another major difficulty is managing IPRs, which requires carefully elaborated contracts.

Drivers of environmental innovation: regulation, customers' standards and internal policies

Ibiden supplies parts to numerous companies. About 80% of Ibiden's total revenue derives from customers outside Japan and many of its innovations are destined to foreign markets. For example, the diesel particulate filter (DPF), a ceramic filter designed to remove suspended particulate matter from diesel engine exhaust, was first installed by European carmakers. Now Ibiden's DPF has been adopted and approved by automobile companies all over the world.

Most of Ibiden's products are customised, and require specific R&D efforts. Ibiden therefore emphasises manufacture and sale close to the customer. Being fully aware of regulation affecting its client's final products and clients needs to comply with such regulation is key for Ibiden's activity. To a large extent, it is the customer itself who informs Ibiden of regulatory requirements. For Ibiden, “new regulations offer new opportunities”. An example of how stricter emission standards contributed to Ibiden's thriving business in diesel particulate filters is provided in Box 20 below.

Box 20. Stricter vehicle emission standards: a boon for suppliers of diesel particulate filters

An article published in 2004 in the specialised press summarises how stricter vehicles emission standards in Europe, Japan, and the United States boosted Ibiden's production of diesel particulate filters (DPFs) – filters designed to remove black smoke and particulates from diesel engine exhaust.

Ibiden, which began mass-producing silicon-carbide DPFs in 1999, expected to boost global sales in 2004 to 700 000 units (up from 300 000) in a run-up to Euro IV regulations in 2005. According to a company official, DPF demand in Europe will grow to three million units in 2006, which relates to 30% of an estimated 8-9 million diesel vehicles to be sold. He expects a DPF penetration rate of 90 % toward the end of the decade when Euro V regulations take effect with unit costs down by half. The official expects

Japanese DPF sales to grow to 100 000 in 2008, essentially one unit for each light, medium and heavy-duty truck and bus produced during the year. In the U.S. market, the official expects sales to grow to 500 000 units in 2008 with demand being driven by new EPA regulations scheduled to go into effect the preceding year.

In 2006, Ividen announced it had “reached an impressive milestone in the global cumulative production and shipment of its DPF, when it shipped the three millionth unit on February 14, 2006. Because of its outstanding features, including 99% collection of black smoke generated from diesel engine vehicles, the SiC (Silicon Carbide) DPF developed by Ividen was the first of its kind in the world to be installed on passenger cars. Installation began in June 2000. With enforcement of the European emission standards in 2005, DPF-equipped vehicles have dramatically increased in Europe. Since tighter limits will be imposed by the next set of emission standards, our DPFs remain in steady demand. To increase production capacity, Ividen has been investing in plant and equipment in its DPF manufacturing sites: Ividen Hungary and Ividen DPF France. Ividen continues to supply DPFs that will contribute to global environmental preservation from its plants in Japan and abroad, to customers operating on a global scale”.

Source : Diesel & Gas Turbine Publications, Gale Group (2004) and www.ibiden.com.

Some of Ividen’s customers have very high internal environmental standards themselves, and place strict demands in this regard on suppliers. For example, Toyota applies a strict green procurement policy for all purchases from suppliers.

Competition among suppliers, for example in the mobile phone, IT, and automotive sectors – in all of which Ividen operates as a supplier of parts – is very strong. It is therefore very important to keep in close contact with the customer, to gain and keep his trust. Developing parts for final products involves close co-operation with the customer, including responding to regulation and customers’ own environmental standards’ with which the final product has to comply.

Moreover, Ividen has set itself high environmental standards and emphasises its commitment to overall environmental improvement, including attaining zero emissions in 2007, as part of its effort “to earn the trust of international society”. It operates three hydroelectric power plants and one co-generation plant using liquefied natural gas (LNG) fuel and applies a strict 3R policy (reduce, reuse, recycle). One key effort of Ividen’s R&D activities is to reduce costs for its client, while applying high environmental standards. As part of its environmental policy, Ividen is committed to communicating its environmental policy to raw material/energy suppliers, related suppliers, and contractors, and to asking for their understanding and co-operation on its environmental management activity. It also aims to construct a cooperative system for green purchasing.²⁹

²⁹ See Ividen’s page on “global citizenship”, www.ibiden.com/eng/eco/01/index.html

Isofotón

This case study highlights the importance of market deployment measures to promote the use of solar energy.

Box 21. Isofotón: company profile

- **Activities:** manufacturer of solar energy technologies. The company's capital and know-how are 100% Spanish and focus on both photovoltaic and solar energy technologies. The company was founded in Malaga as a Polytechnical University of Madrid spin-off. It is Spain's number one solar energy company, number three in Europe, and number 11 in the world.
- **Headquarters:** Madrid, Spain.
- **Employees:** 815 people in 2006.
- **Operations:** it has subsidiaries in China, Bolivia, Ecuador, Italy, USA, Morocco, Dominican Republic, and a project office in Senegal.
- **Sales/and or assets:** EUR 160 million.
- **Other:** production capacity is of 130 MW (photovoltaic) and 200 000 sq. metres (thermal). Its export quota is 50%. Investment in R&D is 7% of turnover (EUR 12 million). Production is 61 MW (photovoltaic) and 30 000 square metres (thermal).
- **Website:** www.isofoton.com.

R&D embedded in the company

Isofotón is Spain's first manufacturer of solar energy solutions. Since its founding in 1981, Isofotón has been consistently engaged in an on-going process of innovation involving state of the art production and technology. Through aggressive R&D investment and advanced engineering, Isofotón has become the leading provider of photovoltaic (PV) solar solutions in Europe and the eleventh largest PV manufacturer in the world. R&D is "embedded" in the company. According to its R&D Director, "if you do not do R&D you miss the boat".

The company's firm commitment to research has led to on-going technological advances and experts from all over the world have emphasised "Isofotón's very high performance cell manufacturing process as one of the best and most advanced in the world" (www.perfectpowernetwork.com).

Location of R&D – how important are outsourcing, relocating, and partnering?

Internationalisation and dissemination of technology is very important for the company: it considers it key that solar energy be developed at the global level, and that it enter the mainstream. At this stage of the market, they see other solar photovoltaic companies not simply as competitors but as contributors to developing a market. According to a company representative, "for us it is important that large companies be involved."

Isofotón does all R&D at headquarters, but is considering opening subsidiaries in other EU countries and in China. This would help to get closer to the markets and have better access to local research, as well as support measures. It does not make sense to establish R&D centres in locations where there is no market.

Isofotón collaborates with many partners in Spain and Europe (universities, local governments, governmental research institutes, companies, including consortia, such as “Crystalclear”). There is a tendency to establish large consortia. In these partnerships the companies co-operate, but also keep their “own secrets”. The advantages of partnerships are: better access to knowledge and keeping abreast of new developments. Disadvantages are mainly those deriving from managing different entities, with different business cultures. Spillovers and free riders are not a major problem. (see: www.isofoton.es/corporatehtml/secciones/tecnologia/investigacioncolaboracion.asp?idioma=_ing for a list of joint research efforts involving the company).

Government measures to support R&D and innovation in solar energy

Isofotón spends a large part of its budget in R&D. It considers that public subsidies to R&D have been helpful, but not key drivers to carry out R&D activities. According to Isofotón’s representative: “we would have done it anyway in many cases.” The company rates the percentage of projects they do regardless of whether they get a subsidy at 60-70%, projects which they do not lead but to which they are associated at 20-25%, and the rest they do only if they get financial help. The company considers the requirements in Spain to obtain subsidies to be very cumbersome: bureaucracy to obtain help is lengthy and complicated; there is a lot of uncertainty, and decision-making is very slow.

For Isofotón, regulation is very important and the company monitors any developments in legislation affecting their products both at home and abroad closely. However, it considers that what really helps companies are instruments that help create markets. One regulation that has been key to Isofotón’s photovoltaic market success was the Royal Decree 436/2004. It established a feed-in tariff for electricity generation by renewable energies, which by law has to be bought by local utilities. This Decree guaranteed the return of the investment made for small PV installations as well as big generation plants. However, in July 2006 the Decree was revoked and the feed-in tariff frozen. A new draft Royal Decree was then discussed among all stakeholders. This has caused uncertainty among the renewable energy sector, although, in the case of photovoltaics, the new draft strengthens its position.³⁰ Other important legislation that supports solar energy, in particular solar thermal energy, is the technical construction code, which was approved in 2006 and requires all new buildings to use solar energy. This regulation has contributed to putting solar energy closer to the mainstream and has greatly benefited companies such as Isofotón (see Box 21).

According to Isofotón representatives, “what we need is a stable legal framework; that the rules of the game be clear and that they are maintained”. It is also important to avoid compartmentalisation, which would favour some but exclude other actors, *e.g.* by focussing efforts on large projects, or on basic research.

Isofotón also considers that companies involved in solar energy technologies need relatively long periods of government support – at least 10 years. Often, however, measures do not go beyond that of a government mandate, *i.e.* a time span of four years. Another area where government intervention is key is putting in place testing facilities and equipment, and prototypes.

³⁰ The new Royal Decree came into force in 2007, and led to a boost of solar energy production in Spain.

Box 22. Spain's new technical construction code: putting solar energy into the mainstream

In March 2006, the Spanish government approved a new construction standard, called the Building Technical Code (CTE - *Código Técnico de la Edificación*), which requires all new or renovated buildings to cover 30-70% of the domestic hot water demand with solar thermal energy. It establishes new quality, security, energy efficiency, and habitability requirements for new or renovated buildings, thus creating a legislative framework that should, *inter alia*, promote technological innovation and development. Spain is the first European country to make the implementation of solar thermal energy obligatory in new and refurbished buildings.

In particular, the standard includes the following basic requirements for energy efficiency of buildings:

- 1. Limitation of the general energy demand of a building.** Buildings will be designed taking into consideration insulation, air permeability, exposure to solar radiation, and the local climatologic conditions, and using the necessary materials and techniques to limit the gain and loss of energy;
- 2. Performance of the thermal facilities.** The thermal facilities of a building (heating, ventilating, air-conditioning, etc.) will have a minimum energy efficiency target, established by current legislation;
- 3. Energy efficiency of the lighting facilities.** The lighting facilities of buildings will be appropriate to meet the lighting requirements of users and at the same time will be energy efficient. To this end, they will have a control system that will optimise the use of natural light and adapt their use depending on the occupancy of the area;
- 4. Minimum contribution from solar powered systems.** A minimum percentage ranging from 30% to as much as 70% of the annual energy requirements for the production of Domestic Hot Water (DHW) demand will be met with solar thermal energy. The percentage will depend on geographical location and the specific demand of the building for domestic hot water; and
- 5. Minimum contribution from photovoltaic systems to the total electric energy consumption.** In certain buildings, photovoltaic systems will be introduced to transform solar energy into electric energy for personal or community use.

It is expected that the estimated 400 000 households to be built annually in the years to come will be equipped with such facilities. It will also be mandatory to install photovoltaic panels in shopping centres, industrial buildings, governmental buildings, hotels, and hospitals with a built surface area of more than 3 000 m².

The energetic impact of the new Building Technical Code

The energy efficiency requirements established by the CTE, which affects residential as well as public buildings, has been mandatory since October 2006. Until then, there was a period of voluntary application. The Spanish Institute for Energy Diversification and Saving (I.D.A.E.) has calculated that with the implementation of these new energy requirements introduced by the CTE, each building will reduce energy consumption by between 30% and 40%. Moreover, the CO₂ emissions associated with energy production and consumption will be reduced by 40% to 55%.

The CTE supports Spain's goal of installing five million square metres of thermal panels and increasing photovoltaic solar energy from 143 to 400 MW by 2010, established by the Renewable Energy Plan 2000-2010. The companies that produce and commercialise solar energy systems and equipment would be among those to benefit the most, as revenues will multiply and approximately 5 000 jobs will be generated.

Source: based on EC; http://ec.europa.eu/environment/etap_2/2/, and IDAE, www.idae.es

In a recent interview, a representative of Isofotón praised the Spanish government's actions in support of solar energy, both through the above-mentioned construction code and the recent Renewable Energies Plan (*Plan de Energías Renovables*).³¹ These measures are the “definite driver”, the last push, needed for a mature technology to succeed in the market, while, at the same time, contributing to the country's goals in terms of limiting GHG emissions, fossil fuel consumption, and energy dependence. Any investments made by government in support of these technologies are largely compensated by the benefits they provide in a relatively short time span: in 10 years, he predicts, electricity produced from solar energy will be less costly than “regular electricity”. At the international levels, measures such as the “Sunshine” programme in Japan, the feed-in tariff in Germany and other European countries, a well established international aid for development effort that includes renewable energies as the means to bring energy where there is no access to electricity (through rural electrification programmes), and the recent legislation on renewable energies, have already contributed to significant development of markets for solar technologies worldwide.

Neste Oil

This case study illustrates the complementary roles between policy tools (EU directives to increase the content of biofuels in conventional fuel mixes) and market factors (influencing a company to become a leader in the biofuels market through an innovative, second-generation biodiesel) in inducing environmental innovation. In this case, domestic markets alone were too small to offer sufficient incentives for making large-scale investments in biofuel technology, so the creation of policy-driven markets has played a decisive role in the scaling up of emerging technologies.

Box 23. Neste Oil: company profile

- **Activities:** Neste Oil Corporation is a refining and marketing company that focuses on advanced, clean traffic fuels. It has four divisions: Oil Refining, Biodiesel, Oil Retail, and Shipping. Activities cover the refining and marketing of oil, and shipping and engineering services. The main products are gasoline, diesel fuels, aviation fuels, marine fuels, heating oils, heavy fuel oils, base oils, lubricants, traffic fuel components, solvents, liquefied petroleum gases (LPGs), and bitumen.
- **Headquarters:** Keilaranta in Espoo (Finland).
- **Employees:** 4 740 employees (as at December 2006).
- **Operations:** most of the oil products are sold in the domestic market. Exports of oil products amounted to 6.0 million tonnes. The Nordic countries, other European countries, and North America were the largest export markets.
- **Sales and/or assets:** net sales of EUR 12 734 million for the year ending 31 December 2006.
- **Website:** www.nesteoil.com.

Finnish biodiesel policies

Finland's role in the biodiesel markets has been minimal and biofuel production has been extremely restricted. The proportion of biofuels in overall sales of transport fuels in 2004 was thus around 0.1% in 2006. The main Finnish institution funding the development of biofuels technology is the Centre for Technology Development (Tekes). The techniques of renewable energies are a strategic area of work at Tekes, and it implements a number of technology programmes and manages several project funds in this

³¹ Article published in *Expansión*, March 2007, www.expansion.com

field. As of 2004, Tekes' funding for technology projects concerning renewable energy sources was EUR 15.5 million of which almost 90% was targeted on bioenergy. According to the report, “the only noteworthy Finnish producer of transport biofuels” is Neste Oil.

Box 24. The global biofuels market

- Growing at the rate of more than 30% from the year 2006, world biodiesel production is likely to touch the mark of 12 billion litres by the end of 2010:
- Contributing about half of the world bio-ethanol production, Brazil is the world’s leading producer, with the US following next. The European Union, with a production of about 0.5m tons, is estimated to be accountable for about 10% of the total bio-ethanol in the world. With the rapid growth in bio-ethanol production, the US will be able to catch up with Brazil in this business in the years to come;
- Production of biofuel (ethanol and biodiesel) exceeded 33 billion litres in 2004. In 2004, ethanol made up 44% of the total fuel consumption in all (non-diesel) motor vehicles in Brazil, while it was being blended with 30% of total gasoline sold in the US.

Source: “Biofuel Market Worldwide (2006)”, www.piribo.com.

In Neste Oil’s view, Tekes, plays a constructive role in promoting environmental innovation in Finland. Among the main benefits of working with Tekes is that the company gets valuable feedback from the team whenever they submit a proposal. These grants also allow the company to connect with the regulators, and they help to create confidence in the company’s project. EU funds are considered to be “expensive money” because it is burdensome to access them given the numerous administrative requirements involved. A project that might move forward in two or three months at Tekes, might take two or three years to be implemented at the EU.

It is noteworthy that Finland’s focus has been on using forest biomass for heating, not biofuels, which might explain why the country’s production of transport biofuels has been so limited. However, burning forest biomass has been excessive, and therefore when all energy consumption is included, Finland tops in Europe with a 25% share. Other countries, in particular Germany, France, and Italy, have set in place far more proactive policies to induce biofuel technology development. Hence, in order to understand Neste Oil’s decision to innovate in the biofuels sphere, it might be useful to analyse the “intra-company context” that led its executives to place biodiesel at the centre of its innovation and growth strategy.

Biofuel markets as an engine of growth

Neste Oil developed a premium quality biodiesel production technology (NExBTL) in 2001-2006.³² This development marks a watershed in the company’s strategy. In the autumn of 2006, Neste Oil’s CEO

³² Neste Oil’s synthetic NExBTL biodiesel is the world’s first “second-generation” biodiesel (*i.e.* made with processes that can accept a wider range of biomass). It was launched commercially in the summer of 2007. Known as NExBTL Renewable Diesel, it can use a flexible mix of both vegetable oils and animal fats, it has fuel properties that meet the tough requirements of automotive manufacturers, and it can be used as a blending component in conventional diesel fuel. According to the company, this attribute offers the company multiple sourcing choices beyond materials that potentially compete with food needs (*e.g.* corn) and thus become controversial. Instead, they can use animal leftovers, among other things. Although NExBTL technology allows for a wider raw material base than any other currently available technology, Neste Oil recognises that it must continue research work in order to widen the feedstocks even further.

made what some view as the company's boldest public statement, saying that the company aims to become "the world's leading biodiesel producer."

Neste Oil is a relatively small player in the oil sector, especially compared to oil giants such as Shell, Exxon, or British Petroleum, but the company considers its size creates a source of competitive advantage (e.g. being smaller allows the company to transform itself more quickly than far larger corporations, where corporate change is slow). As environmental issues became a core challenge for the industry, Neste Oil internalised these issues as a business opportunity quicker than its competitors. A cornerstone of its competitive strategy has been the increase in R&D investments together with a careful strategy on how to spend these funds. The trend toward downsizing represents a turning point for many companies forcing them to choose very carefully the areas in which they will invest the most. In the case of Neste Oil, 90% of the company's increased R&D budget went to biodiesel-related activities — which it views as its central area of growth.

In 2006, Neste Oil's proprietary technology obtained the Finnish Chemical Industry Innovation Award. The award recognised not only the fuel's attributes (reduces particulate and NO_x emissions in vehicle exhausts) but also the lack of a direct competitor, which were decisive factor for the decision by the Scientific Advisory Board to grant the award.³³

Although the process developed by Neste Oil is dependent on the availability of sufficient quantities of suitable raw materials, the company estimates that it could be used to produce a major part of the bio-components needed to meet the EU's diesel fuel requirement mentioned above. The first production plant at Neste Oil's refinery came on stream in the summer of 2007. The second plant is scheduled to begin production towards the end of 2008. The plant will have the same capacity, 170 000t/a, as the first one. The company is negotiating the construction of a new plant based on NExBTL in Austria.

A statement "fifteen years in the making"- Neste Oil's early bird strategy

The message sent to investors in the autumn of 2006 with the statement mentioned above – betting the company's future on a climate-friendly technology – has been 15 years in the making. Many events in the late 1980s and early 1990s led to a major transformation of the company's strategy. Among them were the shift of Russia into a market-based economy, and the growing calls for better environmental practices in the oil industry (especially after the 1989 Exxon Valdez spill). Moreover, at home, the company had to face other environmental challenges, e.g. it was the target of attacks by Finnish NGOs leading to bad press and an internal crisis. In response to complaints by activists and communities, the company agreed to change its strategy by "180 degrees." Neste Oil considers that, being a small company, changing course can occur faster than at a large company.

By the early 1990s, the company agreed to adopt better environmental practices and to start investing in cleaner products even though not all the board members agreed that the company should change course. In those years, environmental issues fuelled many internal disagreements on the best way to tackle them. The company also improved its product offer and had to counterbalance the arrival of new competitors. As a result, Neste Oil decided to take advantage of the opportunities in the Baltic Sea region, since the Finnish market alone would not be sufficient to survive in the long term. Hence, it was also within this context of

³³

The Chemical Industry Innovation Award is granted every other year in recognition of major innovations in the field that can be applied industrially. The Award includes a prize sum of EUR 20 000. The goal of the Innovation Award is to encourage research-based, innovative activities and to promote the commercialization of new innovations, as well as the emergence of new business in the chemicals field. The Award can be granted to a person, a team, or an enterprise that has introduced a promising chemical innovation that can be exploited industrially or that has already been implemented.

business expansion that the company set new targets, including the supply of more environmentally-benign products. This change in strategic direction was a central driver for investing in biodiesel R&D throughout the 1990s. The company's goal was to act quickly enough to benefit from early-mover advantages later on.

In Neste Oil's view, they had an "early-bird" strategy, leading them to give up some short-term profits from their dirtier diesels and to invest in improvements of their products technologically and environmentally to increase profits in the longer term. In retrospective, it considers that it made its investments in environmental R&D on time and at the right level.

In the company's view, the central driver for the changes in the 1990s was not environmental regulation, *per se*, but the decision to adopt an early-bird strategy that would, among other goals, shape future regulation, and not to be driven by it. Neste Oil wanted to be ahead of the regulation they predicted would come and wanted to be the first ones to come up with a competitive biodiesel. Nevertheless, the EU directives on biodiesel have been welcome because they establish specific targets and therefore help increase demand. In other words, regulation is helping to create a potentially large market for Neste Oil. In the company's view, in the absence of this policy-driven market, Neste Oil would be in a more vulnerable position.

Because of the attributes of its product, the company has engaged in local and regional collaborations. It wanted to produce a biodiesel that was compatible with current auto manufactures' requirements. Cars can safely handle only up to 5% of traditional biodiesel made in an esterification process in the fuel mix. Neste Oil's NExBTL Renewable Diesel has far better fuel properties than traditional biodiesel. Auto manufacturers have tested NExBTL and wide acceptance has been found for it among car manufacturers. These collaborations allow testing and improving this compatibility. One example is a bus and waste truck test project in Helsinki. There are discussions with several other European cities about similar tests, *e.g.* a bus project in London. The EU funds are available for these projects. In the future, Neste Oil plans to expand its R&D efforts and to increase the search for talent (within Finland and abroad including, mainly, China).

Nokia

This case study illustrates a company's efforts towards environmental innovation, driven in large part by its internal environmental strategy.

Box 25. Nokia: company profile

- **Activities:** Nokia is a global electronics company organised around four business groups: Mobile phones, multimedia (advanced mobile devices), enterprise solutions (enterprise-grade mobile devices, underlying security infrastructure, software, and services), and networks (network infrastructure, communications and networks service platforms, as well as professional services to operators and service providers).
- **Headquarters:** Espoo, Finland.
- **Employees:** 68 483 people (Dec. 2006).
- **Operations:** production units in 10 countries.
- **Sales and/or assets:** EUR 41.1 billion (2006).
- **Other:** R&D investment of EUR 3 987 million (2006). R&D centres in 11 countries, employed 20 882 people in R&D, representing approximately 36% of Nokia's total workforce.
- **Website:** www.nokia.com.

Drivers for environmental innovation

In the mobile manufacturing business, the “green argument” is not significant from a sales standpoint. According to Nokia’s representative, the environmental attributes of the product are generally not visible and consumers are generally interested in its performance, not whether it was produced in an environmentally sound manner. Even where a company is determined to improve its environmental performance, it is difficult to communicate this information to consumers, or to get them interested in it.

However, Nokia has a proactive environmental strategy that includes efforts to improve energy efficiency. These efforts target both products and facilities and operations (*e.g.* type of energy used and energy efficiency improvements). The company has three units that deal with products and two platforms to support them. Accordingly, each business unit incorporates environmental considerations in their operations — energy efficiency, in particular — though some units do so more than others.

Nokia’s approach to making products more energy efficient is largely voluntary. It is one of the companies that signed the Code of Conduct on Efficiency of External Power Supplies proposed by the European Commission in 2004 (http://energyefficiency.jrc.cec.eu.int/html/standby_initiative.htm). One of the main environmental programmes to develop products is based on a “design for the environment” (DfE) approach.

Nokia has developed environmental requirements with which suppliers must comply (see Box 26).

Box 26. Nokia’s environmental requirements to suppliers

Environmental Management

Environmental management system

The supplier shall have an environmental management system (EMS) ensuring effective planning, operation, and control of environmental aspects. The EMS shall satisfy the requirements of ISO14001 or other internationally recognised standards. The supplier shall be well-informed about environmental legislation and applicable regulations and be able to provide evidence of compliance. The EMS shall include a continuous improvement programme.

EMS certification

The supplier’s EMS shall be certified as compliant with ISO14001 or Eco-Management and Audit Scheme (EMAS).

Raw material content data management

The supplier shall comply with material restrictions, set by applicable law and Nokia, and continuously maintain records of full raw material content data (materials, substances, and compounds) of products supplied to Nokia or of materials used in implementing the services provided to Nokia. These records (including any updates) shall be provided to Nokia in a format specified by Nokia.

Waste management

The supplier shall manage any waste generated from its operations or from products or customer’s assets in its possession, or that reaching end-of-life or being classified as waste according to legal requirements and good environmental practices. The supplier shall establish and maintain procedures ensuring compliance with its waste management obligations. The supplier shall primarily investigate ways to reduce waste generation, and secondarily ways to promote reuse (of non-Nokia-proprietary material) and recycling. Nokia proprietary material must not be reused without prior consent from Nokia.

The supplier shall record information about waste management (*i.e.* how much and where waste is reused, recycled, energy recovered, sent to landfill, etc.) and provide this information to Nokia on request.

Programmes for improving environmental performance

The supplier shall identify and measure the environmental consequences and impacts of its operations and products/services and run continuous improvement programmes to address these impacts. These programmes shall promote efficient use of energy and materials, avoid use of hazardous materials, promote waste minimisation, and improve treatment and control of waste emissions affecting air, water, and soil. The supplier shall be able to provide supporting evidence.

Product Development

Design for Environment requirements

The supplier shall consider environmental aspects in all phases of product development, using, for example, specific Design-for-Environment (DfE) tools or checklists. The supplier shall comply with Nokia product environmental requirements (*e.g.* Nokia Substance List, Environmental Requirements for Nokia products). Choices made during these product development phases shall, whenever possible, reduce or eliminate negative environmental impacts. All reasonable attempts shall be made to reduce or eliminate hazardous constituents from the product, to promote efficient use of materials (*i.e.* to reduce waste), to improve energy efficiency of the product, and to promote recycling.

Source : Nokia, www.nokia.com.

Nokia views the following as the main drivers for adopting a proactive environmental innovation strategy: (a) creating a market and play a leading role in it; (b) improving environmental performance – “the technology might cost more than it will to competitors but it will have some long-term benefits”. One of them is becoming a “leader” in the industry, which in turn can benefit the company in the marketplace; and (c) complying with environmental regulation (mostly that applicable in the EU and in China).

A motivation for adopting energy efficiency measures is to show that Nokia takes the environment seriously, and does not need to be constrained by regulation to act in an environmentally conscious manner. Nokia also wants to have a proactive approach that includes having dialogues with the regulators, for example in the creation of codes of conduct for manufacturers of electronics.

Internationalisation of R&D

Nokia does not see a fundamental difference in the drivers affecting the location of R&D activity as opposed to non-environmental R&D. The main driver at Nokia is to seek access to the best talent globally. For Nokia, the best approach to R&D is to get a mix of complementary measures (*e.g.* strong education systems at home, delivering great engineering capacity, combined with company measures to complement local with global sourcing). The countries where Nokia carries out its R&D activities outside Finland include China, India, the U.S., and several European countries.

Most R&D is conducted outside Finland. The choice to conduct R&D abroad is driven by the goal of going to the places where the job can be done better and close to the market. Nokia also wants to track talent globally in a cost-effective manner. This is because the cost of conducting R&D is rising. In the mobile phone field, there are key countries that they consider. According to the company, the Finnish government understands this landscape. Its main goal is to continue investing in technical and scientific education to have a strong supply of engineers, etc.). In Nokia’s view, “there is little point in stopping companies from sourcing R&D activities abroad”. For example, it is better to help guide PhD research than to challenge the status quo (*i.e.* the outsourcing of R&D that is taking place).

R&D collaboration and partnerships

Nokia is engaged in a number of industry partnerships. One is the Mobile Phone Partnership International (MPPI) under the Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and their Disposal. (www.basel.int/industry/mppi.html) to help develop rules for waste from electronics manufacturing. The idea is to have common rules to deal with transport issues of end-of-life mobile telephones across countries. Nokia has a lot of expertise that can bring useful and informed insights to policy-making. The company does not lobby directly but does it through larger industry associations that try to talk to regulators like the EU and national authorities. It also tracks the developments in other countries, like the U.S., where there are restrictions on the materials that can be included in the products (companies have to pay a fine if they do not comply), as well as energy efficiency measures.

Nokia has R&D collaborative efforts outside Finland that are based on long-term contractual obligations that lead to partnerships in R&D. They include industry partners through both horizontal co-operation” (*i.e.* companies operating at the same market level, even competitors) and vertical co-operation” (*i.e.* with suppliers, customers, and distributors).

The top three motives for establishing international R&D collaboration arrangements are: (1) “reducing time to market”; (2) costs sharing; and (3) risk sharing. Fundamental barriers to establishing international collaborations on R&D or to improve the existing ones are: the risk of transferring knowledge to others (the partners might even get some know-how that they might sell to others) and to obtain knowledge in exchange that does not benefit Nokia. IPR concerns are not a major barrier to establishing partnerships.

The importance of enforcement to ensure a level playing field

Nokia sees “costly, country-specific environmental requirements” as barriers to innovation. In an ideal world, there would be one single “global” approach. In line with this idea, Nokia has promoted that the “substance” of EU regulation be adopted in China, so that the product requirements are consistent.

Ideally, Nokia would like to prepare in advance for regulation – for example, the company could start getting ready today for regulation that will affect the market five years from now. Again, in an ideal world, it would start covering, today, key topics that will be regulated in the future. That is why for the company, a key driver for innovation is transparent, participatory regulation-making. This would allow industry to get ready and to influence the regulation.

The ideal is to have “fair and reasonable” requirements that make sense, technically speaking. It is very important for regulators to establish minimum levels of environmental performance (to set the basis of the game and to avoid free riders, that is, dirty competitors). It is also equally important for the regulators to establish the overall policy goals, the main targets, but then create participatory processes that include industry feedback on how to proceed with the details (manufacturers have a lot of know-how that “desk-based regulators” might lack). The company’s point here is: “avoid that the regulators establish the details that can pose a headache from a manufacturing perspective”.

At the other extreme, the worst case scenario for the company is a very detailed piece of regulation that sets requirements that are hard or impossible to control by market surveillance authorities. In the view of the company, one example of such regulation is the restriction in the use of several substances in the manufacturing of electronics. There are today 29 exceptions to the restriction, however these are very challenging to verify from the final product, and thus the rules are vulnerable to free riders. There were many discussions with the European Commission and Nokia provided input that was ultimately ignored.

According to company officials, “smaller producers will not be able to comply with all the requirements”. And the regulators will not even monitor compliance, with some aspects of the regulation that are almost impossible to comply with, from a technological perspective. Nokia will comply even though it does not make sense from a technological perspective but needs to do so to protect its brand. However, according to company officials “it is unfair that dirty competitors will be able to get away with non-compliance”. They do not have brands to protect and therefore will have very little incentive to comply with rules that have little sense from a manufacturing perspective.

Philips Lighting

This case study illustrates the barriers to large-scale deployment of energy-efficient light bulbs as well as some of the incentives that policy makers could design by accelerating the creation of an international market for energy-efficient light bulbs. It also describes ways in which effective promotion of energy efficiency through public policy contributes to the deployment of innovative technologies.

Box 27. Philips Lighting: company profile

- **Activities:** Philips Lighting has five business areas: lamps; luminaires; lighting electronics, including light-emitting diodes (LEDs) and LED systems; automotive; and special lighting, including ultra-high performance (UHP) lamps, and Lumileds (high-power LEDs). Philips, the parent company, delivers products and services in the areas of healthcare, lifestyle, and technology. The company is a market leader in medical diagnostic imaging and patient monitoring systems, energy-efficient lighting solutions, personal care and home appliances, as well as consumer electronics.
- **Headquarters:** The Netherlands (Philips Lighting is based in Eindhoven).
- **Employees:** 121 700 people (46 500 at Philips Lighting).
- **Operations:** Philips runs manufacturing operations in the Netherlands, Belgium, France, Germany, the United Kingdom, Poland, the USA, Mexico, Brazil, India, Indonesia, Thailand, the People's Republic of China, and South Korea.
- **Sales and/or assets:** EUR 27 billion in 2006.
- **Other:** 80 000 registered patents.
- **Websites:** Philips Lighting – www.lighting.philips.com; Philips Global – www.philips.com

Regulation to induce innovations and market measures to deploy them

At Philips Lighting, a top priority area of its environmentally-related innovation is energy efficiency. The technologies that are necessary to increase energy efficiency have already been developed and tested. Hence, the fundamental policy challenge ahead is the adoption of strategic deployment policies that are consistent internationally.

According to the EU, the direct cost of energy inefficiency among its Member States will amount to more than EUR 100 billion annually by 2020, and realising savings potential in a sustainable manner is a key element in the EU's energy policy. In the Commission's view increasing energy efficiency is the most effective way to improve security of energy supply, reduce carbon emissions, foster competitiveness, and stimulate the development of a large leading-edge market for energy-efficient technologies and products.

EU environmental regulation has been a fundamental driver for Philips' innovation efforts. Recent examples are the EU Eco-design requirements for energy-using products (EuP) adopted in July 2005

(http://ec.europa.eu/enterprise/eco_design/directive_2005_32.pdf). Because the calls for increasing energy efficiency are growing internationally, and in the EU in particular, more policy intervention in this arena is expected — and welcome if, as the company argues, the policies ultimately help to dramatically expand the international market for energy-efficient lighting products. In some cases, regulation in key markets, in particular California has also played a role in inducing certain innovative products.

However, regulation alone is not enough, and governments must also help develop markets for new or environmentally preferable products. If the regulation only calls for changes in manufacturing processes but governments fail to address market concerns (e.g. will consumers buy the environmentally-friendlier, more efficient products?), then the technology is unlikely to be successful from both market and environmental perspectives.

Market incentives have an important role in Philips Lighting's innovation strategy. They are as influential as regulation — in fact the two drivers often reinforce each other. On the one hand, Philips Lighting responds to public policy that requires changes in how they produce their products. On the other, once the regulation is internalised in the company and the engineers have adapted the manufacturing technology to meet the requirements through an innovative solution, then Philips Lighting thrives to become the leader in that field and to gain as much market share as possible.

The company views the divergence of environmental regulation and standards, leading to market fragmentation, as problematic. Even if a company is committed to “green markets”, facing different standards in each region might pose significant barriers, especially in the area of product design.

Technical challenges from regulation and the risks of non-enforcement

Philips Lighting is interested in participating, to the extent possible, in the development of regulation. When regulation is proposed, Philips Lighting, through industry associations, tries to influence it, in particular the implementation measures under EU regulation.

The company considers that some of these measures have been developed without taking into account the technical feasibility, and are thus exceedingly problematic from a manufacturing perspective. A company like Philips, which has a solid brand, known worldwide, to protect, will always comply with regulation, as complex as it may be. However, competitors with a less solid brand may choose not to comply with the technical requirements. In such cases, if governments do not enforce the standards, there is a risk of free riders, who will benefit from a competitive advantage. Sometimes compliance with the technical requirements is very hard to verify and control, and government often do not have the capacity to assess whether a product conforms to the requirements (one example is the lead content in glass used for light bulbs).

Moreover, low quality products from competitors may harm the reputation of other companies. For example, cheap energy-efficient light bulbs with a short life span may give customers (who may often not be familiar with energy-efficient light bulbs) the impression that all such light bulbs are of low quality or have a short life, and may turn away from buying them altogether. Philips Lighting representatives mentioned that, occasionally, they have co-operated with competitors to ensure the latter meet minimum technical standards, with the goal of preserving the “reputation” of the product.

Consumers alone will not create sufficient demand

One of the barriers to environmental innovation is the lack of consumer awareness regarding long-term gains from energy-efficient products. Therefore, market-creation support measures are necessary because the product's environmental performance is only one of the factors shaping purchasing choices — and not necessarily the main one. Other factors such as price and quality play a more decisive role in

consumer purchases. Why would companies invest in environmental innovations, in particular energy efficiency, if consumers might not be willing to pay a premium for the environmentally-friendlier product?

More consumer awareness can play a key role in increasing energy efficiency. If, for example, there were eco-taxes (taxing inefficient lighting and thus discouraging consumers to buy incandescent lamps), Philips Lighting would work even more on energy efficiency than they do now. But there is no such tax on the horizon yet. However, consumers are becoming somewhat more aware that they need to invest in energy-efficient solutions. Their key priority is to find a way to make the case that in the longer term it is better for the consumer's budget to invest in energy-efficient lights and buildings.

Measures that support the development and deployment of energy-efficient products

Philips Lighting uses some public incentives, such as subsidies to conduct energy efficiency-related R&D in the Netherlands. However, these funds are not critical for conducting the programmes. If the company believes in a technology it will invest in it regardless of whether it obtains public support for it. Moreover, the procedures to obtain public support are cumbersome and do not match the rhythm with which R&D is carried out.

In the company's view, Dutch incentives for conducting R&D have no great impact on Philips Lighting – according to the company's representative, it receives greater incentives in Germany and the US. In Philips Lighting's opinion the EU policy framework for innovation is far more influential for the company than the national framework. Accordingly, the company's policy focus, and the debate it follows and tries to influence, is in the US, the EU, and China.

In Philips Lighting's view, policy tools that contribute to the deployment of innovative products and technologies are more important than R&D subsidies. These tools include: carbon credits (associated with the European Trading Scheme), emission rights, product standards, and voluntary mechanisms. Such mechanisms encourage consumers to buy energy-efficient lighting. Other public policy tools that can be influential are those focused on changing consumer behaviour.

Most of the gains, and importantly the potential gains, at Philips Lighting are in the market of institutional, not individual, consumers. For example, ideally cities would invest in energy-efficient infrastructure. However, the main constraint for the cities is that they focus on yearly budgets and thus it is difficult to convince them to increase their yearly budgets because the benefits of such investments would only accrue in a few years. The government could play a very positive role if it found a way of influencing the way in which cities manage their yearly budgets, or by supporting local initiatives (such as street lighting with energy-efficient lamps).

Another policy area that is potentially effective for increasing demand for energy-efficient products is the "greening" of governmental procurement policies. Governments can help increase the demand for a number of products if they agree to use their purchasing power to "reward" environmentally friendlier choices. The Netherlands has incorporated these considerations into its national strategy to promote environmental technologies. The EU is also developing a number of initiatives in this field that could promote energy-efficient technologies significantly. Among the developments is the publication of a Handbook on Green procurement (<http://ec.europa.eu/environment/gpp/guidelines.htm#handbook>). This handbook should be of particular use to local authorities, as they do not always have access to a good range of legal and environmental advice.

A ban on incandescent lights?

In Philips Lightings' view, the single, most useful measure that the government could adopt to promote energy efficiency is by banning incandescent lamps. It estimates that Europe could save eight million tons of emissions per year by switching from outdated office lighting systems to the latest technology. This represents the annual consumption of 25 million barrels of oil. The latest lamp and gear technology is up to 40% smaller and lighter than its predecessors. This means less raw materials are needed to create new fittings or luminaries. This also means less transport is needed to move stock with resultant savings (Philips, 2006a).

Other governmental actions could also help boost demand for energy-efficient products. The company's figures show that if all energy-inefficient lighting in Europe were upgraded to the latest technology solutions – for domestic, public, and private sectors, the annual running cost savings would be in the region of 4.3 billion euros equivalent to savings of 28 million tons per year (Philips, 2006b).

It will also be necessary to educate consumers to increase their awareness about the benefits of using energy-efficient equipment. The EuP Directive could boost demand (by two or three times). Educating consumers, however, is seen as a shared responsibility between the government and companies. Philips Electronics has joined partnerships with two European energy-efficiency networks — the European Federation of Regional Energy and Environmental Agencies (Fedarene, www.fedarene.org) and an association of European local authorities for the promotion of local sustainable energy policies (Energie-Cites, www.energie-cites.org) — to promote awareness of the potential of energy saving and resultant reductions by using new energy-efficient lighting technologies in European offices and street lighting. These partnerships come as new research by Philips revealed that more than 75% of Europe's office lighting is based on outdated and energy-inefficient lighting systems, which do not comply with the EU quality standards for offices.

More access to finance will be necessary to influence budget decision-making by municipalities. Philips Electronics is part of an initiative to provide information to European municipalities and companies on how they can save money on energy costs and reduce emissions through lighting. According to the company, total cost savings of EUR 1-2 billion per year could be possible for municipalities and private business owners in Europe who upgrade their lighting to modern technology.

Sharp

This case study describes the importance of corporate environmental standards and green procurement policies to drive environmental innovation both within a company and through its supply chain.

Box 28. Sharp: company profile

- **Activities:** the Sharp Group manufactures products in the areas of audio visual and communication equipment, home appliances, information equipment, photovoltaic power generation systems, as well as electronic components such as LSI's (large-scale integration) and LCD's. Sharp has been the world's largest manufacturer of solar cells since 2000 with nearly as much generating capacity as the next three largest manufacturers' combined.
- **Headquarters:** Osaka, Japan.
- **Employees:** Sharp Corporation – 22 900; entire Sharp Group – 55 600 (31 000 in Japan and 24 600 overseas) (as at 31 January 2007).
- **Sales and/or assets: (entire group)** JPY 2 797 109 million (consolidated as at 2005).
- **Website:** www.sharp-world.com.

An environmentally advanced company

Sharp has among its objectives “to become an environmentally advanced company” and is taking environmentally conscious action in all business activities to achieve this goal. As part of this goal, it aims to minimise the environmental impact of its worldwide production facilities. In 2004, it defined its corporate vision as “zero global warming impact by 2010”. Sharp also has strict internal rules aimed at environmental improvements throughout the whole production chain, and it imposes high environmental requirements on its suppliers (See Box 29).

Box 29. Sharp: promoting environmental improvements in-house and through the whole supply chain

Environmental improvement in-house: “Green Devices and Super Green Devices”

Environmentally conscious devices are what Sharp calls “Green Devices.” To define the standards and assessment method for their development, Sharp established guidelines, which it began applying in 2004. In 2005, Sharp began developing devices with still higher standards of environmental performance, which even surpass those of Green Devices. These devices are what Sharp calls “Super Green Devices.” Green Devices must satisfy at least 90% or more of all 21 assessment items (nine of which are compulsory) listed in the Environmental Performance Criteria. Super Green Devices must satisfy at least 95% or more of the 21 assessment items (10 of which are compulsory) listed in the Environmental Performance Criteria. They must be either the industry’s number one, or the industry’s first devices in at least one item of the External Environmental Claim Standards.

The development of Green Devices begins at the planning stage, where the environmental consciousness of the product is discussed in every aspect. Sharp then sets specific objectives based on the assessment items of the Green Device Standard Sheet. Finally, in the trial manufacture and mass-production stages, Sharp determines how well the actual product has met the objectives set out for it.

In 2005, both Green Devices and Super Green Devices exceeded their sales ratio targets. In the coming years, Sharp plans to raise these figures still higher.

Green procurement

In 2000, Sharp established the “Green Procurement Guidelines” and began efforts to enhance the environmental consciousness of parts and materials at a supplier level. In the fiscal year, 2003, Sharp formulated its “Survey Manual for Chemical Substances in Parts and Materials” and investigated chemical substance content as determined by the Japan Green Procurement Survey Standardisation Initiative (JGPSSI – a council comprising five organisations and 86 companies, mainly electronics manufacturers including Sharp Corporation, which works to standardise research on chemical substances in parts and materials).

The company also took measures toward eliminating RoHS-designated substances (RoHS stands for Restriction of the Use of Certain Hazardous Substances in Electrical and Electronic Equipment)³⁴. Sharp eliminated RoHS-related substances in all products for Europe by the end of 2005 and in new products, except for a few products for some areas, by 31 March 2006. In 2005, Sharp revised the Green Procurement Guidelines and the Survey Manual for Chemical Substances in Parts and Materials, and it introduced an online survey response system.

Source: Sharp, www.sharp-world.com.

³⁴ These products are listed in the EC Directive 2002/95/EC of 27 January 2003 on the Restriction of the Use of Certain Hazardous Substances in Electrical and Electronic Equipment.

Sharp's production of solar cells totalled 428MW in 2005 (a 32% increase from 2004), recording the world's largest volume consecutively for the sixth year in a row. Sharp is further expanding solar cell production. This is part of its corporate vision of achieving zero global warming impact by 2010, by "compensating" the amount of greenhouse gas emission resulting from its business activities by reducing emissions through the use of solar cells and energy-saving effects of new products manufactured by Sharp.

Most of Sharps solar modules are sold abroad. While the Japanese government had subsidised home owners installing solar modules, this support was later discontinued. When asked about government policies that would promote innovation, Sharp's representatives responded that putting in place systems such as those in Spain and Germany to promote renewable energies would boost its diffusion.

Sharp's representative also considered that government participation in demonstration and pilot projects is key. This is particularly important in developing countries, where, without government support, new energy technologies have difficulty taking off. One recent example is Japans' financial contribution to a demonstration project in Mongolia, where, in 2003, Sharp built a 200 MV solar plant.

Regulation in Europe is boosting Sharp's production of solar modules

In a press release from February 2007, Sharp announced that it will double its production capacity for solar (photovoltaic) modules during the coming year at its production base at Wrexham, North Wales, UK. Capacity will be increased from the current 110kW (as of February 2007) to 220MW annually.

According to the press release: "Up to now, the German market has been the engine driving demand for photovoltaic power systems in Europe, but electricity buy-back guarantee programmes have now been expanded to 20 countries, including Spain, Italy, Greece, and France, where long hours of sunlight, daily, ensure good PV power generating efficiency. Recently, the number of such installations has been growing rapidly, centred on Southern Europe. Sharp is working quickly to meet the rapidly growing demand for PV products in Europe by augmenting module production capacity. Solar energy does not generate substances that impact the environment, and as a leading manufacturer in this field, Sharp is aiming to expand its solar cell business, including working to make cells thinner to more effectively utilise raw materials, and expand production of thin-film solar cells that minimise the amount of silicon used" (www.sharp-world.com).

Expanding demand for solar energy through education

Sharp is also actively engaged in providing "environmental education" that contributes to familiarising citizens with solar energy, and to improve awareness of environmental preservation. According to Sharp's environmental and Social Report of 2006, "Sharp regards it as a crucial role for a solar cell manufacturer to publicise the importance of clean energy and the global environment. For that purpose, Sharp has been holding "Solar Academy" classes in Japan since October 2004. Full-time staff visit schools and citizen courses around the country to explain environmental problems and clean energy using simple methods based on quiz games and hand-made teaching materials. Sharp will continue to advocate the importance of environmental conservation to children, who form the next generation, and promote the widespread use of photovoltaic power generation through constant technological innovation to build a sustainable society.

Solarworld

This case study shows how a small company specialised in solar energy technology grew rapidly thanks, inter alia, to efficient government measures to create a stable market.

Box 30. Solarworld: company profile

- **Activities:** the SolarWorld AG Group is among the three largest solar power companies in the world. The group is dedicated exclusively to the core business of solar energy, combining all stages of the solar value chain, from the raw material silicon to turn-key solar power plants. Solarworld Aktiengesellschaft is the parent company of SolarWorld Group.
- **Headquarters:** Bonn, Germany.
- **Employees:** 1 200.
- **Operations:** the company has subsidiaries in Germany, the Netherlands, Sweden, Spain, the US, Singapore, Canada, and South Africa.
- **Sales:** EUR 515.2 million in 2006.
- **Website:** www.solarworld.de.

Growth through efficient government measures

The company, which started in 1998 with about 70 employees, has grown very rapidly in the last few years, in parallel with the German government's efforts to promote renewable energies. Several programmes such as the "100 000 roofs" initiative, which provided financial support to home owners installing solar panels on their roofs, but which is now discontinued, and legislation establishing a feed-in system, contributed to stimulating demand for solar energy. The real breakthrough, however, came with the adoption of the Renewable Energy Sources Act in 2000, and its amendment in 2004 (see Box 31).

According to Solarworld's representative, the measures preceding the Renewable Energy Sources Act were very cumbersome and bureaucratic, but they were successful in creating a demand for solar energy. The advantage of the new system is that it is very simple, both as regards the financial aspects (feed-in system by which utilities must buy renewable energy at a fixed price) and its technical aspects (connection of solar energy to the grid is technically very simple). It is also crucial that the system is stable and takes a long-term approach: the programme will continue over 20 years (albeit with a digressive effect), and this has a positive effect on innovation. It provides a long-term investment security, while encouraging the producer to lower its prices, as government support diminishes. Moreover, the system is open to all – German and foreign companies – and thereby fosters competition, as well as strengthening the market for solar energy products and technologies.

Box 31. Germany's Renewable Energy Sources Act

The Federal Government's long-term goal is to cover at least half Germany's total energy requirements with renewable energies by 2050 (Sustainability Strategy). One of the means to achieve this goal was the adoption, in 2000, of the Renewable Energy Sources Act (*Erneuerbare-Energien-Gesetz* [EEG]). This Act replaced the Electricity Feed Act (*Stromeinspeisungsgesetz*), which, according to the German government, was successful, but had to be overhauled for a number of reasons: the growth of the green electricity output beyond the 5% ceiling previously set for support entitlement, the need for a national distribution of costs beyond the regions, the lack of planning and investment security, and the adjustments required for compliance with EU directives.

In the Renewable Energy Sources Act (Article 1) the legislator decided to increase the share of renewable energies in the electricity supply to at least 12.5% by 2010 and to at least 20% by 2020. By

2010, the renewable energies' share in primary energy use will be raised to at least 4.2%.

The Renewable Energy Sources Act regulates the prioritisation of grid-supplied electricity from renewable sources. It specifies mechanisms for implementing the option of granting priority to renewable power generation envisaged in the EU Directive on the internal market in electricity. Energy utilities now benefit from compensation for supplying the grid with electricity from renewable sources. By guaranteeing compensatory payments, the act restores a secure climate for investment.

This arrangement has been made available for a period of up to twenty years per plant, with the exception of hydroelectricity installations, which require longer amortisation periods. In addition, the Act incorporated digressive steps, starting in 2002, for plants coming on line then. The Act also offers scope for altering the compensation rates for future installations, if necessary.

This remuneration system aims to create the security needed for investment under present market conditions. There is adequate provision to safeguard the future existence of all the plants already in operation.

The new act has abolished the regulation contained in the Electricity Feed Act, which limited the uptake, at preferential rates, of electricity from renewable energy sources to a maximum share of 5% of overall output. Instead, it introduced a nationwide cost-sharing arrangement. The act should put an end to any fears of excessive financial burdens.

Source : BMU, www.bmu.de/files/pdfs/allgemein/application/pdf/res-act.pdf.

To be successful in global markets, said the Solarworld representative, the pre-condition is to have a strong national market to stimulate innovation and investment. He considered the current German measures to be a boon for solar energy and allow for making the economies of scale needed to expand to other markets. He also highlighted that the take-off of solar energy has contributed to lifting the depressed electronics industry of Germany back into business, and to creating a whole new manufacturing sector.

Measures taken in other countries to promote solar energy are very closely monitored. A table, reproduced below, in Solarworld's annual report reflects measures (public subsidies) "that have an impact".

Table 3. Government measures that have an impact on solar energy production

Country	Public subsidies that have an impact	Status 2006	Market goals
Germany	"Renewable Energy Act". In force since 2000, amended 2004	<ul style="list-style-type: none"> – Fixed feed-in compensation with 20 year guarantee – 5 per cent or 6.5 per cent decline in compensation p.a., depending on the plant type 	25 per cent of power demand to be met by renewables by 2000
Spain	" <i>Real Decreto</i> 436/2004". In force since 2004, amended July 2006 To be amended in 2007	<ul style="list-style-type: none"> – Fixed feed-in compensation with 25 year guarantee – Adjustment to inflation rate – Law is in a transitional phase, but the government has indicated that there will be improved subsidies 	400MW installed photovoltaic output by 2010, but 400MW cap currently in discussion

USA	<p>Nationwide: "Federal Energy Policy Act". In force since 2005</p> <p>California: "California Solar Initiative" and "Solar Bill". In force since 2007; 2007 regarded as transitional phase</p> <p>Other states also adopted new legislation in 2006: New Jersey, Arizona, Pennsylvania, Nevada, etc.</p>	<ul style="list-style-type: none"> – 30 per cent tax concession for installation of photovoltaic systems up to the end of 2007 – Fixed feed-in compensation for systems larger than 100kW – Investment cost subsidies for smaller systems – Programmes vary from one state to another – Investment cost grants – Quota system 	<p>3 GW solar power by 2017</p> <p>All in all, about 4GW installed photovoltaic output by 2021</p>
Italy	<p>"Conto Energia". In force since 2005</p>	<ul style="list-style-type: none"> – Fixed feed-in compensation with 20 year guarantee – 5 per cent decline p.a. – Adjustment to inflation rate – Maximum: 80MW p.a. 	<p>1 000MW installed photovoltaic output by 2015</p>
France	<p>"Décret n°. 2000-1196" In force since 2000, amended in July 2006</p> <p>Additional regional subsidy programmes</p> <p>Tax concessions</p>	<ul style="list-style-type: none"> – Fixed feed-in compensation with 20 year guarantee – Limit of 1 500 full-load hours per kW 	<p>21 per cent of power demand to be covered by renewable energies by 2010</p>
Greece	<p>Law "3468" for renewable energies. In force since 2006</p>	<ul style="list-style-type: none"> – Fixed feed-in compensation with 10 year guarantee – Guarantee may be extended for a further 10 years – Adjustment to inflation rate 	<p>700MW installed photovoltaic output by 2020 as minimum goal</p>
South Korea	<p>Feed-in compensation Act in force since 2002</p> <p>100 000 roof programme. In force since 2004</p>	<ul style="list-style-type: none"> – Fixed feed-in compensation with 15 year guarantee – Investment cost grants up to 70 per cent; alternatively, subsidies from USD 10 000 to 15 000 	<p>1.3GW photovoltaic output by 2012</p>

Source: Solarworld, Annual Report 2006, www.solarworld.de.

Toyota

This case study highlights the importance of internal environmental requirements and green purchasing policies in contributing to promoting environmental innovation.

Box 32. Toyota: company profile

- **Activities:** established in 1937, Toyota Motors Corporation (hereafter Toyota) is a vehicle manufacturer. It sold about 8.8 million vehicles (Toyota/Lexus, Daihatsu, and Hino) worldwide in 2006.
- **Headquarters:** Toyota City, Japan.
- **Employees:** 285 977 people (consolidated accounts); 65 798 people (unconsolidated).
- **Operations:** in addition to various centres in Japan, Toyota has a total of 52 overseas manufacturing companies in 27 countries/regions.
- **Sales and/or assets:** In 170 countries; JPY 21 036.9 billion (consolidated accounts); JPY 10 191.8 billion (unconsolidated).
- **Other:** Toyota now conducts body and major component design and evaluation at R&D facilities in five market regions – North America, Europe, Australia, Asia, and Japan. The function of R&D bases in North America, Europe, Australia, and Asia is to take platforms and base models developed in Japan and modify the specifications and body to reflect the tastes of each.
- **Website:** www.toyota.co.jp/en/index.html.

Environment: a top priority for Toyota's management

Toyota is known for its comprehensive efforts towards environmental improvement in all aspects of its business. It has high environmental aims to promote environmental management on a global scale and to become a company “that is trusted and respected by peoples around the world”. In the company’s own words, it aims for “the world’s highest levels of environmental technology and performance and to reach world leading levels of environmental efficiency”.

To ensure that its products are accepted and well received around the world, Toyota has positioned the environment as a priority management issue and seeks to become a leading company that contributes to the development of a recycling-based society through innovative environmental technologies. In order to achieve this, Toyota has created environmental management systems in all regions around the world and in all areas, and is continually promoting measures with goals set at the highest levels in each country and region. The Toyota Earth Charter (adopted in 1992; revised in 2000) is based on the Guiding Principles at Toyota (adopted in 1992; revised in 1997), and embodies the comprehensive approach to global environmental issues. Based on this Charter, Toyota has made environmental responses a top management priority.

Toyota actively pursues R&D “in order to offer high quality, low cost products that accurately reflect increasingly diverse and advanced demand. In 2006, Toyota’s R&D expenses represented 3.9% of consolidated net revenues. Toyota has R&D centres in seven locations (in North America, Europe, Asia, and Oceania) in order to cater for customer needs in the different regions. One focus in Toyota’s R&D activities is on environmental technologies, aimed at “reducing the burden vehicles place on the environment throughout their life cycles”. One of Toyota’s best-know environmental innovations is the hybrid car, the Prius. Other innovations include fuel cell technologies, and vehicle recycling technologies.

“Globalising and localising” at Toyota

Since 1957, when Toyota began exporting to the United States, the company has expanded the scope of its automobile sales across the entire globe. Fifty years after these first exports, Toyota vehicles have

been exported to over 170 countries and regions throughout the world. As exports have continued to develop so has the localisation of Toyota's production bases, in line with the company's policy of "producing vehicles where the demand exists." Currently there are 52 bases in 27 different countries and regions. In addition, there are design and R&D bases in seven locations overseas, showing that "from development and design to production, sales, and service, Toyota has now achieved consistent globalisation as well as localisation" (www.toyota.co.jp/en/vision/globalization/gpc.html).

There are a number of hurdles that this globalisation of production has to overcome. Among these the most important is "quality assurance," which requires that "no matter where Toyota vehicles are made, they have the same quality." This means that the company needs to spread Toyota's manufacturing philosophy the "Toyota Way" to all of its overseas bases. On top of this, it is important that the company minimises the necessary support that comes from Japan and let each of its overseas bases become self-reliant. For example, the Toyota plant that recently commenced production in Texas made maximum use of the know-how that has been cultivated over the past 20 years by the Toyota plant in Kentucky.

Until recently, when Toyota had a "mother plant system," the personnel development for overseas production bases took place primarily at mother plants in Japan. However, as overseas facilities have expanded in line with the increase in overseas production, the instructional content provided to personnel has become different and varied. In order to ensure quality, Toyota needed to establish "best practices" for itself and then spread these to all of its affiliates; and the organisation created to carry out this mission is the Global Production Centre (GPC). Outstanding personnel from the various Toyota plants within Japan were assembled to determine what Toyota's "best practices" should be, and then company-wide initiatives were begun with the aim of achieving global quality assurance.

Toyota's environmental purchasing guidelines: requesting environmental performance from suppliers

Toyota carries out about 30% of its production in-house, while 70% is sourced from external suppliers. The percentage of outsourcing is increasing and, according to the company, "co-operation with suppliers is needed right from the production planning stages".

Co-operation with suppliers is particularly important in the area of environment. Toyota's "Environmental Purchasing Guidelines", adopted in 1999 (re-named Green Purchasing Guidelines after a revision in 2006), request suppliers to enhance and reinforce environmental management, to acquire ISO 14001 certification, to reduce CO2 emissions, and to proactively promote environmental initiatives related to the suppliers' business activities, including in their purchasing and logistics activities. Thus Toyota's environmental management approach is also extended to its suppliers (and their suppliers), ensuring increased globalisation of good environmental practices.

Emission standards in the automotive industry – a trend towards globalisation

The automobile sector is heavily regulated both in Japan and other countries. According to Toyota's representatives, regulation such as binding emission standards and recycling requirements are one of the driving forces behind the company's efforts to innovate. However, the company does not innovate only to conform to existing standards, but strives to be ahead of regulatory developments when new, stricter standards become compulsory.

In a comparison between regulation and voluntary measures, Toyota sees the advantage of regulation as contributing to fair competition, while the disadvantages are lengthy discussion periods to adopt the necessary processes, lack of flexibility, and the risk of treating only the symptoms of a problem. In comparison, voluntary measures, which are seen by Toyota as a sign of a trend towards maturity of society, have the advantage of allowing for prevention, they grant more flexibility, and allow for more

comprehensive measures. The disadvantages of voluntary measures are that they do not ensure compliance, and allow for free riders.

Regulation is necessary, but compliance has to be within reach both from the point of view of technical feasibility and cost. Where standards are set at a too challenging level of performance, they may not meet customers' requirements and the product will only reach a very limited market. For example, California's regulation for the zero-emission vehicle was technically premature at that time, and it had to be enforced in a way that made it more acceptable to a broader market. It is also important that the resulting vehicles be at a reasonable price for customers. Some conscious customers are ready to pay a premium price for environmentally preferable goods but it has to remain within a reasonable limit. In addition, fuel efficiency and environmental benefits such as recyclability are key to attract customers in a very competitive sector.

Partnerships

Toyota has, for many years, co-operated in R&D projects with a range of partners, including competitors. Box 33 provides an example of a recent co-operation arrangement between Toyota and General Motors to co-operate in R&D for vehicles with advanced environmental technology.

Box 33. R&D co-operation on vehicles with advanced environmental technology

Toyota Motor Corporation (TMC) and General Motors Corp. (GM) reached an agreement during the spring of 1999 to co-operate in research and development of vehicles with advanced environmental technology. The companies' combined R&D efforts are to focus on electric vehicles (EV), hybrid vehicles (HV), fuel cell electric vehicles (FCEV), and other vehicles applying these advanced technologies.

The agreement calls for development of:

- A common set of electric traction and control components for future battery electric, hybrid electric, and fuel cell electric vehicles;
- Batteries and battery test procedures, vehicle safety standards, and continued work on improved inductive charging systems for battery electric vehicles;
- Powertrain and control systems for next generation hybrid electric vehicles; and
- Future systems design, fuel selection and processing to support production of fuel cell powered vehicles.

According to company representatives: "We cannot make a contribution to the environment unless this technology is extensively disseminated so that it can be used widely," said TMC Vice President Wada. "In this respect, the hybrid vehicle is the most promising vehicle with advanced environmental technology in existence today. We have no doubt the market scale for hybrids will grow to rival that of gasoline-powered vehicles early in the twenty-first century (...). If we are to elevate vehicles with advanced environmental technology into practical use, and have these vehicles widely accepted by the public, we will have to create a trinity comprising innovative technologies, reduced cost, and an appropriate infrastructure. If any one of these three elements is missing, we will be unable to achieve satisfactory results. I sincerely hope this technological co-operation with GM will speed up these efforts and ensure that the fruits of our labour will be realised."

In 2001, the companies assessed their collaboration. According to Toyota's representative: "Through our collaboration on advanced technology for electric, hybrid, and fuel cell vehicles, which has been going on now for nearly two years, both companies believe that our joint activities are contributing to the development and accelerated introduction of advanced technology vehicles into the market. We believe in the importance of moving forward, while taking into consideration environmental, cost, and infrastructure

issues, as well as consumer demands, and while cooperating with other car manufacturers, other industries, and government organisations."

GM's vice president for Research & Development and Planning said, "In many ways, ideas are more valuable in the early stages of R&D than racing into production. To date, we have spent the majority of our time exchanging knowledge of technologies, sharing components and parts, and jointly evaluating fuel cell propulsion system design approaches. For an advanced technology collaboration, this pace is very aggressive."

Source: Toyota, www.toyota.com.

Unilever

This case study highlights the importance of internal environmental policies in a company's innovation strategies.

Box 34. Unilever: company profile

- **Activities:** Unilever is one of the world's largest suppliers of consumer goods across three categories: foods, home, and personal care products. Unilever N.V. (NV) is a public limited company registered in the Netherlands; Unilever PLC (PLC) is a public limited company registered in England. The two parent companies, NV and PLC, together with their group companies, operate as a single economic entity (the Unilever Group, also referred to as Unilever (or the Group)).
- **Headquarters:** UK and Netherlands.
- **Employees:** 206 000 people (2005); 5 169 scientific staff is involved in R&D activities.
- **Operations:** 337 manufacturing sites across six continents.
- **Sales:** turnover EUR 39.6bn in 2006.
- **Other:** over 65% of the raw materials come from agriculture, with around 19 000 suppliers. EUR 15.9 billion were spent with some 10 000 suppliers of raw materials, packaging, and goods purchased for re-sale. EUR 953 million were invested in R&D, equivalent to 2.4% of sales.
- **Website:** www.unilever.com.

Drivers of environmental innovation as part of the company's overall innovation strategy

Unilever's R&D strategy does not differentiate between R&D "in general" and "environmental" R&D. Instead, environmental considerations are part of the overall R&D process, which is organised around the company's main brands.

A number of conditions – external and internal – affect the degree to which environmental aspects are included in R&D activities. It is not possible to establish the number of drivers that affect the company's innovation strategy because such strategy is product-specific so the drivers affecting the development of some products might differ from the drivers affecting another set of products — even within the same company.

Some "traditional" drivers for environmental innovation that are mentioned in the literature, in particular "cost reduction" (more efficient products, processes, or services) are relevant for older products

but irrelevant in the case of new products. The search for market benefits (*e.g.* to gain or improve market access) also affects Unilever's products differently. For example, this driver is particularly relevant in the development of organic foods.

Environmental regulation — at home and abroad — is a given, or a starting point, but it is not considered the main driver of the decision to incorporate environmental aspects in the innovation process. In the company's words, "environmental compliance is not what drives Unilever." Clearly, there are instances where a regulatory measure, such as the global ban on CFCs (chloro fluoro compounds), would have a definitive impact on the company's innovation and production strategy. But most generally, regulatory activity is just one among a set of drivers.

Nevertheless, strict and effective regulation is considered to be very important. Moreover, if the regulation is well defined and predictable then it becomes an advantageous factor for companies like Unilever because they have the means — financial and technological — to meet the requirements. Ability to comply, and even exceed governmental expectations, will be an advantage *vis-à-vis* their competitors.

Internal drivers

Other aspects that might "green" the process are internal decisions accruing from risk assessment exercises or market drivers that push the company to be environmentally proactive even if there is no regulatory force behind them. In sum, in order to accommodate environmental aspects in the innovation chain, the company has an internal approval or decision-making process that includes a regulatory component and a "self-imposed" component. The R&D budget is organised around projects, some of which will have a higher budget for R&D than others and the percentage that deals with environmental considerations will vary accordingly. It is nearly impossible, in Unilever's view, to define which component of the corporation's overall R&D budget is dedicated to R&D that meets environmental objectives.

Each product category at Unilever has a number of objectives to meet. These product-specific factors, which are defined internally and consistently with Unilever priorities drive the R&D agenda. As of 2006, these three "big picture issues" were: (1) the social impact of their products, principally on people's health through nutrition and hygiene; (2) the steps to minimise their environmental footprint and secure sustainable supplies of key raw materials; and (3) how their operations create wealth and how this benefits stakeholders and local communities. Once these priorities are adopted at the product category level, then a technical strategy is adopted to ensure they are met in the manufacturing process.

The company also has a code of best practices that affects its environmental strategy and the performance of its products in particular. Depending of the environmental issue at stake, the company decides how changes in the products must occur. Most often, these changes do not happen immediately. Instead, the company establishes trends and a timetable to adapt the products, for example, the banning of some materials or the reduction in the use of some ingredients. The marketing of the message, and the communication of environmental aspects, also changes on a product-category basis. Given the high value of the Unilever brand, a central objective in marketing their products and their environmental claims, is to promote and protect their reputation — the global brand as well as the product-specific family of brands.

Globalisation of the innovation strategy: international outsourcing and establishing international partnerships

Global companies are increasingly outsourcing R&D activities to other companies and research institutes and Unilever is not the exception. It outsources and relocates R&D activities both at home and abroad. The factors affecting the relocation of some of its R&D activities relate to the scarcity of

engineering and scientific experts at home (the UK and the Netherlands); market pressures, including the need to continuously reduce “time-to-market” cycles; and the need to access new markets. According to the company, no fundamentally different factors affect the relocation of environmentally-related R&D.

In terms of international partnerships, Unilever has invested in collaborative efforts in the environmental innovation arena with partners from the public, private, and academic sectors. Some of examples include the participation in a sustainable chemistry forum in Europe (a multi-agency initiative)³⁵; work with business partners, including Germany-based BASF, in projects to reduce energy consumption; as well as projects to promote more environmentally-friendly packaging (e.g. the Sustainable Packaging Initiative)³⁶. Some of the collaboration with non-profit organisations includes the activities under the Sustainable Palm Oil Roundtable, which offers a co-operation platform not only for industry-NGO collaboration, but also includes growers, processors, consumer goods manufacturers, retailers, investors, and non-governmental organisations.³⁷

Unilever’s main international collaborators on R&D are mainly located in the EU (for example, Germany, France, and the Netherlands on chemistry topics) and the U.S, but they are increasingly developing partnerships in other parts of the world. These collaboration arrangements are often set on a contractual basis (to ensure the protection of intellectual property) and most of them fall under the category of “vertical” co-operation (with suppliers, customers, or distributors), as opposed to “horizontal” co-operation (i.e. companies operating at the same market level, including competitors). The catalysts for establishing these arrangements are the facilitation of market access, information sharing and, especially, the search for pioneer environmental technology approaches that might be more feasible to achieve through joint effort.

So far, most collaboration in the environmental technology field has been effective and met its objectives. However, some factors add complexity to the management of international collaboration arrangements, including the weak relationship between firm-based researchers and the scientists working outside the country and unfamiliar with the company’s culture — and the culture of the company’s country of origin. Sometimes even language barriers can turn collaboration into a very difficult enterprise. Another factor that works against the creation of such arrangements is often the lack of knowledge of “what is available elsewhere.” In the EU context, the institutions are working to deal with this problem by disseminating information about the research activities that are taking place at the EU level.

Challenges linked to governmental policies and environmental standards

Although environmental regulation can play a positive role in promoting environmental innovation, as mentioned above, in Unilever’s experience, such regulation can also pose major technological and manufacturing challenges in some cases. Two specific instances are:

- **Country-specific regulation:** standards and regulations are established locally and can lead to fragmented, country-specific requirements. For a global company, the fragmentation of product requirements introduces a very high degree of complexity. It would be easier, from a technological and manufacturing perspective, to meet consistent standards across markets. While

³⁵ The European chemical industry (CEFIC) and the European biotech industry (EuropaBio), in March 2005, launched *SustChem*, as a technological platform to promote EU R&D activities on sustainable chemistry (www.euractiv.com/en/environment/sustainable-chemistry/article-139332).

³⁶ The Sustainable Packaging Initiative is a seventy-member industry group that promotes best industry practice, innovation, and information exchange to improve packaging choices from an environmental standpoint (www.sustainablepackaging.org).

³⁷ Unilever is one of the founders of this initiative, which was officially launched in 2004 (www.rspo.org).

this proposition is difficult to implement because regulators focus on domestic, not international, conditions, it is necessary, in Unilever's view, to bring this problem to the attention of the regulators, since they might be hindering environmental innovation by not coordinating with their peers in other countries; and

- **Ill-informed regulation:** in their view, environmental standards and regulation that are established without proper consultation with the affected industries might lead to prescriptions that are unlikely to work in practice — and therefore risk to fail in solving the environmental problems that the regulation was meant to address in the first place.

Given the size of Unilever, government support for conducting environmentally-related R&D is not critical for the company. In their view, one of the main problems with the governmental framework to promote environmental innovation in the business sector is the lack of co-ordination among the different agencies dealing with the innovation agenda, on one side, and the environmental agenda on the other. Tackling this problem would require not only a sound inter-governmental co-ordination mechanism but also stronger liaisons between governmental, business, and academic research agendas.

Another suggested area of improvement is in the area of setting clear environmental priorities in the long term. By mapping these priorities — which would not change over time — governments could send clear signals to the business sectors that would allow more investment to go to these areas. In Unilever's view, policy uncertainty is a fundamental disincentive to further investments in environmental technologies. Finally, a suggestion for spurring environmental innovation is to adopt measures that increase demand for environmentally advantageous products rather than to offer taxes or subsidies to the companies conducting the environmental research.

United Technologies Corporation

This case study describes a company's innovation efforts based, *inter alia*, on internal drivers, which include quality and environmental goals.

Box 35. United Technologies Corporation (UTC): company profile

- **Activities:** UTC provides high-technology products and services to the building and aerospace industries. It operates in the following business areas: carrier heating and air conditioning systems; (Hamilton Sundstrand), aerospace and industrial systems; (Otis) elevators and escalators; (Pratt & Whitney), aircraft engines; (Sikorsky) helicopters; (UTC) Fire & Security protection services; (UTC) Power. It also owns the United Technologies Research Centre. UTC Power is a full-service provider of environmentally advanced power solutions. It is a leader in developing and producing fuel cells for on-site power; transportation; space and defence applications; and a developer of other innovative combined cooling, heating, and power (CCHP) applications in the distributed energy market. It has installations in 85 cities and 19 countries.
- **Headquarters:** Hartford, Connecticut, US.
- **Employees:** 215 000 employees (2006); more than 60% of employees work outside the United States.
- **Operations:** over 4 000 locations in approximately 62 countries; UTC does business in 180 countries.
- **Sales:** revenues – USD 47.8 billion (2006); sales to US Government – USD 6.4 billion (2006).
- **Websites:** www.utc.com and www.utcpower.com.

Innovation driven by ambitious internal goals

UTC started working on environmental technologies several years ago. The main drivers for the development of innovative technologies were the benefits that accrued to the company as they tried to respond to market needs (requiring technologies with certain environmental attributes) as well as internal objectives to increase cost effectiveness and efficiency.

The company has established a set of internal goals, which are intended to decrease the negative impact of its products and operations. UTC states, “We pursue environmental goals the same way we pursue financial and business goals: by continuously improving our processes at every level of the company.” According to company representatives, environmental leadership is ultimately about having good management in place.

Though environmental regulation plays a role in driving the company to develop environmentally-friendly technology and to develop internal practice, it is not the main catalyst. Instead, the catalyst for environmental innovation is the market, *i.e.* the requests from clients that expect UTC to offer them solutions that improve the efficiency of products in cost effective ways. The company does not draw a distinction between innovation and environmental innovation. The goal is to deliver top quality, products and cutting edge technologies, and to improve their efficiency systematically. It is the search for efficiency and continuous improvements that often leads to products that have a reduced environmental footprint. For example, when designing a new type of elevator, the company had no particular environmental improvement in mind. Nevertheless, these newly designed elevators run more efficiently because they are smaller in size and thereby require use of less material for their construction and less energy is consumed during their operational life. These innovations led to reduced environmental impacts and improvements in efficiency of up to 75%. This example helps illustrate some forms of innovations that fall outside the traditional “environmental innovation” definition but are, in practice, highly advantageous from an environmental and energy standpoint.

In 2007, UTC embarked on a new four-year programme to reduce greenhouse gas emissions by 12%, water consumption by 10%, and non-recyclable waste by 30%, all on an absolute basis as compared to 2006. A significant change is that the energy and water metrics will no longer be normalised for volume and, instead, will be tracked in absolute terms. The new greenhouse gas reduction target, equivalent to taking more than 50 000 cars off the road, is aggressive, as UTC’s performance to date has averaged 2% reduction annually. Since 1997, UTC’s worldwide energy use has gone down by 19%, while revenues have nearly doubled.

Designing for quality and for the environment

According to UTC, its products “turn energy into useful work. Because of their reliability and longevity, the energy efficiency of our products becomes part of our customers’ environmental footprint. This motivates us to design for the environment, creating products that consume fewer resources and produce fewer emissions during manufacture and in operation. We take this approach with everything from fire extinguishers to air conditioners to jet engines”.

Given its high investments in R&D and innovation, the company has built a solid reputation with investors. The company had faced major challenges in the 1980s that led to the search for a business model that would achieve significant cost reductions while improving performance. Increasing the **quality** of operations has been central to building credibility in the investment community. One of the company’s goals has been to build the reputation of a trusted company. The investments in technology together with good management practices have led investment analysts to talk about the “quality of the UTC earnings.”

Internationalisation of activities

The United Technologies Research Center (UTRC), a stand-alone research facility, develops technology that helps UTC deliver high performance products that are also “clean, green, quiet, and safe”. In 2006, 40% of UTRC’s research and development funding went into projects that benefit the environment directly, via clean energy generation, or indirectly, by reducing energy consumption of UTC products in service.

The internationalisation of markets offers many opportunities for the company, including diversifying its risks. As a result, UTC conducts R&D abroad in China, Singapore, and Europe. But the activities deal predominantly with development, and the research mostly takes place in the United States, with some research also taking place in Russia and France.

Globalisation also offers new market opportunities. The development of products is driven by country-specific needs. Once the company has conducted the research, it then tries to adapt the technology to the markets that it serves, but the technology is basically the same. One example is water purification. The research is already available but the development is driven by the needs of and orders from foreign markets, for example India. The European market does not need this type of development.

One area where UTC has attained world leadership is in fuel cells. UTC started its fuel cell R&D programme in the late 1950s. Today most of its fuel cell work is developed under its company, UTC Power. The proactive approach that UTC Power has taken in this field translates into currently being the only company that has R&D and/or commercial activities in all types of fuel cells technologies. As of December 2006, it was granted 682 patents in the US and 1666 abroad. It also has 207 pending patents in the US and 623 abroad.

Pioneering investments in fuel cell R&D and commercialisation efforts have led to a strong internationalisation of UTC Power strategy leading to sales in five continents and 19 countries. The products fall under three categories: transportation, space and defence, and on-site power solutions.

In terms of transportation, UTC Power’s proposition rests on three pillars: high efficiency, environmental stewardship, and energy independence. The products that are offered are bus fuel cell systems for clients in the United States and abroad, including transportation companies and regional transit authorities. The company has also developed relationships with automotive companies that aim to sell fuel cell cars in the future.

Space and defence-related products are sold to NASA (space shuttle fuel cell for power, heat, and potable water) and Navantia (submarine fuel cell for air-independent propulsion). The on-site power solutions include fuel cell power systems, on-site combined cooling, heating, and power systems, as well as geothermal power systems. High efficiency is one of the three pillars of its value proposition of this business unit. For example, with traditional central power plants, significant amounts of energy (approximately 67%) are lost to the atmosphere as waste heat. The amount is reduced to 10 to 20% with the installation of a combined cooling, heating, and power system.

Partnerships to accelerate innovation in energy efficiency and develop standards

One example of the increased efforts by UTC to develop energy-efficient technologies is the decision to lead, together with Lafarge, a “zero net energy buildings” project that builds on UTC’s expertise in optimising building design. The Energy Efficiency in Buildings Initiative (EEB) involves 10 companies and operates under the World Business Council for Sustainable Development (WBCSD). It aims at significantly reducing energy use in buildings without reducing their quality. In the view of EEB members, governmental action in this field is too slow — and decision-making even slower. This initiative

seeks to accelerate the pace of the debate over energy efficiency in buildings, and to produce a roadmap acceptable to stakeholders for commitment. Box 36 provides further details about this initiative.

UTC's involvement in this international initiative was the result of a previously developed internal process that sought to achieve major energy savings. In January 2006 the company achieved 30% of its self-established efficiency targets and showed to the rest of the industry what could be achieved technologically. Then UTC helped draft a standard that derived from what was proven to be feasible technologically. In UTCs' view, it is very important that governmental drafters of regulation and standards know first what technologies can achieve in practice.

Box 36. Energy Efficiency in Buildings Initiative

Buildings consume 40% of the world's total primary energy, making it the most energy-hungry of the major sectors. There is great potential for energy savings and CO2 emissions reductions in the building sector. The Energy Efficiency in Buildings (EEB) project is the leading industry-only group tackling these urgent issues. New integrated building methods, new design, new technology, smarter new government regulations, market pull for green buildings and changed perceptions about the cost and difficulties of sustainable building will all play a role in realising the project's vision of a world in which buildings consume zero net energy.

One of the main users of energy – buildings – is expected to consume more and more as populations grow, migrate, and economies develop. Today China and India are constructing half of the world's buildings. The technology exists today to construct new buildings that consume radically less energy. The number of buildings that generate nearly as much energy as they consume is ever-growing. The main obstacles for greening the building sector are market structure practices, more than technical difficulties.

New technologies and practices have been developed with regard to improved energy efficiency in buildings, but few are being implemented on any scale. This project will attempt to draw these innovations together, addressing all aspects of a building's lifecycle, in order to raise awareness, and advocate and promote action. "Green" buildings are already being erected in various parts of the world but current cost structure prevents widespread adoption by general contractors. The project will build on these examples, aligning costs and benefits in the building equation and by working in close collaboration with architects, builders, suppliers, and building owners to promote a more sustainable approach to construction. Existing standards for energy efficiency in buildings will be the starting point for this industry-led alliance.

The EEB project is one of several around the world focusing on this important aspect of climate change. The key target audiences are major actors in the building sector such as investors, developers, architects, suppliers, and building owners and tenants. The EEB project is promoting a system approach to creating energy-efficient buildings. That change can come about by smarter regulations, new technology, and increased market demand.

The project is led by co-chairs Lafarge and United Technologies Corporation, and has the active participation of eight member companies: Cemex, Dupont, EDF, Gaz de France, Kansai Electric Power, Philips, Sonae Sierra, and TEPCO. Arcelor, BP, ITT, and Rio Tinto are also providing support.

The project will comprise three phases, each producing reports that together will form a roadmap to transform the building industry. The first report will document existing green building successes and setbacks, the second will identify the full range of present and future opportunities, and the third will present a unified industry strategy for realising those opportunities by 2050, specifically in China, India, Brazil, the U.S., and the E.U. Each report will take one year to complete and involve hearings and conferences with building contractors and suppliers, sustainability experts, government representatives, regulators, utility officials, and others.

Milestones include:

May 2007: define and communicate the current state and business of the building market and industry and present the existence of business opportunities towards zero net energy solutions;

May 2008: benchmark and profile barriers that inhibit zero net energy buildings. Using scenario analysis, develop, communicate, and promote an action plan that substantiates the market potential to close gaps;

June 2009: gain project and then industry commitment through stakeholder engagement and promotion and monitor and highlight early adopted actions to showcase impact and promote a validated final action plan.

Source: based on WBCSD www.wbcd.org. and Vitello, P. (2007).

Vestas

This case study illustrates the “internationalisation” of a company’s deployment efforts. It highlights the interaction between domestic innovation and environmental policies to promote wind energy, and the market dynamics that favoured the globalisation of wind turbines.

Box 37. Vestas: company profile

- **Profile:** Vestas’ core business comprises the development, manufacture, sale, marketing, and maintenance of wind power systems that use wind energy to generate electricity. Vestas has 30 000 wind turbines generating electricity in more than 60 countries making it the world’s largest supplier of wind power systems.
- **Headquarters:** Aarhus, Denmark.
- **Employees:** 11 900 employees (September 2006).
- **Operations:** Denmark, Germany, India, Italy, Scotland, England, Spain, Sweden, Norway, Australia, and China.
- **Sales and/or assets:** EUR 3 583 million (2005).
- **Website:** www.vestas.com.

Vestas’ core business encompasses the development, manufacture, sale, marketing, and maintenance of wind power systems that use wind energy to generate electricity. It started to manufacture wind turbines in 1979 with a focus on the Danish market. Initially, it had a staff of around 60 people. Today, Vestas has become the world’s largest supplier of wind-energy systems with more than 13 000 employees worldwide and with more than 30 000 wind turbines installed in more than 50 countries. In the wind-energy industry, business relationships with turbine owners do not end with delivery. Instead, the final delivery of a turbine marks the beginning of collaboration between the manufacturer and the buyer, in some cases for over a period of at least 20 years. That means that at the core of the company is the development of many forms of collaboration with users in the global markets.

In some ways, the development of Vestas is in parallel with the unprecedented growth of the wind energy industry in the past two decades. According to the Global Wind Energy Council, after twenty years of technological progress, wind turbines have come a long way and a wind farm today acts much more like

a conventional power station. A single modern turbine annually produces 90 times more electricity and at less than half the cost than its equivalent twenty years ago. Wind power generation is increasingly competitive with conventional fossil fuel sources and already today is on a par with new coal or gas-fired power stations (www.gwec.net).

Policy drivers – the role of subsidies

Since its early days, Vestas has benefited from proactive policies in Denmark to promote wind energy, which allowed wind turbine manufacturers to test and consolidate the technology domestically and then scale-up deployment by tapping into global markets. In Denmark, only 1% of wind energy production is currently sold in the local market.

The development of the Danish wind energy market is often cited as a successful case of policy intervention to induce climate-friendly innovation. Wind turbines have gone through major improvements in performance and design in the past twenty years, helping wind energy manufacturers to play a leading role in the global market and turning the turbines into a major export commodity (IEA, 2004). In Denmark, wind generation's share of electricity production is the highest of any member country of the International Energy Agency with 20% electricity from wind power in domestic electricity production (IEA, 2004).

To achieve this result, the government has used both demand-pull and technology-push instruments. In the latter case, wind energy has received the highest percentage of investments in renewable energy R&D in Denmark (an average of 45.3 % for the 1975-2002 period). Demand for turbines grew dramatically in the 1990s both in domestic and export markets. The technical developments within Denmark were complemented with market deployment measures that included tax incentives, feed-in tariffs, and turbine replacement incentives. Other tools that have been used in the past and have now been discontinued are: direct production subsidies, fiscal incentives, and offshore wind demonstration support. Feed-in tariffs, in particular, have played a key role in creating and consolidating a local market for the turbines. Because of these tariffs, utilities agree to buy power from private owners of wind turbines at a purchase price approximately equivalent to a fixed percentage of the retail price of electricity. Utilities are also required by law to connect private wind turbines to the grid and to receive and pay for wind-generated electricity. As the wind power energy has matured, the government has shifted its policy approach by transferring some of the costs to consumers and by liberalising electricity markets (IEA, 2004).

Prior to 2002, the share of wind energy in Denmark's energy supply increased by the offering of favourable prices for this technology and by giving priority to renewable energy in power production (IEA, 2004). For example, utilities were obliged to pay wind energy owners a percentage of the electricity price for household consumers. There was also a public subsidy for electricity production from private wind turbines. Many of the tools and priorities in energy policy changed significantly in 2001 when a new government stopped securing further development in domestic wind power capacity in its search for a more market-based approach. In January 2007 the Danish Government published its intention to again boost renewable energy in Denmark with an ambitious plan of having 30% renewable energy in energy consumption by 2025, which eventually could increase Denmark's present 3 000MW to about 6 000MW.

Market drivers: getting prepared for emerging markets

A key change in the global wind energy market is the entrance of some of the largest companies in the world, in particular Shell and General Electric, creating fierce competition among market participants, but also demonstrating the growing appeal of this market. In order to compete successfully amid the increasingly "fierce competition," Vestas is strengthening its investment in R&D.

Vestas has never before used as many resources on R&D as it does today. In 2006, Vestas' research department counted more than 500 employees, who work in Singapore, England, and Denmark. In the first six months of 2006, Vestas had spent on R&D, DDK 320 million (over EUR 40 million), almost twice as much as the amount spent the previous year. Because of the high performance requirement of turbines, which are expected to operate round the clock, 365 days a year, for at least 20 years running, heavy emphasis is placed on their fundamental design aspects and regular maintenance work. Moreover, developing the technology is critical to extract even more power from the already existing turbines. For example, 17 years ago, a generator needed 46 hours to produce power enough for one household. Today, it can do so on one hour.

Especially since 2005, Asia and the South Pacific has increased its demand for wind technology. The company currently has an installed base of over 5 000 wind turbines in wind farms across China, Taiwan, South Korea, Japan, India, Australia, and New Zealand representing one sixth of total installed Vestas turbines around the world. With the establishment of the Asian headquarters in Singapore in September 2006, Vestas seeks to leverage Singapore as a springboard to strengthen its presence in Asia, forge closer ties with customers, and build relationships with new customers across in Asian Pacific markets.

According to the company, everything points to Asia becoming one of their largest markets over the next few years. This is where the real economic growth is happening and where the demand for electricity will increase most strongly. China, in particular, is expected to become the world's largest energy consumer (IEA, 2006) and the government, fearing energy shortages in the future, has passed legislation to increase the use of renewable energies, including wind energy.

The Singapore headquarters will also host an R&D Centre, which will be ready in the first half of 2007 and will employ 150 research engineers. To support this initiative, Vestas will invest up to USD 319 million over the next 10 years. Vestas plans to draw upon Singapore's trained work force and expertise and to leverage on the expertise of local institutions. It has also identified 20 to 40 potential R&D collaborations with research institutes and the Nanyang Technological University (EBD Singapore).

The company chose Singapore as the location for the R&D centre, because it gives them access to "a highly qualified workforce in an international R&D environment." and the opportunity to create closer contact with regional sales and purchasing units, enabling them to supply products that are even more in accordance with their customers' demands. This expansion complements Vestas' effort to expand collaboration with globally leading technology companies, universities, and institutes. The establishment of a new development centre and the world's largest test centre in Aarhus, Denmark and of a new development centre in Asia gives what Vestas views as "the best possible conditions for creating a global and attractive research environment, which can attract the best talents." Additionally, the Vestas Technology R&D Unit is establishing a back office in Chennai in India that will participate in the development work together with the centres in Aarhus and Singapore.

The plants outside Europe will help drive down the costs of transportation of the wind turbines. The company has also opened a sourcing office in China given that most of the company's turnover is generated outside Europe necessitating going beyond the traditional network of European suppliers.

Viessmann

This case study illustrates the efforts of a company to position itself in advance of consumer demands, ahead of, or in the absence of regulation.

Box 38. Viessmann: company profile

- **Activities:** Viessmann, a family-owned medium-sized company based in Germany, is one of the world leaders in manufacturing heating systems.
- **Headquarters:** Alberg, Germany.
- **Employees:** 7 400 people.
- **Operations:** plants in Germany, France, Poland, Canada, Austria, and China; has distribution agents in 35 countries.
- **Sales and/or assets:** EUR 1.4 billion in 2006.
- **Website:** www.viessmann.de.

Drivers to environmental innovation and the role of government

Heating of buildings is one of the main sources of energy consumption. As such, rising energy costs and concerns about energy security have been the major driver to innovate in more energy-efficient products, and alternative energy sources. For many years, Viessmann has invested in developing more energy-efficient heating systems that allow customers to save energy and lower their energy bill while contributing to environmental improvements (e.g. lower emissions).

For Viessmann, the pressure to innovate comes from the consumer, not the government. However, government policies have an impact on consumers and on their capacity to formulate clear demands. The sector has suffered from a period of regulatory incertitude regarding energy policies in buildings, which had clear impacts on home owners, and thus on the business. This “crisis” showed that government policies can stimulate or, on the contrary, stall demand, both of which have direct repercussions on business, and made the company particularly aware of the need to be proactive, to stimulate and respond to consumer demand, even in the absence of clear government policies. Innovation is made if there is demand, or at least clear potential for it.

However, this is not to say that government measures do not play a role – on the contrary. Viessmann monitors closely the deployment measures adopted by governments in countries where it operates. The table below presents a comparison of regulation in the UK and the Netherlands on condensing boilers, published in the UK’s Energy White Paper and referred to on Viessmann’s website.

According to Viessmann’s representative, “the energy sector is very complex, and laws are often made too quickly, without technical knowledge behind them”. The government is also being heavily lobbied, and is put under pressure to act. What governments need to do is to set the goals (of energy savings for example) but not to focus on one or the other technology. For example, in Germany there has been much more support for solar photovoltaic energy than for solar thermal energy, although both produce clean electricity.

Table 4. Condensing boilers: market deployment measures in the UK and the Netherlands

The Netherlands	UK
1980-1987: Subsidies for condensing boilers and a widespread information campaign.	1980s: Development and demonstration of technology under the Government's Energy Efficiency Demonstration Scheme.
Mid 1980s: Demand outstripped supply so manufacturers launched intensive installer training programmes.	1989-today: Promotion under the Government's Energy Efficiency Best Practice Programme.
1990: Subsidies relaunched – government funding matched by funding from energy companies through a customer levy. Housing policy promoted condensing boilers.	1993-4: British Gas-funded cashback scheme.
1995: Building regulations require new buildings to meet standards of energy efficiency only achievable with condensing boilers.	1996-9: Government-funded cashback schemes.
1996: Long-term awareness campaign started, plus energy-efficiency labelling.	1997 onwards: Energy Efficiency awareness raising campaign with labelling of condensing boilers.
1996: Energy tax introduced with hypothecated revenue for energy efficiency.	2000 onwards: EESoP*/EEC and Government fuel poverty programmes installing condensing boilers; Energy Saving Trust working with manufacturing industry.
2000: Subsidies (25%) for energy audits introduced.	2002: Condensing boilers account for ~12% of UK market.
2002: Condensing boilers account for ~75% of Dutch market.	To achieve much higher levels it is likely to require measures such as: – A communications campaign raising awareness of links between climate change and household energy use; – Training of heating engineers and gas fitters; – Voluntary agreement with industry on condensing boilers; and – Higher boiler standards required by building regulations for existing and new dwellings.

Note: * East of England Sense of Place consortium

Source: www.dti.gov.uk/files/file10719.pdf

R&D to meet new challenges

Viessmann has put its focus on moving away from fossil fuel energy sources and is concentrating both on improving the energy efficiency of heating systems and on increased use of renewable energy sources.

The company aims at anticipating customer's needs and being prepared for future demands. By positioning itself as a technological leader in its sector, Viessmann also considers itself better placed to meet the challenges of globalisation, including new demands and increasing competition. In its own words, "Viessmann technology sets new standards. Here, research and development are the basis for success. Jointly with experts from scientific institutions, Viessmann engineers have been working on the development of heating technology for the future." Viessmann considers the ongoing trend towards

globalisation, coupled with increasingly rapid changes in the marketplace, a key factor in its business policies. The continued drive towards economy, the efficient use of oil and gas and the increased exploitation of renewable energy sources are among the demands that these developments impose the company.

Outsourcing of R&D – looking for the best programmes to take full advantage of globalisation

Most R&D is done at headquarters. However, much of the production of parts is outsourced to suppliers, including the R&D necessary to make those parts comply with increasingly stringent requirements.

One obvious reason for the company to do R&D abroad is to take advantage of better R&D support programmes. For example, the EU limits subsidies for R&D to 50%, with a contribution of at least 50% of the total investment by the company. In addition, obtaining support requires going through a maze of procedures and paperwork. Other countries, such as Japan and the U.S., have more generous subsidy programmes, giving up to 90% or even 100% of the total investment. Therefore, it is worth it for the company to do at least some of its R&D abroad – especially when it is related to products that will be produced for international markets. Another limitation of EU support systems is that they run over a short period (four to five years), whereas in other countries (*e.g.* Japan) programmes are designed over a longer (*e.g.* 10 years) period.

Globalisation is opening new ways to benefit from support measures, both at the R&D and the deployment stage. In the field of solar energy, for example, in which Viessmann is heavily investing, a company can now choose to carry out its R&D programmes in the U.S., where it can get up to a 100% research support, produce the modules at lowest costs in China, and then sell them in Spain, where currently the installation of solar energy is heavily supported by government through feed-in and deployment measures.

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