International Science and Technology Co-operation

TOWARDS SUSTAINABLE DEVELOPMENT

SUSTAINABLE DEVELOPMENT



OECD

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Korean Ministry of Science and Technology

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International Science and Technology Co-operation

TOWARDS SUSTAINABLE DEVELOPMENT

Proceedings of the OECD Seoul Conference,
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FOREWORD

This volume compiles the proceedings and results of the OECD-Seoul Conference on "International Scientific and Technological Co-operation for Sustainable Development" held at the COEX Intercontinental Seoul, in Seoul, on 15-17 November 2000. The Conference, chaired by Mr. Herwig Schlögl, Deputy Secretary-General of the OECD, follows the Ministerial meeting of the OECD Committee for Scientific and Technological Policy (CSTP) held in June 1999, and was co-organised by the Korean Ministry of Science and Technology and the OECD. The Steering Group, which was made up of officials from Canada, Germany, Hungary, Japan, Korea, Norway, and the OECD Secretariat, was instrumental in developing the Conference programme and identifying speakers. The following people contributed substantially to the organisation of the Conference: Korean Ministry of Science and Technology: You-Hyun Moon, Byoung-Sul Jin, Se-Jun Yoon, Cha-Dong Kim, Kyung-Hee Lee, and Jae-Shik Uhm; Science and Technology Policy Institute: Sungchul Chung; UNEP: Rajendra Shende; IEA: Hanns-J. Neef; OECD: Risaburo Nezu, Daniel Malkin, Wolfgang Hübner, Candice Stevens, Yukiko Fukasaku, Nick Johnstone, Ki-Joon Jung. The results of the Conference will contribute to the OECD organisation-wide project on sustainable development.

This report is published on the responsibility of the Secretary-General of the OECD.

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PART I

OPENING SPEECHES

Chapter 1

INTERNATIONAL SCIENCE AND TECHNOLOGY CO-OPERATION FOR GLOBAL SUSTAINABILITY

by

Jung Uck Seo
Minister of Science and Technology, Republic of Korea

It is our great honour and pleasure to host the "OECD Seoul Conference on International Scientific and Technological Co-operation for Sustainable Development" Personally, I am delighted to see that the proposal I made at the 1999 meeting of the Committee for Scientific and Technological Policy at Ministerial level is being implemented here today.

On behalf of the Korean Government, I would like to express my gratitude to all the participants, particularly those from abroad, who have joined us here today to discuss one of the most vital issues of our time – science, technology and sustainable development. I would also like to thank Dr. Schlögl, Deputy Secretary-General of the OECD, who kindly accepted our invitation to chair this Conference. His expertise, experience, commitment and leadership in the area of sustainable development more than suffice to ensure that this Conference is both successful and meaningful.

As I open the Conference, I would like to share with you my views on international scientific and technological co-operation for environmental sustainability.

The new Millennium and our future

We entered the Millennium with mixed expectations about the future of our planet. Today, many people remain optimistic, anticipating that the current economic boom will continue and that scientific and technological breakthroughs – information technology, biotechnology and others – will bring unparalleled economic growth to all parts of the world.

However, the scientists warn that our economies are already strained to the limit of the earth's capacity, and further growth, if unchecked, could very well lead to serious ecological imbalances and dangerous political instability.

Over the last century, global industrial output has increased almost one-hundredfold, with the world's population growing to 6 billion people. The environmental consequences of this are horrendous. The concentration of carbon dioxide in the earth's atmosphere has increased by more than one-third since the Industrial Revolution, and annual carbon dioxide emissions exceed the Earth's absorptive capacity by 3.1 billion tonnes.

Adding to this bleak situation is the fact that the world's forest resources have shrunk by half over the past two decades; each year, 130 000 square kilometres of tropical forests disappear – and that represents a country the size of Greece – at the rate of two soccer fields of tropical forests every second.

Ecological problems, such as loss of biodiversity, land degradation, ozone layer depletion, climate change, freshwater shortage, and marine and coastal zone degradation, are more and more frequent. The degradation of the global environment goes on, despite the political momentum generated by the Rio Earth Summit of 1992 and the adoption of a series of multilateral environmental conventions on key issues. Indeed, if we continue to devour our ecological capital in this way, the biocapacity of our planet to meet our needs – not to mention the needs of our children – will be seriously jeopardised.

Environmental issues are trans-boundary in nature and the sources of global emissions continue to multiply as developing countries push ahead with industrialisation. A recent OECD projection shows that the share of the developing non-member countries in global emissions will rise from 45% today to 60% by the year 2020.

This phenomenon highlights the need for global co-operation to address environmental issues. For instance, the Kyoto Protocol's target cannot be achieved without realistic co-operation between the developing and the developed countries.

International co-operation for sustainable development

The road to the promising future that we desire can be found through science and technology. Science and technology can guide us to cost-effective approaches for improving environmental performance while, even more importantly, raising resource efficiency and profitability.

The emergence of new technologies provides us with the means to deal with the challenges facing us today. ICT equipment, such as advanced control systems, sensors, satellite systems, and so on, has made an enormous contribution to reducing materials use as well to the reduction of noxious emissions and undesired wastes. The potential of biotechnology to contribute to sustainable development is vast and diverse. In addition to the clean process technologies that have already been introduced in many industries, biotechnology holds the promise of providing new sources of energy that are free of greenhouse gases.

However, unless the new technologies are adequately diffused and applied at the global level, their optimal effectiveness will not be attained. The challenge for us here today is how to enable the developing countries to properly utilise these technologies through international co-operation.

In addressing this issue, I believe we should pay as much attention to the urgent concerns in the developing countries as we do to the global environmental issues. The priorities of the developing world are not those of the advanced countries – preserving the environment is less important to them than industrial development and improving their economic performances.

In many cases, developing counties are simply not technologically capable of using energy efficiently and moving along the development path in harmony with nature. What is important is that we in the advanced countries have a realistic understanding of the needs of the developing countries and what we can do to help meet those needs. Ultimately, their needs are the needs of all humanity,

especially when it comes to preserving the environment and solving dangerous environmental problems.

So, are we, the advanced countries, content to allow the developing countries to fend for themselves and repeat the same errors we made in developing their economies? Or are we ready to co-operate in order to ensure that *all* our economies move forward in a sustainable way?

Since the market fails to provide a solution in this case, governments should work together to attain sustainable development of the world. Arresting the impending environmental imbalances and ecological instability will require a concerted international effort and will call for a multilateral framework for co-operation in environmental science and technology.

That framework, in my mind, should be an "International Fund for Environmental Science and Technology Co-operation". This fund would function as an instrument to safeguard global environmental sustainability through international co-operation.

The primary functions of the fund would be to facilitate international co-operation, particularly between developing and developed countries, for the development and diffusion of cleaner technologies. Towards that end, the fund would conduct international programmes to combat global environmental problems, co-ordinate collaborative R&D programmes, facilitate technology transfer, and provide technical and financial assistance for developing countries. To identify global environmental problems, the fund would also conduct scientific monitoring of environmental changes throughout the world.

In light of the fact that the objectives of such a fund would benefit all countries of the world, it is incumbent upon the advanced countries to take the initiative and move forward to further define the Fund's specific functions and sources of revenues. The details of how such a fund could be created could be a topic for further discussion during this Conference, or for other international forums in the future.

However, considering the existing gap between the developing and developed countries, it will take time before any meaningful scientific and technological co-operation could be achieved. Therefore, I suggest that, rather than waiting for all of the rules to be defined, we boldly go ahead and act now, and do what we can within our own means.

One meaningful step we could take here is to work to get our public sector environmental R&D programmes linked to each other for global benefit. Government R&D programmes could – and should – be opened further to mutual co-operation among countries. Joint research programmes could bring together the best minds from all countries to work towards the most promising solutions to common environmental problems.

To facilitate such a co-operative exercise, I would also propose the creation of a network on the Internet whereby institutions around the world would be able to communicate their concerns, their proposed solutions and diffuse their research and development contributions in the most efficient way possible. The network would also help identify international experts and R&D programmes and locate appropriate technologies.

I urge you to discuss these issues in a practical manner at this Conference so that we can derive useful policy suggestions that will take us towards further co-operation between the developing and the developed countries.

Innovation and environmental policy in Korea

Korea is no exception when it comes to sacrificing environmental inheritance for economic development. However, our global welfare now depends more upon a well-preserved environment than it does upon the utilisation of the environment. Therefore, sustainable development is not just one of a set of policy options that Korea might choose; is a must – as it is for many other countries.

I would now like to brief you on Korea's policy directions towards environmental innovation:

- First, policy emphasis is more on the *prevention* than on the treatment of environmental pollution. Therefore, cleaner production technology is one of the key target areas of the 21st Century Frontier R&D Programme recently launched by the Korean Government as the nation's main technological initiative for the third Millennium.

- Second, environmental policy needs to be integrated with social, economic and innovation policies, so that environmental policy can promote innovation, economic competitiveness and social welfare. The Korean Government recently created the Presidential Committee for Sustainable Development, members of which include Ministers and leaders from industry, NGOs and civil society, to advise the President on policy co-ordination.

- Third, international co-operation is strongly emphasised as a means for Korea to contribute to the challenge of solving global-scale environmental issues.

Since joining the OECD, Korea has been seeking a role to link the interests of OECD countries to those of the developing non-member countries. Towards this end, in 1997, we hosted an OECD Conference here in Seoul, on the issues of international scientific and technological co-operation. Today's Conference is also the result of an initiative taken by Korea in its effort to promote scientific and technological co-operation between the developing and the developed countries in support of sustainable development.

It is my sincere hope that, through this Conference, Korea will be able to make a modest but determining contribution to bringing together developing and developed countries in a concerted effort to attain the sustainable development of the world.

Conclusion

As you may recall, the ASEM leaders commenced their meeting here in Seoul last month with a video-art performance, from which I would like to quote a phrase on a sustainable world:

> *We want a world where birds fly freely, where we can drink running water, where we can breathe clean air, free from famine and disease… It is a world where we all help and understand each other…*

I sincerely hope that this Conference will set a milestone towards realising such a world through global S&T co-operation.

Now, let us keep in our minds what Mohandas Ghandi had to say about science. He taught us that practising "science without humanity" is one of the seven sins that we commit without perceiving it to be a sin. His message is that the ultimate objective of science should be to serve the purpose of human

advancement. Without a full understanding of the higher human values that science is striving to serve, we are bound to become the victims of our own technocracy.

Today, I would say that it is no less vicious a sin to develop “technology without safety”. Science and technology have a great deal of bearing on our Conference today – let us create a better world for our grandchildren.

I would like to close by extending my appreciation to the OECD Secretariat and to the Korean organisers for their hard work to make this conference such a success. I wish you all the best for a productive Conference.

Chapter 2

THE ROLE OF TECHNOLOGY AND INNOVATION FOR SUSTAINABLE DEVELOPMENT: THE OECD POLICY APPROACH

by

Herwig Schlögl
Deputy Secretary-General, Organisation for Economic Co-operation and Development

Sustainable development

The governments of the OECD Member countries face a major challenge: How can they ensure both the rate and quality of economic growth? What is the appropriate set of policies which will enable them to maximise human welfare over the long term?

The concept of sustainable development offers an integrated framework for addressing such questions. The 1987 report of the Brundtland Commission defined sustainable development as "development that meets the needs of the present without compromising the ability of future generations to meet their own needs".

The overarching objective of sustainable development is to maximise human welfare and provide a sound economic, social and environmental base for present and future generations. This requires that the objectives of increasing economic efficiency and material wealth must take into account social and environmental concerns within an overall policy framework.

At the global level, milestones in the promotion of sustainable development include: the Bruntland Commission (1987), the Montreal Protocol (1987), the Rio Declaration (1992), the United Nations Framework Convention on Climate Change (UNFCCC, 1992) and, more recently, the Kyoto Protocol adopted at the CoP3 (1997), and now the CoP6 and the Seoul Conference.

Formulating policy in a sustainable development framework means incorporating three key elements: a global dimension, complementarity and linkages, and participation.

- A *global dimension* calls for global solutions; success becomes contingent on international co-ordination and negotiations in addition to domestic actions.

- *Complementarity and linkages:* there are trade-offs among the economic, environmental and social dimensions of growth, but their complementarities open up opportunities. Bridges may need to be built to link the various policy communities; heads of government may have to exercise overall co-ordination.

- A *participatory approach* is central, calling for national and international co-operation. Moreover, governments cannot exercise sole responsibility; other stakeholders such as business, community-based organisations and NGOs must become active partners.

The OECD initiative on sustainable development

The ongoing OECD initiative on sustainable development was launched in 1998 with a three-year mandate from the OECD Ministerial Council. This Ministerial mandate, in turn, drew upon the recommendation of a High-Level Advisory Group that called upon the OECD to become the key intergovernmental organisation in the effort to help governments move towards sustainable development. The initiative aims to issue policy recommendations with a view to better integrating economic and environmental objectives and concerns, taking into account the social impacts over the medium and longer term.

In addition, the initiative will focus on a set of priority issues, such as climate change and the management of natural resources, to illustrate in a concrete way how the sustainable development perspective affects policy analysis.

As an example, water management and conservation is a growing source of tension within and between countries in several parts of the globe. The OECD has pledged to work towards the objectives embodied in the Ministerial Declaration from the Second World Water Forum, by examining how economic principles and practices could be better applied to the protection of water security and ecosystems. The major output of this initiative will be a policy report to be presented at the OECD Ministerial Council in 2001, and a supporting analytical report. The policy report will raise key policy issues and provide recommendations. Key policy issues, the last two of which are directly related to the theme of the Seoul Conference, may include:

- How best to establish the right market signals for sustainable development, and how to overcome barriers to their implementation.

- How to develop institutions and decision making, so as to promote implementation, greater openness and participation by different actors, and a better balance between sometimes conflicting objectives.

- How to improve the measurement of the sustainability of economic development by better integrating indicators of economic, social and environmental conditions.

- How to better integrate sustainable development objectives into general economic, sectoral and territorial policies, while ensuring that policy goals are reached through concrete and feasible instruments.

- How to strengthen innovation and implementation of appropriate technologies in order to reduce the negative environmental impacts of production and consumption.

- How best to enhance international co-operation for better environmental and social development, and for forging partnerships with local communities around shared objectives.

The role of technology and innovation for sustainable development

The fundamental contribution of technology and innovation to economic growth is fully recognised, yet the consequences may not always be consistent with the goals of sustainable development. However, technology and innovation are key drivers of sustainable development. Achieving significant reductions in energy and materials use and polluting emissions requires technological advances and these technologies can contribute to improved industrial competitiveness. Global environmental concerns – including climate change, ozone layer depletion and desertification – will require the best scientific and technical insights for assessment and solution.

New technologies such as information and communication technology (ICT) and biotechnology, hold the potential to increase resource efficiency and facilitate the move towards sustainable development. The growth of the ICT sector and the shift to a more service-oriented economy may result in a net reduction in energy and resource inputs in the industry sector. ICT has the potential to make industrial processes and products cleaner, diffuse technologies more effectively and enable more accurate and cheaper monitoring of the environment.

The potential contribution of biotechnology to sustainable development is vast and diverse. Industrial processes using biotechnology operate at lower temperatures and produce fewer, and less toxic, wastes. Biotechnology-based cleaner processes have been introduced in a number of industrial sectors, including chemicals, pulp and paper, textiles and leather, food and feed, metals and minerals, and energy.

The development and diffusion of these technologies, however, are not directly driven by the profit motive since the benefits of environmental improvement are largely public. This results in inadequate private investment, making environmental innovations a typical case of *market failure*. Because of the complex and interdisciplinary nature of environmental innovations, they are also prone to *systemic failure*. Public policy has an important role to play in addressing these market and systemic failures in order to match demand and supply of appropriate innovations and embed environmental sustainability in the economic and the research system.

Stimulating innovation for sustainable development

There is a serious lack of data and indicators of environmental innovation, although the available data indicate that public investment in R&D for strictly environmental objectives remains rather low. In view of the market and systemic failures involved, there may be significant benefits to be had from increasing the public commitment to generating new knowledge and developing needed technologies. At the same time, public policies should enhance the effectiveness of investments in environmental R&D, for example through active programmes undertaken in public/private partnership to leverage private investments. To focus research and development efforts for environment and sustainability objectives, increased use could be made of policy instruments that foster technology foresight and innovation networks such as clusters.

Past experiences with environmental policy instruments demonstrate that many have fallen short of stimulating innovation. However, this does not justify discounting the long-term stimulating effect of well-designed environmental instruments. Economic instruments such as charges and marketable permits have recently been applied by a number of OECD governments and these could prove very effective in stimulating innovation. However, they must be designed and implemented with care. In order to promote not only incremental innovations but also more radical ones, environmental policies need to be complemented by innovation policies that place a premium on new generic technologies whose wide-ranging application could support sustainability objectives. Public policies for sustainability objectives must stimulate both the supply side and the demand side of environmental innovations.

International S&T co-operation: needs and barriers

Achieving sustainable development goals at the global level will heavily depend on the widespread diffusion and application of cleaner technologies in non-OECD countries as well as in OECD countries. Historically, the advanced industrial countries have been the major generators of pollutants. Over the coming decades, however, most of the world's population growth and much of its economic growth will take place in the developing countries. However, if the developing countries simply follow the historic trends of the developed countries, their economic development will not contribute as much as it might to sustainable growth. Modern knowledge and technology can help to address this problem.

There are questions as to whether the developing countries have the capacity to take advantage of cleaner technology options when the knowledge and skills needed to address these problems reside mainly in the OECD countries. Moreover, some problems, such as climate change, are so global in nature that only concerted international action offers any hope of resolving them; sustainable development can be effectively achieved only through close collaboration among countries at the global level.

A number of barriers hinder the contribution that international S&T co-operation can make to the development and diffusion of environmental technologies. Developing countries often face difficulties in accessing appropriate scientific knowledge and technical skills: their own knowledge base needs to be strengthened and the qualified human resources that are needed to develop and implement environmental technologies must be increased. R&D infrastructure and other framework conditions such as effective research network and suitable funding mechanisms to develop and utilise cleaner technologies remain inadequate in much of the developing world.

Enhancing international S&T co-operation for sustainable development

Although efforts are already underway at both the bilateral and multilateral levels, there is room for increased co-operation in a wide range of areas to meet developing countries' needs. In this regard, current international S&T co-operation programmes need to be assessed from the perspective of the needs of the developing countries, and good practices should be identified and diffused.

Governments can play an important role by formulating and implementing appropriate policies involving both the public and private sectors to strengthen international S&T co-operation for sustainable development. Policy tools range from direct and specific measures such as supporting international joint R&D programmes, to indirect and general ones such as creating favourable framework conditions.

In turn, the governments of developing countries need to improve their education, R&D and technology policies to enable them to more effectively reap the benefits of international co-operation. They could also play a crucial role in the identification of country-specific barriers, needs and steps towards the introduction of environmentally sound technologies since effective policy measures should be based on and tailored to the needs and interests of different stakeholders.

Developed countries can assist in vital areas like capacity building, *e.g.* the training of developing countries' human resources in the field of environmental technologies. Policy frameworks conducive to increasing demand for cleaner technologies are also essential; these include designing market incentives such as the removal of inappropriate subsidies and the introduction of fiscal incentives. They could also enhance the flows of technologies arising from their publicly funded R&D programmes by entering into R&D partnerships, etc., with developing countries.

Since the private sector is the largest source of finance for cleaner production and a major actor in technology innovation, diffusion and application, policy efforts should also focus on providing the private sector with an open, competitive and sound policy environment.

Concluding remarks

OECD Ministers have reiterated their governments' commitment to the long-term goal of sustainable development.

Achieving the goal of sustainable development requires actions by all the stakeholders – enterprises, consumers, governments, community groups, financing institutions, NGOs, etc. Improved networks and partnerships among these stakeholders could contribute dramatically to the success of this initiative. International organisations such as the OECD can play an important role in facilitating such networks and partnerships and I believe that this conference provides us with an excellent opportunity to further this role.

PART II

KEYNOTE PRESENTATIONS

Chapter 3

INTERNATIONAL SCIENCE AND TECHNOLOGY CO-OPERATION FOR SUSTAINABLE DEVELOPMENT: THE DEVELOPING COUNTRY PERSPECTIVE

by

Ma Songde
Vice Minister of Science and Technology, China

It is a great pleasure for me to be invited to attend this conference, and I would like to thank the organisers for giving me the opportunity to speak here. I would like to use this occasion to briefly describe the environmental challenge China, my country, is now facing and the demand for science and technology which has arisen from the country's rapid development, and to discuss with you how we can enhance co-operation between China and the OECD countries in the environmental science and technology field.

China faces a severe environmental challenge

The Chinese economy has grown rapidly over the past two decades, with annual average GDP growth rising to 9.7% between 1978 and 1998. Throughout that period, China had the fastest rate of economic growth in the world and the country made historic strides – once poor, its citizens now lead relatively comfortable lives. However, it is clear that this rapid pace of economic development has taken its toll in terms of resources and the environment, and has weakened the natural capital that will be needed to support further development.

Like many other developing countries, China currently faces a number of environmental problems. These include the environmental pollution faced by many other developed countries during their development phase – water pollution, air pollution and solid waste pollution, etc., – as well as a number of new environmental problems. The experiences of other countries have taught us that when GDP averages USD 600-3 000 per capita, environmental pollution is at its highest. Today, China's GDP does not exceed USD 1 000 per capita and the pressures on the environment are intense. Taking water as an example, since it is absolutely vital to the survival of mankind, the average volume of water per capita in China is only 26% of the world's average and water resources unevenly distributed in terms of both season and area. Moreover, the water environment is widely polluted – with serious effects on water resources. Thus, China faces double pressures, *i.e.* that of a developing economy fighting to eliminate poverty and that of solving its environmental problems – an unprecedented challenge which needs to be met if China is to achieve its sustainable development goals. I believe that many other developing countries will also have to face this two-pronged challenge.

It is now widely recognised that the world's environmental problems stem from man's unreasonable exploration and exploitation of natural resources for economic development. The

experience and practice of many countries of the world shows that solving environmental problems needs to be backed by a certain level of economic strength. The majority of advanced countries began to introduce environmental protection measures only once their per capita GDP levels reached several thousand dollars. Today, the developed countries invest vast sums in environmental protection; pollution abatement and control expenditures by the OECD countries represents 1.5-2.0% of GDP, and sometimes more. In recent years, with the development of the Chinese economy, the Chinese Government has continuously increased its spending on environmental protection, from 0.5% of GDP to 1% today. An old Chinese proverb says: "Let him who tied the bell on the tiger take it off himself" – *i.e.* whoever started the trouble should end it himself. Environmental protection and ecological improvement are dependent upon economic development. In the absence of economic development, increasing environment investment is just empty talk.

History has taught us that economic development is dependent on progress in science and technology. Finding solutions to environment problems will depend on the adoption of advanced technologies, while scientific and technological progress will provide strong support for sustainable development.

Environmental science and technology work in China and further demand

China places a high priority on problems related to the environment and to development. Following the Rio de Janeiro Environment and Development Conference, China adopted a high-level programme, "China's 21st Century Agenda – White Paper on China's Population, the Environment and Development in the 21st Century", which rests upon a two-pronged strategy, "Increasing prosperity through science and education" and "Sustainable development", tailored to the specific characteristics of the Chinese population, its resources and environmental features. China emphasises environmental protection as a basic national policy, has been establishing and improving its environmental policy, law and regulation system according to the country's situation, step by step. To remedy the country's severe environmental pollution, China's ninth five-year plan introduced large-scale pollution control, ecology build-up and protection projects in key cities, drainage areas, regions, maritime regions and industries.

Meanwhile, the Chinese Government is paying careful attention to scientific research related to the environment. Environmental science and technology is emphasised in the country's science and technology programmes, such as the state scientific and technological key problem-tackling programmes, key fundamental research programme and high-technology development programmes. During the past 20 years, in relation to environmental pollution control, environment administration, regional environment improvement and cleaner energy development, etc., China has carried out key research projects, developed many pollution control technologies, realised localisation of some key pollution control equipment, clarified many environmental pollution problems, and laid a good science and technology foundation for current and future large-scale environmental pollution control. However, as shown in the following examples, China's current level of environmental science and technology still lags behind that of developed countries and does not fully satisfy the country's environmental protection needs.

- First, key technologies and the facilities needed to control large-scale pollution, such as that arising from inner-city sewage, household rubbish, coal gas and vehicle exhaust fumes, need to be further developed and perfected; many research results for these aspects are still in the laboratory stage or in pilot test phase. The experience gained from the projects is insufficient, and completion, standardisation and integration of the related technical facilities is weak. For example, up until now, no gas desulphurisation project of over 200 000 KW has

been totally designed and constructed by Chinese experts. Special equipment for treating city refuse is in short supply, and the incineration system needs to be further developed.

- Second, there is a lack of mature engineering technology for ecological protection, reconstruction and reasonable utilisation. Although small-scale experiments have been undertaken, a number of technical problems need to be addressed before full-scale practical engineering applications can be developed.

- Third, non-harmful production technologies are in short supply; these include cleaner production technologies for the key polluting industries (energy resources, chemicals, light industry and metallurgical industry, etc.) These technologies not only enable traditional industries to reduce their levels of pollutant discharge to respond to international standards, they can also help them to upgrade their industrial technologies and realise economic growth. China is currently undertaking the required technical modernisation of many older enterprises.

The demand for these technologies is huge and urgent. The gap which exists between the capacities of China and the developed world provides ample opportunities for environmental science and technology co-operation. The developing countries should make full use of the experience and advanced technologies of the developed countries to solve their environmental problems.

Strengthening international environmental science and technology co-operation to raise China's environmental science and technology level

In order to solve their environmental problems, the developing countries must, first, increase their own efforts through implementing strategic structural adjustment programmes and striving for scientific and technological progress. Secondly, they should strengthen international co-operation, especially between developed and developing countries. The developed countries have advanced and mature environmental technologies and a proven ability in the research and development of new technologies. If the technology and ability developed in the advanced countries can be applied and used appropriately in the developing countries, it will be instrumental in enabling them to solve their environmental problems.

China always takes a proactive attitude towards international co-operation in environmental science and technology. Over the past decade or so, China has developed bilateral and multilateral co-operation with many countries and regions – covering project co-operation research, personnel training, direct support for the building of technological capacity, funds and equipment – that have served to increase the environmental science and technology level of the country. We hope that this international environmental science and technology co-operation will be further strengthened and that concrete measures, such as those proposed below, can be taken to make such co-operation more effective:

- *Increasing the financial contribution of international environmental science and technology co-operation through multiple avenues.* The developed countries should bear their historical responsibilities and play a key role in environmental protection, increase their financial contributions to provide new and additional funding for the developing countries. In addition to collecting funds from the private sector, official support funds for technical development should be increased.

- *Environmental technology transfer under favourable conditions and in effective ways.* Once the developing countries have obtained advanced equipment, they need advanced and environmental technology tailored to the conditions of their own countries. Technology transfer, carried out under favourable conditions and in effective ways, is very important for solving the environmental problems of the developing countries.

- *Strengthening support for the building of scientific and technological capacity in the developing countries.* Increasing the environmental technology capacity of the developing countries can enable them to find efficient and quick solutions to their environmental problems. Scientific and technological capacity building, including personnel training, co-operative research, and supply of basic scientific research instruments and apparatus, should be actively supported. More researchers from developing countries should be attracted to join international co-operative research projects.

In an era of economic globalisation, it is necessary to strengthen international environmental scientific and technological co-operation. The developed countries have the technological superiority while the developing countries have a huge and growing market. Environmental co-operation between the North and the South has vast potential. I hope that this meeting can provide further impetus to scientific and technological co-operation between developed and developing countries. I wish you a successful meeting.

Chapter 4

INTERNATIONAL SCIENCE AND TECHNOLOGY CO-OPERATION FOR SUSTAINABLE DEVELOPMENT: A DEVELOPED COUNTRY PERSPECTIVE

by

Lord Sainsbury
Minister of Science and Technology, United Kingdom

I am very honoured to be here today to talk about one of the most pressing – and potentially rewarding – issues we face today. Today, neither government nor business can afford to ignore the environment and the challenge of sustainable development. However, that challenge should not be seen as a threat to business; instead, it should be viewed as an opportunity. Advances in science and technology must be the keys to preserving the environment and delivering new opportunities for prosperity.

We are currently facing alarming changes in our atmosphere, in global temperatures, in weather patterns, in sea levels and in the protective ozone layer. As a result, across the world, millions face drought, flooding and disease. In the United Kingdom, we too face threats – the prospect of new diseases; of increased levels of skin cancer; of floods in some years, droughts in others; of low-lying areas being swallowed by the sea. Recently, we have witnessed unprecedented storms and torrential rainfall resulting in widespread flooding and damage to property and business.

Global population growth will put increased pressure on natural resources. The world population is set to rise from 6 billion to 9 billion by 2050. More and more freshwater is being polluted or simply used up. Demand is doubling every 21 years, while supply is broadly unchanged. Soil degradation has affected two-thirds of the world's agricultural lands over the last 50 years, and the situation is getting worse. Half the world's wetlands have been lost over the past century and with them their unique plants and animals – and this trend is accelerating.

It is imperative that we begin to make much more productive use of environmental resources. It is clear that if we are to continue to grow, and share the benefits of that growth, we must reduce the impact of growth on the environment. Businesses must improve their environmental productivity. That means getting the most out of finite resources, maximising our use of renewable resources and minimising waste.

This is certainly good for the environment. And it also makes good business sense – improving efficiency, cutting production costs, reducing dependency on increasingly expensive finite resources. New technologies, better design, new processes, new ways of doing things will mean major increases, of up to ten-fold or more by some estimates, in economic output per unit of energy, materials or land. And that means competitive advantage for business.

Pollution is a sign of inefficiency and a reflection of unsophisticated technology. Already, environmentally aware oil companies are finding ways to recapture the CO_2 produced by plant and equipment and pump it back underground to enhance the recovery of oil. They are working with car manufacturers on new technologies, from developing fuel-cell cars, to putting hydrogen-powered buses on the road in Europe.

Government has a vital role to play in assisting business to build up the economies of scale in these new technologies so that they can compete effectively. The UK Government is helping this process by investing heavily in new sources of energy from wind, biomass and solar energy.

Cutting-edge science and new technology is essential to improving environmental productivity. As Minister for Science, I believe that science has a major contribution to play in identifying and solving environmental problems. We will not be able to solve many of the problems I have outlined without a firm grounding in the sciences.

Science contributes in four ways, by: *detecting* change in the environment; *diagnosing* why change is taking place; suggesting *solutions*, through this diagnosis, for solving environmental problems; and defining the boundaries of *uncertainty* in our understanding of the environment and reducing this uncertainty. It was strong fundamental science which allowed us to chart the growth in the ozone layer and develop new, more precise methods of Earth observation. The misuse of science has resulted in many environmental problems but from bioremediation to new energy sources, it is increasingly clear that it is science which holds the key to sustainable development.

It is therefore vital for environmental progress that there is a strong science base. That is partly why the UK Government has substantially increased resources to the science base to make sure we have the world-class scientists and laboratories capable of analysing environmental problems and developing new technologies. We have also specifically allocated GBP 30 million to fund a joint programme with industry on sustainable technologies. At the UK Meteorological Office's Hadley Centre, we have one of the best environmental modelling agencies in the world.

Government also has a crucial role to play in setting the type of demanding environmental targets for business to give it the spur it requires for innovation. For both developed and developing countries, we need to help point the way for business.

Business should not see the challenge of sustainable development as a restriction imposed by government – but instead as a great business opportunity. In the words of Rob Margetts, ICI's Vice Chairman: "we see sustainability as a tremendous technological challenge, and one that presents us with new markets and opportunities. It gives a new engine for growth. New products. New customers. New technology." More recently, John Browne of BP has argued that the enlightened company increasingly recognises that there are good commercial reasons for being ahead of the pack when it comes to the environment. And, if you need convincing, you need only look at the relative performance of companies on the Dow Jones. In the first half of this year, the return on equity of the Dow Jones Sustainability Group Index averaged 15%, compared with just 8% for companies in the regular Dow Jones Index.

There are large new markets for business in environmental services. For instance, the sector covering environmental monitoring and instrumentation, water services and energy management already provides employment for over 225 000 people in the United Kingdom. The rapidly growing world market for environmental equipment and services is currently estimated at USD 335 billion,

growing to USD 640 billion by 2010.[1] These are substantial markets, comparable globally to aerospace or pharmaceuticals. The European Commission estimates that the world renewables market now stands at GBP 40 billion. The World Energy Council foresees cumulative investment on renewables of between GBP 150 and GBP 400 billion between 2000 and 2010. This means that there are and will continue to be great opportunities and incentives for business to contribute to improved environmental performance in both developed and developing countries.

Attacking the causes of climate change presents particular opportunities. The United Kingdom is, of course, absolutely committed to its international obligations to cut greenhouse gases by 12.5%, and we have also set ourselves the domestic goal of moving towards a 20% cut in emissions of carbon dioxide, the most significant of these gases. Our climate change programme includes a 10% target for energy from renewables by 2010. It behoves us, as a developed nation and a significant producer of greenhouse gases, to take a lead and set an example for developing nations.

Helping business and other nations deliver on their obligations, helping them reduce their contribution to climate change, offers up a valuable role for technology and environmental service based industry. To help British business export its low-carbon technologies, we are setting up in the United Kingdom the Kyoto Mechanisms Office. By encouraging the private sector to invest in innovative energy projects abroad, it will help tackle climate change and allow British business to seize new opportunities. The Office will start work in April 2001.

Science, technology and business thus have a crucial role to play in ensuring sustainable development. There must be an active dialogue between government, industry and environmental NGOs to make sure that realistic advances are able to be achieved. Moreover, the environment is a global issue. Excessive carbon emissions in the United States, for instance, could cause the loss of low-lying islands in the Pacific. International dialogue is vital – and the United Kingdom intends to play its full part in the discussions at The Hague. We must work hard at discovering the new technologies, ensuring good science, and challenging business to develop the new environmental markets. Across the world, businesses, government, consumers and citizens must begin to act,

So, having shared with you some of the thinking and approaches pursued in the United Kingdom – which I hope provides reassurance that the United Kingdom takes its environmental responsibilities seriously – let me now touch on how the United Kingdom provides international help to facilitate technology transfer. There are many relevant initiatives and activities that the UK Government engages in. They range from the UK Bilateral Development Programme operated by the Department for International Development to smaller-scale projects funded from the Climate Change Challenge Fund of the Foreign and Commonwealth Office. This morning I would like to concentrate on a specific area of assistance that will be useful to anybody, particularly to those from the developing countries wishing to pursue environmental solutions from the United Kingdom.

The United Kingdom has a dedicated team called the Joint Environmental Markets Unit or JEMU. “Joint” because it is staffed from both our Environmental, and Trade and Industry Ministries, which reflects the helpful synergies that exist between environmental policy and trade. JEMU acts a gateway to environmental solution providers from within the United Kingdom. It is therefore a door to technology transfer. The JEMU Web site (www.dti.gov.uk/jemu) provides access to a database of over 5 000 UK environmental goods and services firms.

1. *Source:* Joint Environmental Markets Unit (JEMU).

The Joint Environmental Markets Unit also administers the United Kingdom's Technology Partnership Initiative, or TPI. This is a UK Government initiative to promote best practice and cleaner production internationally on a commercial basis through business partnerships. Through TPI, businessmen and businesswomen in rapidly industrialising countries such as Korea, are given access to British technologies and expertise which can lead to improvements in performance as well as reducing environmental impacts.

The Technology Partnership Initiative has a network of about 6 000 participants around the world. Members receive a quarterly newsletter, "TPI News", which features articles on available technologies and developments in the United Kingdom. In addition to case studies and new technological developments, each edition includes a special in-depth feature. Cellulose technology, environmental monitoring and analysis, and environmental biotechnology are some of the topics which have been covered in recent editions. I hope that those of you in the audience who are not yet network members will join. Membership is free and further details are available via JEMU's Web site or from the British Embassy here in Seoul.

TPI is also used to facilitate events – for example, seminars and exhibitions in overseas markets – which are valuable in a number of ways. They bring people together to discuss mutual problems. They enable British suppliers to speak to potential overseas customers at first hand. And, hopefully, they help tackle environmental problems and foster commercial co-operation.

We also have a wide range of publications which show the benefits to both the companies in industrialising countries and British environmental technology and service companies of working through partnerships.

In forging commercial partnerships in the field of environmental good practice and responsibility, there are many potential beneficiaries. Not only the companies which come together at project level, but the environment itself. If the environment benefits through effective management and reduced adverse impacts, so too will everyone who depends on the environment. At the end of the day, that is local and global populations. In my book, that is certainly something worth striving for, and I am glad that the British environmental industry, backed by the UK Government, is so eager to play its part in that process.

The most effective environmental solutions to environmental problems are likely to be integrated, and fashioned by local conditions. It will not necessarily be an easy task to solve all environmental challenges but if we work together, through effective partnership, I am sure we shall all benefit.

Chapter 5

INTERNATIONAL SCIENCE AND TECHNOLOGY CO-OPERATION FOR SUSTAINABLE DEVELOPMENT: AN INDUSTRY PERSPECTIVE

by

Parry M. Norling
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Since the early 1970s, the challenge for a sustainable future has been seen in this relationship:

$$\textit{Environmental impact} = \textit{population} \times \textit{affluence} \times \textit{technology}$$

How can we increase economic and societal well-being for a greater number of people around the world who are gaining in affluence and in access to the new technologies – all without deterioration of the environment and depletion of the resources upon which future generations depend for their well-being? How can we use technology to lessen environmental impacts and contribute to sustainable development?

We would not be here today if we had not admitted that the above equation is incomplete. Technology does not need to be a detriment; it can in fact work to make a sustainable future possible. We recognise that there are three types of technologies that may contribute to economic development:

1. Those that contribute to deterioration of the environment and use significant natural resources.

2. Those that have little or no effect.

3. And those that restore or improve the environment and draw upon natural resources without significant long-term depletion of resources.

Whether a given technology becomes type 1, type 2 or type 3 may depend on where, when and how the technology is applied – or possibly on how that technology is used in conjunction with other technologies. For example, advanced sensor technologies or hazard containment technologies might allow for the manufacture of a particular hazardous yet beneficial material; the fact that we may not know at the outset whether or not a given technology is beneficial or detrimental can create a number of problems for regulators and policy makers who may want to prohibit, ban or constrain the use or application of a given technology.

Hence, the equation should be rewritten as:

$$\textit{Environmental impact} = \textit{population} \times \textit{affluence} \times \textit{(T1/T3)}$$

Where T1 technologies contribute to negative environmental impact, and T3 technologies lessen that impact.

Our challenge today is to address the "what"s and the "how"s of the second and third types of technologies and the underlying sciences upon which these technologies are built.

"What"s

- What technologies do we want to encourage and develop?
- What are the technologies that can bring true benefits to society?
- What types of research do we want to fund?
- What beneficial technologies can be developed locally?
- What technologies can be readily transferred to regions where they can best be used?
- What sciences should we be exploring so that they can be applied to provide beneficial technologies?
- What technologies show the most promise for the future?

There are a number of other related issues. What technologies should be applied in relation to: quality nutrition, medical care, sufficient energy, air quality, water supplies – both quantity and quality, renewable agriculture, avoiding soil loss, forest resources, biodiversity, solid waste, and expanding population?

"How"s

- How do we deliver the value of these technologies?
- How can we get the technologies to the places around the world where they can be most beneficial?
- How can technologies be transferred around the world and perfected locally?
- How do we overcome the many barriers to such a transfer of technology?

To provide a framework for answering these questions, I will offer (and elaborate upon) six beliefs or perspectives on sustainable development – that may help (or further promote) discussion.

Industry/the business sector must become an actively leader

To make sustainable development a reality, industry must lead and must innovate. Industry as society's producer has a special role in sustainable development. Industry cannot view the environment and business as two different or competing topics. It is industry that can turn the technical solutions and opportunities into realities. It was government that set the policy for phase-out

of chlorofluorocarbons – but it was industry that made the transition happen. US President Clinton recently issued an executive order which focused on renewable resources. Innovation in industry will be needed to increase the use of renewable resources.

A step change is needed

Sustainable development requires step changes in the way we do things and must be built from the ground up. Sustainable development is not something that simply happens; it is built up and derived from a myriad of often independent actions. In DuPont, sustainable development is requiring us to rethink virtually every one of our industrial processes and products. A step change is required in the way we think about all environmental protection, in every individual new product and process development, and in the ways we integrate business growth with environmental objectives. This calls for attention to many of these independent actions and has led us to challenge the mindset, thinking and actions of all DuPonters. The challenge is to strive for the goal of "zero" injuries, illnesses, incidents and emissions, or "zero" wasted resources – natural, human, and capital – in every individual activity that we undertake. This challenge will work because we have learned over the years that sustainable development has to be generated one household, one manufacturing plant, one chemical process, one industrial product, one community, one region at a time.

Economic vitality is essential

Economic vitality is required for long-term environmental protection and sustainable development. We are convinced that long-term environmental protection will only take place in the context of economic growth and vitality. Economic vitality is part of local sustainability: a community has to be competitive educationally, economically and in other ways to attract investment that provides jobs and income. Economic growth, environmental protection and strong social systems must be addressed together as part of an overall vision of sustainability.

Commitment and understanding is needed

There are many science and technology options that will lead to economic growth and be compatible with sustainable development, but it will take commitment on the part of industry and understanding on the part of society for these to be pursued. Think of the opportunities for energy from renewable resources; sustainable agriculture with low-use herbicides or with biotechnology; advanced materials making communications faster and easier, based on recyclable resources; inherently safe and non-polluting manufacturing processes, and more.

We are moving into an era where knowledge, not labour or raw materials or capital, is a key resource. Because it reduces the need for raw materials, labour, space, capital and other inputs, knowledge becomes the ultimate substitute – the central and continually renewable resource of an advanced economy committed to sustainable development. Communicating that knowledge in the most effective ways becomes the important challenge. Here, materials such as fused silica optical fibres, optical switches and wave guides will play an ever increasing role in our communications tools – increasing the ease, power, portability, and ability to store and manipulate information, while decreasing the weight, mass and total resources used.

Expenditures for environmentally related technologies will change

Expenditures on environmentally related technologies will change as we move into the future. Near-term investments in remediation and restoration will involve the cleaning up of target sites. Intensified expenditures in technologies to avoid environmental harm will reap rewards and will continue. By 2040, many industries will be approaching a zero-discharge goal, although some control technologies may still be required to deal with residual discharges. Later in the 21st century we will have moved forward, from a mindset of clean-up and control to one based on anticipation, avoidance and assessment.

For technology transfer there are many options

We have many options for transferring environmentally related technologies and technologies that support sustainable development. Public policy, and possibly some new business models, will be required to deliver the benefits of these technologies around the world.

Some options include donations (products or intellectual property to universities or government-based research centres); exchanges (natural products or microbes as the basis for pharmaceuticals); low royalty or joint venture technology transfers in a way that builds the local economy – and others.

We know that through reverse osmosis, membranes from advanced materials can provide a source of fresh water from brackish water, but did you know that 50 cents worth of a simple nylon mesh fabric can act as a super filter to remove the guinea worm from water in Africa? Guinea worm disease, which ten years ago affected over 3.5 million people, has virtually been eradicated – providing access to clean water where it was not available before.

Having looked at these six perspectives, we may now be ready to address a number of the difficult issues related to the "what"s and "how"s of science and technology in support of sustainable development.

PART III

PLENARY SESSION 1

INTERNATIONAL CO-OPERATION FOR THE DEVELOPMENT OF S&T INFRASTRUCTURE FOR SUSTAINABLE DEVELOPMENT

Chaired by Herwig Schlögl
Deputy Secretary-General of the OECD

Chapter 6

ACCESSING APPROPRIATE SCIENTIFIC KNOWLEDGE AND BUILDING ADEQUATE SCIENTIFIC AND TECHNICAL SKILLS FOR SUSTAINABLE DEVELOPMENT

by

Won-Hoon Park
Korea Institute of Science and Technology

Introduction

The post-industrial revolution brought about by the rapid development of information technology has brought the citizens of the Earth much closer through the networking of countries, communities and individuals. At the same time, environmental pollution on a global scale – depletion of the ozone layer, global warming, climate change, etc. – has reduced the land available for human settlement by spilling pollutants over neighbourhoods, across city and country borders, and into the oceans.

In this new era of globalisation, shrinking space and time are serving to connect people's lives more intensely and more immediately. Globalisation integrates not just the economy, but also culture, technology and governance. We have more overall wealth and technology – and greater commitment to a global community than ever before (UNDP, 1999).

Globalisation is seen as a process that enables the world to become better informed, so that information access is no longer an issue. Is it really true that information technology is allowing the world's population to share the same information opportunities and that the information gap (or divide) is narrowing? Unfortunately, all the available statistics indicate the contrary.

Since I presented a paper on technology transfer between developing and developed countries at the Eleventh World Clean Air and Environment Congress in Durban. South Africa in 1998, the global situation is becoming more urgent and calls for the immediate implementation of the action programmes that have already been proposed – rather than the elaboration of fanciful new ones (Park, 1998).

A review of technology transfer

The world community has reached the conclusion that, in the transfer of environmentally sound technology (EST), developing countries are facing severe constraints in their efforts to advance in technology transfer and co-operation since they lack adequate financial resources and have limited human and institutional capacities. The following three key areas need priority attention in order to

support the transfer of ESTs on terms that will promote their use and rapid diffusion: *i)* dissemination of and access to information on ESTs; *ii)* institutional development and capacity-building; *iii)* financial arrangements, technology co-operation and partnerships.

So far, a number of proposals have been made for implementation through various international channels. These include:

- Inventory of existing technology information networks.
- International network of clearing houses.
- National referral services.
- Independent technology transfer agencies.
- Case studies.
- Creation of "one-stop shops".
- Establishment of Environmental Technology Centres.
- Demonstration projects.
- Expansion of UN programmes.
- Venture capital fund for ESTs.
- Public purchase of patents.

Nevertheless, with respect to the key issue of financial arrangements, technology co-operation and partnerships, the gap between the views of the North and the South remains wide. The North emphasises the key role of the private sector as a principal conduit through which technology is developed, transferred and disseminated and the need to mobilise private sector investment. On the other hand, the South stresses the need to promote and finance the transfer of environmentally sound technologies and corresponding know-how on favourable terms, to promote long-term technological co-operation and partnership between holders of environmentally sound technologies and potential users, and to improve the indigenous capacities of developing countries to develop, assess, encourage and utilise such technologies through, *inter alia*, research and development, education and training.

It must be noted that ESTs should not be limited to hardware technologies but should also include scientific knowledge, management skills, information and other types of software technologies. This implies that human resource development, as well as the infrastructural capacity to provide and select appropriate technologies, also needs to be included.

The topic of enhancing the transfer of ESTs has stimulated a great deal of debate. However, we are still searching for answers. Perhaps we believed too hard in the existence of a panacea – a unique solution or single mechanism which could solve all the problems related to the transfer of ESTs.

We now understand that there is no one answer nor one solution. There can only be many recipes for country- and sector-specific cases, and various combinations resulting from these cases. Actually,

since there are so many recipes, we are at rather a loss. This is why we need some framing guidelines for setting up effective and efficient action programmes to facilitate EST transfer.

A framework for technology transfer

The technology transfer mechanism can be easily classified into two categories, according to the commercial aspects of the transfer; namely, contracted commercial (or official) transfers and non-commercial (or unofficial) transfers. Recently, technologies have become an important commodity in the trade market. However, most technologies are still transferred through non-commercial channels, and this may be the reason why the access to appropriate scientific knowledge becomes so important.

The other classification criterion is the level of effort put in by the receiving side of the transfer, or the level of technological capacity of the recipient. This criterion plays a very important role in analysing the success of the technology transfer, and, up to now, most studies on technology transfers have dealt only with cases in which the technology donor assumes the active commercial role of deciding the form of technology transfer (Table 1).

Table 1. **Mechanism of technology transfer**

	Active receiver	Active donor
Non-commercial	Imitation Knowledge through information search Idea through trade market, etc	Foreign consultation
Commercial	Procurement of capital goods	Foreign direct investment Joint venture Turn-key project Licensing Management contract

Korean experiences over the last three decades – as a country that overcame poverty in the aftermath of the Korean War to become a newly industrialising economy, but which remains a developing country in terms of environmental protection – suggest some valuable guidelines:

- Programmes should reflect the different technological levels of recipients, or the different technological capacity and capability of the recipient.

- Technological levels can be conveniently grouped into three categories; namely, low, intermediate and high:

  - High denotes the level which does not require any outside assistance on favourable terms in three key areas of: *i)* information; *ii)* capacity-building; and iii) financing and technology co-operation.

  - The intermediate level denotes that outside assistance on favourable terms is required in one or two of the key areas, usually in financing and technology co-operation.

  - Low denotes the level which requires outside assistance on favourable terms in all of three key areas.

- Programmes should primarily target low-level recipients. Since technology transfer is a phenomenon in which the flow makes its way from a higher level to a lower level, programmes for low (and/or lower) levels have vertical characteristics and should be of non-commercial mechanism, proactive donor, and aid projects.

- As for recipients of intermediate and higher levels, programs of horizontal characteristics of co-ordinating commercial mechanism and technological co-operation will prove sufficient.

Table 2. **Some framing guidelines**

Technology level or capacity	Passive receiver	Active receiver
Low	Non-commercial	Non-commercial
	Public information	Information networking
	Foreign consultation	Education / training
	Aid projects	Aid programmes
Intermediate/High	Commercial	
	Proprietary information	
	Favourable financing	
	Technological co-operation	

The widening divide

According to the UNDP *Human Development Report 1999*, disparities between the haves and have-nots are widening. The income gap between the fifth of the world's population that live in the richest countries and the fifth who live in the poorest was 74 to 1 in 1997, up from 60 to 1 in 1990 and 30 to 1 in 1960. By the late 1990s, the fifth of the world's population living in the highest-income countries had:

- 86% of world GDP, while the bottom fifth had just 1%.

- 74% of world telephone lines, while the bottom fifth had just 1.5%.

- 93.7% of internet users; the bottom fifth just 0.2%.

- OECD countries, with 19% of the global population, have 71% of global trade in goods and services, 91% of all Internet users.

- In 1993, ten countries accounted for 84% of global research and development expenditures and controlled 95% of the US patents of the past two decades. Moreover, more than 80% of patents granted in developing countries belong to residents of industrial countries.

Table 3. **Stark disparities between rich and poor in global opportunity, 1997**
In percentages

	World GDP	Telephone lines	Internet users
Richest 20%	86	74	93.7
Middle 60%	13	24.5	6.5
Poorest 20%	1	1.5	0.2

Box 1. **Aspects of Internet, 1998**

Despite the potential for development, the Internet poses severe problems of access and exclusion:

- *Geography divides.* Thailand has more cellular phones than Africa. South Asia, home to 23% of the world's people, has less than 1% of Internet users.
- *Education is a ticket to the network "high society".* Globally, 30% of users had at least one university degree.
- *Income buys access.* The purchase of a computer would cost the average Bangladeshi more than eight years' income, the average American, just one month's wages.
- *Men and youth dominate.* Women make up just 17% of Internet users in Japan, only 7% in China. Most users in China and the United Kingdom are under 30.
- *English talks.* English prevails on almost 80% of all Web sites, yet less than one in ten people worldwide speak it.

This exclusivity is creating parallel worlds. Those with income, education and connections have cheap and instantaneous access to information; the rest are left with uncertain, slow and costly access. When people in these two worlds live and compete side by side, the advantage of being connected will overpower the marginal and impoverished, cutting off their voices and concerns from the global conversation.

This risk of marginalisation does not have to be a reason for despair. It should be a call to action for:

- *More connectivity:* setting up telecommunications and computer hardware.
- *More community:* focusing on group access, not just individual ownership.
- *More capacity:* building human skills for the knowledge society.
- *More content:* putting local views, news, culture and commerce on the web
- *More creativity:* adapting technology to local needs and opportunities.
- *More collaboration:* developing Internet governance to accommodate diverse national needs.
- *More cash:* finding innovative ways to fund the knowledge society everywhere.

Source: UNDP, *Human Development Report*, 1999.

Knowledge is becoming a new asset – as indicated by the fact that more than half of GDP in the major OECD countries is now knowledge-based. Globalisation is beginning to lay claim to knowledge by, for example, tightening intellectual property rights, and the global gap between the "knows" and "know-nots" is widening (Box 1 highlights some of the global effects of information technology diffusion).

This widening disparity poses severe problems, even for a country like the United States where the Internet was invented. Unequal access to technology and high-tech skills depending on income, educational level, race and geography could serve to deepen and reinforce the divisions that already exist within society. However, access to technology is only the first step. It is important to give people the skills they need to use technology, and to promote content and applications of technology that will help empower under-served communities.

The Clinton-Gore Administration is keen on achieving the policy of "From Digital Divide to Digital Opportunity". In his budget, President Clinton announced specific proposals to help create digital opportunities for more Americans – including USD 2 billion in tax incentives to encourage private sector activities such as computer donations, and USD 380 million in new and expanded initiatives to serve as a catalyst for public-private partnerships.

Box 2. **President Clinton's budget initiatives**

1. USD 2 billion in tax incentives over ten years to encourage private sector donation of computers, sponsorship of community technology centres, and technology training for workers.
2. USD 150 million to help train all new teachers entering the workforce to use technology effectively.
3. USD 100 million to create 1 000 Community Technology Centres in low-income urban and rural neighbourhoods.
4. USD 50 million for a public/private partnership to expand home access to computers and the internet for low-income families.
5. USD 45 million to promote innovative applications of information and communications technology for under-served communities.
6. USD 25 million to accelerate private sector deployment of broadband networks in under-served urban and rural communities.
7. USD 10 million to prepare native Americans for careers in information technology and other technical fields.

The reason I intentionally emphasise the Clinton "Digital Initiative" is that the remedies proposed can usefully be applied to the global situation. In one sense, the recipes fit even more neatly to disparities at the global level. It is in this spirit that I reiterate my proposals for action programmes made in Durban, South Africa (Park, 1998).

Action programmes

Environment Keeping Operation

In the case of passive recipients of low technological capacity (Table 2), a massive and heavy vertical programme should be installed. A programme in the format of an Environment Keeping Operation (EKO) or Environment Corps, which can be conceptually compared to the Peace Keeping Operation (PKO) or Peace Corps, is recommended. EKO will undertake the following main duties:

- On-the-spot, face-to-face environmental survey.
- Environmental awareness education.
- Survey of information needs.
- Identification of areas in need of financial, technological aid (Environment Aid Programme).
- Establishment of capacity-building roots.

EKO is composed on a voluntary basis, or in some cases, dispatched through UN co-ordination. EKO members are professionals with a technological, environmental and regional development background. They will deliver available public information and will be supplied with the necessary facilities to undertake outside networking. EKO may be terminated at such a time when the recipient has become proactive (in a positive way) and has built up indigenous capacity.

Environment Aid Programme

Just as in an emergency, first aid is the decisive factor in the patient's recovery, for the environment, well-designed environment aid is the most important factor for the future build-up of technological capacity and capability. A number of recommendations have been made to guide Official Development Assistance (ODA) in this direction. However, there is a strong need for an independent Environment Aid Programme, which would mainly target active recipients of low technological capacity.

The Environment Aid Programme would cover such projects as, *inter alia*:

- Demonstration projects.
- Establishment of national referral services.
- Build-Operate-Transfer (BOT) operations.
- Environmental technology centres.
- One-stop-shops.

Regional and sectoral programmes

The majority of technology recipients share the same environmental problems and constraints, in both regional and sectoral terms. If existing UN programmes can be reorganised to better serve specific regions and sectors, the resulting programmes will prove more economical, efficient and effective. In this regional and sectoral regrouping, careful consideration should be given to North-South (vertical) and South-South (horizontal) factors; to the extent possible, the project should aim for a well-balanced membership consisting of indigenous capability. This approach has proven far more effective than sporadic and inconsistent dispatches of foreign consultants.

Partnership programmes

For recipients of intermediate and higher technological capacity, action programmes will be more effective and more efficient if commercial incentives are taken into account: there is greater demand for privately owned proprietary technologies than for ESTs in the public domain. Unless such economical factors are respected, the diffusion of ESTs will not be satisfactorily achieved.

One way of solving this problem is by setting up financing arrangements (the more favourable, the better) through an international body. International or regional co-ordination, and bilateral arrangements, are key factors.

Possible co-operation and partnership action programmes are listed below:

- Environmental expositions.
- Technomarts.
- Partnerships (regional, bilateral).
- Bilateral environmental co-operation agreements.
- Joint seminars, symposiums.
- Co-operative R&D programmes.
- Venture capital funds for ESTs.
- Public purchase of patents.
- International information networks.

Cleaner technologies

For all the programmes listed above, there is a prerequisite for a baseline criterion enabling the efficacy of cleaner ESTs to be evaluated. In the absence of an international monitoring system, there is a danger that dirty environmental technologies be transferred in the guise of environmentally sound technologies. Unless the paradigm shift from pollution control to pollution prevention is strongly emphasised in all action programmes, and unless access to and dissemination of information on cleaner ESTs is enhanced, the road to global environmental preservation will prove long and arduous.

The main obstacle to the diffusion of cleaner technologies (CTs) lies in the fact that cleaner technologies belong to production technology rather than to environmental technology. Cleaner technologies are basically production process technologies, since they deal with innovations to existing processes or with the substitution of old processes by new ones. The diffusion of cleaner technologies can only be expedited in the context of industrial policies or industrial restructuring. Furthermore, the environmental industry is firmly established with end-of-pipe technologies and products and will not voluntarily hop on the bandwagon of cleaner processes and technologies. Therefore, unless environmental standards and regulations can be strengthened in such a way that there is no choice but to opt for technological innovation, cleaner technologies will continue to be developed or adopted at a very slow pace.

Current efforts focus more on supply-side policies and activities, resorting to financial and technical support for the promotion, development and deployment of cleaner technologies. However, in the absence of demand for cleaner technologies, their diffusion will likely come to a halt. This calls for greater efforts in the design of demand-side policies. The creation of strong and explicit demand for cleaner technologies should precede supply-side strategies, especially in developing economies.

To summarise the lessons learned from Korean experiences, technology demand is an evolutionary rather than a revolutionary process, and policies aimed at enhancing the demand for ESTs and CTs must reflect the local and site-specific level of technological capacity.

Table 4. **Stages of demand creation**

Technology level	Demand creation priority	Strategies
Low	Awareness building	Demand-side
Intermediate	Capacity building	Demand-side
High	Market development	Supply-side

The following demand-side strategies are recommended for implementation in accordance with country- and sector-specific circumstances. A good strategic recipe would be an optimum mix of the policies prescribed for each case:

Baseline

- Clear national environmental goals and priorities.
- Strict but flexible environmental regulations and standards.

Awareness building

- Public education and participation.
- Information dissemination.
- Product labelling.
- Awards system.

Capacity building

- Infrastructure.
- Organisational restructure.
- National cleaner technologies centre.

Private sector engagement

- Demonstration projects for SMEs.
- Industrial audit programmes.
- Voluntary agreements.
- Matching funds for R&D.
- Favourable financial arrangements.

UNEP/UNIDO has been championing the promotion of cleaner production. It has established 19 National Cleaner Production Centres (NCPC) in developing countries and economies in transition. This programme primarily targets the transfer of know-how rather than the transfer of technology, so the centres have not had much involvement in technology transfer (Clarence-Smith, 2000). Since cleaner production without technology transfer can be said to be a half-success, strategies to enhance private sector engagement should be implemented with more emphasis in the future (Park, 1995). Furthermore, there is a need for an international project for the standardisation of technology cleanness so that cleaner technologies prevail in technology trade.

Korea could play a major role in this project, since, as a newly industrialising economy, we can share recent experiences with cleaner production which are more appropriate for developing economies.

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Chapter 7

INTERNATIONAL CO-OPERATION IN R&D IN ENERGY AND ENVIRONMENT

by

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Introduction

Global environmental threats such as acid rain and global warming are serious not only because of the dramatic negative impacts they can have on the developed countries (which were responsible for emitting the pollutants which caused the environmental threats in the first place), but also because their effects are also felt by the developing countries. In the foreseeable future, emissions of pollutants by the developing countries will contribute significantly to the worsening of these threats to the environment. There is thus an urgent need for international co-operation in R&D by researchers from both developed and developing countries to ensure the efficient and worldwide distribution of pollution reduction and control technologies.

The first and the most important condition for the success of such a co-operative project is that all participants, whether they be from developed or from developing countries, can sustain their scientific interest throughout the duration of the study. If this can be achieved, the project will keep up its momentum and will be carried out with enthusiasm. If participants from different parts of the world are to maintain their scientific interest in the same technology objectives, it is important to take full account of the regional characteristics of the project. In other words, the project will attract the interest of both the developed and the developing countries only if the technological requirements vary according to regional economic, social and geological conditions.

In our discussions on co-operation between developed and developing countries, much has been said about the appropriateness of the target projects, but little mention has been made of the meaning of the term “appropriateness”. I would like to point to two types of projects which could be categorised as “appropriate” in this sense: one is the modification of existing technologies, whose required characteristics are heavily dependent on local conditions; the other is the introduction of innovative technologies, which can enable developing countries to “leapfrog” to a more advanced stage of development.

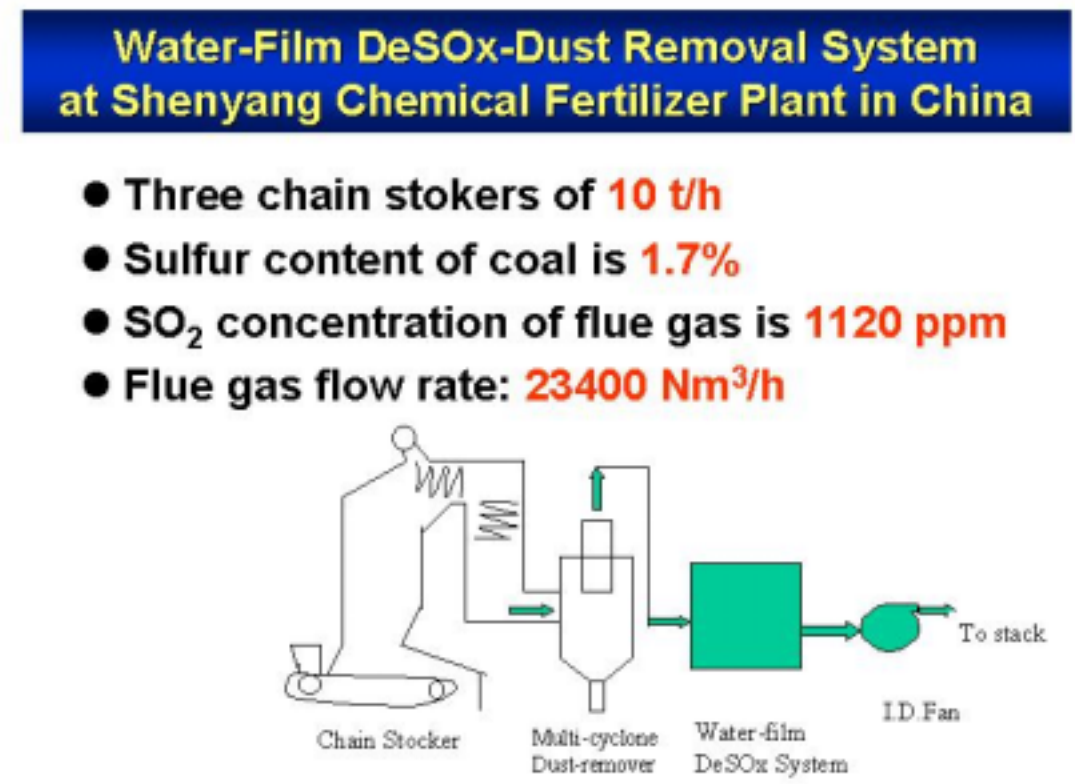
Modifications to existing technologies

A good example of the first type of project is the new desulphurisation devices currently being developed through a co-operative effort by the University of Tokyo and Tsinghua University in

China.[1] China is heavily dependent on coal, particularly for electric power generation, and suffers from SO_X emissions and the resultant acid rain. The introduction of desulphurisation devices is therefore urgently needed. The most serious barrier to the introduction of such devices is their prohibitive cost; the majority of power plants therefore continue to operate without any desulphurisation. In addition, the acute water shortage from which almost all regions in China suffer call for the adoption of desulphurisation processes which are economical in terms of water use.

Taking these two points into account, chemical scientists from the two universities worked together to produce a low-cost, water-efficient device; the trade-off was an SO_X removal rate which was slightly lower than usual. The basic design of the new device is shown in Figure 1. This system is economically attractive for the following reasons: first, the whole process is simplified, *e.g.* the dust remover and desulphurisation devices are combined in a single process; second, the air oxidisation process is also simplified. In addition, the by-product of the device is plaster, or $CaSO_4$, which can be used as an effective fertiliser for alkaline soil in North China, thus contributing to enhancing the economic feasibility of the device.

Figure 1. **Basic schema of a low-cost desulphurisation device**



In March 2000, an experimental plant was built in Shen Yang. Plant cost was reduced to almost one-quarter of the cost of conventional plant. In addition, recycling led to a reduction of 50% in water use.

1. These projects are partially or fully sponsored by the Japan Science and Technology Corporation. For further information, please contact Mr. Kaya at the Environmental Research Office, Japan Science and Technology Corporation (y-kaya@st.rim.or.jp).

Innovative technologies

"Appropriate" technologies also include innovative technologies which give full consideration to the specific characteristics of the regions involved. An example is bioremediation of soil and water. This technology is considered more advanced than conventional chemical methods since toxic chemicals are absorbed by living micro-organisms in a more natural way than is achieved by conventional chemical methods.

Professor Maekawa's team from Tsukuba University (Japan) is currently working with Peking University (China) on bioremediation around Lake Dianchi in Southern China (Figure 2). Prof. Maekawa has done a great deal of this kind of work, but the micro-organisms and target toxic chemicals vary from region to region. In this study, the goal is to remove nitrogen from the lake water. The location of the site and the schema of the experiment are shown in Figures 2 and 3. The project researchers believe that this groundbreaking project is just the first of a number of projects around the world and are therefore very excited to be working on the study.

Figure 2. **Location of the Chinese bioremediation experiment**

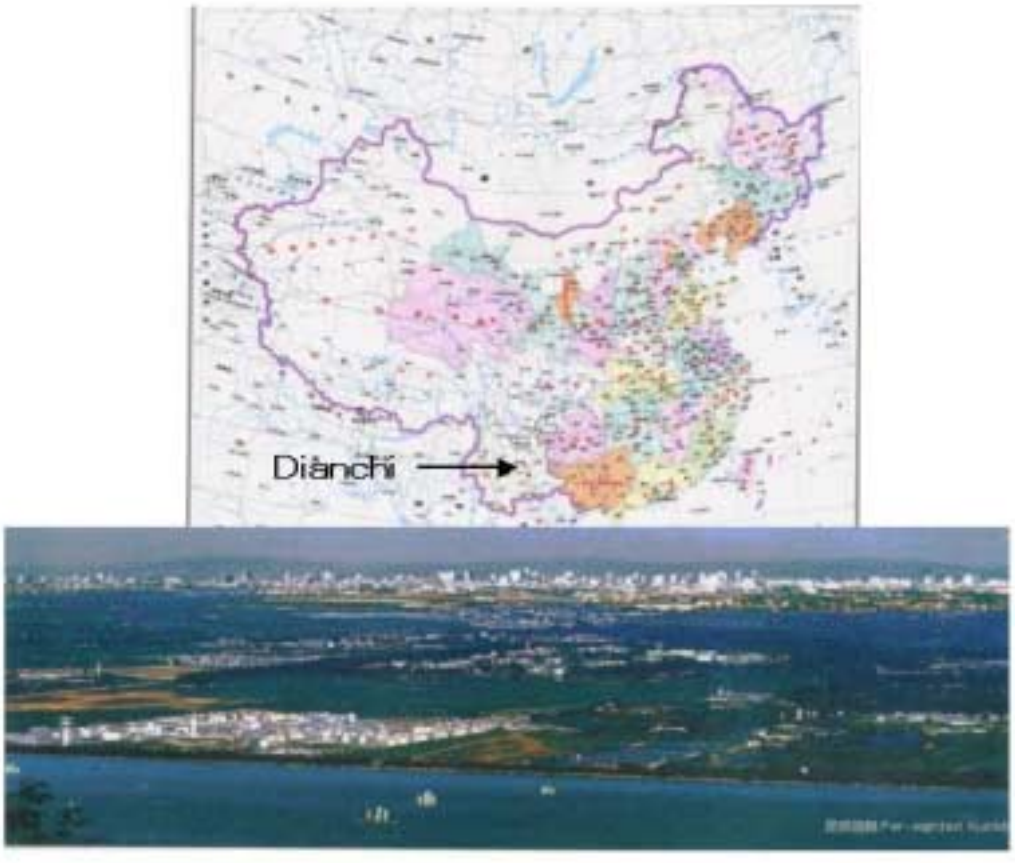
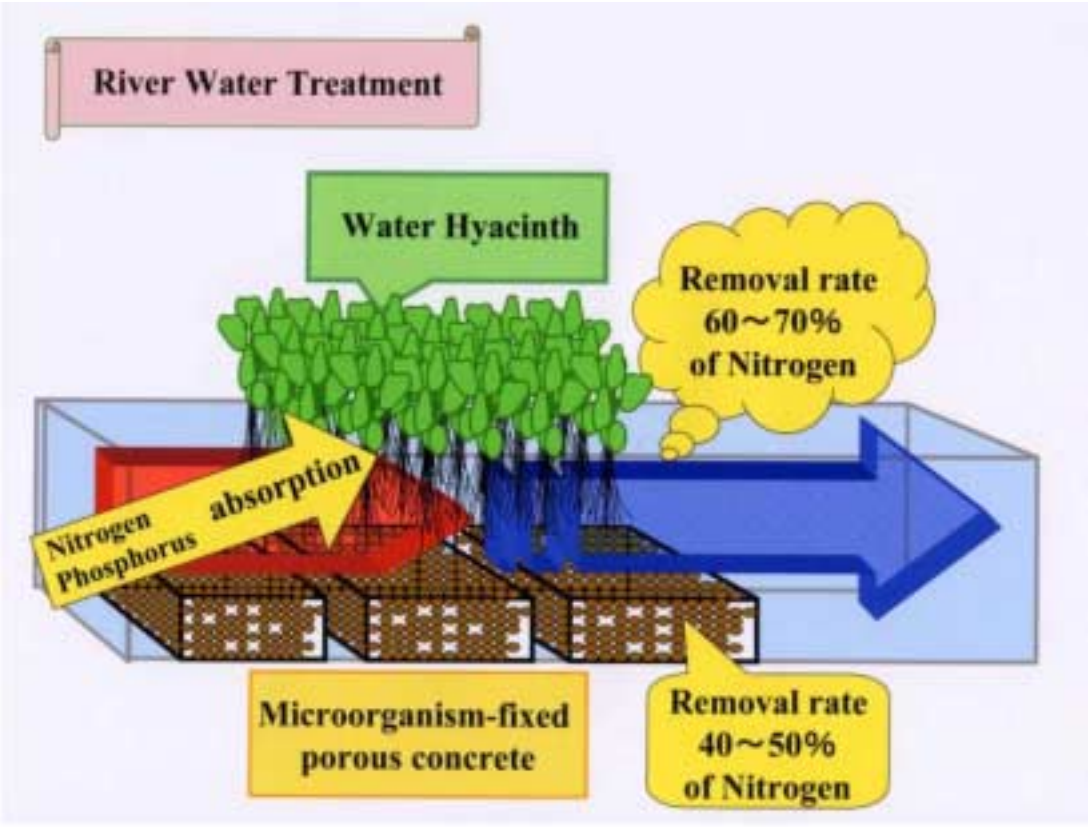


Figure 3. **Outline of the Dianchi bioremediation process**



Another interesting illustration is the co-operative project between social scientists from developed and developing countries on the Clean Development Mechanism (CDM), which is an economically rational way of reducing greenhouse gas emissions (see footnote 1). The details of CDM are still under discussion and, prior to its implementation, it will be necessary to identify what projects are really appropriate and to what extent they are feasible. Needless to say, collaboration between the developed and developing countries is indispensable. Professor Sawa of Kyoto University has organised a team of economists from three North-East Asian countries, *i.e.* Japan, China and Korea, to work towards this objective. The team, known as the "BeSeTo" (Beijing, Seoul, Tokyo) group, is now up and running, and the members are in close contact with one another.

The future concept of environmentally benign mega-cities should also be included among the candidates for R&D co-operation. Urbanisation is occurring throughout the world and the environment in all our cities is deteriorating day by day. It is therefore crucial for the survival of mankind to redesign our cities to encompass the three "e"s, *i.e.* they need to be made more **e-**fficient, more **e-**conomically rational and more **e-**nvironmentally benign.

In the past, two extreme ideas have been put forward. One involves the decentralised garden city, the other revolves around the notion of a centralised building complex, *i.e.* the "compact city" which has been proposed by urban technologists for a number of years. In the first concept, houses are located rather sparsely and interspersed with trees and gardens; citizens benefit from a green environment. In such cities, however, transportation requirements may be much larger than for

conventional cities and implementation of an efficient energy network, such as local district heating, may be more costly and less efficient.

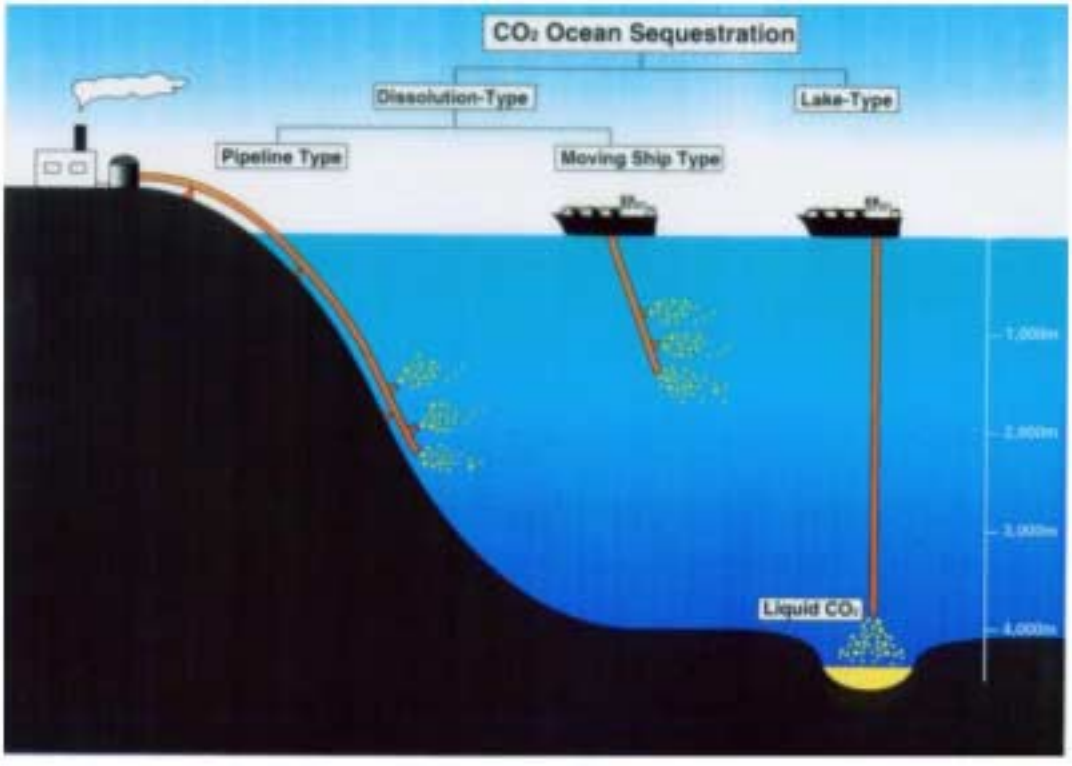
On the other hand, the “compact city” concept means concentrating the population of the city in a small area with large building complexes. Compact cities may contribute to reducing total mass and demand for transport, but it is unclear whether the inhabitants would feel comfortable in such an environment.

In this sense, both notions are far from ideal and we need to establish a new image of “3e” mega-cities which can be varied according to local climatic, economic and cultural conditions. Such studies call for a collaborative effort involving not only architects, but also other experts from both advanced and developing countries.

Co-operation on the global issues

Finally, but no less importantly, there is a urgent need for collaboration among developed countries – hopefully, together with developing countries – on global issues such as global warming. Since these issues are both global and long term in nature, it is often a case of utilising our common territory to mitigate the issues; this requires international consensus in implementing combative measures. An important step towards this objective would be to organise an international research team to study the issue.

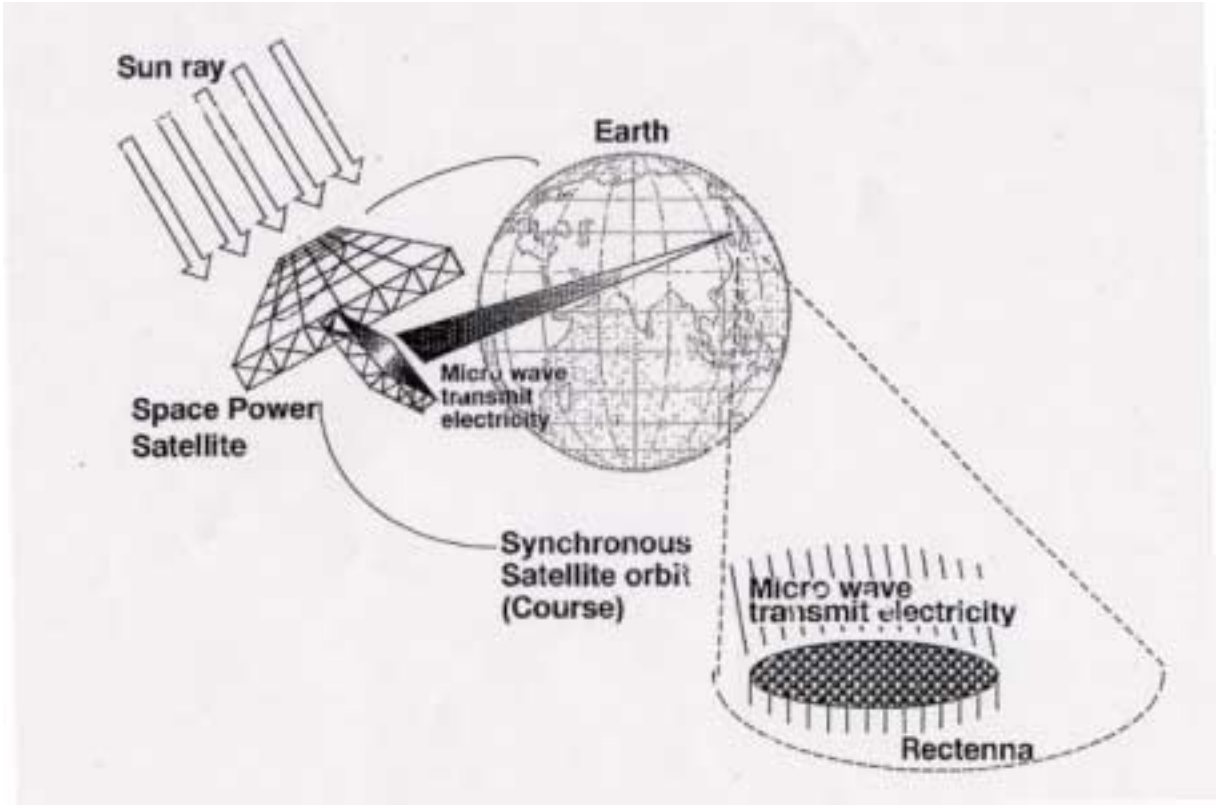
Figure 4. **Some ideas for CO_2 ocean disposal**



A good example of such collaboration is the CO_2 ocean sequestration project. The basic idea is simple, as seen in Figure 4. This is an end-of-pipe technology which will not be introduced before other preventive measures have been implemented. However, since the reduction of greenhouse gases obtained solely through only preventive measures such as energy conservation and fuel switching, is rather limited, end-of-pipe technologies may provide a solution when mankind becomes very afraid of the threat of global warming. A number of studies have been carried out on CO_2 recovery from flue gas and its disposal underground and/or in the ocean, but experimental data is needed before the technology can be implemented. An international team was formed in 1997 for the purpose of an experimental study on CO_2 ocean disposal, with the participation of the United States, Japan, Norway and a number of other countries (Herzog *et al.*, 1999). A number of collaborative studies are being carried out.

In the long run, not only our oceans, but also outer space, will need to be used for various purposes. This will require collaborative study groups from around the world, partly because of the high cost of R&D, but also because these as-yet unexploited regions are owned not by a single nation but by the whole of mankind. In the long-term future, one of the candidates for study is the space power system shown in Figure 5, *i.e.* electric power generation in outer space by photovoltaic satellite with power transmission by microwave to the Earth.

Figure 5. **Space power system**



Conclusion

R&D co-operation in energy and environment technologies among developed and developing countries requires clear incentives. The above discussion has highlighted the importance of stimulating the scientific interests of all participants in co-operative projects, using two examples. It is also necessary to stress the importance of co-operation among countries throughout the world in the development of technologies which utilise as-yet unexploited regions in and beyond the globe – areas which are a common heritage of mankind.

In view of the seriousness of global environmental issues such as global warming and deforestation, we need to place greater emphasis on collaborative studies among countries.

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PART IV

PLENARY SESSION 2

INTERNATIONAL CO-OPERATION FOR DEVELOPING AND DIFFUSING CLEANER TECHNOLOGY

Chaired by Risaburo Nezu
Director for Science, Technology and Industry, OECD

Chapter 8

DEVELOPING AND DIFFUSING CLEANER TECHNOLOGY: GENERAL REVIEW AND ASSESSMENT

by

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Introduction

In the United Nations Conference on Environment and Development (UNCED) recommendations (Agenda 21), specific chapters were dedicated to science and technology co-operation:

> There is a need for favourable access to and transfer of environmentally sound technologies, in particular to developing countries, through supportive measures that promote technology co-operation and that should enable transfer of necessary technological know-how as well as building up of economic, technical and managerial capabilities for the efficient use and further development of transferred technology. Technology co-operation involves joint efforts by enterprises and governments, both suppliers of technology and its recipients. Therefore, such co-operation entails an iterative process involving government, the private sector, and research and development facilities to ensure the best possible results from transfer of technology. Successful long-term partnerships in technology co-operation necessarily require continuing systematic training and capacity building at all levels over an extended period of time. It is necessary to improve conditions and processes on information, access to and transfer of technology (including the state-of-the-art technology and related know-how), in particular to developing countries, as well as on capacity-building and co-operative arrangements and partnerships in the field of technology, in order to promote sustainable development. New and efficient technologies will be essential to increase the capabilities, in particular of developing countries, to achieve sustainable development, sustain the world's economy, protect the environment, and alleviate poverty and human suffering. Inherent in these activities is the need to address the improvement of technology currently used and it's replacement, when appropriate, with more accessible and more environmentally sound technology. (Chapter 34)

Trends in technology co-operation

Since that UNCED conference in 1992, numerous more or less successful initiatives have been launched to initiate and facilitate technology co-operation between developed and developing countries. There is evidence that the shift from pollution control to resource efficiency has gained

momentum. Many developed and developing countries and economies in transition have adopted cleaner production and eco-efficiency policies and programmes, which put emphasis on the introduction of integrated technological solutions in production processes. It has, however, been realised that the level and pace of technology transfer and technological transformation, required to accelerate progress towards cleaner, more resource efficient systems and processes of production in many developing countries and economies in transition, is fairly slow, especially related to the pace of economic development. In the last decade, several workshops and studies[1] have been launched to discuss general, or topic-related, trends in technology co-operation in order to obtain more insights into barriers and effective strategies and, thus, improve co-operation for actual transfer and diffusion. The following trends have been identified:

- Technology holds the key to addressing many environmental problems and achieving sustainable patterns of economic growth. In many cases, the appropriate technological solution already exists. However, the technology may not be in widespread use because of its price, the lack of information on the part of firms or other market failures. Technology diffusion is essential to realising sustainable development goals. There are many types of environmental technology diffusion programmes and services on offer. Providing information is at the core of all diffusion programmes and this is increasingly being done through electronic networks such as the Internet. Also prominent are demonstration programmes, which illustrate the technical feasibility and benefits of new environmental technologies, and benchmarking schemes, which help firms, compare their environmental performance to that of similar enterprises. Technical assistance programmes provide more hands-on advice in diagnosing environmental problems and finding the appropriate technological solutions. Governments are increasingly mounting "soft" diffusion activities which focus on workforce training and encouraging managerial and organisational changes within firms to improve their ability to assess and adapt environmental technologies. Lastly, financial assistance is often provided in differing degrees to facilitate industry adoption of new environmental approaches.

- Environmental regulations have been the most important public policy tool for stimulating industrial innovation in environmental technology. In the past, the need to comply with regulations forced industry to develop and adopt various pollution control technologies and equipment. A few decades of experience with environmental regulation have shown that the kind of regulatory measures adopted influence the type and extent of industry's innovative efforts. Designing regulatory measures that maximise efforts to generate suitable environmental technologies is of fundamental importance. In this context, recent experiences in OECD countries indicate that innovations in environmental technologies are best stimulated when various regulatory measures and economic (market) instruments are flexibly combined so as to take into account industry-specific and, in some cases, firm-specific contexts. Well-designed technology policies, including public/private research partnerships, can also help combine and direct various mechanisms to induce cost-effective cleaner production and product innovations.

- Inducing appropriate innovations in environmental technology, especially cleaner products and cleaner production processes, is a growing concern of technology policy in the OECD area. Until the last decade, technology and environmental policies had not been adequately integrated, partly because technology was not regarded as potentially able to solve environmental problems and partly because regulatory approaches were oriented not towards stimulating new technology development but towards "best available techniques". For this reason, technological innovations did not generally seek to improve the environment and contribute to sustainable development. This situation, however, has changed as a range of

techniques – largely end-of-pipe technologies such as desulphurisation equipment and catalytic converters – have contributed significantly to pollution abatement. Advances in energy conversion and energy efficiency technologies have also made positive contributions to improving the environment. Technology is increasingly regarded as the source of solutions to cleaner production, particularly as environmental technology has shifted from end-of-pipe solutions to cleaner processes and products. These developments have given rise to a growing industrial sub-sector, which produces environmental goods and services.

- Successful technology transfer involves more than the transfer of physical hardware. The skills to use the equipment are crucial to success. Without the education and training to enhance the capabilities for scientific inventions and technological innovation, for adaptation and absorption of technologies, sustaining sound business operations, implementing environmental and quality management systems, and maintaining the equipment, the hardware will almost certainly fail to fulfil its purpose. Technology transfer and capacity building to adapt, absorb and diffuse technologies and, finally, reach a higher level of capability for technological innovation are two sides of the same process.

- In identifying or developing technological solutions, it is essential to ensure that these solutions fit the conditions, needs and capacities of the potential users, and are consistent with community requirements for sustaining economic growth, lifestyles and the environment. Thus, suitable technological solutions are often the result of merging high-tech industrial knowledge transferred from abroad with low-tech indigenous knowledge existing in the user country.

- Technology transfer between developed and developing countries is not a one-way flow of resources. It works best when it builds upon sustained partnerships or co-operative arrangements in which all partners can realise their interests and share responsibilities and benefits over the entire technology transfer process.

- Technology transfer is primarily a business-to-business transaction. This pattern is being steadily reinforced as foreign direct investment (FDI) becomes increasingly larger than Official Development Assistance (ODA). A government's enactment of an economic and legal framework, with a practical system of environmental regulations, compliance mechanisms, and supporting economic and fiscal measures, is accordingly the greatest single facilitator for accelerating and enhancing the demand for, and transfer of, ESTs. Although the main impact of policies will most likely remain through environmental regulations and standards, there can be a gradual shift noted in a growing number of countries towards balancing regulatory regimes with the use of economic instruments and voluntary approaches to provide more flexibility in achieving economic results, while practising environmental responsibility in production and market operations.

- The biggest challenge for resource efficiency exists with small and medium-sized enterprises (SMEs). SMEs make up the bulk of business ventures around the world and their environmental implications and resource demands are equally large. In many countries, in particular developing countries, the bulk of untreated industrial waste and pollution originate with the SMEs. However, at the same time, SMEs, especially in developing countries, have particular difficulties in adopting ESTs, due to limitations in technological capacity and access to finance and information.

- Governments, enterprises, R&D institutions and intermediaries concerned with technology development, transfer and dissemination are increasingly working together to accelerate the

application of research results to commercial production. Different forms of technology co-operation are being created to combine the resources and capacities of the various partners in research, developments, commercialisation, adaptation, dissemination and further innovation. However, this co-operation is largely limited to developed countries. There is a strong need to extend them to include partners from developing countries.

Examples

Capacity building for managing technological change

Building local capacities is essential to transfer, diffuse and innovate technological solutions that respond best to a particular social, economic or environmental problem. Capacity building for technology management is an important element of technology co-operation between developed and developing countries. Activities undertaken by donors in the areas of environmental legislation and planning, education and training, awareness raising, institution building, environmental management, etc., have been directly or indirectly instrumental to the development of local demand for ESTs as well as the ability to identify technological needs and assess available options.

Technology needs assessment and environmental technology assessment

Technology needs assessment (TNA) can be a useful tool enabling the government or other constituencies of a particular country to identify a portfolio of technology transfer projects and capacity-building activities that need to be undertaken to facilitate, and possibly accelerate, the development, adoption and diffusion of ESTs in particular sectors of the national economy, and thereby fit that portfolio to the conditions, needs and capacities of the potential users, so that it is consistent with community requirements for sustaining economic growth, lifestyles and the environment.

Practical experiences gained by some countries and international agencies in carrying out TNAs yielded concrete results in different ways. They presented an opportunity to emphasise the demand-driven approach. Identified technology transfer and capacity-building projects were tailored to the actual needs of the local beneficiaries in the developing countries concerned, and helped co-ordinate follow-up activities at the national level. They also offer opportunities for the collaboration of donors in financing and implementing the identified projects. As many providers and recipients of ESTs are private enterprises, a determined and early effort is needed to harness their potential technology and financial capacities.

If undertaken on the basis of an integrated and participatory approach – with the governments as the formulators and enforcers of economic and legal policies, NGOs and the scientific community as environmental agencies which know the most about the resilience and carrying capacity of the Earth, and the private sector as the prime mover for technological development, transfer and diffusion – TNAs can also contribute to the essential need of policy integration by making both public and private decision makers more aware of the environmental consequences of their actions.

Despite these favourable opportunities of TNAs, application is limited. At international level, there has been an emerging interest in sharing experiences gained by a number of countries and international organisations in conducting and implementing TNAs and demand for facilitating TNAs. Therefore the UN-CSD has launched a National Cleaner Technology Strategies Initiative,[2] aiming at promoting research and development activities and transfer of cleaner technologies on the basis of

partnerships with domestic and foreign private companies, and at promoting the development and commercialisation of cleaner technologies and modernisation of national industries. First activities in Latin America and the Eastern European region have been initiated with demonstration projects in Colombia and Slovakia. The projects look promising, but it is too early to review and evaluate actual outcomes.

Cleaner production centres as facilitators in technology transfer and technological transformation

National cleaner production centres (NCPCs) were established as the result of country initiatives as well as, in a number of developing countries and economies in transition, with the support of donors or international organisations, including in the framework of multilateral and bilateral co-operation projects.[3] They have begun to play a major role in developing a "culture" for cleaner production in local communities and country-wide by co-ordinating cleaner production programmes, acting as an interface among industry, government, universities and non-governmental organisations (NGOs), and building the human capacities required to acquire and manage cleaner technologies. Key tasks of all cleaner production centres are: *i)* demonstration projects; *ii)* training; *iii)* policy advice; and *iv)* technical assistance.

The main incentive for local companies to engage in cleaner production efforts is the expectation of enhanced competitiveness and more cost-effectiveness. NCPCs need, therefore, to focus on the argument of economic benefits by providing detailed information about the cost-benefit ratio and the payback periods of successfully implemented cleaner production programmes. Demonstration projects which display "technology in action" are essential to enhance confidence of entrepreneurs that invest in ESTs that such investments not only render their operations environmentally more sustainable but make good business sense as well. Consultation and information exchange, including through the use of interactive electronic networks, among existing national cleaner production centres and with other parts of the local or national EST support structure is important (*e.g.* information systems and sources related to ESTs, technical advisory and consultation services, marketing support and legal advice services, and institutions of research and development).

According to OECD experiences gained in working on specific environmental issues in Central and Eastern Europe, cleaner production centres are very useful in co-ordinating and running cleaner production programmes, with the support of, among others, professional engineers' associations, technical institutes or industry associations. Regional/Sub-Regional Centres for Training and Technology Transfer being operated under the Basel Convention have become important vehicles for the promotion of the transfer of ESTs related to hazardous wastes. And intermediary independent evaluation of the UNIDO/UNEP programme and in-depth discussions at meetings of the NCPCs reveal similar opinions. However, at the same time, NCPCs regard their present facilitating role in technology transfer as limited, due to: *i)* the lack of in-depth sector-specific technology know-how, leading to problems during the identification of the most appropriate solutions and their technical design; and *ii)* the lack of know-how of suppliers of that technology, which means that they are not able to facilitate the actual commissioning of the technology. Strengthening their role requires more assistance, training and access to information.

Improving access to and dissemination of information on environmentally sound technologies

There is, in general, no lack of information on ESTs or of the systems and sources that provide such information. Over the past years, there has been a proliferation of databases, information systems and clearinghouse functions – public and private, national and international – dealing with particular

types of ESTs or providing technological information more generally. A survey of information systems and sources related to ESTs undertaken by the United Nations Environment Programme (UNEP) provides useful insights into the modes of operation of these systems and sources, their interaction with the relevant institutional infrastructures, and the services they provide. Problems that exist in information access and dissemination are related to: *i)* the ability of technology suppliers, users of ESTs and intermediaries to know about and to be able to access information systems and sources; and *ii)* the level of co-operation and compatibility among these information systems and sources. The UNEP survey emphasises the need for concrete measures to increase compatibility and co-operation among information systems and sources related to ESTs, including the usefulness of a consultative mechanism to improve communication between information providers and users. Very recently, during the Pollution Prevention Summit in Montreal (November 2000) an international, multilateral initiative was launched by UNEP and several bilateral donors to establish such a consultative mechanism which would take the form of a loosely knit network of institutions that provide and use information on ESTs. Its specific function will be to improve the dissemination of information on ESTs to industry and national and local authorities, and to enhance the abilities of users and decision makers to assess the social, economic and environmental performances of available technological options.

Information and communication technology (ICT) is at the forefront of technological advances in environmental protection (environmental monitoring, risk control, management systems, simulation and so forth). ITC is also a means to spread best practices. The use of ITC for environmental protection, exchange of experience, information access and technology transfer is becoming an important factor in efforts towards sustainable development.

Interactive electronic networks, such as the Internet, offer a wide range of new opportunities for communication and information dissemination among technology providers and potential users. On the other hand, it is sometimes noted that, to date, industry has not made sufficient advances in exploiting the opportunities provided by electronic communication and networking in their business operations.

Information technology is no longer restricted to industrialised countries, either in innovations or applications. In fact, rapidly industrialising countries, in particular in Asia and Latin America, are already competing successfully with industrialised countries in software development and data management techniques. However, a considerable number of developing countries still lack the technologies – "software" and "hardware" – to make adequate use of the rapid development of sophisticated modes of information and communication. The Conference on Information Society and Development, held in Midrand, South Africa, in May 1996, organised by the South African Government in co-operation with the G7 Members and the European Union (EU), underlined the tremendous potential of information technologies for meeting basic needs of developing countries. It also recognised that there is insufficient investment in developing information infrastructures in most developing countries, despite the fact that there is an extensive unmet demand for information and communication technologies and services.

Financing and partnership arrangements

Studies have indicated that the problem is not just a lack of financing *per se* for the transfer of ESTs, and that the issue is more on market development than existence of funds. According to this argument, if the market for ESTs is properly developed, particularly within developing countries, perhaps there will be no lack of finance available on reasonable terms. This view contends that, as of now, there is no firm market for cleaner technologies in many developing countries, hence finance is

not being attracted to such technologies. The first step, therefore, is to provide an appropriate context for private sector investment to take place.

A successful example of financial resources being made available by governments and demonstrably accelerating the transfer of ESTs is the Multilateral Ozone Fund under the Montreal Protocol. Since 1991, USD 0.5 billion has been invested in developing countries for the transfer of ozone-friendly technologies. The financial mechanism under the Montreal Protocol to Protect the Ozone Layer is the first international instrument to mobilise the resources required to change over to ozone-friendly technologies and successfully implement large-scale technology transfer. Each country which is a Party to the Montreal Protocol has listed and estimated in its Country Programme the resources required for the transfer of technologies. A preliminary estimate amounts to USD 3-7 billion. Forthcoming environmental funding programmes (such as the World Bank Carbon Fund) are seen as new opportunities.

At the same time, despite the advantages of cleaner technologies, accessibility to and mobilising of investment funds seems to be a major constraint in enabling them to be more widely used. Financial institutions and other sources of private sector funding follow a well-defined due-diligence process when evaluating loan and investment proposals, which consists of verifying the technical, financial and legal aspects of the project, evaluating the creditworthiness of the borrower, and assessing the various risks involved. Environmental risks still tend to be undervalued in this process and many environmental management costs are hidden in company overhead accounts. In many developing countries, bank loans are considered unattractive due to high interest rates and unfavourable terms on loans. Most companies require low-interest, long-term loans for environmental projects. Furthermore, the procedures for borrowing money from commercial banks are often complicated and costly. In many banks, the due-diligence process considers mainly the financial aspects of loan applications, without paying much heed to technical ones. However, some countries are gradually beginning to translate environmental considerations and sustainable development into financial markets. Although many financial institutions are familiar with environmental opportunities, environmental investments remain small.

To understand the reasons for this and to develop instruments to alleviate constraints, UNEP/DTIE is executing the project “Strategies and mechanisms for promoting cleaner production investments in developing countries”, financed under a trust fund from Norway.[4]

Public-private partnerships are being implemented to try to link the advantages of private sector companies – access to finance and technology, managerial efficiency, entrepreneurial experiences and engineering expertise, the capacity for producing technological innovations – with the social responsibility, environmental awareness raising, scientific research and job generation functions of local or national governments. In implementing public-private partnerships, a strategic interaction has been established, in some cases, among governmental agencies, private sector entities and institutions of science and technology.

Unfulfilled expectations and constraints

Although no concrete data are available, there is overall recognition that the level of technology and technology-related investments from public and private sources in developed countries to developing countries has, in general, not been realised as it was envisaged at UNCED. Increased private flows have led to investments in industry and technology in some developing countries and economies in transition. However, many developing countries have been left behind; thus slowing the process of technological change in these countries. Particular concern has been raised by developing

countries over the lack of commitment of developed countries "... to promote, facilitate, and finance, as appropriate, the access to and the transfer of environmentally sound technologies and corresponding know-how, in particular to developing countries, on favourable terms including on concessional and preferential terms, as mutually agreed, taking into account the need to protect intellectual property rights as well as the special needs of developing countries for the implementation of Agenda 21". It is for the same reason that representatives of developing countries have highlighted the importance of access to, and transfer of, ESTs that are in the public domain.

Many developing countries continue to lack the level of national scientific capacity including a critical mass of well-trained scientists, technicians and engineers, which is required to generate scientific inventions and produce technological innovation, and to adapt and absorb technologies. In this context, there is great need for developing and supporting intensive interaction between institutions of education and training and of research and development, on the one hand, and local industries, on the other.

More attention has to be given, including in technology co-operation and partnerships between developed and developing countries, to the promotion and use of environmentally sound indigenous technologies and related knowledge that exist in developing countries. Joint ventures or other forms of foreign direct investments in developing countries that combine high-tech industrial knowledge of developed countries' companies with low-tech indigenous knowledge of the host countries' enterprises could become effective mechanisms for stimulating the demand for ESTs and, thus, promoting their transfer to, and diffusion in, developing countries.

Challenges

More information is needed from both national and local governments and the private sector regarding the effectiveness of policies to facilitate and accelerate the transfer and diffusion of ESTs. Such information could provide greater insights into: *i)* the relationship between environmental concerns and the demand for technologies and technological innovations; *ii)* the effectiveness of company strategies to adapt to the requirements of technological change and support for production processes which are environmentally responsible and competitive; and *iii)* trends regarding the dynamics of national environmental technology markets and more accurate international data regarding technology flows to developing countries.

The promotion of cleaner production in developing countries, including through development co-operation and public-private partnerships, is an important issue. Work under way and practical experience gained on this issue should be shared with interested parties in order to improve the understanding with regard to the policies that must be in place and measures to be taken to successfully implement cleaner production efforts in developing countries. Opportunities for the transfer and diffusion of ESTs that are in the public domain should be addressed.

Handling the human resource and capacity building component of the technology package has become a key requirement. More sophisticated education and training of firm managers, engineers and other senior staff involved in scientific inventions, technological innovations and technology adaptation and absorption are needed. Strengthening the developing countries' ability to incorporate EnTA as a basic principle for decision making on technology transfer and diffusion is also important.

The predominant role of the private sector in the transfer and diffusion of ESTs and, more importantly, its leading function in the transition to cleaner production, has increased the private sector's responsibility to ensure that technology-related investments and industrial and business

operations are consistent with community requirements for sustainable lifestyles and environmental protection. Corporate responsibility must become an essential element of company policy, and the precautionary principle is practised to avoid the transfer and diffusion of technologies which could have negative impacts on human health or the environment.

The strategic interaction between private sector entities and institutions of science and technology needs to be strengthened and supported by local governments. SME demand for ESTs is growing in the process of adapting to cleaner, more efficient production processes. Small firms do, however, lack the resources to engage in R&D. R&D institutions need to orient their activities more towards the production of marketable R&D results. They have the manpower resources, technical equipment and experiences to produce technological innovations that would meet the needs of SMEs for ESTs.

This chapter is based on a review of key reports and proceedings of conferences on these issues in the last ten years, personal discussions during several of those conferences and a critical assessment of major international technological co-operation programmes (including multilateral, bilateral and intergovernmental programmes as well as programmes involving industrial firms) that contribute to the protection of the environment and the promotion of sustainable development. The author would therefore like to thank all the participants that contributed actively during those conferences.

NOTES

1. Relevant workshops and conferences in the last ten years at which the theme of this paper was (in)directly the subject of discussion include: Workshop on Development Assistance and Technology Co-operation for Cleaner Production in Developing Countries (Hanover, 1994); Workshop on Access to and Dissemination of Information on Environmentally Sound Technologies (Seoul, 1994); Roundtable on Technology Transfer, Co-operation and Capacity Building (Vienna, 1995); African Regional Workshop on Technology Needs Assessment in Support of the Transfer of ESTs and International Technology Co-operation (Dakar, 1996); Asia-Pacific Expert Group Meeting on Transfer of ESTs among SMEs (New Delhi, 1996); Facilitating International Technology Co-operation (Seoul, 1997); Technology Co-operation Workshop (London, 1997); Expert Meeting on the Role of Publicly Funded Research in the Transfer and Diffusion of Environmentally Sound Technologies (Kyongjyu, 1998); European Roundtable on Business and Sustainability (Brussels, 1998), Technology Foresight and Sustainable Development (Budapest, 1998). Annual meetings of the UNIDO/UNEP Network of National Cleaner Production Centres (Vienna, 1995; Nyanga, 1996; Bangkok, 1997; Prague, 1999; Bern, 2000; and Montreal, 2000), National and Regional Cleaner Production Roundtables, Conferences of the Greening of Industry Network and the Annual Sessions of the UN Commission of Sustainable Development.

2. National Cleaner Technology Strategies Initiative (NCTS). The general objective of the project is to encourage governments to develop and implement National Cleaner Technology Strategies. The initiative includes four regional meetings: Latin America and the Caribbean (Bogota, October 1999); Eastern Europe and the Former Soviet Union (Bratislava, June 2000); Asia and the Pacific (scheduled for winter 2001); and Africa (scheduled for fall 2001). This initiative is intended as a starting point for a process of development and testing of national cleaner technology strategies. It will address issues relating to economic growth and social conditions, as well as environmental protection.

3. UNIDO and UNEP launched its National Cleaner Production Centres (NCPC) Programme in 1994. Since then, 19 centres have been established in developing countries and transition economies (in parentheses the year in which they were established): in Africa, United Republic of Tanzania (1995), Zimbabwe (1995), Tunisia (1996), Morocco (1999), Ethiopia (2000), Kenya (2000), and Mozambique (2000); in Asia, China (1995), India (1995), and Vietnam (1998); in Europe, the Czech Republic (1994), the Slovak Republic (1995), and Hungary (1997); in Latin America, Brazil (1995), Mexico (1995), Costa Rica (1998), El Salvador (1998), Guatemala (1999), and Nicaragua (2000). In a new development, a sector-specific cleaner production centre was established in Russia in 1999, focusing on the oil and gas industry. Furthermore, projects have been undertaken in Uzbekistan (1995) and Croatia (1997) and a new project is starting in Macedonia, with the possibility of centres being established in some of these countries at a later date. Other centres have been established in the same regions by others – USAID, the World Environment Council, and the Swiss State Secretariat for Economic Affairs (SECO). In a recent trend, the countries themselves have established centres, such as the new centre in Chile.

4. As part of the project, UNEP/DTIE has studied the experience of eight developing countries and countries in transition and reviewed how selected financial institutions in the developed world address environmental issues, particularly related to CP. The countries studied include Guatemala, India, Lithuania, Mexico, Nicaragua, Tanzania, Vietnam and Zimbabwe.

Chapter 9

DEVELOPING AND DIFFUSING CLEANER TECHNOLOGY: EXPERIENCES AND PRACTICAL ISSUES

by

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Introduction

The 1972 UN Conference on Human Environment, held in Stockholm, and the Earth Summit, held in Rio 20 years later, can at best be described as two small dots on the spectacularly rising curve of global economic development – although this growth has occurred mainly in the OECD countries. In the last 28 years, the world's GDP has more than doubled, increasing from USD 15 000 billion to USD 35 000 billion. In the next two decades, GDP growth in the OECD countries is expected to double yet again and it is likely to increase even more dramatically in the developing countries, albeit from a lower starting base. However, this radical economic progress is taking place without sufficient regard to the principles of the precautionary approach or the adoption of preventive measures to help protect man's common global heritage. Stockholm and Rio served as a blue-print for cleaner production and technologies – but their development and dispersal has since been buried under the debris of economic windfall.

Rapid economic development is not the only culprit for the environmental damage that has been incurred. Serious and fatal imbalances in wealth creation and gross disparities in the distribution of production and services have sent issues such as environment and poverty spiralling down the political agenda. Environmental stewardship lags behind economic and social development. Moreover, the process of globalisation – aided and catalysed by information technology – is further aggravating the imbalance. The generation of wealth through goods and services will continue unabated into the next century and is even projected to accelerate. Such activity, under a "business as usual" scenario, will result in a widening of the gap between the developing and the industrialised countries.

Over-consumption in the industrialised countries and increasing poverty in the developing countries are causing further environmental deterioration. Only the development and diffusion of cleaner technologies or environmentally sound technologies (ESTs) can prevent irreparable and irreversible damage to the environment. Cleaner technologies embody eco-efficiency, pollution prevention and waste minimisation strategies.

Agenda 21 and the Commission on Sustainable Development continue to emphasise the importance of promoting, facilitating and financing the development and diffusion of cleaner

technologies through co-operation and capacity building – specifically in developing countries. The successful application of this strategy would call for a change in attitudes, behaviour and policies. A tripartite venture between government, industry and civil society operating through the appropriate use of information technology, is needed to translate these strategies into a sustainable future.

The concept and the drivers of clean technologies

Two centuries ago, the wheels of textile machines and the engines powered by steam heralded the Industrial Revolution. The euphoria of mass production and increased productivity overshadowed the tremendous damage caused to the environment and to the health of our populations. When the impending dangers became only too obvious 150 years later, the immediate reaction was to "take curative measures rather than taking a preventive approach". Control and dilution of pollutants became the key curative measures. Over last 25 years, however, the preventive approach – the basic tenet of cleaner technology, also known as environmentally sound technology (EST) – has gained ground, primarily due to the principles proclaimed at Stockholm and Rio. Developing countries, however, have yet to benefit from cleaner and environmentally sound technologies.

Before investigating the reasons for such an inactive scenario, it is useful to look closely at the concept and the various facets of the development and diffusion of cleaner technologies.

What are the drivers for the development and diffusion of such technologies? Reductions in environmental impact is the result of – but not necessarily the driver for – deploying cleaner technologies. In contrast, reductions in production costs due to optimised inputs is a key driver for encouraging enterprises to develop cleaner technologies. New market opportunities and the associated competitive edge also serve as an impetus to develop and diffuse cleaner technologies. Furthermore, an improved work environment and ethical image in the eyes of shareholders can also serve as engines to seek EST pathways. Finally, multilateral environmental agreements (*i.e.* the Montreal Protocol to phase out ozone depleting substances) may force enterprises to look for environmentally sound and alternative technologies.

Pathways to cleaner technologies

Pathways to cleaner technologies can take one or two forms. The firm may seek to modify its production process in order to make it cleaner or it may set out to innovate (*i.e.* produce the product in a totally different way). Good housekeeping, efficiency improvements in existing processes and services, optimisation of material inputs, redesigning of processes and equipment to enable reduced inputs of material and energy, and substitution of materials for improved efficiency through modifications, are all pathways towards cleaner technologies. Co-generation processes in power plants are an example of such pathways.

Innovation is often the result of fundamental changes in the way products or services are produced. Examples of innovative pathway include simulating bio-processes such as enzymatic reactions to produce semi-synthetic antibiotics, and not-in-kind technologies like no-clean technologies to produce PCBs (printed circuit boards) that avoid the use of solvents.

Barriers to cleaner technologies

If cleaner technology offers economic advantages, then why do businesses not immediately move onto one of these pathways? There is always resistance to change. This applies to clients as well as

enterprises. Resistance becomes stronger where government policies encourage continuity in existing processes. Subsidised electricity to energy-intensive production may turn out to be an inhibiting factor, discouraging enterprises from implementing process change. The current life-style of indiscriminate consumption also acts as a barrier. The absence of legally binding agreements, the lack of environmental stewardship, the dearth of finances to innovate and the paucity of political will to adequately invest in research and development are all formidable blocks to the development of cleaner technologies. In some ways, the scarcity of cleaner technology development acts as a major barrier to the diffusion of such technologies.

The OECD countries are best able to afford the major investments in R&D required for the development of environmentally sound technologies. In reality, however, the opposite holds. For example, in the United States, investment in R&D over the last 40 years has remained more or less constant at 2.5 % of GDP, and the scenario in other developed countries follows a similar trend. Flows of Official Development Assistance (ODA) and of Foreign Direct Investment (FDI) can be taken as indicators of the transfer of technologies to developing countries. In last 20 years, ODA has decreased to a mere 0.2% of OECD countries' GDP, far below the promised 0.7%. However, FDI flows are increasing. Mainly in terms of portfolio investments, flows of technology-transfer-related investment have remained stable at about USD 100 billion. As no major technology evolution is taking place in the field of cleaner production – again due to inadequate R&D investment in the OECD countries – it is doubtful whether much FDI is really used for the diffusion of cleaner technologies.

UNEP experiences

UNEP periodically assesses progress and helps to identify remaining gaps in the deployment of cleaner technologies. UNEP's International Cleaner Production Declaration fosters cleaner technologies through voluntary commitment and has received an enthusiastic response from governments.

For the last 10 years UNEP has been working with industry and governments in setting priorities and strategies for the promotion and deployment of cleaner technologies. Raising awareness for these technologies is the mission of UNEP's Division of Technology, Industry and Economics, located in Paris. Awareness leads to increased consumer demand for ESTs. Training and exchange of information, followed by demonstration projects, strengthens the capacity of industry and governments. Technical case studies in ESTs are as important as policy case studies. A recent UNEP project involved promoting investment in cleaner production in developing countries to demonstrate the catalytic effect of diffusing cleaner technologies by working with policy makers and financial institutions.

Progress to date has been significant:

- 20 National Cleaner Production centres have set up to raise the awareness at all levels and undertake the demonstration projects.

- Surveys and the compilation of information systems have been conducted, as well as policies to identify the principal sources of information relating to cleaner technologies.

- Over 1 000 case studies and a number of guides, manuals, training modules, Web site, CD-ROM (ICPIC, OASIS, MAESTRO) have been developed.

- The EnTA (Environmental Technology Assessment) tool has been developed.

- The Global Reporting Initiative (GRI), Financial Institute Initiatives (FII) and Global Compact initiatives are parallel programmes that complement and supplement the cleaner production programme.

The impact of these activities has reached nearly 300 institutions, including the World Bank, IFC and ADB, which acknowledge and work towards the adoption of cleaner production values. A number of industries, such as the fertiliser industry, have shown sector-wide commitment to the principles of cleaner production. India and China have initiated cleaner production as policy for sustainable development.

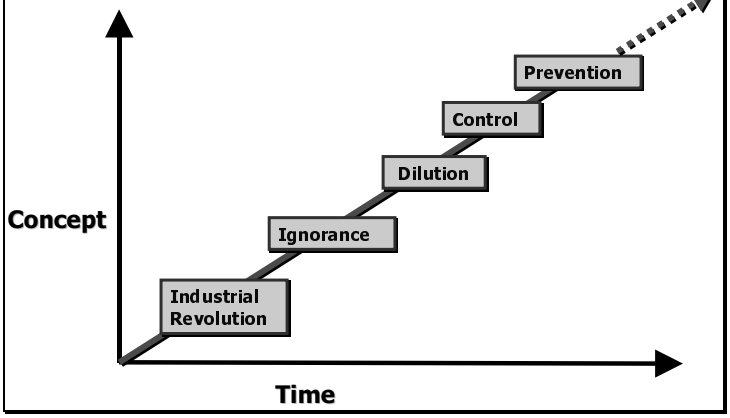
However, the work falls far short of what is needed. Development, diffusion and deployment of cleaner production has to become an integral component of policy making in the OECD and developing countries. There is a need for benchmarking of R&D for cleaner technologies. Successes as well as failures need to be catalogued for analysis. Finally, environmental accounting and life-cycle analysis (LCA) need to be developed as tools for capacity building, as drivers for cleaner technologies and as levers for policy makers. The Cleaner Production Declaration initiated by UNEP is a step in this direction.

Policy recommendations

In light of the above, the following recommendations can be highlighted:

- Promote the voluntary approach, along with legally binding agreements for cleaner technologies.
- Promote policies to enhance R&D for cleaner technologies.
- Build capacity to assess and select.
- Encourage not-in-kind technologies, bio-mimicry and nature-mimicry.
- Build networks of R&D institutes to share information through collaboration and accelerate the development of ESTs.
- Reinvigorate traditional and local technology and knowledge.
- Redirect finances along cleaner technology pathways.

Cleaner Technology: Context



Drivers of Cleaner Technologies

- Reduction of environmental impact
- Reduction in costs: Improved competitiveness
- New market opportunities
- Improvement in work environment and ethics
- Ease of compliance with MEAs

Cleaner Technologies Pathways

- Modified processes
- New technological processes

Pathways: Cleaner Technologies

MODIFICATIONS :

Good housekeeping

- **Efficiency improvement**

Process change

- **Material optimisation**
- **Process control, modification and redesign**
- **Equipment modification and substitution**

Pathways: Cleaner Technologies

INNOVATIONS

Environmentally sound technology through R&D

- **Mimic nature and simulate nature**
- **Simulate bio-proecess**

Not-in-kind technologies

- **No-clean**
- **Fundamental change in product design**



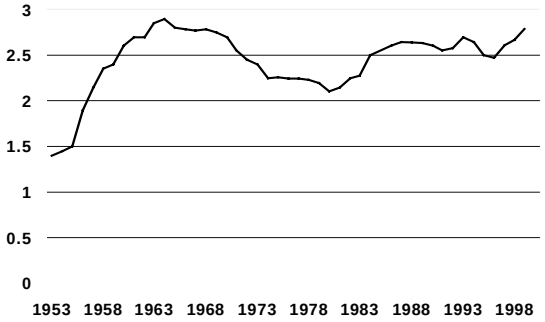
UNEP

Barriers to Cleaner Technologies

- **Prevailing attitudes**
  - End-of-pipe preference
  - Resistance to change
  - Lifestyle of indiscriminate consumption
  - "Go West"
- **Lack of information**
- **Absence of legally binding agreement**
- **Lack of resources in developing countries**
- **Lack of political will to invest in R&D**

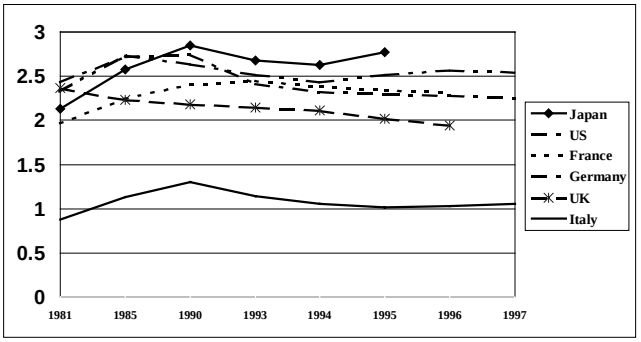
R&D Expenditures in the United States

(as a % of GDP)

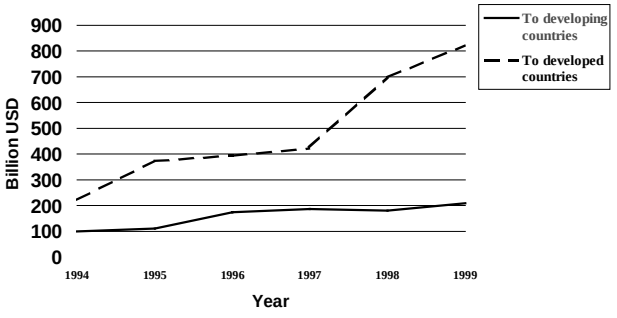


R&D expenditures in industrialised countries

(as a % of GDP)



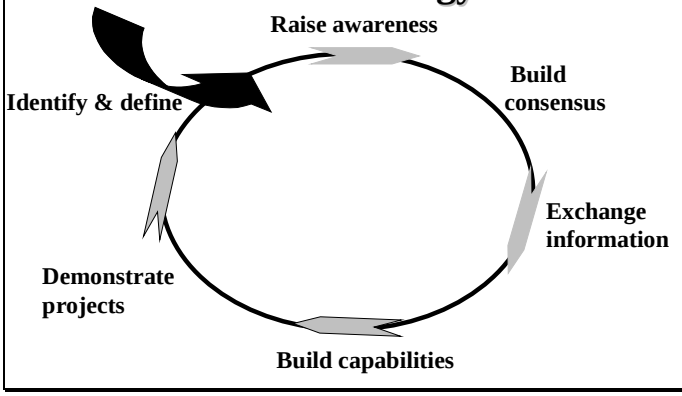
Trends in FDI flow



UNEP and Cleaner Technology STRATEGIES

- Raise awareness to create demand
- Catalyse policy setting to enable and empower
- Build capacity to assess and select
- Redirect the investment to implement

UNEP Approach to Cleaner Technology



UNEP CP ACTIVITIES :Impact

- Over 300 institutions incorporate the concept
- Countries such as India and China have initiated CP in their policy framework
- Over 100 educational institutions offer CP-related programmes/research
- Major international and regional financial institutions (WB, IFC, ADB) have acknowledged the value of CP
- Industries like CFA have shown sector-wise commitment

Chapter 10

THE TRANSFER OF ENVIRONMENTALLY SOUND TECHNOLOGIES (ESTs) FOR CLIMATE CHANGE FROM DEVELOPED TO DEVELOPING COUNTRIES: A SUMMARY OF SIX COUNTRY STUDIES

by

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Introduction

The purpose of the FCCC study was to understand the impact of industrialised countries' publicly funded research and development on environmentally sound technologies (ESTs) to developing countries. In order to analyse that impact, it is also necessary to understand the whole picture within the developed countries. The total amount of R&D public funds is often difficult to identify in developed countries:

- For political reasons (legislative groups may not recognise the environment as a priority area for R&D).
- Or, due to classification areas that might not readily be seen as part of ESTs (some developed countries will finance ESTs but as part of the defence or military budget).
- Or, because business and political leaders are in conflict as to whether there is any climate change problem in the first place (in many developed countries the issue is still debated as if there is either no problem or it exists only in the imagination of extremists).
- Or, finally, the ultimate question is whether the government should even invest or sanction R&D in the area of ESTs.

These issues are all represented in one way or the other in the case studies. However, the FCCC study was not able to summarily conclude or categorise a particular pattern in developing countries. Instead, the study had to focus on specific EST cases in order to understand the mechanisms and modalities in which developed countries took R&D and turned it into commercial technologies and then supported their dissemination in developing countries. It is at this level that the study was able to identify similarities and differences. While it is left it to the reader to discover the subtle, and not so subtle, differences between countries, our task is to try to summarise across the six cases.

In the end, and due to other constraints, the study focused on three countries: the United States, Germany and Italy. The FCCC study felt that the United States, as will become obvious, tends to apply (perhaps a better phrase in English is "push") its own view or public policy about publicly funded R&D on other nations. While this perspective differs according to the different political parties in the United States, the result is the same in that the international community hears fairly consistent and repeated policy pronouncements from the Americans.

Recognising the significance of the US views toward publicly funded R&D for ESTs, the FCCC study analysts spent considerable time and effort on this case. The study also found that while there is an American "surface" or public policy as articulated by the US State Department, there is also a "deep" or underlying reality in the United States towards publicly funded ESTs. To get at that the more subtle, and even more potentially useful, modality for replication in the United States and other industrial countries, the study and the concluding papers focused on successful advanced technological EST development sponsored by the US Government and matched by industry funding.

The basic strategy for addressing climate change in the United States is to provide public R&D funds for programmes that address and commercialise energy generation, efficiency, planning, transmission and distribution, including regulatory, policy and planning of environmental programmes. The issue in the international arena appears to be an inherent conflict between the public political policies exposed by the US Government and the reality of actual social and economic programmes within the borders of the United States.

Examples can be seen in the US Department of Energy national laboratories such as NREL (the National Renewable Energy Laboratory in Idaho) and LBNL (the Lawrence Berkeley National Laboratory in California). While the latter case focuses on energy-efficiency issues and demand-side management, the former concentrates on renewable energy generation technologies and systems. What is remarkable about both laboratories is the extensive amount of international work they perform.

NREL, for example, has programmes to support developing countries in planning energy systems and optimising economic policies for energy generation. Some renewable generation technologies such as photovoltaic are commercialised through US companies with joint venture partners throughout the world. In this way, the laboratory is able to fund further research as well as provide demonstration and beta test technologies for other nations.

In other words, in spite of the US State Department pronouncements, the reality within the US Government is often different. The United States is not shackled by what other countries see as laws that prohibit the transfer of its ESTs funded by government funds. Quite the contrary. The US Government has programmes which support and advocate the transfer of the technologies in terms of licensing, joint ventures and even outright sale. In most cases, the technologies are further supported by US Government technical staff and advisors.

The issue for the US research community tends to focus on obtaining R&D funds no matter what their source, since public funding of R&D for ESTs has in real dollar terms remained static or declined over the last decade. International currencies converted into dollars works as well as any other form of payment. The issue is finding commercial partners who can provide the continued research and commercialise the technologies themselves.

This is one of prime reasons why licensing and technology transfer offices have been established and flourish at all US university campuses and research institutions and why the system continues to function within US Departments such as Energy, Environmental Protection and even Defense. Furthermore, there are few restraints on global partners and collaborations with international firms.

The only restrictions occur with certain "sensitive countries", and these barriers are rapidly diminishing.

Theoretical perspective

Consider the transfer of EST technologies from an economic theoretical perspective. That is, in order to fully appreciate and understand public policy for R&D of ESTs, it is important to first describe the underlying economic orientation of developed countries.

Then, if there is new knowledge transferred to a firm, , there must be intellectual property, know-how, skills, process and other measurable means of value to the firm. Research literature and consultancy firms abound in this area to the point that a wide variety of approaches are advocated for transferring technologies (defined broadly) from one entity to another. Elsewhere, this literature is reviewed and critiqued (Clark, 1994 and 1995c). There is a need to update government policies and programmes which appear to dictate to what extent technology transfer is actively promoted.

If the US model for technology transfer is to be used as a "learning model" or the "ideal type" for most developed countries, then it must be considered in its appropriate economic context. First, it is true that the United States has had extensive (more than 30 years) experience in the transfer of university technologies. This experience, however, is in large part due to the long historical US experience in "patents". The US Patent Trade Office (USPTO) in Washington, DC, was established as part of the American Constitution in 1781 and has operated since the end of the 18th century.

Individual researchers (in universities, private companies or as private inventors) have always used the USPTO system. In the early 1980s, however, the USPTO changed from a nominal "free service" to a "fee service" which led to the demands that universities help researches and inventors file patents. In addition, during the later part of the 1980s, other national laws were passed which need to be taken into consideration in the development of a national model of technology transfer.

The most significant legislation came in 1986 with the Steven-Wyler Amendment which provided incentives for scientific researchers to retain control of their inventions. The national government directed most of its attention and resources towards nationally funded research, and primarily research conducted under or as part of its vast network of research labs (over 700, with annual budgets exceeding USD 70 billion). The Amendment specifically provided that large national agencies and departments use their resources to help fund the transfer of these inventions and discoveries to the private sector. For example, large departments for technology transfer were institutionalised in national research laboratories in the early 1990s.

What should be noted in this legislative process, however, was that the national government recognised the need to move away from defining technology transfer only as "patents" and "licences". Instead, the legislation specifically authorised the US national departments and agencies to enter into agreements with anyone (private companies, universities or others) for joint research. One such mechanism was the CRADA (Co-operative Research and Development Agreement), which was considered to be the cornerstone of the US technology transfer model. The impact on the universities was direct and immediate. Most US universities and researchers became partners with the national labs and receive large national financial research support.

Patents themselves, or their licensing, were not the "US model for technology transfer" in the university or research community. The US patenting system is only a small part of the technology transfer at most US universities. One clear example exists with the University of California System, cited by the authors. With over USD 30 million in royalties reported in 1993, over two-thirds of the

funds came from one patent, a gene-slicing process shared with Stanford University (Wooten, 1993). In short, the number of patents is not correlated to the royalty revenues.

Another problem exists in the conclusion made by Gering and Kobek that patents themselves represent technology transfer. In fact, patents and technology transfer are only one small part of a larger whole – technology commercialisation (Clark *et al.*, 1992). Most major US universities today are more concerned with technology commercialisation (Preston, 1993), than with the mere transfer of a patent. The problem is that the universities realise that technology transfer must involve business ventures such as joint ventures, partnerships, and may even mean creating companies to commercialise what their scientists have discovered.

MIT has taken the lead in this process, with a number of innovative "business" oriented programmes to commercialise its technologies. New companies have been formed, with MIT as an equity partner. While MIT is a private university, it receives large amounts of national public grants and is considered the leading US university in technology commercialisation.

The University of California System, likewise, is actively pursuing the same commercialisation avenues. While some internal professorial posturing took place, the establishment of a University of California (UC) Private Foundation finally occurred in the late 1990s after considerable debate.

Theories of economic development

It is important to briefly review basic philosophical patterns in order to better understand the present and future policy directions of the United States. Chart 1 sketches a continuum of economic theories from which US economic policy has been historically derived.

Chart 1. **Historical continuum of economic theories**

Smith	Keynes	Marx
(Conservative) <----------	(Liberal) ----------	----------> (Radical)

Perhaps the best place to start is Adam Smith (1723-90) and his *Wealth of Nation*s (published in 1775) from the late 18th century. Smith's ideas about separating government and business had a profound impact on the leaders of the American Revolution. Published at the time of the Revolution, Smith's concepts on economics were well known to many American revolutionaries. More importantly, the Scottish philosopher articulated ideas that were "revolutionary" and complementary to the call for freedom heard throughout the British colonies: individualism, free trade, laissez-faire, and limited role of government.

Smith built his theories on the assumption that individuals were motivated and driven by the desire to create wealth for themselves and that the wealth of a nation was built on this collective desire. There was little room in this theory for government – colonial or otherwise. The government simply built the roads and operated the canals. Given that limited role of government, an "invisible hand" would help those who could not survive in society. In short, the government would not need to help or assist the economic development of society. It had to operate on its own, depending on what today is termed "market supply and demand".

Neo-classical economists today argue that even the involvement of government in infrastructure sectors (such as roads, telephones, waste and energy) should be "privatised" in order to foster

competition. The private sector is viewed as being better at operating such sectors than the public or government. Hence the basic conflict over climate change: if the energy sector, for example, were left to supply energy to communities, would the power be both clean and environmentally friendly? Most public leaders doubt it. Even industry knows that it must be more competitive over price than concerned with climate change.

Chart 2. **21st century economic theories**

Smith	**Schumpeter**	**Marx**
Neo-classical	Entrepreneurship	Control
Capitalism	Social capitalism	Communism

The question is where will the developing economies focus their efforts? How do developing countries acquire the new advanced ESTs when the developed countries tend to see the need to make a profit for the company at the expense of the public (*e.g.* climate) good. Even more significantly, will the developing economies take what works in each theory and apply it to their own needs and citizens? The developing countries have an even more critical series of issues and policies to consider.

Social capitalism: a particular perspective

A pattern appears to be emerging. Aside from the ideologies of the neo-classical economists and the now subdued rhetoric of the control economies, business realities have set in. A middle ground, exemplified by Chinese (PRC) policies but firmly ensconced in the US economic system, is symbolised by "social capitalism". This theoretical economic perspective is a reformation of some very traditional and historical tenants in the philosophy of science (Li and Clark, 2000a).

The most current example of economic programmes and policies can be seen in China (although the United States has implemented such programmes for more than 50 years). The new Five Year Plan in China specifically calls for "social capitalism", while the Americans have practised it but never used the term in any governmental polices or programmes.

Basically, the idea is that there is a core concept that binds citizens and governments; people have a social contract with their governments (Reinert, 1997). It is only through that contract that governments are allowed to rule, provide services and promote the common good (Chomsky, 1998). What is social capitalism? In part, it is the support of social concerns within a society: education, health, infrastructure like roads, water, waste systems. However, it is also a societal concern with the environment and those systems that pollute it such as vehicles and energy sectors.

Some scholars would take exception to the characterisation of government financial support as bringing a positive contribution or benefit to society (Chomsky, 1997 and 1998), because they would see the government support of military and defence research as part of governmental "welfarism" for the wealthy. Such programmes have been a characteristic of US economic policy since before World War II. Even with the end of the Cold War, these programmes have been a significant part of US economic growth (Clark 1995a and 1995b).

However, there is another side to US Government financial support to the military and defence establishment. For good or bad, such financial support has also been the consistent and strongest

support for R&D in ESTs. Without the national government financial support in the military and defence arena, energy and environmental R&D in the United States would be almost non-existent.

What "social capitalism" is not concerns the oft-cited notion prevalent in Scandinavian countries until the mid-1990s whereby the government does everything for its citizens and rarely if ever attempts to look upon social issues in a business-like manner. This has changed dramatically in Scandinavia, with more attention being paid to partnership with the private sector and with some degree of privatisation of public sector monopolies (Clark and Jensen, 2000).

When US economic policies are examined in the early 1990s, prior to the "New Economy" but nonetheless as the prelude to it, there is clear evidence that bipartisan national economic policies and programmes were examples of social capitalism at work (Clark, 1993, 1994, 1995a and 1995b). Programmes such as "dual use" established under the Bush Administration in the early 1990s and later carried through by the Clinton Administration – but this time as the Advanced Technological Program (ATP) through public-private partnerships – were enormously effective in stimulating the US economy that was deep in recession at the time.

These programmes, and dozens more under technology transfer as well as many others with a focus on energy and environmental issues, propelled the United States into the technological leadership of many fields. What is often forgotten by US foreign policy makers is that these programmes can be replicated elsewhere; and more importantly, successfully partnered with US foreign policy interests – to abate the degradation of the world climate.

The role of governments

In all the case studies, financing was a key and fundamental issue. Three issues arise with ESTs for climate change:

- The need for legal and administrative mechanisms that exist in developed nations (although not in consistent or standard ways) and are difficult for developing nations.

- In-country capacity building (as broadbased education and training) which is not a normal private sector activity with the sales and operations of new technologies.

- Financing of the commercialisation process itself when it is considered to be different from R&D and more in line with what the private sector might term "beta tests" or demonstrations.

The key is the transfer of the technologies – not just from the research organisation to the private sector but more importantly into the areas, regions, communities and countries where they are needed.

When the cases are examined in terms of specific technologies, a pattern arises (which is not unknown to industry but clearly a surprise to governments): new technologies do not just appear in the marketplace. Indeed, new technologies (designs, processes, etc.) must be financially profitable to the private sector.

Therefore, new technologies must be either subsidised or supported until such time that the number of sales will make the price both competitive and profitable. For example, the introduction of wind turbines from Germany and Denmark was supported by their respective governments for many years before industry could begin to make a profit. As a result, Denmark is the market leader and

Germany ranks second. Developed countries need, therefore, to take an active role in this "commercialisation" process. Finance may be through direct funding, but can also be effected through multilateral organisations and banks.

Policy recommendations

Publicly funded R&D programmes for ESTs could play a useful role for climate change technologies in modalities such as:

- Increasing accessibility to these programmes.
- If possible, joint R&D programmes.
- If really serious, then the US Government could exercise its licensing right and make such technologies available to developing countries.
- The need to remove barriers such as the Bayh-Dole Act.

What became obvious in the case studies is that public financing of ESTs now exists in the R&D phases for all industrialised countries. The actual funding mechanism might be labelled differently but the net result is the same: governments fund research and development of new technologies that address climate change. The extreme example might be Denmark with its wind turbines, but Germany, the United States and the United Kingdom all do the same in various ways. Each has a concern for a social issue (climate change) but seeks to address it with business models that produce profits.

In the United States such funding is acceptable by politicians of both parties. For example, as long as the word "security" is used in the programme scheme, bipartisan acceptance is almost assured. Hence "environmental security" is now a popular concept in which to fund climate change research. US public funding of EST R&D work needs to be embedded in concepts such as defence, national security and protectionism of some kind.

Or, consider the notion in the United States of "government welfarism" popularised by the Republican Congress in the mid-1990s. Few politicians turned down government projects in their districts, but more importantly, they created new terms for traditional economic concepts. Profits for government programmes, for example, became "cost recovery" and government funding became "leveraged" resources. The list goes on.

The public funding of EST in industrialised countries is a matter of particular concern. Here, especially for international exploitation of the technologies, the developed countries take a variety of tactics. The most common, as seen in the case studies, is government support of exports (through national banks or development programmes) and of multinational institutions.

The United States, again, for example, strongly supports the commercialisation of clean coal technologies through these and other programmes.

In almost all cases in the developing countries, the emphasis is on finding "in-country" partners. The role of NGOs appears to have increased over the last decade, with NGOs often becoming the "brokers" or facilitators of commercial partnerships through conferences, meetings and "field visits", often sponsored by developed country agencies. The modality that appears to work best, therefore, is partnerships between developed and developing country commercial entities.

Environmentally sound technologies are critical in addressing the issue of climate change. Typically, government or public sector funding are the primary and consistent source of support for research, development, demonstration and commercialisation of ESTs. Developed countries finance some ESTs (normally restricted to R&D).

Private sector firms rarely finance R&D and almost never the commercialisation of ESTs. Hence, there is a need for governments and multilateral organisations to finance ESTs in the R&D stage as well as during the demonstration or commercialisation phases. This is especially true for ESTs in the developing countries. Five policy recommendations should be pursued:

- Provide a multilateral fund for the commercialisation of ESTs in the demonstration and even prototype stages.

- Provide an Intellectual Property Trust for new EST technologies.

- Actively seek emerging companies to commercialise ESTs through partnerships with "IP owner" countries.

- Create international partnerships in line with the three-way model used in Europe and the United States: IP supported by a government and controlled by a firm; cash from a multinational organisation; and technical support, training and education from public-private financing.

- Provide a global business model whereby governments as well as firms obtain a return on their investments in terms of equity, shares and profits.

In the end, if social issues (such as climate change) can prevail as part of all governments' contracts with their citizens then the policies and programmes directed at making a profit from ESTs is to everyone's benefit. Social capitalism can be a global guiding principal for the economic benefit of all countries. When linked to climate change, private firms can make profits or recover their costs. So also can governments, who should share in those profits and see economic benefits from EST investments returned to their citizens.

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Chapter 11

BARRIERS TO INTERNATIONAL TECHNOLOGY CO-OPERATION: ASPECTS RELATED TO ENERGY TECHNOLOGY

by

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Introduction

Technological progress plays a crucial role in economic development (Zheng *et al.*, 1995). A large number of studies have shown that energy demand in developing countries is expected to increase rapidly with economic development and population growth (Nakicenovic *et al.*, 2000). The environmental problems associated with energy production and use raise a huge challenge for future possibilities for energy development. However, analysis shows that future energy development could be strongly affected by advances in energy technology and that environmental problems could be abated if clean technologies were developed for energy production and use (Jiang *et al.*, 2000). International collaboration on advanced technology development and diffusion can significantly affect technological progress in both developed and developing countries. This chapter reviews energy technology co-operation in China and describes the possible future of energy demand and the role of technologies. Important obstacles to technology co-operation are identified, based on Chinese experiences with energy technology. The analysis presents the reasons for these obstacles from an institutional and non-institutional point of view. In addition, policy recommendations are made for the removal of obstacles to international co-operation.

Energy technology co-operation in China

Technological progress is dominated by the industrialised countries because higher levels of support are made available for technology R&D in these countries. The gap between technology developments in the industrialised and the developing countries remains enormous, and improving technology development in the industrialising countries with a view to attaining shared global prosperity is a difficult and long-term process. Over the last several decades, China's economic development has emphasised technological progress and Chinese experience in learning and importing technologies from abroad could serve as a useful example for examining ways to implement technology co-operation between developed and developing countries.

Over the last 40 years, China has made tremendous progress in technology transfer, in terms of scale, technology source, pattern and channel of introduction, participants and administration. Before 1979, technology transfer in China could be described as follows:

- Technology imports were controlled by central government.
- The size and focus of technology imports strictly followed the economic development requirements outlined by the Chinese Government as part of its long-term plan.
- The adaptation of imported technologies to local conditions was centrally managed by the responsible ministries.
- Technology imports were mainly traded in the form of complete sets of technologies.

After 1979, a number of changes took place in terms of technology imports for the purpose of economic reform:

- Local government began to participate in the management of technology imports.
- Participants in technology import programmes began to shift away from government towards the firm.
- New laws were passed to replace the old-style management through government regulation.

Total contract payments for technology imports totalled USD 14.8 billion for the period 1950-78; rising to USD 30.2 billion for 1979-90. Major areas of technology imports include energy, the metallurgical industry, the chemicals industry, and the mechanical and electrical industry. Table 1 shows the distribution of projects.

Table 1. **Distribution of imported technology**

	1950-90	**1950-78**	**1979-90**
Total	100.0	100.0	100.0
Agriculture	0.1		0.1
Industry	96.3	98.1	95.4
Of which:			
Energy	25.6	22.3	27.3
Petroleum	3.0	2.2	3.4
Coal	3.6	8.4	1.2
Electricity	19.0	11.6	22.7
Metallurgical industry,	19.6	23.7	17.5
Chemical industry	24.9	36.0	19.3
Textile	3.0	2.5	3.3
Light industry	2.7	2.0	3.0
Mechanical and electrical industry	18.5	10.6	22.6
Building material	1.9	0.8	2.5
Forest industry	0.1	0.2	
Transport, telecommunication	2.3	0.7	3.1
Other	1.3	1.2	1.4

Source: Chen, 1997.

Taking the energy industry as an example, imported technologies from industrialised countries made a significant contribution to domestic technological progress. China imported large capacity power generators from Japan, the United States and other countries. The adaptation of these imported technologies to allowed China to modernise the existing power system; and unit energy use for power generation dropped from 459gce/kWh in 1980 to 376 in 1998.

Chen (1997) summarises the major problems that China has experienced in the diffusion of imported technologies from other countries. From the domestic viewpoint, these include:

- The project did not reach the planned pathway, which is expected to have step-by-step changes in terms of the method and structure of the technology import. The main emphasis was on hardware and imports as a complete set, rather than on software and adaptation to local conditions. This makes it difficult to diffuse technologies in China.

- Emphasis focused on increasing production capacity in certain heavy industry sectors; there was no obvious improvement to avoid importing the same technology several times, and efforts to adapt the technologies to local conditions were not well promoted.

- There was an imbalance among industrial sectors in terms of importing technologies and achieving technological progress. Some sectors made outstanding progress, while others were slow to change. Although this situation has since improved, the experience should be noted for future possible technology import programmes.

A review of progress in technology imports in China over the last several decades gives rise to the following findings:

- The success of technology imports is very closely related to the opportunities provided to the host partner to participate in the learning process and adapt the technologies to match local conditions.

- Official Development Assistance (ODA) from developed nations tends to limit the selection of technologies, leading to whole-set technology imports and low efficiency in technological progress.

- China has invited large amounts of foreign investment. However, the share of investment from companies with advanced technology tended to be small. This situation is generally changing with the improved macroeconomic environment of recent years.

- The effectiveness of foreign direct investment is lower than that of technology imported through international trade. Since the share of foreign direct investment is likely to increase in the future, greater attention should be paid to this problem.

- Building up know-how about imported technologies requires increased domestic investment. Such knowledge is key to the successful diffusion of imported technologies.

- Enhancing the effectiveness of technology imports in developing countries is dependent on coherent and well-designed government regulations.

Demand for clean energy technologies

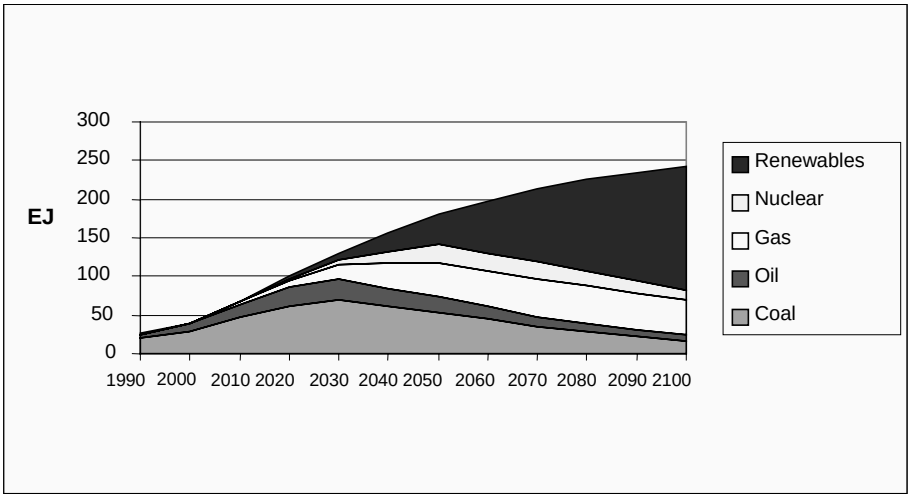
In its efforts to accelerate the pace of its economic development, China is beginning to open its markets to the world. Environment problems have inevitably occurred owing to the rapid growth of economy. Water pollution, air pollution, soil distortion, etc., are becoming increasingly serious and the Chinese Government has recognised that sustainable development is essential. Technological progress is believed to play a very important role in China's extremely rapid economic development. To respond to both domestic environmental problems and global issues such as climate change, the developing countries need to build their own capacity to develop and utilise advanced technologies through technology transfer – this is a win-win game.

The IPCC recently conducted a comprehensive study on emission scenarios in order to explore the effects of climate change over the coming century. We participated in this study, using the Asian-Pacific Integrated Model (AIM).

In all AIM non-intervention scenarios (Jiang *et al*., 2000a), the technology gap between the developed and the developing world persists through to 2100. However, since climate change is a global issue, actions to respond to greenhouse gas mitigation require the participation of all actors. Against such a background, environmentally friendly technologies should be widely diffused throughout the world. The developed countries will continue to play a key role in research and development for these technologies. A time delay is assumed for developing countries to widely use these technologies. Technology transfer from developed to developing countries is considered to be an important factor for mitigation scenarios in AIM. In some scenarios, developing countries will tend to catch up with the technology leaders once they achieve economic prosperity. R&D could also be promoted by increased demand for the technologies based on resource availability; for example, the Integrated Gasification Combined Cycle (IGCC) could be developed and used in East Asia. Due to the recognition of the possible impacts of climate change, technology transfer and diffusion will take place at a faster pace than is the case today.

Figure 1 presents an AIM scenario based on the assumption of high economic growth and technological progress (Jiang *et al.*, 1999). Renewable energy technologies are assumed to be well developed. This scenario illustrates the importance of technological progress and technology transfer from developed to developing countries.

Figure 1. **Primary energy in China, C_B scenario**



A group of intervention scenarios were developed for comparison with non-intervention scenarios (Jiang *et al.*, 2000b). The intervention scenarios identified a number of "robust policy options" for climate stabilisation. Each modelling team proposed several robust options based on their simulations. The following list summarises some of the findings relating to technological progress:

- Efficiency improvements for both energy-use and energy-supply technologies, social efficiency improvements, renewable energy incentives and the introduction of energy price incentives such as a carbon tax can be regarded as robust policies.
- In all the non-intervention scenarios, robust options include natural gas and the promotion of biomass resources.
- Innovative "transitional" strategies which use natural gas as a "bridge" to a carbon-free hydrogen economy (including CO_2 sequestration) are at a premium in a possible future world with low emissions.
- In all mitigation scenarios, gas combined-cycle technology bridges the transition to more advanced fossil and zero-carbon technologies.
- The future electricity sector is not dominated by any single technology; however, hydrogen fuel cells are the most robust technology among all the stabilisation scenarios.
- Cost-effective pathways for climatic stabilisation require the introduction of natural gas and biomass energy in the first half of the 21st century, followed by either plutonium recycling or carbon sequestration in the latter half of the century.

The analysis shows that the development of clean technologies will strongly influence the future global development path, especially in relation to technological progress in developing countries. Studies also show technology demand in China in response to climate change (Table 2).

Table 2. **Technology list for CO_2 emission reduction in China: results from AIM/China**

Sector	Technologies
Steel	Large-scale equipment (coke oven, blast furnace, basic oxygen furnace ,etc.), coke dry quenching equipment, continuous casting, TRT, continuous rolling, coke oven gas equipment, OH gas and BOF gas recovery, DC-electric arc furnace
Chemicals	Large-scale equipment for chemical production, waste heat recovery system, ion membrane technology, improvements to existing technologies
Papermaking	Co-generation system, facilities for residue heat utilisation, black liquor recovery system, continuous distillation system
Textiles	Co-generation system, shuttleless loom, high-speed printing and dyeing
Non-ferrous metal	Reverberator furnace, waste heat recovery system, QSL for lead and zinc production
Building materials	Dry process rotary kiln with pre-calciner, electric power generator with residue heat, Colburn process, Hoffman kiln, Tunnel kiln
Machinery	High-speed cutting, electric-hydraulic hammer, heat preservation furnace
Residential	Gas cooking, centralised space heating system, energy-saving electric appliances, high-efficiency lighting
Service	Centralised space heating system, centralised cooling/heating system, co-generation system, energy-saving electric appliances, high-efficiency lighting
Transport	Diesel truck, low energy use car, electric car, natural gas car, electric railway locomotives
General technologies	High-efficiency boiler, FCB technology, high-efficiency electric motor, speed adjustable motor, centrifugal electric fan, energy-saving lighting

Source: AIM/China.

Key technologies for the reduction of CO_2 emissions in China from the long-term viewpoint are listed below:

- Modern renewable energy production (solar energy, etc.).
- Advanced nuclear power generation.
- Fuel cell.
- IGCC.
- Advanced gas turbine.
- Unconventional natural gas and crude oil production technologies.
- Syn-fuel production technology.

Barriers to technology co-operation

Based on our studies and on a reading of the relevant literature (Chen, 1997; Metz *et al.*, 2000), obstacles to technology transfer could be summarised as follows:

Financial support

- Lack of financial institutions or systems to ensure initial investments for the utilisation and extended use of transferred technologies.
- General lack of support for an open and transparent international banking and trading system.
- Risk aversion and business practices that favour large projects in financial institutions including multilateral developing banks.
- Inadequate resources for project implementation.

Technology

- Insufficient R&D due to lack of investments in R&D and inadequate science and educational infrastructure.
- Lack of confidence in unproven technologies.
- Scarcity of data, information, knowledge and awareness, especially on “emerging” technologies.

Mechanism and policies

- Imperfect market hinders the transfer of sustainable technologies.
- Lack of full-cost pricing which internalises environmental and social costs.
- Poor macroeconomic conditions, including, *inter alia*, underdeveloped financial sector, high import duties, high or uncertain inflation or interest rates, uncertainty in tax and tariff policies, investment risk.
- Low private sector involvement due to lack of access to capital, in particular inadequate financial strength of smaller firms.
- Low, often subsidised conventional energy prices, resulting in negative incentives to adopt energy-saving measures and renewable energy technologies.
- Lack of a market for advanced technologies due to lack of confidence in economic, commercial or technical viability, lack of manufacturers, insufficient consumer awareness and acceptance of technologies by the general public.
- Lack of supporting legal institutions and frameworks, including codes and standards for the evaluation and implementation of advanced and clean technologies.
- High transaction costs.

Information

- Weak information media relating to suitable technologies (information media includes technology information networks and public media).
- Lack of understanding of the role of developed and developing countries and international institutions in the failures and successes of past technology co-operation efforts.
- Reluctance to identify and make available technologies that are in the public domain.
- Insufficient science, engineering and technical knowledge available to private industry.
- Inadequate vision about and understanding of local needs and demands.
- Lack of understanding of clean technologies among the general public.

Capacity

- Insufficient human and institutional capabilities.
- Insufficient access to relevant and credible information on potential partners to allow for the timely formation of effective relationships which could enhance the spread of advanced technologies.

- Lack of sufficient assessment for technology transfer to support policy making.

- Insufficient capacity for public education on clean technologies.

- Inability to assess, select, import, develop and adapt appropriate technologies.

In addition to the obstacles listed above, key aspects requiring policy attention include:

- Due of the weakness of the economy, enterprises in developing countries play a passive role in technology transfer projects. In terms of technology choice and transaction process, developing country participants do not enjoy a strong bargaining position.

- Because of the different interests in technology transfer (greater emphasis on environmental friendliness in the developed countries, greater emphasis on income in the developing countries), there is a risk that environmentally unsound technologies may be introduced into developing countries.

- The objectives for technology transfer are different. Participants in developed countries hope to extend their market in developing countries, while participants in developing countries expect to obtain technology to improve the performance of their economies. The differences in objectives could introduce discrepancies in technology transfers.

- Energy-intensive industries and other harmful environment or human production may be moved to the developing countries due to environmental pressures in developed countries.

- Technologies are increasingly advanced and complex, making it difficult for developing countries to adapt them to local conditions. The adaptation of technologies to regional specificities requires simultaneous improvements to many of their characteristics. However, such improvements call for long-term processes, beginning with education.

Policy recommendations

Technology co-operation could contribute to technology progress in both developed and developing countries. A well-designed framework or mechanism could improve existing technology transfer. The following suggestions are made, based on the above discussion:

- Improve the global environment to encourage the transfer for environmentally sound technologies in support of global sustainable development.

- Information networks for the industry and public sectors need to be ameliorated: existing information centres should be improved; a global clean technology network for industry partners should be established; government involvement in the network needs to be encouraged.

- An international institution should be established to control harmful technology transfer. Developing countries should be protected from harmful technologies.

- Multi-channels for clean technology transfer should be developed.

- The existing co-operation framework should be improved, such as technology transfer through ODA and adaptation to local conditions through direct investment.

- Policy assessment for technology transfer should be emphasised.

As climate change becomes crucial to global development, co-operation for technology transfer should enable full consideration to be given to this issue. One of the themes put forward at the United Nations Conference on Environment and Development in 1992 was to transfer environmentally sound technologies (ESTs) to developing countries. The key to achieving global progress on the Framework Convention on Climate Change, implementing the *Agenda 21*, mitigating global environmental problems and hence promoting sustainable development is whether, when and how developed countries will fulfil their commitment to provide ODA up to 0.7% of their GNP to developing countries and transfer ESTs on preferential terms. This statement is the starting point of the following views:

- Developing countries are the potential markets for the world's advanced technologies including ESTs. The mainstream, priority and long-term choice for developing countries will be pollution-prevention technologies and technologies for improving output and efficiency rather than pollution-control technologies. These preferred technologies could facilitate the technological innovation process, enhance energy use efficiency, increase output and replace outdated technologies.

- The key of technology transfer is to set up funding and a mechanism which will serve to stimulate suppliers to provide more and better technologies and increase demand for ESTs.

- From the developing countries' point of view, requirements for technology transfer include: preferential terms; non-commercial; suitable for the economic level and special situation of developing countries; close the technological gap with developed countries; facilitate industrial progress; low cost, easily accessible; easy duplication and propagation; easy to upgrade; easy to digest, assimilate and develop; both hardware and software should be transferred to avoid dependence on the providers, thus the effect and benefit of the transfer will be enhanced.

There is huge potential for improving energy efficiency in the developing countries. From a long-term viewpoint, based on China's experience, clean technology and next-generation technology utilisation in developing countries is a crucial issue for global development. The potential market for the propagation and transfer of high-efficiency energy conservation and sound environmental technologies is enormous. The introduction of advanced technologies will be crucial to increasing efficiency and protecting the domestic and global environment.

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Chapter 12

BARRIERS AND DRIVERS TO INTERNATIONAL SUSTAINABILITY SCIENCE AND TECHNOLOGY CO-OPERATION FOR ECO-EFFICIENCY AND CLEANER PRODUCTION

by

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Introduction

Economic development is essential to improving the welfare of the Earth's population, especially that of the poor. As economic activity, and particularly urban growth and industrial production, have environmental impacts, governments need to redouble their efforts to re-orient the forces underlying economic growth towards sustainable development. Carrying out this change of course in an economically efficient manner calls for a paradigm shift in environmental policy to place greater emphasis on pollution prevention and eco-efficiency rather than on traditional end-of-pipe pollution management and control measures.

Nowhere are the shifting patterns of economic development towards less-intensive use of energy, natural resources and materials, and the reduction of pollution and waste, more challenging than in the rapidly industrialising economies, particularly in Asia.

To avoid these countries having to re-invent the wheel and allow them to "leapfrog" to eco-efficient processes, products and services, international science and technology (S&T) and R&D co-operation towards sustainable development [hereinafter referred to as international "sustainability" S&T co-operation (ISSTC)] is becoming a necessity.

Focusing on Asia, this chapter briefly highlights why environmental ISSTC is important and what may be the key barriers and drivers. It concludes with some suggestion for future facilitation.

Why does ISSTC matter?

Towards the end of 2000, Europe welcomed back salmon in the upper reaches of the Rhine, a major waterway which was diagnosed as dead 30 years ago. Meanwhile in Asia, more than 800 million people still do not have access to safe water and more than 2 billion lack rudimentary sanitation services. The proliferation of slums, alarming levels of traffic congestion, uncontrolled industrial growth, unprecedented degradation of air quality, encroachment on natural systems – all these factors are at the root of acute deprivation, high rates of water-borne diseases, impaired health

for many, unacceptably low standards of living for millions, as well as diminishing the capacity of the region to prosper. Against this backdrop, international trade continues to expand, leading to new links between trade, investment and the environment that signal growing globalisation of environmental issues ranging from greenhouse gas emissions to the greening of the global supply chain. For the citizens of the developed countries, who have the luxury of a clean environment, this means that personal environmental welfare is becoming less and less contingent on local environmental problems and increasingly dependent on the capacity to address environmental challenges in far-flung areas of the world.

A first argument in favour of ISSTC is that it is the increasingly rapidly industrialising developing countries, especially those in Asia, that have the greatest need for the advanced and economically effective environmental solutions that are coming out of the S&T laboratories of the developed countries. Whatever the topic, there are vast amounts of existing S&T knowledge – often gathering dust on the shelves of the developed countries' research centres – that could be transferred to Asia and immediately benefit the environment. Environmental R&D projects that focus on local environmental issues in developed countries may have diminishing global environmental returns.

A second argument is that researchers in developed countries cannot even dream of solving far-afield environmental problems from their laboratories. Clearly, the future S&T challenge for attaining global environmental sustainability will have to address developing countries' problems and will call for researchers in developed and developing countries to join forces to share experiences, ideas and projects in mutually reinforcing and beneficial ways. Intriguingly, increased ISSTC may be in the immediate research interest of the developed countries: as the rapidly industrialising developing countries in Asia face unparalleled environmental pressures and enjoy growing economic power, they will necessarily attract the world's most advanced and innovative solutions for eco-efficiency and environmental sustainability.

Does Asia present a real opportunity for ISSTC?

Just as Western Europe began its environmental renaissance some 30 years ago when Holland realised that it could no longer treat Rhine water because of its high pollution, it is bare economic necessity that will drive Asian environmental renewal. Three major trends lead me to believe that ISSTC opportunities in Asia are becoming real.

First, the cost of environmental degradation in Asia can no longer be ignored. The spread of ramshackle shanty towns, snarled traffic, poor air quality, the open dumping of garbage, the mishandling of toxic and hazardous waste, and increased flooding is costing Asia dearly. The economic impacts of pollution in Asian cities, in terms of loss of human productivity and health costs alone, have been estimated by the Asian Development Bank as ranging from between 1% and 5% of national GDP. Given the interdependence of the Asian urban-industrial development complex, it is possible that the overall foregone loss of capacity for economic growth owing to current Asian environmental *laissez-faire* is a two-digit percentage point. Clearly, losses of 10% or 15% of GDP cannot be neglected. Sensible national economic development boards need to tackle environmental costs and show improvements and ISSTC may be the only way to move forwards sufficiently swiftly.

The second trend may have to do with the nature of the development cycle. At the initial stage of development, the Asian economies – like Europe 30 years ago – focused on pollution- and energy-intensive manufacturing and primary resource industries. With rising wealth and a growing educated middle class, many first and second tier Asian countries are now entering downstream, more value-added assembling and tertiary services including S&T and R&D. These activities are not only less

dramatically polluting, they often need cleaner environmental conditions to run efficiently and can thus contribute to the creation of effective environmental solutions. Governmental and public pressure for better environmental quality is therefore growing in the rapidly industrialising developing countries in Asia. This is creating a virtuous circle, reminiscent of the situation in Europe or the United States in the last 30 years, where greater wealth strengthens local S&T, R&D and engineering capability and where enhanced public participation helps to generate more willingness and capacity to deal effectively with environment problems.

The third trend is the consequence of the future growth prospects that are beginning to be seen in the economic development blueprints of many Asian countries. In spite of its outstanding achievements in the last 30 years, Asia is still in the early stage of industrialisation. The rapid multiplication of industrial parks across Asia signals a momentous further expansion of industrial investment necessary to feed the large, young and growing urban populations of the region. Most, if not all, of the industrial stock that will be in place in Asia 15 years from now, does not yet exist. In combination with the expected increases in population, the consequence will be a very large increase in the consumption of natural resources, especially energy, water and land that the region and the world may have difficulty in yielding. Out of a necessity to sustain economic growth, the industrial and urban development of Asia will soon have no choice but to change course towards S&T-driven improved efficiency of resource use and reduced waste dissipation. The target will be a quantum leap in eco-efficiency in order to reduce, within perhaps one generation, the intensity of consumption of basic natural resources to levels unprecedented today even in the most developed countries.

In which areas will ISSTC develop?

Given the growing Asian environmental problems and the pervasiveness of environmental issues, the potential for ISSTC is unlimited.

Among the ultimate solutions needed to solve Asian environmental difficulties are hard technology, engineering solutions, infrastructure and equipment needed by municipalities and companies to produce and create wealth efficiently with minimal wastage and environmental impact. Environmental engineering will also be an important avenue. These fields are classical and promising areas for S&T co-operation that meets the core interest and competence of R&D communities in developed countries.

As reliable information and data on the state of the environment in the developing countries are fragmented and incomplete, more ISSTC on global, regional and local environmental stresses, pressures and responses will also be needed. This will necessitate the monitoring, processing and interpretation of a multitude of environmental indicators and data about environmental media (essentially water, land and air ecosystems) and environmental health in a variety of urban, rural, industrial, ecological, economic and social sectors.

It is clear, however, that technology alone will not solve Asian environmental difficulties. Due to the intricate economic, social and health interdependence of environmental matters, system integration involving enabling policies, institutional and financial frameworks and advanced management practices is necessary. This will bring a widening of ISSTC opportunity to cover non-technology areas such as science-based integrated policy development, institutional engineering, financial engineering and environmental management tools without which environmental progress cannot really start in Asia. These are areas where developed countries have accumulated substantial expertise which is readily available for transfer to developing Asia.

What are the barriers to ISSTC?

The obstacles to ISSTC are multiple and appear in many guises. For simplicity, they can be grouped under four headings.

Weak environmental policy frameworks of developing countries

The developing countries have less sophisticated environmental policy frameworks. They tend to rely on "technology prescribing" command and control policy copied from the West that hampers the unfolding of the S&T innovative capacity of developers. Lax enforcement regimes distort the environmental playing field and deprive economic operators of the pressure needed to focus the attention of decision makers on the development of innovative solutions. The developing countries also tend to use utility subsidies, keeping the price of natural resources such as water, forest, coastal resources and minerals low, and the economic rents from extraction high. This sends a biased cost signal to users of natural resources, accelerating depletion and degradation and providing a disincentive to look for more efficient S&T uses and processes. The lack of incentive schemes for environmental stewardship beyond environmental compliance and the absence of market-based instruments to help maximise economic rewards to environmental innovators is another hurdle.

Fragmented environmental policy and weak enforcement also contribute to a poor understanding of the accelerating dynamics of environmental regulatory trends towards global interdependence and the internalisation of environmental costs. The absence of a publicly communicated national environmental strategy that emphasises environmental improvement as a source of productivity gains also hampers eco-efficient S&T development.

Limited S&T absorption capacity of developing countries

S&T absorption capacity is related to the availability of technology-transfer capabilities, which are often lacking in developing countries. Weak S&T organisational and networking capacity and constrained human and finance resources contribute to the lack of an "R&D culture". Investment decision makers in many developing countries tend to rely too much on governmental drive for environmental action. They lack proactive management capacity to mobilise finance and encourage innovative development in response to market needs.

Lack of S&T facilitation mechanisms in developing countries

S&T interest needs to be actively encouraged in order to create and maintain a R&D culture across a national economy. For environmental S&T, this means the availability of governmental support for R&D financing and market mechanism facilitation.

On the financial side, S&T developers often face limited access to bank loans not least because of the perceived unattractive risks and project cash flow of R&D projects. Weak banking systems in developing countries exacerbate the situation while the limited availability of dedicated governmental S&T funding programmes, typical of developing countries, further compounds the problem. Official Development Aid (ODA) – an important source of funds for less developed countries – could, in principle, help to mitigate the situation as sustainable development is traditionally a major field for ODA action. In practice, however, ODA is biased towards poverty alleviation, which explains why

few development aid projects really contribute to S&T efforts in developing countries (with the exception of micro solutions targeting the very poor).

On the market side, weak environmental enforcement deprives economic operators of the regulatory "push" to advance S&T solutions, while the failure to perceive environmental eco-efficiency as a win-win opportunity leads to a lack of market "pull".

TRIMs rules such as import limitations or local content specifications, may also impact negatively on supply and demand for environmental S&T innovation. Such rules deprive economic operators of a desirable exposure to the internationally available state-of-the-art techniques and practices that are so important for stimulating innovation.

Limited ISSTC interest of the developed countries

Barriers to ISSTC also exist from a developed country perspective. S&T programmes in developed countries, and especially those addressing eco-efficiency, are often viewed in terms of strategic national interest rather than as a vehicle for ODA or international economic co-operation. Their main purpose is often to build the competitive edge of industrial sectors to stand up to international competition. Although many universities run projects (including environmental projects) involving partners from developing countries, these projects tend to be small, end-of-pipe oriented, bilateral in nature and self-serving from the sponsoring developed country perspective. There is little effort in many developed countries to look for mutually beneficial environmental S&T topics with developing countries that could genuinely transfer R&D capacity building competence, especially in the win-win areas of eco-efficiency and pollution prevention. Exceptions may be ISSTC efforts undertaken in the frame of Multilateral Environmental Agreements (MEA) such as the Basle Convention, the Montreal Protocol or the CDM mechanism under the Kyoto Protocol. The interest of developed countries to see the MEA implemented could help them to muster the political will needed to pay more serious attention to the S&T transfer clauses frequently included in MEAs.

In general, however, governmental agencies dealing with S&T programmes in developed countries have a poor understanding of the real S&T interests, needs and capacity of developing countries. Working in ministries with limited opportunities for international economic co-operation dialogue especially towards developing countries, many S&T programme developers fail to see ISSTC with developing countries as a source of mutually beneficial opportunities in terms of demand for innovation and market-opening processes.

On the global or regional scale, there are few ISSTC funding programmes and forums in which to discuss and promote them. The European Union (EU), through successive EC-sponsored S&T European (and international) framework programmes such as "Brite EuRam", "Eureka" or "Inco-Dev", is a notable exception. These S&T programmes stem in part from the EC "cohesion encouraging" mandate towards the EU and share, *inter alia*, the objective of reducing S&T differentials among the countries or regions of the EU. The "Greening of the Industry Network" (GIN) is another interesting global initiative. It encourages the international networking of peer environmental management researchers to share and review projects addressing environmental sustainability themes. However, there is little effort to encourage multinational ISSTC projects. In fact, in spite of the multitude of scientific and technology congresses and conferences taking place around the globe on sustainability issues, there is precious little structured overall capacity for matching environmental S&T interest between researchers for multi-country, multilaterally financed R&D projects benefiting both developing and developed countries.

The Bangkok-based Asia Europe Enviromental Technology Center (AEETC) was created in 1998 by the first Asia Europe ASEM meeting, to help fill part of this gap in the limited context of the ASEM framework for a few selective environmental themes (such as mega-cities). Since its inception, however, little action has been undertaken by this centre due to a lack of real financial R&D commitment from the participating countries.

What can be done to foster ISSTC?

Suggestions fall into three categories.

Fostering an enabling framework in developing countries

Under this heading, a first type of effort would be to build greater awareness and interest in the developing countries for science-based environmental policy development. Environmental policy decisions in developed countries are increasingly integrative and rely on broad science-based surveys of environmental pressures, states and responses and research of the possible impacts of alternative policy options. These efforts rely heavily on S&T infrastructures and services and the evaluation of large quantities of environmental data collected from arrays of indicators and monitoring networks. By comparison, environmental policies in developing countries are often simply adapted from developed countries' regulations. Conversion is frequently based on a local political rationale rather than on science-based interpretation of hard data. Given the growing pervasiveness of environmental problems, encouraging science-based environmental policy-making processes could help to foster an S&T culture and the building of research capacity in a multitude of related fields.

A second line of action relates to environmental policies themselves. Choice-enabling policies favouring performance standards over technology prescriptive conformance regulations are probably desirable. Devolution of environmental technology choice (preventive or mitigating) to individual economic operators along the (ecologically sound) principle of subsidiarity should also help. Furthermore, the enactment and enforcement of policies based on market-based measures and economic instruments such as taxes, levies and the removal of subsidies can also be supportive. These help internalise the externalities and capture the environmental and social costs of inaction and therefore encourage innovative development. Finally, as people tend to be mobilised more effectively by the carrot than by the stick, policies providing economic incentives towards excellence beyond regulatory compliance should equally help.

A third group of initiative relates to the macroeconomy and the encouragement of financial reforms towards competitive and open national markets and the fair flow of international capital that are conducive to attracting foreign direct investment.

Building S&T absorption capacity in developing countries

In progressing from a developing to a developed state, the S&T capacity of a country moves through incremental steps of technology transfer and absorption capacity. At the lower level, a country essentially gathers operative competence to maintain technology. It then moves to an acquisitive stage in which it seeks to upgrade, search, procure and negotiate technology transfer. The next step is a supportive technology access capacity in terms of project management, HRD, defining market needs and arranging funding. Finally, the highest level is the innovative capability to adapt and duplicate imported technology, build prototypes and test new products.

All these steps are accompanied by ever-increasing human, organisational and networking capacities that strengthen S&T and related R&D capacity. In a mature developed country, S&T increasingly flows through private networks of information and assessment services, researchers, management consultants, financial firms, lawyers, accountants and technical specialist groups. Local government, consumer groups, industry associations and NGOs ensure that S&T meets local needs and demand.

In this perspective, it is important that governments of developing countries foster local support networks such as professional associations, consumer organisations and public interest groups. They should also build information, financial, legal and business support services that enable technology benchmarking and project financing. Improving information diffusion systems and linking them to international or regional networks is also desirable.

Developing facilitating mechanisms for multilateral ISSTC

To boost the facilitation of ISSTC to an higher level calls for the establishment of multilateral or regional initiatives and ISSTC funds that can encourage multi-country and multidisciplinary teams of researchers to work together on sustainability R&D projects to their mutual benefit. The objectives of such ISSTC funds could be to provide catalytic seed funding to promising S&T ideas, to lower transaction cost for multi-country R&D projects and to facilitate downstream access to traditional finance sources for creditworthy application of S&T results.

An ISSTC fund could be created by pooling resources from various countries. Alternatively, countries could agreed to combine resources only for the management of an ISSTC fund and engage themselves to finance from their national S&T budgets up to an agreed limit, own-country efforts in multilateral joint R&D projects identified and selected through the operation of such a fund.

The management of an ISSTC fund would ideally comprise appointed specialists and administrators delegated by participating countries with allegiance to the mandate and objectives of the fund beyond national interest. Selection of the projects to be supported could be achieved through periodic calls for proposals in order to ensure adequate demand drive and comparability of proposals. Only the best projects would be selected and supported based on clear, transparent and published eligibility and evaluation criteria. Selection procedures could involve neutral external evaluators of specialists coming from top S&T and R&D centres in participating countries.

The list of selected projects and the reporting of results (with due regard to intellectual property rights) would be published and widely disseminated for peer review and information dissemination across all the countries participating in the fund.

To be eligible, proposals should come from multilateral partnerships involving professionals and/or organisations from a number of countries contributing to the fund. To ensure wide application of results, project proposers would preferably be alliances of S&T academics together with private sector solution developers and users that have a vested interest in the external commercialisation of R&D results.

Although the main focus of the fund would be to support ISSTC R&D projects, support should be extended to facilitating actions beyond R&D projects, such as seminars, conferences, training courses, diagnostic surveys, studies and matchmaking activities. These could help to brainstorm desirable new technology themes for ISSTC, debate fund performance, refine fund objectives based on evolving

needs and forge new international alliances of interested parties that could submit proposals for subsequent R&D co-operation projects.

To attract wide interest among potential applicants, the fund would finally have to be actively marketed, with easy-to-fill-out application forms widely disseminated across participating countries through the Internet, advanced multimedia communication technologies, and the congresses and conferences that traditionally attract interested parties. The largest of these events could be used to reward regional ISSTC participants that were particularly effective in developing projects with clear benefits for the global environment.

How can the OECD facilitate ISSTC?

In conclusion, it may be worth highlighting that a good ISSTC is, without doubt, a win-win strategy with mutual economic and environmental benefits for all participating countries and actors. Given the lukewarm interest shown by many developed countries to engage in ISSTC, the OECD may want to survey and analyse the history of national sustainability S&T programme expenditure patterns in developed and developing countries, and their economic benefits and environmental impacts.

Although the interpretation of data may be difficult, the OECD may succeed in identifying telling trends and be able to estimate the costs and benefits of national sustainability S&T programmes, and especially the components which involve international partnership. On the basis of the findings, the OECD could then suggest and disseminate to both developed and developing countries guidelines on desirable national sustainability S&T programme expenditure levels, expected economic costs and benefits and perhaps even desirable national sustainability S&T expenditure levels, preferably dedicated to ISSTC.

PART V

PLENARY SESSION 3

ROLE OF FINANCIAL INSTITUTIONS AND GOVERNMENT

Chaired by Herwig Schlögl
Deputy Secretary-General of the OECD

Chapter 13

THE WORLD BANK'S ROLE IN SCIENCE AND TECHNOLOGY

by

Lauritz B. Holm-Nielsen
The World Bank

Introduction

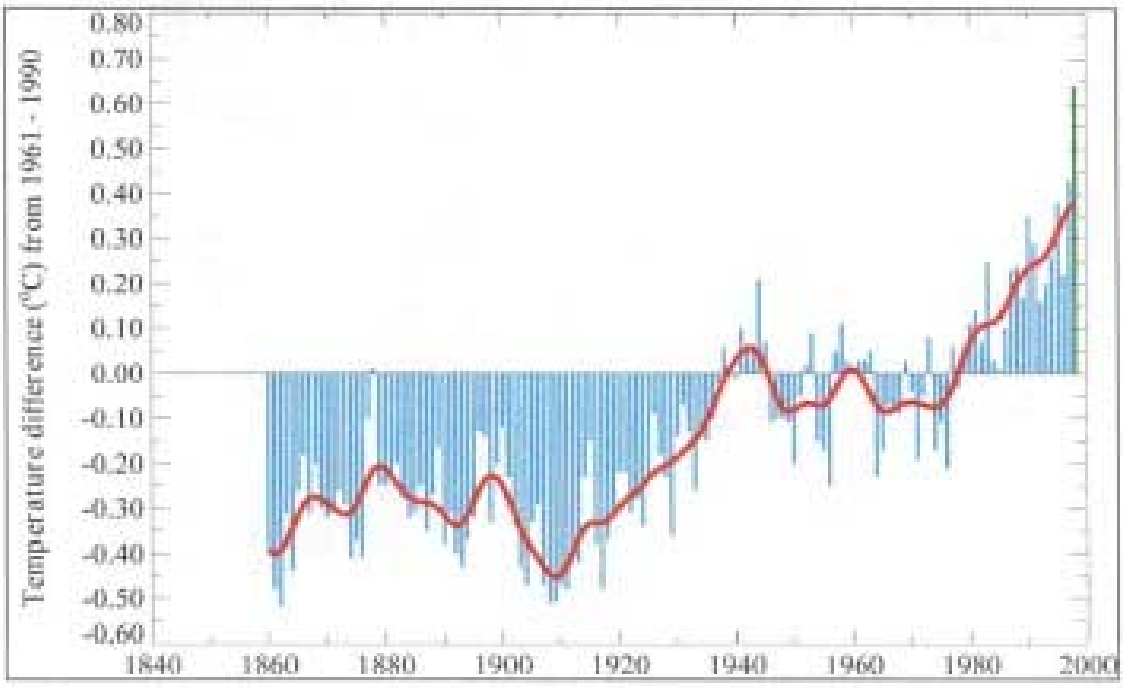
The ability of a society to produce, select, adapt, commercialise and use knowledge is critical for sustained economic growth and improved quality of life. Scientific and technological knowledge, when defined narrowly as what is produced by formal R&D systems based on Western "scientific method", is produced by a small number of the world's richer countries,[1] who derive great benefit from its use. Many countries in this exclusive group enjoy the fruits of a virtuous circle in which the concrete benefits of research help produce the wealth and public support needed to continue the investigation of science's frontiers.

Meanwhile, many of the rest of the world's nations are attempting to establish scientific and technological research systems that can invigorate their economies and provide solutions to their social needs, and to find ways to use existing S&T knowledge more effectively. Unfortunately, the logic of S&T research systems favours the scientifically strong becoming stronger. Countries that want to improve their S&T capacity have to make significant efforts to gain and maintain the "critical mass" of appropriate infrastructure, institutions and human capital which function to allow benefits to start to accrue. To make matters worse, this process is often viewed as long-term and full of uncertainty, and scarce resources are always under pressure from competing needs. At the same time, science and technology continue to grow in importance as sources of critical solutions to the problems of poverty and development. Countries will find themselves looking increasingly to science and technology for answers to social and economic problems.

One example, on a global scale, of the urgent need to develop S&T-based solutions to human problems is climate change. The Earth's climate is changing because of human activity. Global scientific and technological capacity is required to counterbalance that fact. Countries at all levels of development will have to become active partners in pursuing sustainable environmental and social development.

Figure 1. **Global observed temperatures**

Combined global land, air, and sea surface temperatures
1860 to August 1998 (relative to 1961–90 average)



Source: UK Meteorological Office (1997), *Climate Change and Its Impacts: A Global Perspective*.

Knowledge is a critical determinant of economic growth and standard of living. It is widely accepted among policy makers of the member nations of the OECD, multilateral institutions and others that *knowledge is the most important factor in economic development*. The benefits to scientifically and technologically advanced countries are proliferating. For example, the real growth of value added in knowledge-based industries has consistently outpaced overall growth rates in all OECD Member countries for more than the past decade.

At the same time, the disparities between rich and poor countries in S&T capacity, in terms of both input and output, are startling: R&D spending by the 29 countries of the OECD in 1998 was greater than the total economic output of the world's 61 poorest countries (USD 500 billion vs. USD 464 billion)[2]. In low-income countries, the ratio of patents filed by non-residents to those filed by residents is 690 to 1, while in high-income countries the ratio is 3.3 to 1. Evidence is emerging that correlates long-term economic growth with the percentage of population having tertiary education.

Despite the difficulties, there are good reasons to expect that aspiring countries can make progress in closing the gaps. First, new information and communications technologies are providing unprecedented access to existing knowledge, and are greatly diminishing the disadvantages of physical distance as a deterrent to research collaboration. Second, more is being learned about the process of innovation, and the policies and practices that make investments in S&T effective. Third, much of the international science community is by nature open to cross-border collaboration, as the progress of science depends on a culture of freely shared basic knowledge.[3] Fourth, much of what countries need to accomplish in order to use scientific and technological knowledge more effectively does not involve winning Nobel prizes for research, but rather revolves around the mundane yet essential tasks of

developing well-trained people and implementing effective policies and institutions in S&T-related sectors.

Science and technology affect the poor. Scientific and technological progress has already brought tremendous benefits to the poor. Looked at from a longer historical perspective, it is difficult to deny the pervasive and overwhelming influence of scientific and technological progress in lifting huge numbers of people out of the ranks of poverty. Even when viewed from a shorter perspective, many of the significant recent improvements in the lives of the poor have come from the successful application of knowledge to the problems of development. Two well-known examples are the dramatic rise in agricultural yields ("the green revolution") and the control (or elimination) of diseases such as smallpox, polio and measles. These two achievements alone contributed significantly to the more than 50% increase in life expectancy in the developing world in the period 1950-98. In addition, improved understanding of climate variation, land use change, and the dynamics of ecosystems now provides new ways to protect the current well-being of the poor while preserving the natural resource base on which their future income depends.

Recognition of the importance of S&T for development is not new. It is important to emphasise that concern for the role of S&T for development is not new. The goal of promoting new technologies and increased capacity to exploit scientific knowledge has been a part of the World Bank's work since its beginning. Virtually every sector in which the Bank operates deals with issues involving some type of technology transfer, and usually some related building of capacity to understand and use new technologies.

Emphasis on improved use of knowledge, transfer of technology and information, and creation of S&T capacity has varied widely by sector. However, several sectors such as agriculture, education and private sector development have made it a priority to build local capacity to either generate or utilise new knowledge for development. In total, about 2.5% of total Bank lending is devoted to the improvement of S&T capacity in this area.[4] However, no clearly defined strategic pattern for S&T as a whole emerges from an examination of previous experience.

Previous World Bank lending experience in S&T

Global characteristics of bank lending for S&T

Aggregate lending for S&T outside the agriculture sector has been examined. During fiscal years 1980-99, 59 *non-agriculture-sector* projects with specific S&T goals were approved. These projects account for USD 5.2 billion of the USD 381.8 billion (1.4%) lent by the Bank during those 20 years. There were on average three S&T projects per year, representing 1.2% of all projects. Annual average lending for S&T was USD 260 million and the average cost (lending plus expected counterpart contribution) of an S&T project was USD 181 million.

Some S&T projects are broad attempts to intervene throughout the entire sector – in other words, to increase both the capacity to produce scientific knowledge and its direct use in production. Brazil's *Science and Technology Reform Support Project* (PADCT III), for example, is devoting nearly USD 147 million (nearly half of the total project cost) to peer-reviewed, competitively awarded research grants in six priority scientific disciplines. S&T projects aimed at human resource development through improvements to training systems in tertiary and secondary education often finance the provision of infrastructure and the upgrading of laboratory equipment.

A typical private sector development project would include significant components in any or all of three basic categories: restructuring of public R&D institutes; technology development in industry; and MSTQ (metrology, standards, testing and quality). The bulk of the *Mexico: Industrial Technology Development Project* took the form of a line of credit to the country's major industrial fund, in order to strengthen its ITD financing of private industry and development of R&D capability in industry, research centres and engineering firms. Restructuring of R&D centres and metrology investments were also provided for in the project.

Some projects address R&D and technology policy concerns, but with specific focus on environmental issues. In the *China: Environmental Technical Assistance Project*, programmes of both the Chinese Academy of Sciences and the National Environmental Protection Agency were supported. All supported programmes sought to increase China's ability to understand and manage environmental problems. The Chinese Ecosystem Research Network and the Biodiversity Research and Information Management Programme, two initiatives of the Chinese Academy, were supported, as were waste minimisation, clean production, and an environmental monitoring and assessment programme of NEPA. Environmental research in the Chinese university system was also supported.

Support for R&D in agriculture and for National Agricultural Research Systems (NARS)

In the Bank's recent history, there has been a clear shift in focus from primarily agricultural development to other rural economy concerns, as evidenced by the increasing emphasis on such needs as rural roads and finance sustainability. Maintaining the natural resource base, for example, has become a priority for the rural sector. A similar transition toward a wider scope for the agricultural sector's impact on sustainable development has occurred within the CGIAR. The CG research agenda is now approaching balance between agricultural S&T and natural resource management.

Still, Bank support for agricultural S&T *sensu stricto* has not diminished. The Bank is the largest donor for both the agricultural sector and the agricultural research sub-sector.[5] Since 1980, support for the expansion and improvement of National Agricultural Research Systems has been an explicit priority. From 1981-96, the Bank lent USD 3.9 billion for funding of agricultural research through 458 projects in 91 countries.[6] At these levels, agriculture's share of all lending for support of research is larger than that of all the other sectors combined.

Clean energy technologies in the World Bank's lending portfolio

The Bank's risk profile is such that it prefers to base its investments on equipment that is off the shelf. Hence, it is seldom a developer or "first adopter" of clean energy technologies. It is important to bear in mind that the Bank's primary interest is not in the development of new technologies but in their ability to facilitate a wider development agenda. Hence, they are usually introduced as part of a package of activities which may include policy and regulatory reform, financial or management restructuring, private sector participation and other "non-hardware" investments which may have equal, or even greater, impact on environmentally and socially sustainable development.

Supply side. The rapid growth of gas turbine technology, particularly in combined cycles (CCGT), is probably the most significant example of a new, cleaner energy technology introduced into the power sectors of Bank clients in the past 10-15 years. The twin benefits of increased energy efficiency and lower specific emissions of global and local pollutants account for its rapid uptake. Other supply-side efficiency technologies include loss-reduction equipment, prepayment meters (which tend to reduce consumption) and upgrading of district heating installations.

The introduction of clean-up technologies is worth mentioning, particularly those relating to meeting the requirements set out in the Bank's Pollution Abatement Handbook. Of these, flue gas desulphurisation, particulate removal and low NO_x burners are the most significant and are introduced for all projects with Bank financing.

Demand-side efficiency. The Bank's efforts have been focused on facilitating the uptake of demand-side efficiency technologies, through the development of energy service companies (ESCOs) and other intermediation entities. Thus direct involvement in technologies has been somewhat limited. Nevertheless, some projects have upgraded district heating systems to reduce system losses through better distribution systems, controls and management.

Fuel switching and improvement. Substantial Bank work has been dedicated to increasing the supply of gas, which is an attractive substitute fuel – and which is a prerequisite for fuel switching. Extensive efforts in Eastern Europe have included fuel switching in district heating plants, principally from coal to peat, biomass and geothermal sources.

Renewable energy sources. The Bank has been investing in renewable energy projects for power production since at least the early 1990s. Initial investments were in geothermal and small- or medium-scale hydro. Subsequently, as the newer renewable energy technologies have come to commercial maturity, they have been introduced. Investments in technologies using agroforestry wastes (especially bagasse), landfill gas and wind energy are now quite diverse and extensive. Both solar thermal and photovoltaics (PV) for grid connected power are now under consideration. Other modern biomass technologies using energy crops have yet to make a significant showing. The Bank has also been active, with GEF, in promoting solar water heating for industrial and household use.

Household energy supply. Off-grid electricity supply has been considerably increased using renewable energy sources. For remote mini-grids, small hydro is often the least-cost solution compared with, for example, small diesel generators. There is renewed interest in indoor air pollution, which is primarily caused by the fuels used for cooking, and its effects on health, particularly of women and children.

Recent World Bank involvement in the area of clean technologies

Uptake of CCGTs. In 1979, combined cycle gas turbines (CCGTs) did not enjoy their present reputation as a world-beating technology – they were new in the marketplace and were unknown in the Indian power sector. IFC lent USD 10 million to Ahmedabad Electric Company to invest in a CCGT. Perceived technological risks were mitigated through commercial guarantees negotiated with the equipment supplier and the location of a field service and repair facility in India.

Efficient industrial boilers in China. The Efficient Industrial Boilers Project is a stand-alone GEF operation designed to improve the energy efficiency of new coal-fired small and medium-sized industrial boilers. In addition to broad support for the industrial boiler industry, GEF financing supports the procurement of technology and technical know-how from international partners for nine Chinese boiler manufactures to develop different types of more efficient industrial boiler designs. Counterpart financing (USD 68.6 million) provides much of the support to put the new boiler designs into mass production for the Chinese market.

Wind energy development in India. Bank participation in the wind sector in India has catalysed over 900MW of capacity financed by the private sector. The Bank's role has been to finance the Indian Renewable Energy Development Agency which has acted as technical and financial

intermediary for the sector. Perhaps more significant than the installation of the capacity has been the creation of an industry – with over 20 manufacturers and a full range of consultants, engineers, financiers and other entities essential to build, operate and maintain wind farms.

Compact fluorescent lamps in Mexico. The ILUMEX project in Mexico was the first GEF grant funded project implemented by the Bank. The project aimed to replace about 1.7 million incandescent light bulbs with compact fluorescent lamps (CFLs) in Guadalajara and Monterrey. By project closure, the target had been achieved, and by six months after closure, this had increased to 2.5 million CFLs. Estimated CO abatement was 764 000 tonnes. The project had a 35% IRR.

Towards a World Bank strategy to promote the use of science and technology for development

As shown, the Bank has long been a conduit for both technology transfer and capacity building in agriculture, health, energy, transportation and other sectors. However, notwithstanding the recent improvements, the Bank's support for S&T has been undertaken in an unco-ordinated or non-strategic manner; Bank policy towards the sector has not been formulated in an integral or holistic way. The Bank is now examining whether a more explicit strategy and more focused activities for the support of S&T are warranted. This will lead to a coherent strategy that gives the proper weight to S&T issues within the Bank's overall priorities.

As part of this direct focus on S&T, the Bank is examining the policies and practices that are prerequisites for countries to reap social and economic benefits from their investments in science and technology. In this context, it is important to consider how national strategies for S&T should vary according to particular country circumstances, as well as how the World Bank and other organisations can best contribute to the promotion of S&T capacity.

Building S&T capacity is an essential part of comprehensive development

Science contributes to development, but countries need a certain level of capacity in order to reap the benefits of S&T. Countries that lack this capacity will suffer greater consequences as the frontiers of science and technology advance. Lagging countries will not only miss out on new benefits (rising life expectancy, lower infant mortality, improved health, nutrition and sanitation, etc.), they will be increasingly vulnerable to emerging threats.

The Bank recognises that making lopsided or unbalanced investments (for example, in prestige science to the neglect of technology development) can be as fruitless as doing nothing – and more expensive. It is with this in mind that we are currently analysing the idiosyncrasies of various S&T-related practices, as well as how they should be sequenced and balanced. This analysis breaks down into four main sub-categories:

The enabling environment: starting from the most "macro" or generic considerations (low inflation, openness of trading regimes, policies towards foreign investment, and the quality and maturity of the banking system) and moving towards the more specific (the role of intellectual property right protection, incentives to acquire and adapt technology, and the public sector's role in metrology and standard setting).

Firm-level considerations: involving the ability of enterprises to "deepen" the use of technology. While policy environments and supporting institutions will always remain crucial to successful S&T development efforts, business enterprises are the fundamental actors in the technological innovations

that turn benefits from science and technology into reality. It is the Bank's position that progress in use of technology by firms is the *sine qua non* for reaping the benefits of science and technology.

Public role in support of S&T: A key question under consideration is the proper role for public action in the promotion of S&T. An integral part of the public role for S&T is the way in which governments define, identify, promote and protect S&T-related public goods. A central issue is the balance between private interests and the concomitant incentives to innovate vs. legitimate social goals that require knowledge, information, products and processes to be publicly available through means other than markets. Also worthy of consideration are the government's role as a consumer (as opposed to a funder or performer) of research, the diversity of the research portfolio and its match to national needs, balance of long- and short-term research, as well as basic and applied, and the stimulation of partnerships among government, industry and academia.

Building and maintaining human capital: Critical among the public sector's responsibilities are those which involve the development of human capital. Appropriate policy will take into account the dynamics of knowledge production systems, from basic education through higher education to the creation of knowledge in private sector laboratories by highly trained specialists. Clearly of concern is the role of science in basic education, and the preparation of young people prior to reaching university age.

National strategies and the role of the World Bank and the international community

A number of issues in S&T are of particular concern to countries as they seek to improve their research systems. Two such issues are: *i)* brain drain, and ways to counterbalance the migration of talented and highly skilled people in an increasingly globalised market for human capital,[7] especially as rich countries continue their efforts to lure the best and brightest to jobs in the developed world; and *ii)* combining excellence and relevance in science research, and avoiding the tendency to define, fund, and recognise as excellent only those research topics that are of concern to rich nations and dominate prestigious international journals.

We must continually seek to enhance the role of the international S&T community (of both scientists/researchers and multi- and bilateral donors, including the World Bank). Research is now being done to estimate the size and impact of bilateral funding on researchers in the developing world.[8] The Bank is also examining different conceptions of support for centres of excellence in the developed and developing worlds, and different models for providing support to outstanding researchers, in order to identify the aspects of successful programmes that have succeeded (or have the potential to succeed) in a variety of developing country settings.

In its effort to develop a clear science and technology policy strategy, the Bank has been mindful of many considerations: what changes should be made to country dialogue and lending; how to improve co-operation and knowledge management among staff working on science and technology issues; and how the Bank should work with the international S&T community and multi- and bilateral partners.

Towards innovative action: the Millennium Science Initiative

In parallel with the development of a comprehensive science and technology strategy, the Bank is seeking to stimulate greater operational collaboration with client countries for improvement of S&T capacity. To make this possible, a number of innovative actions are planned and others underway.

These include projects undertaken under the aegis of the Millennium Science Initiative (MSI). The MSI is not a new initiative *per se*: it makes use of the Bank's existing lending instruments, but strongly emphasises the need for countries to improve the performance of their science and technology systems. To date, three clients are participating in the MSI. Chile and Venezuela have taken Learning and Innovation Loans to fund MSI projects, and Mexico has adapted a previously existing S&T loan to include an MSI pilot. Discussions are underway in Brazil, Thailand and Romania for additional projects or project components. In addition, the Bank is working with partners from the international science community to find ways to make the MSI an effective option for science in Sub-Saharan Africa.

Simply stated, the MSI is lending designed to support projects that award large multi-year research grants to top researchers, through a transparent and highly selective competition. The grants normally fund institutes that function as centres of excellence in their domains; the grants do not fund physical infrastructure or buildings, and are made for a fixed time period. The basic idea behind MSI projects is to stimulate a part of the national S&T system to function according to international best practice for research funding. The belief is that if these practices are followed, the quality and cost-effectiveness of research performed in the developing world could more closely resemble that of rich countries.

All MSI projects will provide targeted support that focuses on: *i)* research excellence; *ii)* human resources training; and *iii)* linkages to partners in the international science community and in the private sector.

While the amount awarded will vary, MSI projects will usually follow a two-tiered system. In the first tier, a very small number of truly international-level groups are selected for longer-term funding (5-7 years or longer). In a second tier, promising groups, often composed of younger investigators, are awarded shorter (3-5 year) grants that may be renewable. MSI funding is also used for specific international networking activities that may be outside the grant process.

The expected direct and indirect benefits include:

- A model for the transparent, merit-based allocation procedures that forge "cultures of quality".
- Increased training opportunities for young people, and reduction of "brain drain".
- Global and regional networking with other researchers.

Progressing with our partners

The Bank is, and will remain, actively engaged in efforts to further enhance the contributions of S&T to the social and economic sustainable development of its client countries. The Bank's approach towards lending for S&T thus far has been relatively unco-ordinated and non-strategic, limiting its overall effectiveness. The collaborative formation of a comprehensive strategy for S&T lending arose from the Bank's recognition of the limitations of its previous approach. The strategy, informed by a rigorous consultation process, is compatible with the accelerating importance of knowledge for development. Cutting across sectors, the strategy will stress the interconnections among knowledge assimilation and use, human capacity, and the government roles of setting a proper framework and providing needed public knowledge goods.

While the Bank is undertaking to co-ordinate its work in the S&T arena, it is simultaneously experimenting with innovative actions to stimulate and refocus efforts to improve the scientific and technological capabilities of its borrowers. The Millennium Science Initiative is going forward in parallel with the development of the S&T strategy so that lessons from its implementation can be incorporated into the strategy. The first two operations under the MSI, for Chile and Venezuela, are Learning and Innovation Loans, and lessons from their implementation, will be incorporated into future MSI projects and the strategy. Likewise, the finding of the strategy will have implications for the MSI and the other options the Bank has for supporting improved S&T capacity. As these activities go forward, each will provide complementary lessons to the others.

NOTES

1. The best data available measure R&D in its more formal or traditional sense. The world's richest countries collect this data using criteria defined in the OECD's *Frascati* and *Olso Manuals*. Such data show that OECD Member countries accounted for 85% of investment in R&D. China, India, Brazil and the NICs of East Asia accounted for 11%. The rest of the world's countries accounted for 4% (UNESCO, *World Science Report*, 1996). It is important to emphasise, however, that R&D defined in this way is only one element of an innovation system. Other, no less important, means of innovation – especially those that take place in the productive sector or close to the end user – are more idiosyncratic and difficult to quantify.

2. The low-income countries, excluding China and India (data from World Bank's *World Development Indicators* 2000).

3. While this remains true for a large number of areas of basic research, a growing number scientific fields that produce commercially applicable knowledge are rapidly becoming more "closed" and less willing to co-operate freely for the sake of building capacity. Biotechnology is the chief example of such a field. The magnitude and consequence of this change are being studied by the Bank.

4. These figures are based on analyses of Bank lending for S&T from 1992-98. Other analyses put lending for S&T in agriculture/rural development closer to USD 350 million per year of new commitments. The percentage figure is for overall lending, a substantial proportion of which is adjustment lending that has no specific sectoral focus.

5. All data and information in this section are from "The World Bank's Role in Strengthening National Research Systems", Chapter 4 of *Strengthening National Agricultural Research Systems: Policy Issues and Good Practice*, Derek Byerlee and Gary Alex, World Bank, 1998.

6. This figure represents the actual amounts devoted to the research projects/components; it has been disaggregated from the (much higher) total value of projects containing agricultural research components.

7. United States Public Law No. 106-313, "American Competitiveness in the Twenty-first Century Act of 2000".

8. "Reaching Out: Canada, International Science and Technology, and the Knowledge-based Economy: Report of the Expert Panel on Canada's Role in International Science and Technology", presented to The Prime Minister's Advisory Council on Science and Technology, 23 June 2000.

Chapter 14

EFFECT OF THE ECO-FUND MECHANISM ON INTERNATIONAL SCIENTIFIC AND TECHNOLOGICAL CO-OPERATION FOR SUSTAINABLE DEVELOPMENT

by

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Introduction

I would like to begin by sharing with you recent developments which have occurred in Japan since the introduction of what I call the "eco-fund mechanism".

About two years ago, I set up an investment-advisory company, "The Good Bankers Co., Ltd.", as a way of introducing a socially responsible investing mechanism into Japan. Socially responsible investment, or SRI, relates to investment in companies whose business behaviour or products, or both, is conducive to achieving a sustainable world for future generations. This new style of investment is now spreading rapidly throughout the world.

The new concept focuses on the environment and establishes a new mutual fund: the "eco-fund". Its major objective is to facilitate sustainable development by investing in environmentally friendly companies. Such funds are generally known worldwide under the terms "green funds" or "eco-efficiency funds".

Fortunately, the Nikko Group, Japan's prominent investment banking group reacted favourably to the proposal and Japan's first socially responsible investment product, "the Nikko Eco-Fund", was created in August 1999. The fund invests in environmentally friendly companies with proven environmental performance in the development of eco-friendly products and technologies. Our company provides the Nikko Group with the environmental screening results of Japanese corporations.

The success of the eco-fund

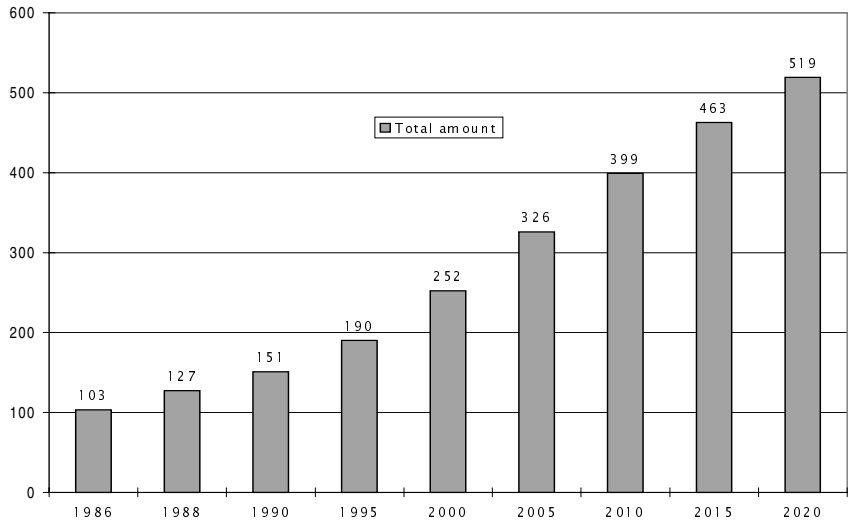
The Nikko Eco-Fund earned more than four times the projected initial sales, reflecting stronger than expected interest among Japanese individual investors in this new investment vehicle. It is now Japan's 17th largest mutual fund and one of the largest green funds in the world. Six more financial institutions have since followed, launching similar mutual funds. Six months after the launch of the Nikko Eco-Fund, in January 2000, the total assets of Japanese green funds under management were already some USD 2 billion.

The immediate popularity of these funds caused a sensation in the Japanese financial services industry. Over 90% of investors are individuals, including women and younger people – who have not traditionally been major players in the stock market. This trend indicates a greater awareness of SRI in Japanese society.

Japan was a late entrant in the field of socially responsible investment. However, the Japanese people seem to be catching up quickly in learning how to bring a social component to the management of their money. The new concept has awakened "the sleeping investors", such as the labour unions, in the traditional market. For example, "Rengo", a confederation of labour unions with 8 million members and investment assets of JPY 1 trillion (USD 9.3 billion), announced that they would be developing investment guidelines for eco-funds. Some labour unions have already invested in the Nikko Eco-Fund.

Furthermore, in October 2000, the Tokyo Teachers' Mutual Aid Association announced that it would set up the first eco-fund among institutional investors in Japan. In the near future, public pension funds with assets of USD 1.4 trillion and private pension funds with assets of USD 1 trillion may join the trend. Prospects for growth in the Japanese pensions market are highly promising (Figure 1).

Figure 1. **Growth in the Japanese pensions market, including future prospects**



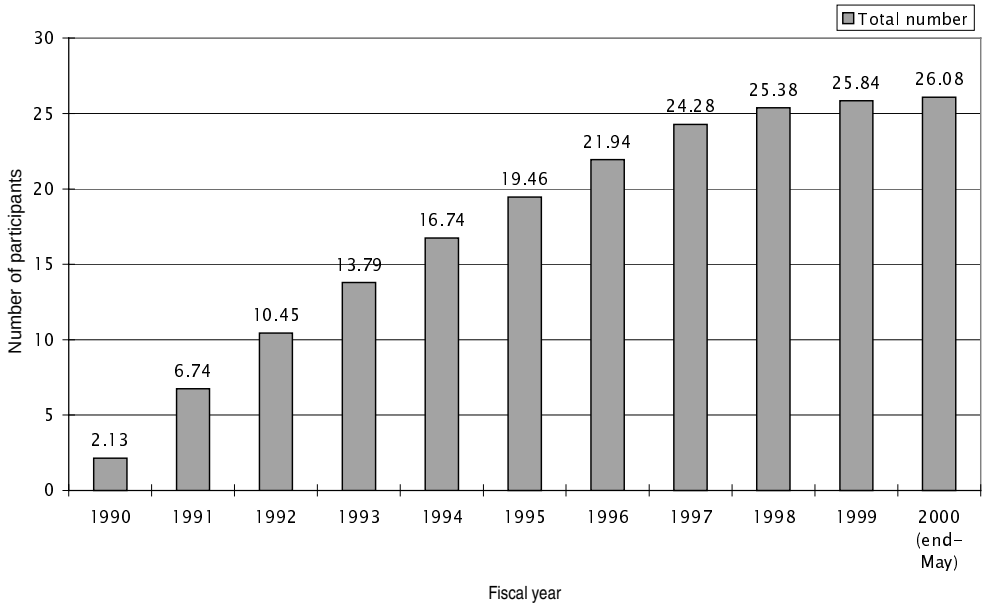
In fact, as Mr. Masashi Kaneko, President and Chief Executive Officer of Nikko Securities, stated at the May 2000 UNEP Conference in Malmo, the total assets of the eco-fund market are forecast to expand to JPY 1 trillion (USD 9.3 billion) over the next three years.

Reasons for success

Judging from their enthusiastic response, Japanese consumers seem to have been waiting for this type of financial product. In 1990, the postal savings bureau introduced a scheme, the Postal Savings for International Voluntary Aid Programme, under which 20% of savings income would be

contributed to international co-operation projects or NGOs for the welfare of people in developing countries. In spite of Japan's sluggish economy between 1990-2000, the number of participants in the scheme increased to 26 million. It would appear that people are not only interested in maximising their profits, they also wish to make a positive contribution to society (Figure 2).

Figure 2. **Participation in the Postal Savings for International Voluntary Aid Programme**



Source: Ministry of Post and Telecommunications Web site.

The statistics show that "green consumerism" has become a widespread trend in Japan. For example, according to a *Keidanren* survey in 1998, 90% of women agreed that they would willingly lower their standard of living in an effort to protect the environment. In 1997, 72% of the readers of *SPA*, a popular magazine among young men aged 25-35, responded in a similar vein. A survey by *Dentsu* (Japan's largest advertising company) in 1997 showed that 74% of people aged between 15 and 59 in the Tokyo metropolitan area would accept to pay more for environmentally friendly goods, compared to 55% in 1993. In addition to these trends, Japanese interest rates, which are at a historical low, and Japan's steps towards financial deregulation are other factors driving the introduction of new financial products.

The impact of success

Environmental awareness in the corporate world has increased, particularly since the COP3 Kyoto Protocol signed in December 1997. In Japan, the number of corporations that achieved ISO 14001 accreditation jumped from 44 in March 1996 to over 3 500 in 2000, the highest level in the world.

However, even last year when we started environmental research, many Japanese companies were reluctant to answer our questionnaires or spare the time for a meeting. They were not always willing to disclose information on their environmental performance.

The success of the eco-fund has dramatically changed Japanese companies' attitudes towards their environmental policy. Today, the majority of firms are willing to collaborate with our research – and it is they who ask us if their stocks can be included in the eco-fund portfolio. More and more leading companies are implementing environmental managerial accounting and issuing reports on their environmental performance. Now that firms are aware of the benefits of being environmentally friendly, it has clearly become an incentive to further improve their environmental performance.

The example of the Nikko Group

I would like to describe the experiences of one Japanese leading company since its involvement with eco-funds.

When I proposed a blueprint of the eco-fund, the initial reaction of the Nikko Group was a little sceptical. Like most of traditional male fund managers, they said, "it is a moving story about an new product, but Japanese investors won't buy it because their major interest is to maximise their returns". However, the positive reaction from investors to this new financial product encouraged the Nikko Group to become involved in the global movement towards sustainable development.

In March 2000, Nikko Securities, Nikko Asset Management and my company became the first Japanese signatories of the UNEP Financial Institutions Initiative statement. In May, the first report on the environmental performance of the Nikko Group was issued. The group is currently preparing to obtain ISO 14001 and is actively reinforcing its eco-friendliness by digitising its offices, installing solar panels and replacing company cars with low-emission vehicles. Moreover, it recently announced a plan to establish a charity fund through the WWF to financially support environmental protection activities.

The eco-fund mechanism

The success of the eco-fund in Japan can be attributed to ordinary citizens' strong awareness of environmental issues. I believe that they are attracted to the idea that by investing their private money, they can help to change society. In the past, people felt powerless and believed that only the public sector was responsible for investments in social development. Today, thanks to the example of the eco-fund, we realise that the private sector too can play an important role in changing society.

By investing in the eco-fund, ordinary people can become directly involved in the course of the world, and especially with global environmental issues. This new trend may serve to liberate the citizens of the developed countries from the apathy of their "modern lifestyles", where everything seems to last forever and where they have no opportunity to enact change. Our ultimate objective is to revitalise people's lives by showing them that they can become active members of society by investing in the eco-fund. This is the core of what I call the "eco-fund mechanism".

The eco-fund mechanism can probably be applied to other projects, ranging from micro-finance to international technological co-operation for sustainable development.

The micro-credit system (micro-finance) that started in Bangladesh has spread to other countries. In South Africa, the Women's Development Bank has been managing micro-credit for the poorest women to support their financial independence. I was impressed by the project and thought we could show our solidarity by setting up a mutual fund to support such micro-credit systems. In addition, we felt that establishing a new eco-fund for "International Scientific Technological Co-operation for

Sustainable Development" might attract people's attention instead of paying more taxes for government ODA. It would be worthwhile investigating the possibility of setting up a fund along similar lines to Japan's Postal Savings for International Voluntary Aid Programme.

One survey shows that only 15% of the world population benefits from existing banking systems. The remaining 85% are denied access to banks because of poverty and lack of collateral. It is our duty to propose alternative banking systems for these people. Of course, there are a number of obstacles, such as the assessment of true green technology or difficulties in attracting investors. However, I believe that co-operation between the public and private sectors can successfully overcome many of these barriers.

Policy recommendations

To promote this new financial trend, the following factors need to be incorporated into public policy:

- Active co-operation between public and private sector finance.
- Interactive communication among scientists, technical experts and the general public relating to technologies for sustainable development.
- Identification of technologies by experts.
- Governmental stimuli to investment by the private finance sector, such as tax incentives.
- Project transparency through the provision of detailed information to the public.

Conclusion

The success of the eco-fund in Japan has proved that this mechanism can be applied in many ways to promote global sustainable development. The eco-fund has shown that ordinary citizens are the key factor in changing the world. It is important to build up a sound financial infrastructure enabling ordinary people to participate in large-scale projects like "green technology development", which they never thought they could help before. The amounts of money invested by each person may be very small but, through the "eco-fund mechanism", they can go a long way towards sustainable development.

Chapter 15

THE ROLE OF GOVERNMENTS IN TECHNOLOGY CO-OPERATION FOR SUSTAINABLE DEVELOPMENT

by

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Introduction

This chapter will focus on the role that governments can play in the formulation and implementation of science and technology (S&T) policy to strengthen international S&T co-operation for sustainable development. Particular emphasis will be put on the integration of issues specific to developing countries in public R&D programmes with possible applications for environmental technologies, the contribution to the training of developing countries' human resources in S&T, and the incentives to facilitate public-private partnerships in R&D programmes that can benefit the diffusion of technologies to these countries. The chapter will also touch upon developing countries' education, R&D and technology policies that can strengthen their absorptive capacities and ensure they fully reap of the benefits of international co-operation.

The term environmentally sound technology (EST) is used in this chapter. Other terms include cleaner production/cleaner technology, eco-efficiency, waste minimisation, pollution prevention, green productivity and industrial ecology. While the terms are slightly different, the common denominator is the focus on the sources of pollution. The strategy is to change raw materials, processes and product specifications in order to reduce emissions to air, water and waste. This "win-win" strategy applies to processes, products (EcoDesign), as well as services. A number of tools exist which allow this preventative strategy to be applied at plant level. In my opinion, it is important to develop a policy for technology transfer and improved efficiency for both existing industrial activities and new activities.

This chapter draws upon the experience of Norway, especially during 1990-95, at which time a number of programmes existed for the promotion of environmentally sound technology. Bilateral programmes funded by the Norwegian Ministry of Foreign Affairs and the Norwegian Agency for Development Co-operation (NORAD) are also examined. In addition, there were a number of Norwegian assistance programmes in Central and Eastern Europe and the Newly Independent States (CEE/NIS) in close co-operation with the OECD and developing countries. The description will also touch upon the UNEP-UNIDO National Cleaner Production Centres which, over the last five years, have contributed important and valuable experiences.

Partnerships between governmental institutions and industry and user–driven research programmes – the Norwegian approach

The Industry and Energy Division, one of the six research divisions of the Research Council of Norway, promotes wealth creation by funding research in R&D-based industrial and service enterprises. The goal is to attain sustainable development by promoting innovation and wealth creation in Norwegian business and industry. This will be accomplished by encouraging:

- International competitiveness and sustainable business- and industry-based knowledge, expertise, networking and learning.

- Bold industrial R&D efforts that emphasis long-term socio-economic dividends.

- An increase in the number of enterprises that take a systematic approach to research and development.

- Collaboration and networking based on the principle that a whole can be greater than the sum of the parts.

Europe is the most important market for Norway's industrial R&D collaboration. Accordingly, efforts are directed towards the EU Framework Programmes and EUREKA co-operation, as well as towards the United States and South-East Asia. Preference is given to participating in international programmes that will benefit Norway's national priorities. Priority is given to user-oriented downstream technical and industrial research.

For budget year 2001, the Norwegian Government has proposed the establishment of a new facility for the promotion of private sector demand for R&D from universities and research institutes. The proposed budget for 2001 is NOK 200 million (USD 21 million). The maximum funding covers 25% of project costs, with a limit of NOK 1 million per project and company.

In 1990-95, comprehensive efforts were undertaken towards the development of environmental technology for R&D projects and demonstrations of new technologies. This project was organised as a partnership between different governmental organisations, with the Research Council as the responsible agency. Two programmes were organised by the Research Council of Norway:

- FORFOR, which was aimed at solving environmental problems for industrial activities in Norway and the development of new tools. Among the projects initiated, was the development of life-cycle analysis linked to Nordic co-operation and based on a number of projects for Nordic companies.

- EKSPOMIL, which was aimed at the development of new technologies for engineering companies (problem solvers). The projects were organised as partnerships between EKSPOMIL, the companies having an environmental problem (the problem owners) and a technology-engineering company (the problem solver). Potential project areas were identified in close co-operation with the Norwegian Pollution Control Authority (SFT) which has an overview of future demand for necessary environmental improvements and can thereby highlight potential future Norwegian and international markets for environmental technology.

In addition, SFT organised a programme on environmental technology for the funding of demonstration projects. Close co-operation between EKSPOMIL and SFT ensured funding of

promising projects from the R&D stage to full-scale demonstration. The Norwegian Industrial and Regional Fund (SND) was also included in the co-operation and provided support for the commercial project development.

The third link was the establishment of NORVIRON – organised as a co-operation between the Research Council of Norway, SFT and the Norwegian Trade Council with a view to stimulating exports of environmentally sound technology.

The importance of demand-driven activities

International conventions on climate change, ozone layer depletion, persistent organic and inorganic pollutants (POPs and PIPs), international waters and biodiversity are the basic international drivers for the development of demand for ESTs. The use of GHG emission trading, joint implementation and the clean development mechanism will probably play an increasingly important role for stimulating demand for cleaner technologies.

However, the main drivers behind the implementation of ESTs in all countries are environmental regulations, either through direct regulation and/or through financial instruments. Over the last few years, voluntary or negotiated agreements between governments and industries have grown in importance. Especially in Europe, environmentally conscious markets play an important role in developing demand for ESTs. Large firms and retail chains are increasingly implementing supply-chain management strategies for their suppliers in developing countries and requesting ISO 14 001 certification or other criteria for product delivery to their customers. However, for the time being, this tendency is of limited importance outside the OECD area.

A fundamental task for governments in developing countries is to establish a comprehensive legal and enforcement system. In addition, there is a need for an institutional framework at central, provincial and local level.

At country level, there are a number of stakeholders in addition to government. Some of these stakeholders require more information on policy questions (national as well as international), others need information on technologies that can solve their specific environmental problems. Companies (sellers, customers and service providers) need information on the financial facilities available to them. NGOs need information in order to lobby and obtain improvements in policy. Governments should undertake an analysis of these needs in order to establish a platform for the design of a demand-driven strategy for increased demand for ESTs.

Instruments for promoting environmentally sound technology

While it is industry that must ultimately implement environmentally friendly and energy-efficient measures, the role of the government is to develop, design and implement an appropriate mix of instruments that will accelerate the process and encourage industry to initiate its own improvement programmes. The appropriate instruments may be divided in three categories:

Regulatory framework

- Regulations.
- Guidelines.

- Permit systems.
- Voluntary agreements.
- Enforcement schemes.

Financial instruments

- Tax, duties and fees to discourage unwanted practices (*e.g.* water and energy pricing, landfill taxes).
- Grants and subsidies.
- Soft loans, funds to encourage improvements.

Information and training/education

- Dissemination of lessons learned from demonstration projects.
- Centres of expertise.
- Newsletters.
- General manuals.
- Sector specific manuals.
- Databases.

Videos

- Conferences and seminars.
- Education curricula.
- Research and development programmes.

Although legislation has traditionally focused on end-of-pipe solutions, in the 1990s the focus has gradually changed to cleaner production strategies and now constitutes a pressure on companies to implement environment improvements. The environmental impacts (externalities) have to be internalised through an appropriate mix of "sticks" and "carrots". Another approach is to mix different types of instruments according to the following principles:

- Companies have to be *able* to identify improvements.
- Companies need to have the *will* to identify improvements.
- The *pressure* on companies needs to be increased.

Governments, in close co-operation with industry, have the responsibility to ensure that these three requirements are met.

Case studies, training and dissemination of lessons from case studies can all serve to improve companies' abilities and willingness to undertake the necessary improvements. Pressure has to be maintained through the application of a well-designed mix of regulatory and economic instruments. These elements combine to constitute capacity building.

Key words for efficient technology transfer are development of a regulatory framework, financial facilities, institutional development, and training and awareness raising. Experience shows that there is considerable room for increased efficiency through housekeeping measures and low- and medium-cost investments in existing facilities. For new and existing facilities, the challenge is to develop mechanisms that can ensure the installation of effective equipment, followed up by maintenance and continuous improvement programmes, backed up by the implementation of effective management systems.

The development of a regulatory framework and effective institutional framework is a government responsibility. Ensuring clear divisions of responsibilities among various governmental institutions at the central level (horizontally) and between the central, provincial and local levels (vertically) is especially important.

The design of economic instruments to discourage unwanted activities is also a government responsibility, while the setting up of financing arrangements, including soft-loan facilities, dissemination of case studies, and training and awareness raising fall partly under the responsibility of the government and partly under that of the private sector (business associations).

Training programmes as a basic platform for capacity building

Based on Norwegian experience gained from the cleaner production training programmes launched in Poland in 1990, the OECD published in 1995 the "Best Practices Guide for Cleaner Production Programmes in Central and Eastern Europe". The background for the Guidelines was a recognition among policy makers and the emerging private sector in the region that cleaner production represents a cost-effective way to raise profitability, upgrade competitive advantage in the international marketplace and improve environmental performance.

A key element of the Guidelines is a training programme for engineering professionals at plant level as well as for professionals in consultancy companies, central and local authorities and business associations. The training is organised as a combination of four sessions of classroom training and project work in the participating companies. The classroom training is divided between lectures and group work. The companies are normally visited twice by an adviser during the intermediate periods between the classroom sessions.

Typically, 10-20 companies take part in a training programme which last about seven months. The main principles applied during the training are:

- Training by doing.
- In-plant training.
- Training the trainers.

One of the goals of a number of the training programmes is to build up a group of national experts who can continue the training as well as advise companies on how to increase their

productivity and implement environmental improvements. The training takes a practical approach and the focus is on real measurable improvements. As an example, in Tanzania, a textile plant identified improvements which involved:

- Reducing water use by 11 000 m^3, saving USD 10 000 per month.
- Reducing steam use by 55%, saving USD 1 000 per month.
- Reducing waste by 8%, saving USD 16 000 per month.

All these improvements involved only minor investments.

Norway (funded by the Ministry of Foreign Affairs, Ministry of Environment and NORAD) has also supported cleaner production training programmes organised along the lines described above in Poland, north-western Russia, the Czech Republic, the Slovak Republic, Lithuania, Tunisia, Zambia, Tanzania, Indonesia, China and Pakistan.

Together, UNEP and UNIDO have established 19 National Cleaner Production Centres, with the main objective of developing national capacity for cleaner production through:

- The development of case studies for various industrial sectors.
- The dissemination of lessons learned from the case studies.
- Training of national expertise on how to apply cleaner production strategies at plant level.
- Policy development for cleaner production.

The need for efficient management

The implementation of technologies at plant level normally has two dimensions:

- The technology as such, or the equipment designed for a specific purpose (the “hardware”).
- Over the lifetime of the technology, there will be a tendency towards reduced efficiency. Management of the technology then becomes more and more important until such time as the technology is decommissioned. The EU has introduced the term “techniques” to include the management element of technology. According to the EU, “techniques” “shall include both the technology used and the way in which the installation is designed, built, maintained, operated and decommissioned”.

In the absence of appropriate training in operating, implementing regular maintenance and management process, with time the efficiency of the equipment will be lowered – lower capacity, poorer products, reduced energy efficiency and increased emissions to air, water and waste.

On the other hand, well-maintained and well-operated technologies can increase efficiency and reduce environmental impacts by 20-30% through the implementation of housekeeping measures such as improving existing management routines and introducing new management routines.

Cleaner production assessments may be used as a platform for increased management efficiency and as a starting point for developing a documented management system and, at a later stage, a certified management system in line with ISO 14 001. The increasing demand for ISO 14 001 acts a driving force for improved environmental improvements where cleaner production assessment is an important tool.

Investment promotion

Even after nearly ten years' experience in promoting the cleaner production strategy, existing industries in developing countries continue to encounter difficulties in financing cleaner production (CP) investments, although finance is available for other types of industrial investments. At the same time, evidence is growing that new industrial establishments do not yet sufficiently capitalise on available CP opportunities.

The funding of CP investments in developing countries has yet to be systematically assessed and remains a complex, and at times intangible, issue. Current efforts to promote CP in developing countries are largely limited to the transfer and dissemination of technical information and technology. Transfer of financial knowledge and instruments and strengthening of financial institutions and industrial authorities are also necessary in order to make funds available for the purchase of CP instruments.

Environmental policies in developing countries lean heavily on environmental regulations without having an appropriate enforcement system in place. Incentives (including investment promotion), which typically have more direct and longer-lasting impacts on industry decision making, are not widely used.

This is why UNEP's Division of Technology, Industry and Economics (TIE), initiated the project on "Strategies and Mechanisms for Promoting Cleaner Production Investments in Developing Countries". The project was launched in Oslo in September 1998, is implemented in five countries (Vietnam, Zimbabwe, Tanzania, Guatemala and Nicaragua) and will run for three years. It is funded by the Government of Norway.

The project is supported by the Government of Norway and aims to demonstrate how investments in cleaner production can be stimulated by helping financial institutions to understand the importance of cleaner production and helping local cleaner production experts to develop creditworthy investment proposals.

Investment promotions for business development in developing countries

The Norwegian Investment Fund (NORFUND) became operational in 1998. NORFUND's mission is to invest in profitable private enterprises and promote business developments in these markets. NORFUND supports the realisation of viable commercial projects which balance social, environmental and economic considerations. NORFUND contributes to the success of its co-investors by providing risk capital and professional expertise. Two investment strategies have been developed:

- Direct investments are made jointly with Norwegian companies, often in co-operation with a local partner. NORFUND can provide up to 49% of equity and is a provider of risk capital. In such cases, NORFUND participates actively at the board level and provides networks and expertise in addition to capital. The focus is on sustainability and profitability.

- Participation in local investment funds is not tied to Norwegian companies. This participation is normally carried out together with other development investors – multilateral as well as bilateral. It is focused on priority countries for Norwegian development assistance.

As an example of the direct investment strategy, a small Norwegian company has joined forces with local partners in Ecuador to introduce new Norwegian technology that reduces pollution from palm-oil production and at the same time increases the amount of oil extracted from raw materials and thereby raises productivity.

NORFUND has joined forces with Commonwealth Corporation and five other investors and launched a new private equity fund for Tanzania (Fedha Fund Ltd.) capitalised at USD 13 million; this project is a typical example of the investment fund strategy. Fedha will provide risk capital finance of between USD 200 000 and USD 1 million to well-managed Tanzanian companies. Investments for projects in agro-industrial processing, telecommunications, transport and tourism have already been approved.

Revolving funds as an instrument for promoting cleaner production

In September 1997, the Board of Directors of the Nordic Environment Finance Corporation (NEFCO) approved the establishment of a revolving facility for cleaner production. Cleaner production assessments typically identify three types of action:

A. Housekeeping actions including minor investments with some few months payback on investments.

B. Short-term (< one year) investments to be financed from operating budget or through small loans.

C. Long-term (> one year) investments, requiring external loans.

Actions of type A and, partly, B can normally be financed out of the enterprise's operating budget. Financing for actions of type C and, partly, type B, needs to be obtained external sources, either as a commercial loan or through soft loans. The revolving facility is targeted primarily at investments of type C, and partly of type B.

The objective of the facility is to finance on favourable terms the implementation of high-priority cleaner production investments with rapid payback that yield both environmental and economical benefits ("win-win projects"). The investments should be commercially viable with an identifiable and secure stream of earnings that has to be used to repay the loan.

The facility was initially funded with DKK 15 million and is earmarked for projects in Lithuania, Estonia and north-western Russia. Preference is given to enterprises that have already participated in cleaner production or energy efficiency programmes. The maximum loan size is equivalent to USD 200 000, with a minimum amount of USD 50 000. By October 2000, 59 loan applications had been evaluated and 24 loans approved; 45 projects are in the pipeline.

The approach has so far proved successful and the concept will be tested on a commercial basis in the Czech Republic in the near future.

Private sector development in developing countries

In February 1999, the Norwegian Government formulated a new strategy aimed at providing support for the strengthening of the private sector in developing countries. A sound and entrepreneurial private sector is necessary to combat poverty and to improve the level of social services in any country, and Norway intends to commence targeted interventions to enhance the development of this sector in the South.

Support for private sector development comprises assistance for measures that contribute directly to increasing production within primary industry, the industrial sector and the service sectors. Agriculture plays a major role both as a source of jobs and income and as a supplier of raw materials to industry.

Norway wishes to improve the framework conditions for investments, the development of local enterprises and the participation of the general public in business and industrial activity, focusing on the major role played by the private sector in the production of goods and services. The major elements of the strategy are:

- Strengthening the institutions that are responsible for determining the operation parameters for private sector development, and provide support for the development of the necessary infrastructure.

- Improving access to more productive, well-adapted technology and expertise through support for research, training and advisory services.

- Providing support for savings and credit schemes for both women and men in poor population groups, including those in the informal sector.

- Providing support in the form of grants and loans for the establishment of enterprises and production units.

- Providing support for exporters in partner countries and regions in order to promote the export of products, with an emphasis on measures and product development of high quality.

The strategy has been followed up by concrete action plans in three pilot countries: Uganda, Mozambique and Sri Lanka.

Matchmaking in Sri Lanka

The “Matchmaking” programme supports industrial and commercial development in Sri Lanka and has as its objective to enable Norwegian and Sri Lankan companies to come into contact with each other. A co-ordination centre has been set up in Norway, with a corresponding centre in Sri Lanka – the Ceylon Chamber of Commerce.

Since the beginning of 1995, the programme has received 96 company profiles from Sri Lanka and 120 from Norway. The company “profile” includes a presentation of the company and its wishes in relation to a partner. To date, 78 of the companies have visited Sri Lanka and 22 have gone further and have carried out preliminary studies. Letters of intent have been signed by 26 firms. Of these, 16 companies have signed co-operative agreements. In addition, 12 agreements for “joint ventures” are well on the way to being signed and an additional ten were to be finalised by the end of 2000.

The partnerships cover diverse branches, ranging from boat-building to furniture and mattress-making, fishing, data and environmental inspections. From both countries' point of view, the "matchmaking" programme is perceived as a success.

Furniture production in Sri Lanka: a practical approach

A NORAD-supported joint venture project in Sri Lanka provides an example of Norwegian expertise. With the benefit of advice and training in practical skills, such projects can result in considerable profits for industrial companies in both countries. Furniture is produced for local and regional markets, based on Norwegian design and experience. The project has provided job opportunities for women, reduced the local environmental impact and has had a number of other positive impacts and benefits.

It began as a joint venture between a local company and three Norwegian partners. The National Institute of Technology, Oslo, was involved from the outset and has provided advice on the project development and practical training since the establishment of the project in 1995. Since the co-operation started, productivity has tripled and the company staff has doubled to 60 employees. Other positive results include the fact that forestry workers are now better paid due to the increased value of rubber trees. The activities of the company have in addition developed a platform for 20 employees for sub-suppliers. As part of the project, NORAD has also assisted in the upgrading of the road infrastructure.

Although environmental improvements were not the main objective of the project, it has had an positive environmental impact through the more efficient use of existing forest resources.

Co-operation between Indonesia and Norway on research and technology development

As early as 1993, an Memorandum of Understanding (MoU) was signed between partner governmental organisations in Indonesia and Norway. Based on this MoU, eight maritime, environmental and aquaculture projects were initiated. However, due to a lack of financial resources on the Indonesian side, it has been difficult to sustain project co-operation between industrial partners in the two countries.

The Office of State Ministry for Research and Technology of the Republic of Indonesia and the Research Council of Norway are in the process of developing an MoU on a framework for co-operation to encourage research and technology development, transfer and diffusion. Industry project participation will be an important criterion for project identification and selection. The scope of co-operation under the agreement will probably include the following fields:

- Marine resources.
- Energy-related activities, including oil and gas technologies.
- Empowerment of SMEs.

Forms of co-operation under the agreement may include the following activities:

- Exchange of scientific and technical information.

- Advice and consultation.
- Visits and exchanges of scientific and technical personnel.
- Collaborative projects, including joint research and joint technology development.
- Training of Indonesian scientists, engineers and students in both countries with assistance from the Research Council of Norway, with the possibility of funding for postgraduate students.
- Development of partnerships with other agencies.
- Supporting the formation of strategic technology alliances between SMEs in the two countries.
- Access to and dissemination of scientific and technical literature.
- Other forms of co-operation, as mutually agreed upon by both parties.

The key elements are:

- Exchange of information.
- Training and education.
- Joint R&D projects with companies in both countries.
- Developing partnerships between SMEs in the two countries.

The role of the governmental organisations in both countries is to assist in matchmaking activities, helping to identify potential partner companies in the two countries and facilitating the development of joint projects and funding projects according to normal procedures for government-supported R&D projects.

Based on the experience gained with the first MoU, the co-operation project will begin with an exchange of visits between scientists from the two countries, funding of postgraduate studies and institutional capacity building, thereby building a platform for future R&D co-operation between Norwegian and Indonesian firms. The Research Council of Norway and the Norwegian Agency for Development Co-operation (NORAD) will co-ordinate their financial tools with the aim of sustaining project co-operation between Norway and Indonesia.

Conclusions

The experiences gained from promoting R&D for sustainable development can be summarised in the following key elements:

- Focused programmes on environmental improvements are important for the development of tools and instruments, in addition to solving specific environmental problems.

- Integration of environmental considerations in other industry-related R&D projects is a key strategy.

- Partnerships between different governmental authorities (Environment, Transport, Industry, Agriculture) and the private sector (business associations) are crucial for ensuring demand-driven R&D activities.

In addition, especially for developing countries, there is a need for:

- Capacity building: an enabling framework (regulatory system in place as well as a institutional framework) for developing demand for ESTs.

- Training/human resource development: in order to ensure the adoption of sound management practices at plant level.

- Establishing centres of excellence: National Cleaner Production Centres are a good illustration.

- Financing facilities with a specific focus on viable SMEs.

- Ensuring synergistic effects between bilateral and multilateral sponsored programmes.

PART VI

PARALLEL SESSION 1

ENERGY AND SUSTAINABLE DEVELOPMENT

Chaired by Hanns-Joachim Neef
International Energy Agency

Chapter 16

THE CLIMATE TECHNOLOGY IMPLEMENTATION PLAN IN THE SOUTH AFRICAN DEVELOPMENT COMMUNITY AND THE TECHNOLOGY CO-OPERATION AGREEMENT PILOT PROJECT IN THE REPUBLIC OF KOREA

by

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Introduction

The Technology Co-operation Agreement Pilot Project (TCAPP) and the Climate Technology Implementation Plan (CTIP), supported by the Climate Technology Initiative (CTI),[1] are considered to be two of the most successful pilot programmes for technology transfer in support of the United Nations Framework Convention on Climate Change (UNFCCC). This chapter presents a brief history of the origins of both programmes, and an example of how each is being used to transfer requested technologies. CTIP use in the Southern African Development Community (SADC) will be addressed, and TCAPP implementation in the Republic of Korea will be discussed.

The US Government launched TCAPP in 1997 to provide a model of a country-driven and market-relevant approach to technology transfer implementation under the UNFCCC. TCAPP is currently assisting Brazil, China, Egypt, Kazakhstan, Mexico, Philippines and Korea in implementing actions to attract investment in clean energy technologies that will meet their sustainable development goals, while reducing greenhouse gas emissions. The international business and donor communities are actively engaged in the implementation of these clean energy technology actions in the countries. On behalf of CTI, the National Renewable Energy Laboratory (NREL) is also assisting 14 countries in the Southern African Development Community with the development and implementation of a clean energy technology investment plan. This CTI work is referred to as support for Co-operative Technology Implementation Plans (CTIP) and builds on the TCAPP approach, applying this framework at a multilateral scale with active participation of numerous OECD countries through CTI.

TCAPP combines four major activities to help countries accelerate implementation and investment of their clean energy technology priorities. As depicted in Figure 1, these activities include:

1. The Climate Technology Initiative (CTI) was launched at the First Conference of the Parties to the United Nations Framework Convention on Climate Change (UNFCCC). CTI is a multilateral initiative of 23 IEA/OECD countries and the European Commission to promote the objectives of the UNFCCC by fostering international co-operation for accelerated development and diffusion of climate-friendly technologies and practices for all activities and greenhouse gases.

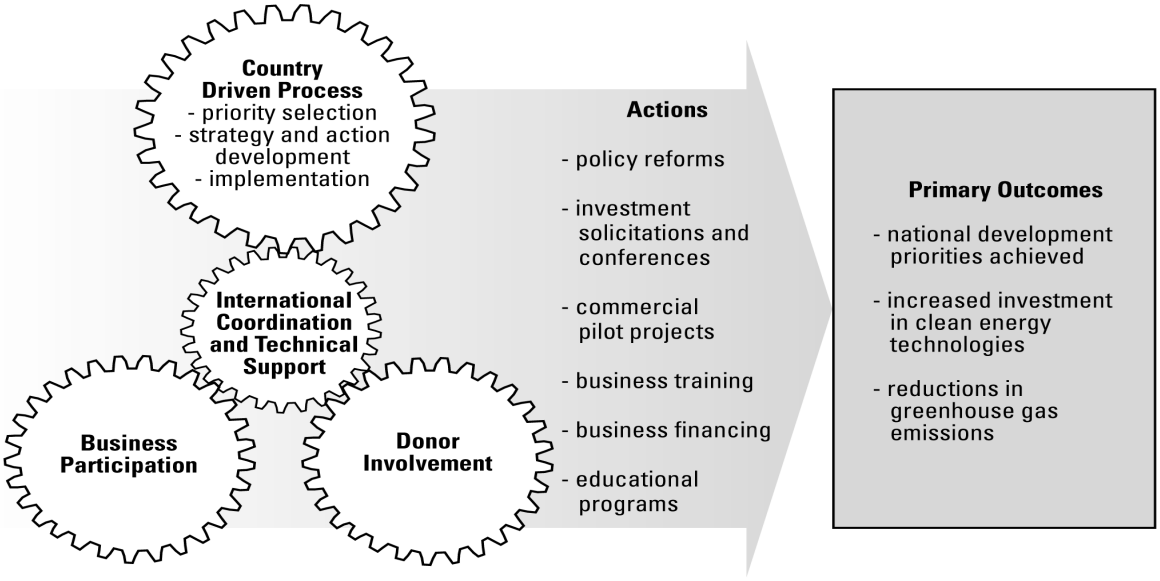
- A country-driven process for selecting priority technologies and for designing and implementing actions to overcome barriers to investment and deployment of these technologies.

- Active in-country and international business and investor participation in the design and implementation of these actions to ensure that they will be effective at catalysing sustained private investment in the priority technologies.

- Bilateral and multilateral donor participation to secure ongoing donor support for actions that require further donor funding and to promote effective integration with current donor programme.

- International technical support to assist countries with the design and implementation of their actions and to effectively link the work of the country teams with the business and donor community.

Figure 1. **The Technology Co-operation Agreement Pilot Project**



The TCAPP and related CTIP work in Southern Africa have made considerable progress in removing market barriers and increasing implementation and investment in the clean energy technology priorities of the participating countries. TCAPP and CTIP have also become leading models for implementation of technology transfer under the UNFCCC. Highlights of TCAPP and CTIP results to date include:

- Implementation of more than 20 actions to remove clean energy market barriers and build technology and business capacity in the participating countries. These actions included renewable energy policy reforms in the Philippines, development of an industrial Energy Service Company (ESCO) pilot programme in Mexico, a sugar mill co-generation financing workshop in Brazil, energy auditing training in Korea, development of refinery energy efficiency pilot projects in Egypt, and many other similar activities.

- Facilitation of the development of 13 new clean energy business investment projects in the participating countries and initiation of work on over ten additional prospective projects. If these projects are fully implemented, they will result in up to USD 100 million of new investment in the clean energy technology priorities of the participating countries and reductions in GHG emission of up to 200 000 tons of carbon/year and around 4.0 million tons of carbon over the lifetime of the projects.

- TCAPP and related CTIP work in Southern Africa have become a leading international model for technology transfer implementation under Article 4.5 of the UNFCCC. The participating countries have highlighted the value of the TCAPP and CTIP approach at side events at the climate change negotiations and during the UNFCCC technology transfer consultative process.

- Over 400 international business representatives participate in TCAPP, including engaging in the development of new investment projects and in business-to-business training and capacity-building activities and in providing input on the implementation of market barrier removal actions in the countries.

- More than ten bilateral and multilateral donors are engaged in TCAPP and related CTIP work in Southern Africa, and TCAPP and CTIP are helping the countries to secure ongoing support from these donors for continuing implementation of the technology actions.

Climate Technology Initiative in the Southern African Development Community

This initiative grew out of a request by ministers and other senior officials from the Southern African Development Community (SADC) attending the Climate Technology Initiative Industry Joint Seminar on Technology Diffusion in Southern Africa held on 17-18 March 1999 at Victoria Falls, Zimbabwe. The Ministers requested that CTI support an assessment of technology needs in order to identify actions for attracting investment in clean energy technologies that would promote economic development while helping avoid greenhouse gas emissions. This SADC-CTI initiative is designed to identify the clean energy technologies that have the greatest potential across the SADC region for meeting sustainable development needs while reducing greenhouse gas (GHG) emissions through accelerated private investment and to assist the SADC countries in mobilising this investment. The SADC Environment and Land Management Sector (SADC ELMS) in Maseru, Lesotho, administers this project in close collaboration with lead officials in each of the countries. The Zimbabwe-based Southern Centre for Energy and the Environment and the US National Renewable Energy Laboratory provide technical support for this effort.

Project objectives

- Identify shared priorities within SADC for attracting investment in clean energy technologies that will meet sustainable development objectives and reduce greenhouse gas emissions.

- Develop a co-operative technology implementation plan that identifies actions that SADC countries and regional institutions can undertake in partnership with international donors and the private sector to accelerate investment in these technologies.

- Assist SADC in securing international donor support and private sector participation in implementation of actions to attract private investment.

- Enhance the technical and institutional capacity of SADC countries and regional institutions to attract international investment in clean energy technologies.

Technology priorities

During a workshop in September 1999, the SADC countries established preliminary priority areas based on several criteria. The criteria considered when selecting technology areas were:

- The development benefits the technology would provide.
- The technologies' market readiness.
- The greenhouse gas (GHG) avoidance potential.
- How appropriate the technology was for the region as a whole.
- The local environmental benefits (besides GHG avoidance) the technology might offer.

The resulting priority areas are:

- Renewables.
- Electrification – where it replaces higher-carbon emitting fuel use.
- Domestic fuel switching.
- Supply-side fuel switching.
- Industrial demand efficiency.
- Residential demand efficiency.

National consultations and technology co-operation actions

Eight of the SADC countries have completed their national consultations to refine the selection of priority technologies and identify regional actions for facilitating investment in these clean energy technologies. The eight countries that have completed consultations include Botswana, Lesotho, Malawi, Mauritius, Seychelles, Swaziland, Tanzania and Zambia. During these consultations, representatives from key government agencies meet with businesses, technical experts and other stakeholders to identify the specific technologies within the six broad priority areas that will support the region's sustainable development goals while addressing the other selection criteria. Once these priority technologies are identified, the participants in the consultations then review barriers to widespread implementation of these technologies and propose actions that can be implemented across the region to overcome these barriers.

The Southern Centre for Energy and Environment has prepared a draft report synthesising the results of the consultations from the eight countries. This report identifies the following specific technologies as the highest priorities resulting from the consultations:

- Photovoltaic lighting and compact fluorescent lighting for households and commercial buildings.
- Energy-efficient electric motors and industrial boilers.
- Energy-efficient housing design.

- Solar crop drying.
- Biomass electricity co-generation.
- Natural gas technologies.

For each of these priority technologies, the report identifies a portfolio of actions (based on the consultation results) to help attract investment and overcome barriers to technology transfer. These actions include creating business networks to better link suppliers, distributors and customers, developing standards and labels, training programmes, establishing revolving loan funds, public awareness and education campaigns, and developing model independent power purchase agreements. This draft report is currently under review by the SADC countries, SADC ELMS, the Climate Technology Initiative, and international technical and investment experts. Through this review process, from three to five actions for mobilising clean energy investment across the region will be selected for implementation.

Key next steps

- Secure funding for implementation of the selected technology transfer actions (November/December 2000).
- Initiate design and implementation of high-priority technology transfer actions (December/January 2000).
- Establish regional and international business network to support design and implementation of the actions (December 2000/January 2001).

Technology Co-operative Agreement Pilot Project in Korea

The Republic of Korea joined TCAPP in January 1999, with TCAPP work led by the Ministry of Commerce, Industry, and Energy (MOCIE) and the Korean Energy Management Corporation. Since that date, Korea has made outstanding progress in implementing actions to accelerate investment in three priority areas: energy management, methane recovery, and heat recovery using heat pumps. Energy management is the highest priority for TCAPP work in Korea. In this area, a energy efficiency upgrade investment project is under development with Korean and US business partners and training activities have been completed. Landfill methane and waste-heat recovery projects and technical assistance activities are also under development.

The Korean TCAPP team

The Ministry of Commerce, Industry and Energy (MOCIE) of Korea chairs a TCAPP steering committee and has designated the Korea Energy Management Corporation (KEMCO) to lead the implementation of technical TCAPP activities for Korea.

Priority selection

The Korean team held a scoping meeting in March 1999 to select priority technologies for climate change technology co-operation. In addition to greenhouse gas mitigation potential and energy development benefits, four additional criteria were used in selecting priority technologies:

- The technology must hold near-term market potential.
- Successful widespread implementation of the technology requires intervention by public institutions to overcome market barriers.
- There is a need for demonstrating new technologies or energy management systems to open up new markets for advanced technologies.
- Soft technologies (*e.g.* energy management systems and other tools for use of advanced technologies) should be given consideration along with hardware.

Based on these criteria, three priority technologies were selected:

- Energy management (know-how in energy management, advanced energy auditing and ESCOs, etc.).
- Methane recovery from organic waste.
- Waste energy recovery using heat pumps.

Strategy and action developments

Energy management

The energy management and auditing concepts pursued under TCAPP are working to increase the knowledge of Korean industry, ESCOs and government agencies involved with energy auditing. The concept includes both training by international experts and involvement with joint projects pursued by Korean and international ESCOs. This concept is the first priority for TCAPP Korea. The other technologies will be pursued as part of this concept, or as time and resources permit.

Actions are also underway to improve the Korean ESCOs' ability to install energy-saving projects by removing barriers to investment. Another major initiative that is part of this concept is encouraging international ESCOs to partner with Korean ESCOs in the pursuit of energy-saving projects. The partnering process is aimed at improving local ESCOs' ability to install projects, as well as developing international dialogue between ESCOs from Korea and other countries related to the implementation of energy saving projects.

Training

To meet the goals of TCAPP in Korea, training sessions have been held to teach energy auditing techniques and considerations. The first of these courses was an advanced auditing class conducted in January 2000. The course addressed topics such as risk analysis and compilation of findings. The aim

of the second course was to move beyond the simple gathering of data to sophisticated analysis and use of the information.

The class was designed to build on the basic information presented in a class given in the fall of 1999. The Asian Economic Programme (AEP) arranged the first class. It covered the essential elements of an audit and demonstrated how to use such an audit in implementing energy efficiency projects.

US experts in the field of energy auditing taught both of these courses, in Korea. Arrangements for the training and advertisements for the courses were co-ordinated by the Korean Energy Management Company (KEMCO). The Korean Association of Energy Service Companies (KAESCO) was also instrumental in announcing the events to its members.

Certification

The KAESCO, in conjunction with KEMCO, is working to develop a certification programme to provide a measure of expertise to the energy service industry. A system of training and testing is envisioned to give energy engineers an opportunity to gain the knowledge they need. The testing and certification will provide a standard against which to measure the knowledge of energy professionals. The US Association of Energy Engineers is expected to provide some assistance, based on their system of certification of energy engineers.

Pilot projects

The initial joint project of the energy management concept is in its initial stages. Hyundai Motors' Ulsan manufacturing complex has agreed to participate as the initial pilot project. The preliminary site survey was planned for late September 2000. It was anticipated that a decision regarding the feasibility of the project would be made by the end of November. If the feasibility study finds a likely project, installation of energy conservation measures is forecast for the summer of 2001.

A series of meetings were held in January 2000 between US and Korean companies interested in partnering on future energy efficiency projects. KEMCO and NREL facilitated these discussions. KEMCO and NREL continued to facilitate communication between interested companies through July 2000. At this time, Sempra Energy Services of the United States and EPS Korea decided to proceed to the next step, a joint audit of the Hyundai facility at Ulsan. The audit was conducted during the fourth week of September 2000.

The audit required the joint efforts of Hyundai, EPS Korea, Sempra Energy Service and KEMCO. Engineers from Sempra spent a week with auditors from EPS Korea and KEMCO at the site. The entire team developed priorities for auditing the plant based on the greatest potential for savings. The Sempra team has developed an initial proposal, based on information already received about the plant, information gathered during the week in Ulsan, and other data received from Hyundai. That proposal is now being evaluated in Korea.

During the onsite visit at the plant, as well as during development of the initial proposal, the parties involved began refining the roles each will play in implementation of the project. These roles are being developed based on the capabilities of the parties and requirements of the project. Developing these roles is essential to successful project implementation and is one of the most challenging aspects of this type of international undertaking.

It is envisioned that the majority of the technical support of the contract will be co-ordinated by the Sempra-EPS Korea-Hyundai team. KEMCO's role, in addition to supplying expertise during the initial audit, will include a review of the proposal, barrier reduction and financing assistance. NREL will continue its support through facilitation of communications between the parties, review of the proposal, and assistance with performance contracting questions as needed.

NREL and KEMCO will also use this pilot project to develop a model for further joint projects in Korea. It is expected that the model developed during this project will be used to implement several other projects. These projects will be used to improve the capabilities of other Korean ESCOs and make energy-saving projects easier to put in place.

Methane gas

The goal of this concept is to capture the methane gas produced from various industrial and commercial operations. It aims to directly reduce the amount of hydrocarbons released into the atmosphere, while offsetting the use of petroleum-based fuels. The concept is being pursued through a combination of outreach and direct project assistance as in the energy management concept.

Outreach

In this concept, the US Environmental Protection Agency's (EPA) methane outreach team will present one or more seminars to the management of possible user sites. This audience is made up of national government agency officials, municipal government officials and industrial officials.

The first outreach visit is tentatively scheduled for March 2001. The trip will be co-ordinated by KEMCO. The session will showcase successful projects that are operating in the United States. The EPA team will answer questions on the successful implementation of projects. They will also address common obstacles to successful implementation of methane-recovery projects, and how they have been overcome in the United States and other countries.

Pilot project

Direct project assistance is being pursued by pairing up Korean firms interested in pursuing methane-recovery projects with international firms which have expertise in this area. It is anticipated that these partnerships will help native Korean firms develop expertise in this area, while initiating international dialogue on these kinds of projects.

A pilot project for this concept has been identified near the city of Ulsan. A large landfill there is in close proximity to a major industrial campus. The tentative project envisions purification of the landfill gas and use of the methane for typical natural gas applications in the industrial park.

SK Corporation of Korea has tentatively agreed to pursue the project under the TCAPP programme. Duke Engineering of the United States has initially agreed to investigate the project as the US partner. Initial communications between the two possible partners and other partners in Korea and the United States are taking place.

An initial scoping of the project and further testing of the site was expected in late 2000. An initial joint meeting of the partners that may be involved with the project, as well as a site visit to the landfill and industrial park was also expected in late 2000.

KEMCO and NREL will co-ordinate these visits, as well as securing additional technical expertise if needed. They will also work together to identify barriers to successful project completion and solutions to these problems.

Funding for the project is as yet an unanswered question. Financing a third party and repayment from the sales of the gas is one approach to funding this project. It may be possible for this project for the installing companies to finance the project independently. This is one of the questions to be answered during negotiations between the partners involved with the project.

Recovery of waste heat using heat pumps

The goal of this concept is to increase the acceptance of this technology in projects in Korea. To do this, it has been determined that the quality of heat pumps must be improved, the cost decreased and the advantages of heat pumps must be better publicised.

This concept is being pursued by seeking opportunities for use within the energy management projects, as well as in stand-alone projects to showcase the technology. The concept will make use of internationally manufactured heat pumps, and seek out opportunities to develop Korean/international partnerships between hardware manufacturers.

The ESCOs involved in the Hyundai project will look for opportunities to use heat pumps to recover waste heat in that project. At the same time, KEMCO has identified a government agency, the Korean District Heating Corporation, that is trying to showcase combined heat and power technologies. This agency is developing a plan and searching for a pilot site to showcase the technology.

KEMCO and NREL are currently looking for Korean and US companies interested in working together on a pilot project to demonstrate this technology. The Business Council for Sustainable Environment is assisting in the search for an international partner.

The goal of this concept, as with the other projects described above, is not to simply implement pilot projects. The idea with these projects is to overcome barriers for successful implementation of the projects, and to develop models that can be applied to similar projects. In this way, technologies and techniques for energy savings will become better understood and more projects will be initiated.

Key next steps

- *Improve the capabilities of energy service companies*: KEMCO, Hyundai, EPS Korea and NREL will evaluate the initial proposal for the Hyundai project. Solidification of the project team roles and responsibilities, as well as finalising the scope of the Hyundai project.

- *Capture and reuse of methane gas from waste:* Determine roles and responsibilities of participants, KEMCO, Duke, SK Corp., and others. Outreach by the US EPA methane gas outreach programme to inform municipal leaders about this type of project. Initial survey of the project, finalisation of the scope of the project, determining financing type and source, and finalising team responsibilities.

- *Heat pumps:* Identify building site for possible heat pump project – Korean District Heating Corporation, KEMCO and NREL. Other key steps include identification of an international

partner for the project, determining the roles of the various participants, and determining the type and source of funding for the project.

- *TCAPP:* Identifying the key lessons learned in pursuing each concept pilot project, and modelling an approach for duplicating successful technology transfer in other projects.

Conclusions

TCAPP and CTIP have become leading models for implementation of technology transfer under the UNFCCC. They are effective because they depend on the host country playing a pivotal role in the identification and prioritisation of the technologies pursued.

The reliance on the role of private industry is another key to the success of the programme. This provides opportunities for companies from developed as well as developing countries and is the primary motivation for involvement of companies from both countries. While a tremendous strength, the negotiation of protections for the private industries from each country involved in the project is also sometimes one of the most sensitive aspects of project completion.

Participation of the government stakeholders in each project is important in uncovering barriers to successful project implementation, and successful technology transfer in all areas. The government's role is also critical in overcoming barriers as they are identified.

International donors play a critical role in funding support for the facilitation and successful implementation of projects. In many cases, one of the key barriers to successful project implementation is securing or augmenting available funding. Donors are critical in filling these voids.

Supplying the required technical support is also a critical role for international donors. This support is vital in providing an honest broker to assist in the evaluation of the advisability of these projects. International experts provide essential back up to the in-country experts who are entrusted with oversight of the projects.

The final key aspect of TCAPP and CTI which makes them effective technology transfer mechanisms is that the pilot projects pursued under the programmes are not the goal or objective of the programme. Instead they are tools for developing models which will be replicated many times within that country and other countries to ensure effective transfer of clean energy technologies through out the developing world.

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Chapter 17

PROMOTING INTERNATIONAL COLLABORATION IN R&D IN ENERGY TECHNOLOGIES: HOW POLICIES CAN PLAY A CATALYTIC ROLE

by

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Introduction

Energy use is closely linked to societal development. During the last quarter of this century, energy use has also been associated with adverse environmental impacts. Fossil-fuel use and its resulting emission of carbon dioxide, a major greenhouse gas (GHG), has resulted in an increased concentration of CO_2 in the Earth's atmosphere. At the dawn of the third Millennium, the global community has woken up to the inescapable fact that today's energy patterns cannot be sustained into the long-term future.

Future patterns of energy use and energy resources in the developed and developing countries will define the path of sustainable development. The global environmental issues that have arisen in the past decade are challenging the ways in which we produce, distribute and use energy. In the coming years, environmental concerns – and specifically climate change – will significantly affect patterns of energy use around the world. The threat of global warming is no longer a distant prediction but is now on our doorstep. Frequently overlooked in the global warming debate are the other negative impacts of energy use, such as the health-related consequences of air pollution. Such impacts are most severely felt in the developing countries due to the continued use of outdated fossil-fuel-burning technologies. Urbanisation is growing at a speed that can no longer sustain the growth in energy use and the absence of corrective measures due to lack of energy resources. The vicious circle of increased fossil-fuel use leading to rapid development, air pollution, health impacts and poverty has emerged as the most formidable barrier to achieving sustainable development in industrialising countries.

Today, the drive to enhance energy efficiency has become a major tool in the developed and developing economies' struggle to protect the environment. However, renewable energy remains a challenge that needs to be squarely met if the concept of sustainable development is to become reality.

Business as usual

GDP growth and the corresponding increase in energy demand are directly related. Any developmental process over the next 50 years will therefore lead to a surge in energy use. The next two decades are expected to see an increase in primary energy demand of more than 50%.

Maintaining current patterns of usage in a "business as usual" scenario will result in a proportionate increase in fossil-fuel use and its associated global and local environmental hazards. In fact, forecasts show that, even with the planned shifts to co-generation and the efforts to use renewables, the share of oil will increase from 35% to 40%, that of gas from 20% to 25%, and that of renewables from 0.4% to 0.8%. Hydroelectric will remain stable at 2.5%, while the share of nuclear power will fall from 7% to 5%.

So, what is needed? The situation calls for a paradigm shift in development aid to the energy sector. Aid should be targeted to supporting technological innovation rather than following the traditional pattern of supporting conventional energy technologies. The need to adapt new and conventional technologies to local conditions should be explicitly recognised as an integral part of this paradigm shift, and the costs of doing so should be incorporated as a prerequisite to the successful support of sustainable renewable energy sector development. At the institutional level, the centralised energy model is becoming increasingly obsolete and renewable sources are, in fact, more suitable to the new decentralised trends. UNEP experience shows that promoting and redirecting funding towards renewable energy and building the local capacity required to manage it are crucial to the realisation of this new paradigm. Policy intervention to promote R&D and create enabling conditions through co-operation will encourage good practices in energy management.

Options

Some of the options for shifting away from fossil fuels include:

- Improving energy efficiency.
- Expanding use of renewable energy sources – solar, wind, biomass, geothermal and hydro.
- Reducing dependence on energy through the adoption of not-in-kind and reduced-energy-intensity processes.

Sinks are considered to present a viable option to the continued use of fossil fuels. However, sinks are in fact end-of-the pipe solutions – and in any case, do not avoid local pollution.

Recently, efforts to improve energy efficiency have increased significantly in both developed and developing countries. Such efforts were undertaken on a massive scale in the wake of the 1973 oil crisis. However, efficiency improvements, like thermodynamics, have limitations. Hence, a paradigm shifts is necessary to develop and commercialise the use of renewables in the medium term, and reduce reliance on energy in the long term. These are the options to aim for.

Need for paradigm shift

Such paradigm shifts call for a high level of investment. To continue to fulfil the world's energy requirements, even under a "business as usual" scenario, would require an investment of USD 15 trillion over the next 30 years, *i.e.* USD 0.5 trillion every year. Of this amount, USD 10 trillion are required in the developing countries, *i.e.* some USD 300 billion a year. If we compare this to the total current FDI flow of USD 100 billion per year (excluding FDI for portfolio investments), the gap between demand and supply becomes evident. However, it should be borne in mind that developing and commercialising renewable sources would in fact require much higher investments than stated above.

The mobilisation of domestic savings in developing countries, together with massive financial transfers from developed to developing countries, would appear to be the only options for financing the shift away from fossil fuels. Aid agencies could also make a significant contribution to the implementation of technological "leap-frogging" by changing their practices to support the adoption of advanced technologies and by assuming some of the risk associated with cutting-edge investments in renewable and related R&D.

Financing capital investments in cleaner energy and investing in R&D for renewables needs to be encouraged. The record for OECD countries in R&D investment has been dismal. R&D funding for the energy sector has been decreasing over the last 20 years; consequently, innovations in the energy sector have been very minor and have not contributed to rapid commercialisation or reductions in the cost of production of renewables.

The UNEP Energy Programme

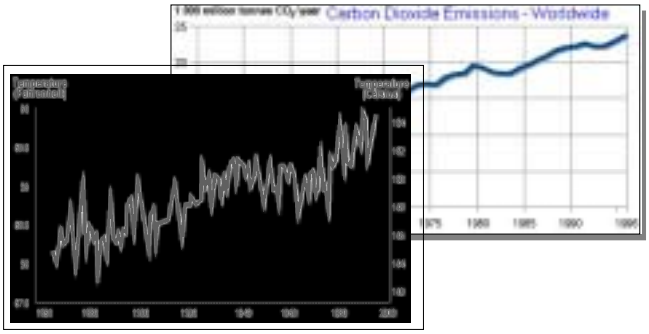
The UNEP Energy Programme focuses on promoting and redirecting commercial investments towards cleaner energy. Providing targeted advisory services to financial institutions in order to encourage investments in renewable energy technologies, and promoting seed-capital schemes for small enterprises to set up a rural renewable energy business, are just some of the small, but pivotal, schemes undertaken by UNEP's Division of Technology, Industry and Economics. SEAF (Sustainable Energy Advisory Facility), and ARREED (African Rural Renewable Energy Enterprise Development) are two projects which are expected to catalyse policy making towards financing renewable energy.

Promoting policies for collaboration and networking

Large-scale penetration of renewable technology is possible only if the political will exists to promote the massive financing of R&D. Scales of economy push prices down to affordable levels. However, such price decreases have limitations; innovations in technologies must go hand-in-hand with increased scale of production. R&D collaboration between the private and public sectors, among research institutes and between developed and developing countries will spark innovations. Investments in R&D are crucial to unleashing the renewable energy potential. Policies that promote R&D networks and collaboration among institutions may also help to bring down time and cost constraints.

Energy and Environment

Climate Change: Global Impact



▼ **Problem: CO_2 and other Greenhouse Gases (GHG)**

Energy and Environment

Air Pollution: Local and Regional Impact



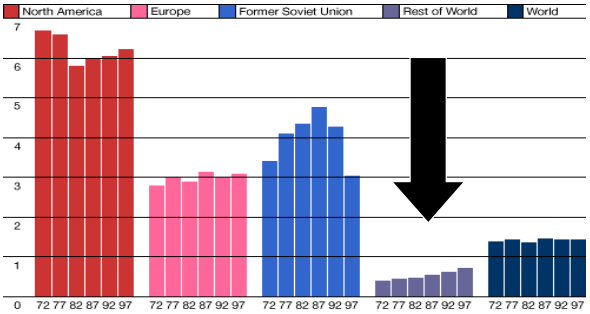
▼ Problems: Lead, carbon monoxide, smog, particulates

The Energy Poverty Link

- **Energy is also essential for health clinics, schools and community services.**
- **The poor spend 10-12% of income on energy, the rich 2%; the rich get the bulk of the subsidies.**
- **Huge time savings and health benefits for women and children after introduction of electricity and better cooking fuels.**
- **2 billion people need modern energy sources and communication options (in Africa, 90% have no electricity).**

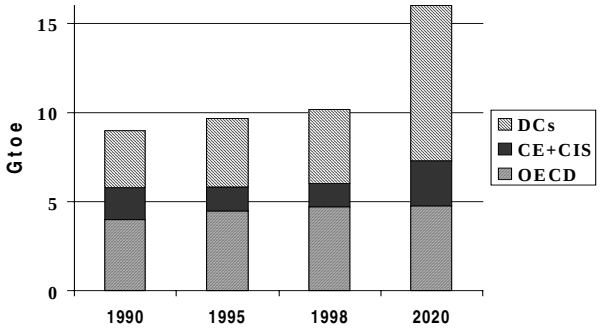
Per Capita Energy Consumption Disparities

Tons of Oil Equivalent



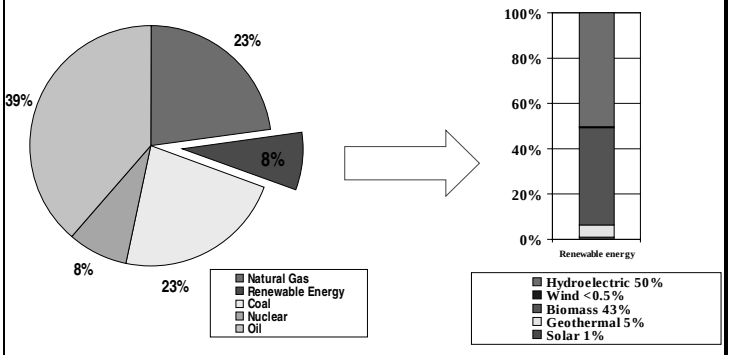
Primary Energy Demand Projection

(in Gtoe)



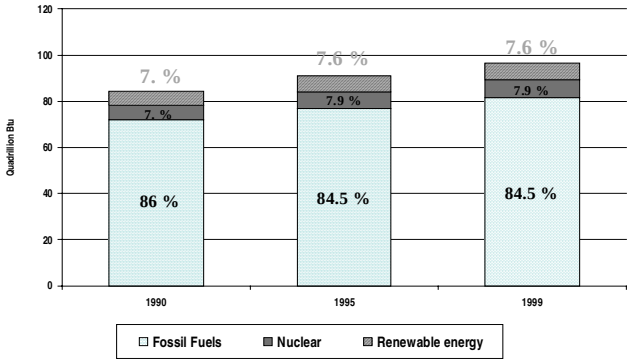
Energy Consumption 1998 - USA

(in % by source)



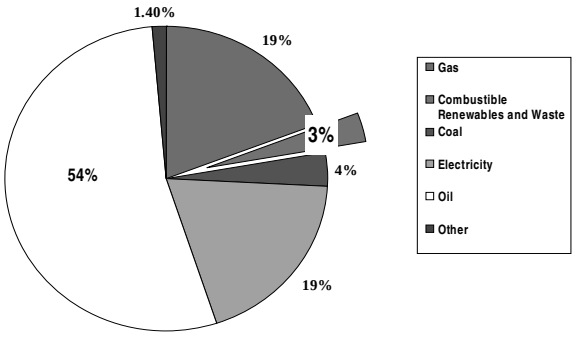
Share of Renewable Energy Consumption - USA

(in %)



OECD Energy Consumption by Source - 1998

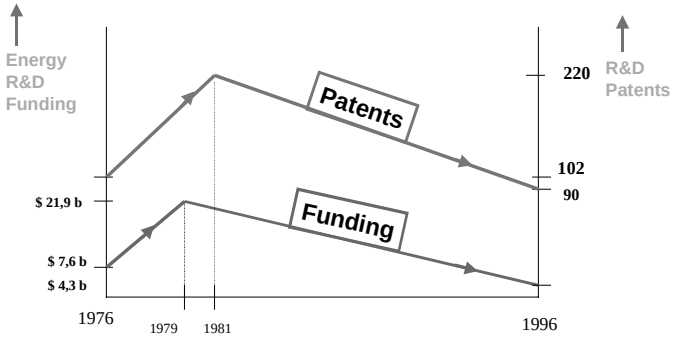
(in %)



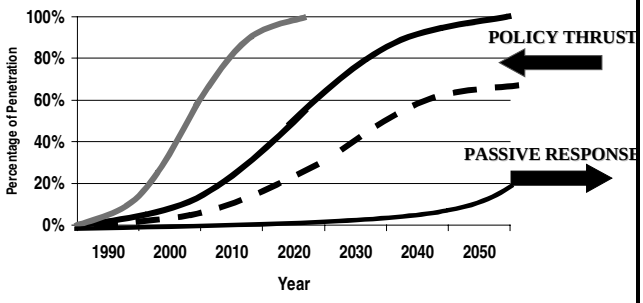
Other: Geothermal, Solar, Wind, Heat…etc

ENERGY R&D FUNDING AND PATENTS

Response to Soft Targets - USA Scenario



Technology Penetration and Policy Interventions



UNEP's Energy Programme: STRATEGY

- Leap-frog carbon intensive technologies
  - * Cleaner and renewables
  - * R&D collaboration
- Identify and Enable overcoming of the barriers
  - * Providing Good-practices and policy guidance
  - * Encouraging Voluntary Initiative
  - * Capacity building for small entrepreneurs
  - * Supporting Energy Start-Up
  - * Financing of low-carbon and non-carbon technologies

UNEP's Energy Programme

- ARRED
  - - 16 Projects with local Agencies
  - - Seed Financing tied up with DBSA
- SEAF
  - - Initiated with Botswana, Mali Ghana and Jamaica
- RET/EE - IAF
  - - Mainstreaming of RET/EE in 6 investment proposals
  - - 2 proposals funding through investment banks in Guatemala and Tanzania
  - - 1 proposal to promote carbon mitigation

Financing Energy and Sustainable Development

- ***UNEP's Emphasize :***

  huge capital investments will be required in the coming decades to offer even modest modern energy services to the worlds' poor.

- ***UNEP's energy sector response...***

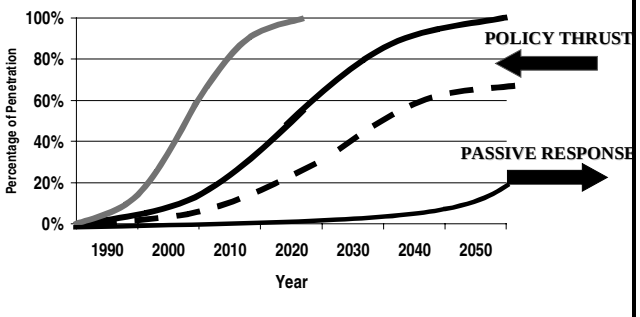
  places new emphasis on the finance sector, helping it respond to opportunities for financing a cleaner energy future.

The Transition in the Global Energy Industry

From: Monolithic provider of "Public Service" under social & environmental constraints

To: Clean, decentralized, customer-oriented service businesses in new market niches

Technology Penetration and Policy Interventions



Chapter 18

CLIMATE TECHNOLOGIES: OPPORTUNITIES FOR LEAP-FROGGING IN DEVELOPING COUNTRIES

by

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Federal Environmental Agency, Berlin

Introduction

Developing a sustainable energy future means that today's generation has to use energy in such a way that future generations will be able to meet their needs. This is obviously a very difficult goal to attain, but it is definitely feasible. In this chapter, I will provide some strategic hints for sustainable energy development derived from German experience with climate protection.

Climate protection is the key challenge for sustainable development

The generation of today's fossil energy resources began some 500 million years ago. The first man, *homo erectus*, lived about 1.5 million years ago. During the first half of man's existence, the only source of energy was metabolic energy, as is the case for all other creatures. In an overall historical context, man only recently started using mechanical energy supports such as ox ploughs, energy slaves, water and windmills. And just a blink of an eye ago, he began to use power plants and motor engines. And just think how completely dependent we are on energy today!

On the other hand, the environmental impacts caused by energy consumption have a short, but extremely violent history – smog fatalities in the London of 50 years ago, damage caused by acidification 25 years ago, the Chernobyl disaster 14 years ago, the greenhouse effect, etc. Compared to 500 million years of energy history, the collapse of the natural fundaments of man is occurring explosively – an explosion of mainly energy-related impacts on the biosphere.

The greenhouse effect threatens the very heart of our existence. The global mean temperature today is 0.5°C higher than it was in 1860. If you look at the ten warmest years of the last century, eight have occurred within the last decade. With the year 2000, this development seems to be continuing. The sea level rose by 10-25 cm during the last century. Coral reefs – the tropical forests of the oceans – may not withstand the temperature rise of the oceans, thus perhaps endangering the stability of equatorial coast lines.

In 1998, the Larsen and Wilkins ice layers in the Antarctic lost an area of 3.000 km². In one year, this represents about half the total loss which occurred during the 50 preceding years. In Greenland, the permafrost is shrinking by 3 km³ every year. In another 30 years or so, the North Pole could be bare of ice. At about the same time, the Himalayas, the world's largest mountain range could see its glaciers melt. During a long heat wave in the American Midwest in 1995, 700 people died from heat stress. In 1999, El Niño affected Australia and the wheat harvest decreased from the usual 24 million tonnes to just 16 million tonnes. In February 1998, in a space of just 48 hours, seven tornadoes killed 42 people and destroyed 1 710 houses in the US town of Kissimmee. In 1998 alone, weather-related natural disasters caused USD 90 billion worth of global damage, *i.e.* far more than total losses during the 1980s.

The conclusion of third assessment report of the IPCC (Intergovernmental Panel on Climate Change), that "the balance of evidence suggests a discernible human influence on global climate" seems to be reasonably founded. In a thorough statistical study, the University of Frankfurt has proved that there is close statistical correlation between the increase in the emissions of greenhouse gases and worldwide climate change – and the greenhouse emissions of today will affect the global climate for the next 100 years or so.

The potentially catastrophic consequences of climate change warrants the urgent attention of all the countries of the world. After all, climate change is not a local or regional issue, but truly a global issue – we are all in this together and we are all contributing to the increased concentration of greenhouse gases.

In recognition of the importance of climate protection, more than 160 countries met in Rio de Janeiro, Brazil, in 1992, to formulate and sign the United Nations Framework Convention on Climate Change (UNFCCC). This landmark agreement established a process under which all countries are working towards reducing the concentration of human-produced (anthropogenic) greenhouse gases to levels consistent with the principle of sustainable development. Parallel to this OECD Conference in Seoul, in the Hague the 6th Conference of the Parties is discussing policies and measures for global climate protection. Taking global action for climate protection is not easy, it affects national economies and interests. Therefore all nations – all mankind – should not take slow progress in this UNFCCC process as an excuse for continuing with business as usual. We are all responsible for ensuring that appropriate actions are taken in our countries and for co-operation for sustainable development. Science and technology are important and promising spheres of co-operation for improved energy efficiency, for renewable energies, for mitigating climate change, etc.

Climate protection in Germany

Ten years ago, Germany was reunified, after being divided into two for more than 40 years; there was a wall between the two parts of Berlin, my home town, and an "iron fence" all around the German Democratic Republic. Our experience in Germany shows that the conditions for activities aimed at enhancing energy efficiency are generally favourable throughout the world. Over the last ten years, CO_2 emissions in East Germany have decreased by more than 50% while the standard of living has increased remarkably. The development of East Germany is *the* success story in terms of energy efficiency and climate protection. All countries have the same opportunities for achieving success in sustainable development, although the starting conditions are often very different. Changes in the prices of fuels and energy are beginning to make the population aware that energy is a scarce resource. Well-educated technicians and engineers easily can detect losses of energy in existing processes and can recommend and put in place best practice efficiency technologies. However, there are obstacles – non-existent or inappropriate market structures, strong resistance by those who stand to lose from the

changes, inadequate structures for decision making, and insufficient capacities for research, scientific and technological co-operation, education and training courses. In Germany, we have already tackled some of the obstacles to sustainable development, but we still have a long way to go.

Germany is a densely populated, highly industrialised country. Environmental problems rank high in the public conscience. There is strong popular support for the phasing out of nuclear energy. Having achieved remarkable success in reducing pollutant concentration in cities and acidic emissions from power plants in the 1970s, public interest in environmental problems concentrated on climate change in the early 1980s. The Federal Ministry for Environmental Protection was founded in the wake of the Chernobyl disaster. At the same time, the *Bundestag*, the German National Parliament, entrusted an Enquête Commission to study the state of art of climate change and identify policies and measures for climate protection. The Enquête Commission worked very successfully and made intensive use of the media. Ten years ago – in 1989, before the wall fell – the German Government decided to reduce CO_2 emissions in West Germany by 25% between 1990 and 2005. This target was confirmed by the new "red-green" government in late 1998 and by a new climate protection programme implemented in summer 2000. A long-range target has not yet been adopted by the German Government, although the Enquête Commission is targeting an 80% reduction in CO_2 emissions for all industrialised countries by the middle of the next century.

So, the target for action is set. But, how to act? The conditions for climate protection are different in each country; nevertheless, there are important elements for climate protection strategies that apply to many countries:

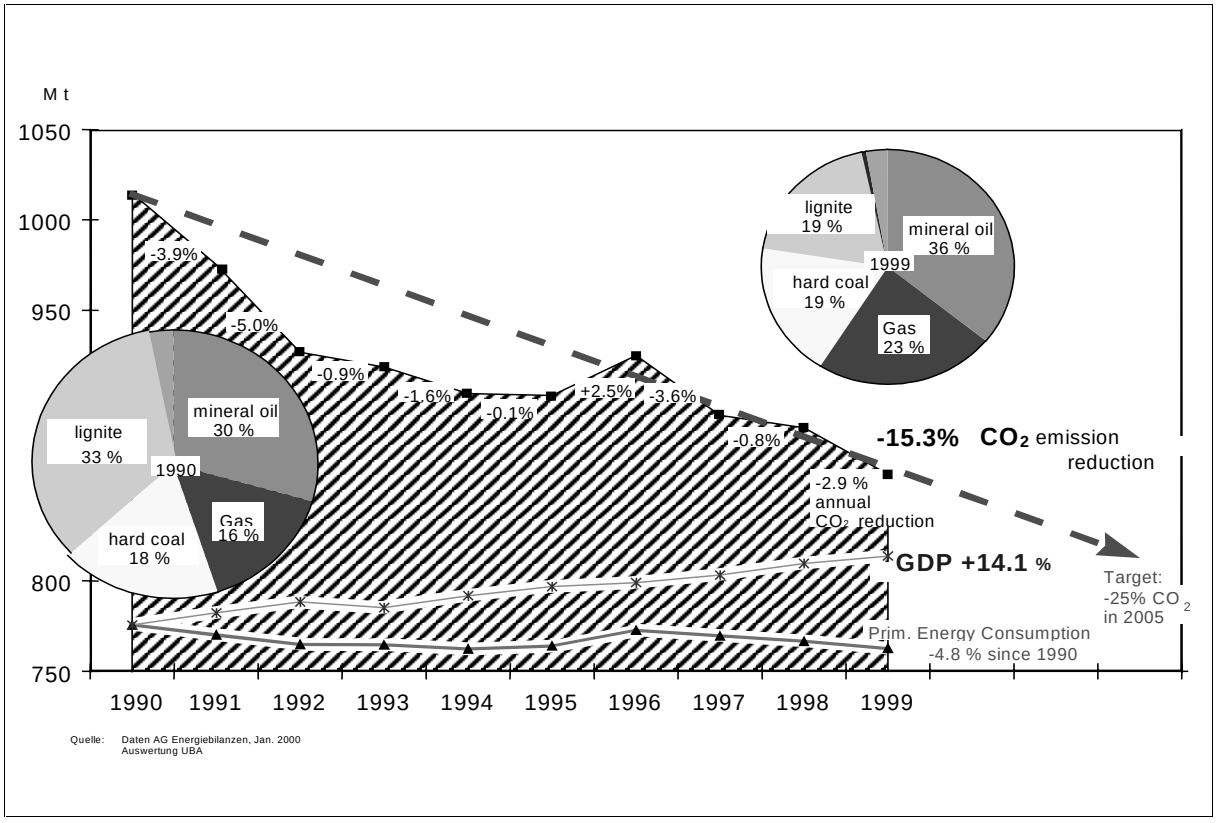
- It is important to raise public interest.
- It is necessary to set national emission reduction targets.
- Cross-institutional committees and institutions are very useful.
- Reducing emissions is a continuous, step-by-step process, not a do-it-once-and-then-forget-about-it policy.
- Government, provinces, enterprises, municipalities and consumers – all need to act.
- Decentralisation is one of the principles of sustainable development; and this is valid for climate protection, too. A national government can decide the frameworks, but everyday actions need to be decentralised.
- It is not sufficient to take one or a number of measures in isolation, an overall policy approach is called for, to be implemented step by step.
- Price/market structures and controlled liberalisation are important and useful framework conditions.
- Voluntary commitments by industry, single enterprises, municipalities and governments worked well for Germany.

- Many small potentials add up to a big potential, *i.e.* the stand-by losses from TV appliances in Germany are equal to the electricity produced by a large atomic power station.

- Education, research, training, capacity building, campaigns, awareness raising, scientific and technological co-operation by industry, administrations and research institutions, and many other "soft" measures, all play a crucial role.

- Last but not least, climate protection is a win-win-strategy as many policies and measures simultaneously have positive effects on the national economy and social benefits, especially on employment. Or, to put it plainly: each kilowatt-hour saved pays you back and saves your money!

Figure 1. **$C0_2$ emissions in Germany**



Source: Daten AG Energiebilanzen, Auswertung UBA, January 2000.

Many of these strategic elements were applied in Germany and emissions reduction followed the target line overall. Energy sources have changed from carbon-intensive lignite to more gas and oil. While consumption of primary energy decreased by 4.8% and CO_2 emissions fell by 15.3%, gross domestic product grew by 14.1% – clear proof that climate protection is a win-win-strategy.

It is often argued that the success of the programme was not due to the strategy but was the result of German reunification – just a wall-fall profit, with no effort involved. This argument does not take account of the special problems and above-mentioned strategic elements of sustainable development.

Climate protection can only partly be ordered by government and by law. It must be based on the activities of many players and decision makers in society: the national parliament and government, provinces, municipalities, industry, all kinds of organisations, each end-consumer. We call it a multi-player, multi-measure strategy of climate protection. It is true that CO_2 emissions in East Germany decreased by more than 50%, while they remained stable in West Germany. It is also true that emissions reduction in East Germany is not the result of climate protection policies alone. It is the result of common sense and common action, the result of industrial investments, of government funding and of law. Altogether, it is a success story of energy efficiency that could be repeated in many other countries.

Technologies for a sustainable energy future

For today's German Government, nuclear energy is not a sustainable energy technology. The "zero CO_2 emissions" produced by the nuclear energy system are often highlighted, with many protagonists claiming that nuclear energy is indispensable. On the contrary, nuclear energy does not conform to the four principles of sustainable development:

- Uranium is a finite geological energy carrier that is basically incapable of regeneration. Although resources can be stretched by using plutonium-uranium mixed-oxide fuel rods (MOX), and even more by breeder technology, reserves will last only a couple of hundred years if current energy consumption levels continue.

- All stages of the nuclear fuel cycle involve emissions of radioactive substances that remain in the environment for a very long time.

- Nuclear accidents and reactor meltdowns would involve grave threats and risks for human health.

- Final disposal of radioactive waste requires a time frame of more than 10 000 years.

Moreover, as market forces come into play, nuclear energy is being phased out.

Germany does not need nuclear energy to achieve its CO_2 reduction target. The new German climate protection programme is implementing policies and measures to meet the –25% CO_2 reduction target and is starting to phase out nuclear energy at the same time. Today, one-third of our electricity is produced by atomic power plants. Nuclear energy tends to stabilise supply-side oriented structures of energy systems, which is a serious obstacle to the efficiency improvements necessary for sustainable development.

There are so many different technologies, technologies that are so much more efficient and beneficial, that we don't need nuclear energy or sequestration for climate protection. The win-win-strategy for climate protection and phasing out of nuclear energy includes

- Many different energy sources instead of the few fossil fuels used today, including renewables.

- Increasing energy conversion efficiency, *i.e.* up to 60% with steam and gas power plants.

- Networking of energy systems.

- Different forms of end energy appropriate to particular consumer needs, including different types of electricity.

- Energy recycling instead of the once-in/once-out energy economy of today; for instance, the use of waste heat or solar energy to produced chill for air conditioning or the production of electricity by kinetic or brake energy or by waste heat from gas compressor stations.

- Using biogas, landfill-gas, waste-water-treatment-gas, mining-gas, mainly in co-generation.

- Waste incineration for highly effective heat and electricity production.

- More decentralised energy systems, appropriate to local conditions, municipal energy networks and other municipal activities.

- More co-generation units (CHP) as the heart of intelligent energy systems; best practice technologies to link industry and municipalities with strong potential for fuel cells and micro turbines.

- Compressed natural gas (CNG) buses and trucks, 3 litre cars, telematic traffic control and integrated systems for public transport in municipalities.

- Low-energy and even zero-energy houses.

- Increased energy efficiency, especially in the end-use sector, offers by far the best energy resource, with a potential of up to 90% for pumps and motors, 95% for stand-by equipment, 80% for elevators, and 60% for lighting, etc.

The basic principle for sustainable energy development is: ***use your brains instead of wasting energy.***

A two-way strategy for sustainable energy development in developing countries

In industrialised countries and in most countries in transition, energy is not a limiting factor for further development. In the industrialised countries, there is enough energy for the foreseeable future. Even the remotest places are connected to the grid.

The situation is different in many of the developing countries where the choice is between:

- Supplying mainly rural areas with energy – according to the World Bank, 2 billion people lack access to electricity and only 25% of households in South-East Asia are connected to a grid.

- And increasing energy efficiency and substituting carbon-rich energy resources by renewable energies.

The second option is roughly consistent with the sustainable energy strategies of the industrialised countries or the transition economies. The first option calls for special instruments for technology transfer and financing mechanisms like the Global Environmental Fund (GEF), Joint Implementation (JI) or other financial assistance. Political discussions often focus on this option. This is unfortunate because the general public is often unaware of the existence of other potential win-win strategies, especially for increasing energy efficiency, and it makes it difficult to take appropriate decisions on policies and measures. For example, in the cities, industries and commercial buildings of the developing countries, the same potential for energy-saving measures exists as in the advanced countries, tapping into them depends on the political framework. The developing countries pay the same prices for energy on the world market as do the industrialised countries; thus, energy-efficiency investments in the developing world ought to pay back in the same time as in the industrialised countries. Undertaking these investments has the same win-win-effects in developing countries as in advanced countries. Policies and measures aimed at increasing energy efficiency make sense in all countries, not only in industrialised ones; they are fundamental for all sustainability strategies. Recognising this is important for fostering appropriate and efficient scientific and technological co-operation for sustainable development between industrialised and developing countries.

Looking at the complex systems of sustainable energy technologies and the multi-player principle, on the one hand, and the win-win situation with increasing energy efficiency, on the other, it becomes clear that a crucial strategic element relies on strengthening market forces in the energy sector. Governments need to set conducive framework conditions but they cannot manage the shift to a sustainable energy future alone. The best strategy is to increase energy efficiency fostering market forces. In Germany, we have had remarkable success with market instruments such as EPC (Energy Performance Contracting), TPF (Third-party Financing), PPP (Public Private Partnership), Energy Contracting and IPC (Independent Power Producers), but are only just beginning to use these instruments properly. Letting market forces guide the energy system does not mean having no democratic influence on energy utilities or, as is often suspected, broadly stepping back from environmental protection. On the contrary: sustainable development in the energy sector needs a legal framework for environmental protection and public funding, including environmentally sound energy technologies such as CHP, renewables, energy efficiency centres, science, technology development, etc. Setting up market forces and establishing a suitable legal framework are not diagonally opposed strategies, rather they are partners for sustainable development.

Leap-frogging – a real opportunity for developing countries

The energy systems and energy economies of the industrialised countries have developed gradually over more than 200 years, since James Watt invented the steam engine and created the basis for the industrial revolution. Today, as we become aware of the necessities for sustainable development, it is increasingly obvious that this history of long-established structures of the energy economies, of centralised energy systems and closely linked social structures presents obstacles. Arguments like “it has always been like that, why change it?” or the resistance of those groups who stand to lose from change are tricky to handle. Changing business-as-usual attitudes is more difficult than setting up a new business.

The developing and transition economies often show a tendency to simply copy the experiences of the industrialised countries. Technology transfer quite often involves straight copying, which can also mean copying errors and unsustainable structures and technologies. Why not skip energy systems that we know are not sustainable? Why not implement leap-frogging technologies and systems right now? Most of these are ready for the market, they have proved their worth and there is a great

potential for further development in countries that apply these technologies now, with later on the possibility of selling them.

Let me give some examples:

- Connecting all rural areas to the grid is costly; moreover, it creates obstacles to changing over to decentralised technologies – a necessary element for a sustainable development. Solar homes supply electrical comfort, they are high-tech, appropriate and sustainable.

- Decentralised biogas units do not require a connection to a gas grid; they can use waste water or animal excrement.

- CHP systems operate with natural or biogas or renewable energies, bigger ones, fired with coal, are more sustainable than condensing power plants and separate heating with fossil fuels; now is the time to prepare the terrain for applying fuel cells in the future.

- Local or municipal energy networks.

- Waste heat can be used in many different ways, including to produce electricity.

- Producing chill from waste heat or solar energy instead of from electricity; there is a huge market potential for ab- and adsorption chill production.

- Houses are long-lasting investments; eco-houses with low-energy intensity often do not require air conditioning.

- Second-hand plants – refineries, cement or chemical plants, etc. – are often more energy-intensive than new ones; the total cost of a new plant can be cheaper in the short to medium term.

- Decentralised and regionalised structures linking economical and residential areas reduce traffic and the growing of unsustainable mega-cities, thus reducing energy consumption and protecting the climate.

I could cite many more examples. Of course, not all are applicable everywhere, Africa's needs are different from those of South-East Asia. In the same way, the opportunities for leap-frogging vary, although the idea is applicable everywhere. Setting the points right now and skipping unsustainable energy technologies is the best and most direct path to sustainable development. In many cases it will be not avoidable or even better to combine both strategies, especially for countries in transition.

Decision makers sometimes seem to think that decentralised energy technologies are low-tech "toy" technologies. This is not the case: photovoltaics, chill from heat, fuel cells, low-energy houses, energy recycling, linking energy units to efficient systems – are all modern energy technologies. At their most efficient, even solar cookers or bio-gas units can be high-technology. Understanding what is high-tech and what is the best technology for sustainable development in developing countries should not be dominated by the principle of "Go West", as Rajendra Shende calls it. High-tech in a developing country can be very different from high-tech in an industrialised country, and even more different from the generation-oriented, business-as-usual thinking which is dominant in Western energy economies.

Co-operation for leap-frogging

Leap-frogging in sustainable development does not just happen by itself. In many cases, it needs funding. However, it does not need more funding than conventional energy technologies, usually it needs less. For the most part, leap-frogging requires co-operation, it requires learning from the experiences of others, it requires networking and the support of like-minded experts, institutions or countries.

This makes it very clear where international scientific and technological co-operation for sustainable development has to fit in – not only in basic research and high-technology development, but also in practical co-operation with best practice, appropriate technologies, mainly in energy end-use, with developing efficient energy appliances, with learning-by-doing, with political and social science co-operation, with joint learning through the exchange of experiences, with educational, capacity building and soft-measures, and with joint investment projects. The strength of this concept of international scientific and technological co-operation for sustainable development is that it is not as cost-intensive as scientific co-operation for basic research and it can be practised between industrialised and developing countries, as well as between developing countries. Co-operation for leap-frogging in sustainable development is highly effective and highly efficient. It is not a one-way street: exchanging experiences and co-operating with colleagues in developing countries can give valuable hints, support and power to the experts working on implementing sustainable energy systems in "developed countries".

This kind of co-operation has to be fostered and it has to be organised and funded. International co-operation for leap-frogging doesn't happen all by itself, just as leap-frogging doesn't simply happen. It takes organisation. Organising this kind of co-operation is a rewarding task for the industrialised countries, for the many relevant institutions engaged in sustainability and for the private sector, too. International co-operation of this kind has to include energy-efficiency centres and networks, NGOs, municipal and local delegates, research and technology experts, industry, civil servants, *i.e.* a broad range of engaged persons. Just as energy efficiency and climate protection are based on a win-win strategy, co-operating for leap-frogging in energy technologies is a win-win-strategy for sustainable development.

However, the usual understanding of international scientific and technological co-operation is oriented either towards one-way technology transfer or towards cost-intensive basic research. Ideally, as they become aware of the increasing necessity for global sustainable development, the relevant institutions should foster and concentrate on the "leap-frogging" kind of international scientific and technological co-operation. Since I am speaking at an OECD Conference, there is no need to emphasise that this hint is especially addressed to the OECD.

The OECD Climate Technology Initiative

Article 4.1(c) of the UN Framework Convention on Climate Change calls for all parties to the Convention to: "Promote and co-operate in the development, application and diffusion, including transfer, practices and processes that control, reduce or prevent anthropogenic emissions of greenhouse gases ... in all relevant sectors, including the energy, transport, industry, forestry and waste management sectors". Article 4.5 of the Convention directs developed countries to: "take all practicable steps to promote, facilitate and finance, as appropriate, the transfer of, or access to, environmentally sound technologies and know-how to other parties, particularly developing country parties, to enable them to implement the provisions of the convention. In this process, the developed

country parties shall support the development and enhancement of endogenous capacities and technologies in developing countries."

Based on this mandate, the OECD Climate Technology Initiative was launched in 1995 by 23 developed countries and the European Commission. The mission of the CTI is to promote these technology-related objectives of the Framework Convention. It does so by fostering co-operation for accelerated development and diffusion of climate-friendly technologies and practices for all activities and greenhouse gases. One of the core activities of the CTI (although not the only one) is to build capacity in developing countries and economies in transition.

Capacity-building consists mainly of supporting the creation of local and regional infrastructure and know-how that integrate cultural values, technologies, capital stock, technical skills, regulatory mechanisms and financing so that mitigating climate change becomes part of a reasonable and readily acceptable policy approach to achieving sustainable development. CTI appreciates that building local capacity and infrastructure is a long-lasting benefit and is in fact the only true way to achieve long-term "technology transfer" as envisioned under the Framework Convention. Through the mobilisation of resources by means of a multilateral effort such as the CTI, we can hope to achieve real progress.

However, to address the OECD for the second time, it would be necessary and promising to considerably strengthen CTI activities. If we really want to achieve tangible progress in global sustainable development, we have to foster international scientific and technological co-operation of the kind discussed above. The economic interests of the industrialised countries should be sufficiently large for them to recognise the opportunities to be gained from fostering international co-operation.

Negotiations within the UNFCCC process seem to have come to a point where further progress can be achieved by practical successes in co-operating on all kinds of technical projects. We should not wait for positive outcomes in the climate negotiations before we start to act. On the contrary: we should strive for success stories in modern, sustainable energy technologies first; then we will achieve progress in the climate negotiations, too. This is another reason why I recommend fostering OECD CTI and other co-operation activities.

Conclusions

Let me close by citing the German Chancellor, Gerhard Schröder. Opening the Fifth Climate Conference in 1999, Mr. Schröder impressively underlined the necessity of climate protection for sustainable development:

- "Climate change threatens the future of mankind more than any other impact on the environment.

- We need a global revolution in energy efficiency. I am deeply convinced that a continuous and intensive increase in energy efficiency will become a major characteristic for modern economies.

- Those who try to slow down climate protection or who just make no headway will lose contact with the most important global economies of the next century in just a few years time."

Undoubtedly, “making headway” includes fostering international scientific and technological co-operation for sustainable development, especially for implementing leap-frogging energy technologies.

Chapter 19

SOCIETY'S PREFERENCE: WHERE SHOULD ENERGY COME FROM AND HOW TO PROMOTE ENERGY SAVING?

by

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Introduction

While it may be easier to grasp the links between energy and the environment (such as adopting alternative forms of energy or modifying energy use to reduce or eliminate environmental degradation) or between energy and economics (as in the economic viability of various sources of energy, or the use of energy to improve material conditions of people's lives), what we refer to as social aspects can be just as crucial to the policies, planning and provision of energy. All human activity (including those often analysed separately as economics or politics) can be seen as social: the interaction of people with each other in production, pleasure, living and reproductive arrangements. Or as cultural: the concepts, institutions, skills, habits, tools, etc., of a people. This of course includes what energy sources people decide to use, how people distribute or allocate the access to energy sources, and how they develop, use, modify and transfer technologies that use these energy sources.

Social and cultural conditions are both the context of our actions and their outcome. When seen in terms of energy use, technology transfer and energy saving, social and cultural conditions provide:

- A *context* for sustainable development and technology transfer, even while
- technological changes brought about by technology transfer can in turn *modify* social and cultural conditions.

As an extreme example, the past several decades have shown that the central role of the automobile in US life provides a social and cultural context that makes it difficult to introduce forms of transport not as individual and independent (single person driving wherever and whenever he or she wants to go, in his or her own private vehicle). And so it would also be safe to assume that any major changes in the nature or form of automotive transport would itself have considerable impact on life in the United States.

This chapter focuses on three social factors that can affect preferences for energy sources or the promotion of energy saving. The first considers energy in terms of property (or rights to the resource and its use). The second looks at equity issues: differences in fuel use by different socio-economic groups. The third concerns social or cultural attitudes that either promote or hamper energy saving,

and efforts to encourage or to change these attitudes to promote energy saving and the use of cleaner technologies.

Whose energy? Property issues

In October 2000, several thousand people in southernmost Thailand protested against the laying of a natural gas pipeline near their communities. The government was unprepared for the extent of violence, nor indeed for the depth of opposition among those living in the proposed project area. This project, agreed upon by the Thai and Malaysian Governments, is expected to provide new supplies of cheap natural gas to the area. The project is considered a rare case of government-government co-operation, with gas reserves in the Gulf of Siam that are claimed by both Thailand and Malaysia being tapped and exploited under this joint project (*The Nation*, 1999). The project proposes the laying of gas pipelines into Songkhla Province in southern Thailand, along with the construction of a gas separation plant (*The Nation*, 2000). The project fits with proposed industrial development of the region. Despite the strong government support and the apparent economic benefits, local residents protested against and rioted at the public hearing on the project. Why?

Several reasons for local objections were reported: dissatisfaction with the public hearing process, which many felt to be neither open nor transparent (only a selected number of registered persons within a target population would be invited to participate), and objections to the placement of the pipeline and separation plant in the area, along with general objections to the potential development that would result from the project. There are those who did not want the pipeline to impinge on their private or community land. There are others who suspected that politicians and government officials would benefit from this project. And there are those who do not believe they will benefit from the project. Each case can be considered an issue of property, or a sense of ownership of the project and its results.

Property issues concerning technology transfer involve more than intellectual property matters. Rights to land, to productive resources, to the use benefits derived from the technology are all crucial to the acceptance of types of energy and their use. Among the property issues that need to be considered for the transfer of any technology are:

- What is the scope of the exploitation, use and benefits derived from the energy sources? Is it at the national level, sub-national region, a mini-watershed, or at the community/group of communities level? The sense of people's participation will differ at each level.

- Who has rights to the resources? In much of the developing world, there are differences between legal and traditional forms of ownership. Legal rights to resources often lie with the state, but long-time and actual forms of use and control of these resources are with local communities or groups. Attempts by the state to exploit these resources frequently come into conflict with local forms of property rights that pre-date the state claims (National Research Council, 1986).

- Who owns the sites where energy is extracted, produced and distributed? Aside from the obvious matter of accommodating or compensating or involving the legal owners of the land, traditional patterns of land control and use also need to be considered. Some of the lands where the pipeline is to pass in southern Thailand are under traditional forms of property, and some opponents see the pipeline as impinging on those rights.

- Who has rights/power to regulate or manage the use of energy? Is it the state? A group representing the general public? A private company? These all imply different stakeholders and different levels and types of involvement by the broader society. In the Thai case described above, the people in the area where the project is to be implemented did not feel they had a voice in the control or management of the resource.

- Who has the rights to use the energy? Some of the objections in the Thai case come from the feeling by many local residents that they will not be the ones who benefit from the gas pipeline.

- Who is affected by any detrimental impacts? Based on experience in other parts of Thailand, the protesters believe that extensive industrialisation of the area will lead to serious environmental degradation and the deterioration of their standard of living, without contributing much to their economic or material well-being.

Energy and equity

Energy use is not distributed equally among different groups in society. When energy is sold, those who have more money can, of course, afford to buy more of that energy. This holds true for nations as well as individuals. The United States and its citizens are able and willing to pay much more for oil to power their vehicles, heat their buildings, etc., than are most of the countries and people of the developing world. The poorer tend to bear a greater burden in energy purchases, even if the cost of energy is partially subsidised, because of the need to use a much greater proportion of their incomes to pay for their electricity, gasoline, heating fuel, etc.

Types of energy may also be distributed unequally. The energy sources of the poor may not be the same as those of the more well-to-do in a society. Indeed, those of the poor may not even be reported or considered in government energy policy. The primary energy sources for the countries of the world are generally considered to be oil, coal, hydropower, geothermal power, or natural gas. Solar or wind power are emerging alternative energy sources. However, wood as an energy source is rarely included in national energy calculations, nor is wood considered an important energy source to be developed.

Yet hundreds of millions of people throughout the world still rely on wood as an important energy source. Nearly all are poor; nearly all are rural residents. The Regional Wood Energy Development Program of the FAO estimated the proportion of wood-based fuels (wood, charcoal) as a proportion of the total energy use of selected countries in South, East and South-East Asia. The results of their survey were admittedly based on data that are not completely reliable, since accurate measures of total wood-based fuel use is not easily found. Still, even taking into account overestimates in some places, the chart below shows that the widespread use of wood-based fuels in this, the most populous part of the world, cannot be denied.

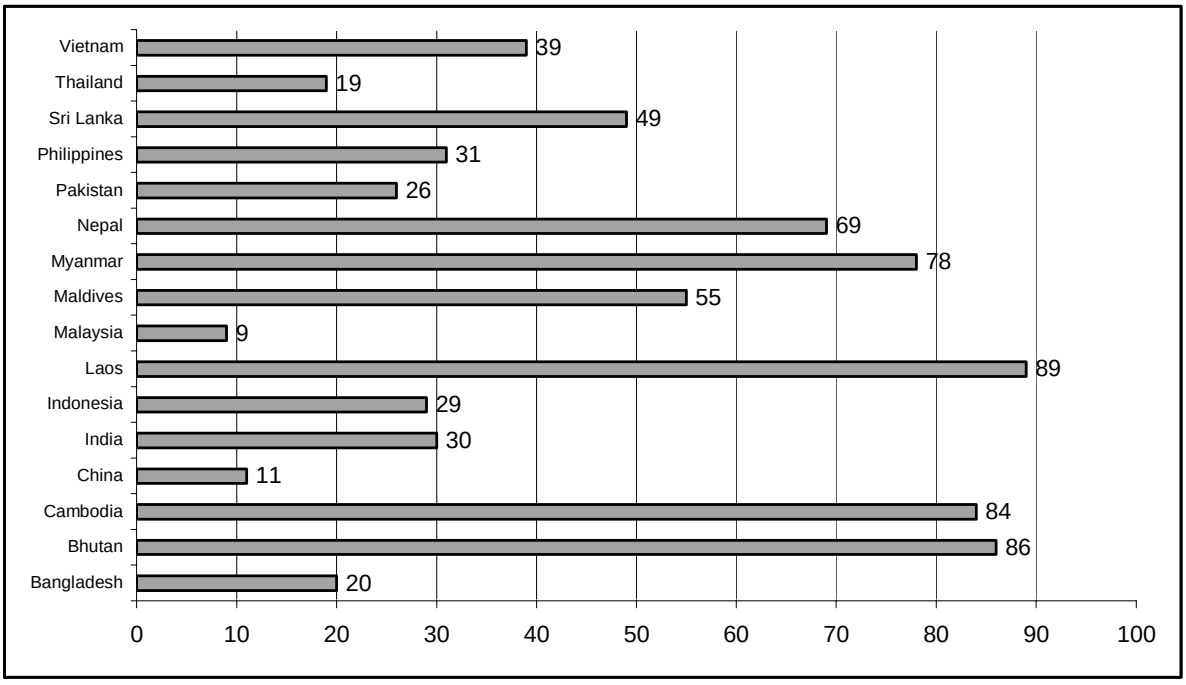
Of course, the nations with the greatest proportion of fuel met from wood-based sources are among the poorest, with the largest rural population, such as Laos, Cambodia, and Myanmar. Yet even in Thailand, it is estimated that about one-fifth of all energy use is met from wood-based sources, one-tenth of the energy in China is from wood-based sources, and nearly a third of the energy in India and Indonesia is from wood and charcoal. Most of this wood-based fuel – about 85% to 90% – is used in homes, for cooking and heating (FAO, 1997).

One implication for the energy policies of these countries is to explore ways to make wood-based fuel use more efficient. With much of the wood and charcoal used for cooking, efforts have been quite

successful, particularly in the countries of the Hindu-Kush region, to improve the efficiency of wood-burning stoves. Technologies for improving the stoves have been developed and have spread rapidly throughout the region.

Figure 1. **Estimates of the proportion of national fuel needs met by wood-based fuels**

Percentages



Source: FAO (1997). Chart taken from http://www.rwedp.org/.

One possible reason for the rapid spread of these energy-saving technologies is the lack of potential for profit, since they are low-cost technologies that are aimed mainly to help the rural poor. Research has been conducted by the public sector (government and universities) and NGOs rather than by the private sector. Thus, there have been no disputes over intellectual property rights, no disputes over costs, allowing the free transfer of the technologies. The beneficial impacts have been widespread: the stoves have helped the environment by reducing demand for wood-based fuels; with less wood needed, the workload for women, the main wood gatherers in many of the countries of the region, has been reduced; and with improved efficiency, the indoor pollution in households caused by the stoves has been reduced, which also helps women who cook and their children who stay with them (ICIMOD, 1998).

Differences in energy use by different socio-economic groups are rarely as stark as this, where we find the predominantly poor rural population depending upon completely different sources of energy than their more well-to-do and urban compatriots. Furthermore, the wood-based energy sources used by the poor are not always considered in national energy records and so might not even be an important element of national energy policy, even though worldwide nearly 2 billion people depend primarily on wood or other biomass as their main source of fuel (UNDP, 1997).

Yet even when the same energy sources are used, various socio-economic groups may well have different *patterns* of energy use, and thus policies that affect energy use will have different impacts on the various groups. Poor households tend to use most of their fuel for cooking. Wealthier households use fuels for a greater variety of purposes, including space heating, lighting and transport. The poor also use a much larger proportion of their incomes to meet fuel costs than do their wealthier compatriots. Energy policies can directly affect the nutrition of poor households: increased energy costs will force people either to use less fuel to cook or to pay more for fuel and less for food (UNDP, 1997).

Energy and culture

Culture plays a key role in energy use and the adoption of new technologies. An important component of any culture is its system of knowledge, or what is often referred to as "indigenous knowledge". The acceptance and adaptation of a technology depends upon its fitting within the context of local knowledge. That is, adoption of new technology depends *on local perceptions* of *local problems*, and on application of *local knowledge* to solve those problems within *local social conditions*. When most people refer to indigenous knowledge, they usually limit the concept to local technical knowledge. In fact, there are several types and levels of indigenous knowledge, each of which is crucial to technology transfer. These can be summarised as:*Technical knowledge*: what is usually called indigenous knowledge. A new technology should fit into the context of the existing technical capacity and skills if it is to be adopted and used competently and effectively.

- *Social organisation*: how people organise themselves to manage resources. Any new technology will either reinforce the existing system of resource management or will lead to changes in that system.

- *Decision making*: how local groups make decisions. The adoption of a technology will depend upon the acceptance by and influence of those with the power to decide. A new technology may be potentially beneficial to some in the society, but if they do not have the power to decide, that technology may not be accepted.[1]

- *Innovation and experimentation*: how local people innovate or change their systems of production. Any new technology needs to fit in, be adapted to, and thus change a system of production or use.

- *Values and belief systems*: how they perceive the role of their own knowledge. This extends to the adaptation of a new technology to their values and belief systems, especially if that technology alters social organisation and the systems of knowledge.

- *Teaching and learning*: how they receive and give information, the teaching and learning processes of the group. The adoption and adaptation of technology is complete only when it

1. The author found this when working on a drinking water project in a village in Nepal. The main purpose of the project was to bring cleaner water to the village through a gravity flow pipe water system. The increased availability of clean water was also expected to improve general sanitation by providing more water for washing and cleaning as well as consumption. The women in the village would no longer have to carry large pots of water about a half-hour from the spring. Yet the men in the village did not feel a great need for the water system – they were not the ones who had to carry the water – and so they made little effort to provide the labour to build the drinking water system.

is incorporated in the teaching and learning process, or able to be passed along to others in the group.

Energy saving through such efforts as energy labelling depends as much on cultural values and attitudes as other forms of knowledge and understanding. Because success in energy labelling depends on sufficient public awareness, education campaigns should be made appropriate to local culture and values in order to assure greater acceptance. The energy labelling campaign in Thailand is considered a success. The initial information, financial support and method of the campaign were obtained from international donors. However, the adaptation to Thailand used elements central to Thai culture. Leading respected figures in politics (such as former Prime Minister Anan Panyarachun) and in the entertainment field provided initial support. More importantly, advertisements in television, radio and the print media were presented with humorous messages. In Thai culture, humour has been shown an effective means to convey serious messages. Labelling was clear, simple, with voluntary support from refrigerator and air conditioner manufacturers. Compliance by consumers was also voluntary. Indeed, in Thailand, attempts at compulsory enforcement generally fail. Many people gain greater satisfaction at avoiding rather than following rules and regulations. Whether this is due to a strong individualist streak in Thai culture, or to a defiance of government control, environmental programmes that rely on compulsory compliance and punishment tend to fail in Thailand.

The results after less than three years of application were dramatic:

- 80% of the Thai population was aware of energy labelling.
- 50% of consumers considered energy-saving labels in decisions to purchase refrigerators or air conditioners.
- In comparison, only 5-20% of US consumers look at labels.
- And less than 50% of US consumers understand the labels (Huh, 1999).

The impact on producers was just as drastic: labelling encouraged manufacturers to make their goods more efficient. In February 1995, at the start of the campaign, only 13% of refrigerators received a 5 (top) rating. Because of consumer demand for top-rated refrigerators, by December 1996 the manufacturers had modified their products, making them sufficiently efficient so that 70% of participating models received a rating of 5 (Egan, 1999).

Estimated energy savings by the end of the third year are shown below.

Product	Peak MW savings October 1997		GWh/year savings October 1997		CO_2 (tons) reduced May 1997
	Target	Achieved	Target	Achieved	Achieved
Refrigerators	27	39 (144%)	186	297 (154%)	177 000
Air conditioners	22	13 (59%)	117	297 (254%)	102 000

Source: Egan (1999).

The immediate impact of energy labelling on air conditioner use was less effective than for refrigerators, particularly during peak hours. This is because purchases of air conditioners increased greatly during the years of the assessment (1995-97). Some people even believe that the energy-saving

campaign led consumers to buy more air conditioners, since manufacturers advertised the great energy savings of their products just when people had more money available to buy the appliances. However, it can also be argued that people would have bought the air conditioners in any case, with the increased purchasing power of the rapidly growing Thai economy of the mid-1990s, and the energy labelling campaign helped reduce what could have been an even greater increase in energy use.

Since the success of the energy labelling campaign, Thailand has embarked on several new energy-saving efforts. These include:

- A campaign to encourage use of more energy-efficient lighting.
- An effort in Bangkok to reduce automobile use on selected roads during peak hours.
- The “Divide by Two” conservation campaign, which is directed to reduction of waste (of water, food and other resources) including improvement of house designs to reduce energy needs for air conditioning and artificial lighting.

The most effective components of these campaigns are based on education through humour, encouraging voluntary compliance. These are crucial components of Thai culture. Children repeat the advertising slogans and jingles, and it is hoped that the messages will remain with them, contributing to a wiser, more efficient and sustainable use of resources in the decades to come.

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PART VII

PARALLEL SESSION 2

TRANSPORT AND SUSTAINABILITY

Chaired by Wolfgang Hübner
Transport Division, Directorate for Science, Technology and Industry, OECD

Chapter 20

TRANSPORT AND SUSTAINABLE DEVELOPMENT

by

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Introduction: concepts of sustainable development

Most work on sustainable development takes as its starting point the path-breaking efforts of the Brundtland Commission, which defined sustainable development as "development that meets the needs of the present without compromising the ability of future generations to meet their own requirements". The Brundtland Commission's views included that sustainable development is not only about environmental sustainability in the longer term; it is also about remediation of current social and economic deficiencies. Remediation envisaged by the Commission which is relevant to this Conference included: more rapid economic growth (in both developed and less-developed countries); freer market access for products of less-developed countries; and greater technology transfer.

In 1992, the Rio Earth Summit elaborated the Brundtland Commission definition to include these additional views, embedding the three pillars of sustainability (economic, social and environmental) in the definition, and describing sustainable development as development "meeting present economic, social and environmental needs without compromising the ability of future generations to meet their own requirements".

Applying sustainability concepts

Since 1992, many international and national organisations have devoted considerable resources to assessing the relevance and implications of the new sustainability concepts and considering the best approaches to their application. The resources currently devoted across OECD countries and sectors to addressing sustainability concerns are still rising as the concepts take their place alongside long-standing economic, environmental and social objectives.

While there is not unanimous accord, there is widespread agreement on the broad approaches:

- Pursue economy-wide approaches as these represent "first-best" solutions to addressing sustainability concerns. It is important to avoid sectoral actions which could be unintentionally welfare-reducing – a real risk if "sectoral sustainability" (*e.g.* sustainable transport) is pursued on a standalone basis.

- Clarify overall objectives and the balance between competing objectives, including sustainable development.

- Assess the most effective measures across sectors aimed at achieving the balance in the objectives and outcomes being sought, including much improved longer-term sustainability.

- Ensure that policy measures and proposed actions are well researched, fully evaluated and cost-effective.

The following sections of this chapter, while following the general approach outlined, have as their focus *strategic issues, strategic actions* and *international co-operation* in relation to transport and sustainable development. They deliberately avoid being prescriptive and detailed, recognising that the most appropriate approaches will depend on the circumstances and the policy context of the individual countries involved.

Objectives

The initial transport policy task is to seek the optimum balance between all relevant objectives. Traditionally, transport objectives have related to matters such as efficiency; accessibility and community development; environmental responsibility; safety; and international competitiveness. The additional objective now being emphasised is (more) sustainable development – with sustainable development itself generally seen as a longer-term goal to aspire to. Using the terminology of the Conference, improving transport's contribution to sustainable development involves moving people and goods in cleaner, greener, healthier and safer ways – without detracting from transport's efficiency and positive contribution to the economy. In doing so, attention has, of course, to be given to the trade-offs involved between environmental and other objectives and priorities, *i.e.* to achieving an appropriate balance between economic, environmental and social sustainability aspects.

Traditional objectives and meeting current needs

Meeting current needs invokes many of the issues that have long been included in transport policy agendas but have not been fully or adequately addressed. Many of these are environmental, public health and safety matters that are of growing importance in the longer term. Consistent with sustainable development objectives, the current issues that need to be better addressed – without detracting from transport's positive contributions – include the following:

- Transport safety – especially road safety.

- Transport efficiency – particularly the efficiency of government-owned transport operations.

- Motor vehicle pollution/emissions – especially in urban areas.

- Public health impacts – particularly relating to noise and emissions.

- Urban amenity/transport congestion.

- Maritime oil spillages – especially in environmentally sensitive locations.

Despite the progress made in many countries, there are ongoing transport impacts in many locations that require further attention.

Environmental objectives and general longer-term concerns

Sustained high levels of economic growth have required growth in transport sector outputs. While these have meant increasing transport contributions to overall economic welfare, adverse impacts have increased raising longer-term issues such as: greenhouse gas emissions/climate change; water quality; and biodiversity. A continuation of current trends would mean increasing the transport impacts associated with motor vehicle ownership, increasing road transport and aviation and falling rail and public transport shares of freight and passenger transport. Other longer-term impacts, such as urban congestion, noxious emissions and urban amenity, will depend on land use/transport interactions, as well as the balance in contributions from anticipated demand growth and – as yet unknown – technological improvements.

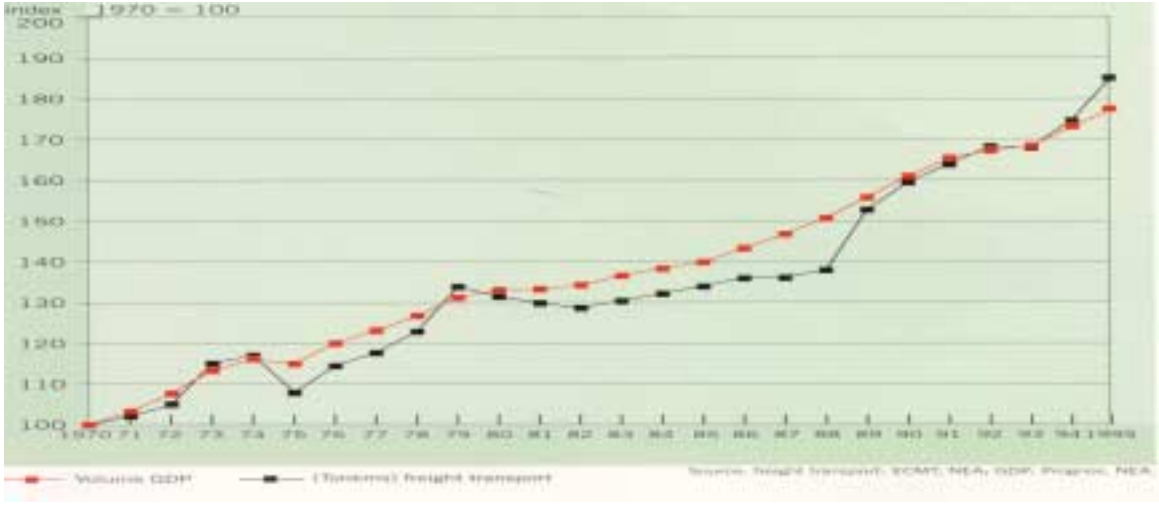
Principal *future* transport-related concerns in OECD and developing countries include:

- Transport (especially motor vehicle) fuel consumption – which is directly related to emissions.

- Climate change/greenhouse gas emissions – in particular the increasing transport share of CO_2 emissions generated in OECD countries.

- Future levels of urban amenity/congestion associated with continuing growth in per capita incomes and related vehicle ownership and use in OECD countries and even faster growth in non-OECD countries.

Figure 1. **Changes in GDP and freight transport, 1970-95**



Source: European Conference of Ministers of Transport.

It is clear that these longer-term concerns can only be addressed effectively through integrated and coherent policy and technological approaches at international, national and local level, which focus on the three sustainability pillars, each of which has priorities for policy action:

- Economic sustainability – create incentives for efficient transport response to business and consumer needs.

- Environmental sustainability – promote more liveable settlements and reduce adverse external transport effects

- Social sustainability – focus on meeting transport needs for access and public health.

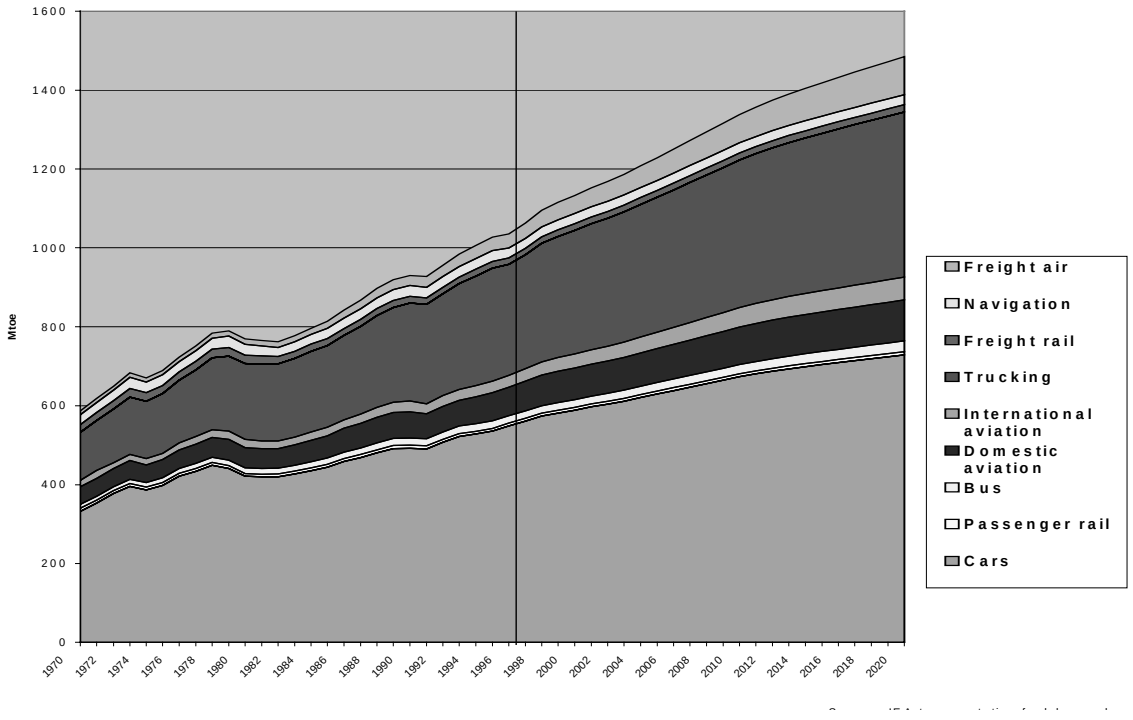
One of the policy issues currently under discussion in various organisations is the prospect of a "de-coupling" of economic growth and transport demand. In the freight transport sector, freight transport and economic growth traditionally have been strongly linked. During the 1990s, there was very strong growth in transport passenger and freight demand associated with sustained high levels of economic growth. Clearly, freight transport has been growing more quickly than GDP in recent years. Given the recent history, "de-coupling" looks optimistic as a policy goal.

Policy concerns: transport emissions

Fuel consumption outlook

According to International Energy Agency (IEA) forecasts, transport fuel use in OECD countries is expected to increase by 40% by 2020 (Figure 2). The overall share of fuel consumption and the expected increases in fuel consumption are predominantly road-based (passenger cars and trucks).

Figure 2. **OECD energy use forecasts, by transport mode**



Source: International Energy Agency, transportation fuel demand projections, 2000 (ongoing project).

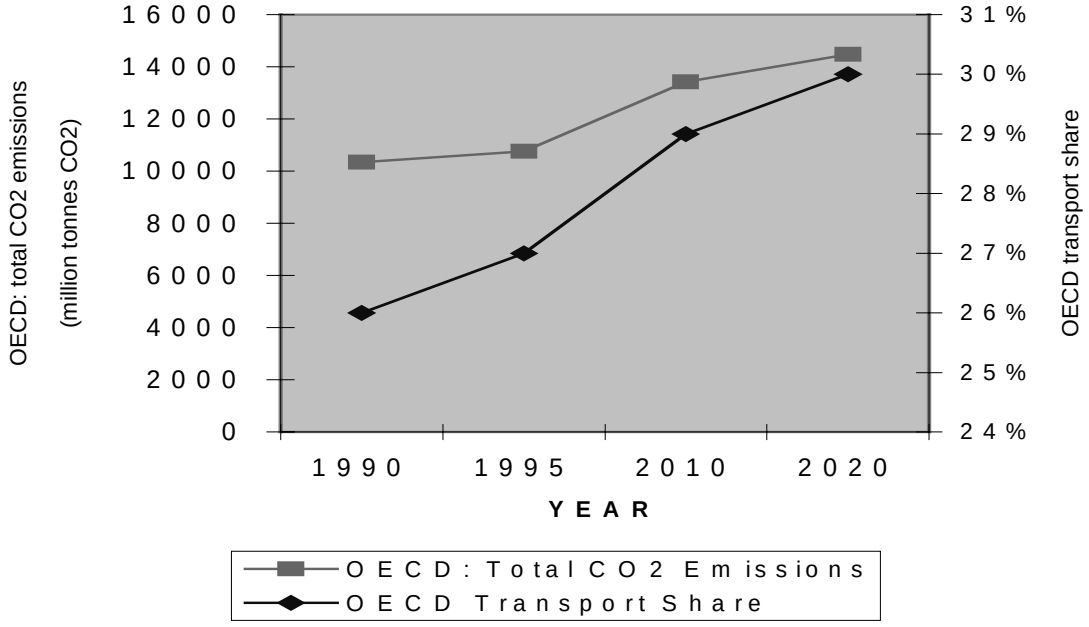
CO_2 emissions in OECD countries

Greenhouse gas emissions are a principal focus due to climate change concerns. CO_2 emissions – which comprise the largest share of GHG emissions – are directly related to fuel consumption. At present, OECD countries:

- Generate close to 50% of *total* CO_2 emissions (from all sources).
- Produce two-thirds of the world's *transport-related* CO_2 emissions.

In future, in OECD countries, the transport share of CO_2 emissions is forecast to increase under "business as usual" scenarios (Figure 3).

Figure 3. **Transport share of OECD CO_2 emissions**

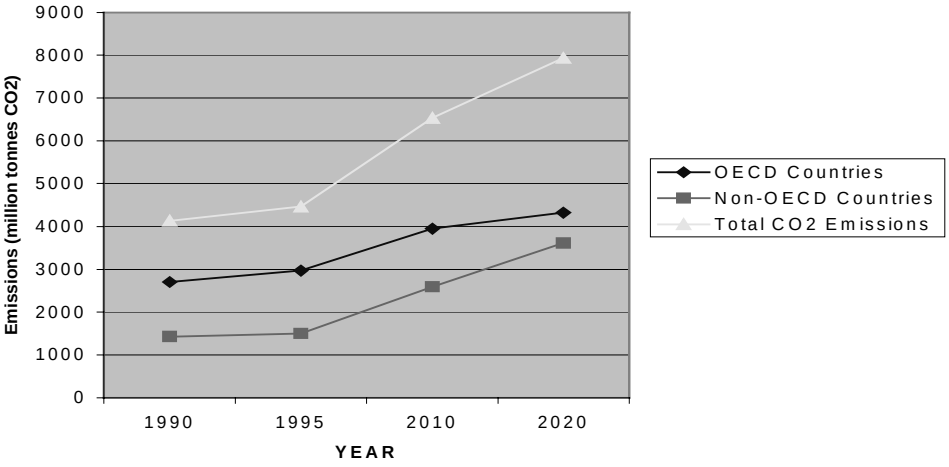


Source: International Energy Agency, 1998.

CO_2 emissions in developing countries

At present, developing countries generate around 50% of *total* global CO_2 emissions but only around one-third of total *transport-related* CO_2 emissions. By 2020, developing countries could account for 45% of *transport-related* CO_2 emissions worldwide (Figure 4).

Figure 4. **Transport CO_2 emissions in OECD and non-OECD countries**



Source: International Energy Agency, 1998.

Global outlook for transport-related CO_2

In summary, the global outlook for transport-related CO_2 is:

- Transport emissions are increasing strongly.
- Transport sectors are not likely to contribute proportionately to national economy-wide Kyoto GHG emissions target reductions (OECD, forthcoming in 2001, *CO_2 Emissions from Road Transport*).

In addition, the latest research from the International Panel on Climate Change (IPCC) suggests that by 2030 the global warming impact from *aviation* GHG emissions may match the global warming impact from cars.

Major CO_2 policy implications

One of the most important policy conclusions that can be drawn from the current work on CO_2 emissions is that only slow improvement can be expected in the fuel intensity of motor vehicles in vehicle fleets and therefore in fleet fuel efficiency. While manufacturers are making more *fuel-efficient* cars, they are also continuing to produce more powerful cars. As incomes rise, consumers are choosing to buy higher proportions of *more powerful* cars. The combined effect of forecast increases in demand and these patterns of vehicle purchasing will be to increase CO_2 emissions well above the lower target levels which are technically feasible.

This policy conclusion suggests that, if government, industry and the general public are serious about the importance of reducing transport-related CO_2, it will not be sufficient to rely on markets and individual consumer choices under current policy frameworks. Additional action will be required. Government incentives/taxes are likely to be needed to provide appropriate individual incentives.

Many OECD countries (*e.g.* Finland, Korea, the United Kingdom) have already recognised this and are taking action in relation to vehicle purchase and vehicle use. Clearly there needs to be close global collaboration among countries to address longer-term motor-vehicle-related CO_2 and other GHG emissions.

Policy concerns in urban areas

Urban areas present another major sustainability challenge in OECD countries and the challenges are even greater in developing countries. In most locations, the outlook is for an increasing proportion of national populations to live in cities, thus increasing both population levels and the employment base.

Household and industry preferences for more space and less expensive land and accommodation have been major contributors to the geographical spread of cities. Transport system improvements and motor vehicle ownership have allowed these household and business preferences to be satisfied. However, improving transport systems to serve suburban and greenfield development locations facilitates the further spreading out of cities. Once land use development is dispersed in this way, there is pressure to improve the transportation facilities as demand intensifies. Under business as usual approaches, urban sprawl will continue and cities will consume more land in future, particularly if higher transport speeds allow people to travel to and from more distant locations within normal travel time budgets.

Under this type of scenario, which has played out in many locations for many years, the outlook for transport in urban areas continues to be for an increasing share of road-based transport and a falling public transport share of passenger transport in urban areas. This outlook has well-known implications for the amenity of urban areas that expand in this unstructured way. The primary driving forces contributing to reducing amenity in urban areas include:

- Dispersed locational patterns of consumer and business demand and land use development.
- Rising car ownership associated with increasing GDP/income levels.
- Increasing demand for road freight as a result of changes in freight composition – short distance; high-value freight suited primarily to road transport; and the development of supply chains and “just in time” deliveries.
- Increasing congestion on the roads, associated in particular with unrestricted access to roads and the absence of direct location-specific charges for use of roads.

The expected growth in motor vehicle ownership and use per capita presents major challenges. Recent analysis by the International Energy Agency has produced some useful insights into the relationships which deserve careful attention, particularly in developing countries.

Transport impacts in urban areas in OECD and developing countries

The major transport impacts on sustainability are well known and can be expected to include:

- Noxious emissions and noise.

- Fuel consumption and CO_2 emissions.
- Congestion – worsening levels of service on roads.
- Safety – especially road safety in developing countries.
- Funding difficulties for public transport.

Expected trends in congestion on roads and decreasing public transport shares are not likely to satisfy either motorists or public transport users. These problems will be most acute in major cities in developing countries.

Policy concerns relating to transport efficiency

Much progress has been made in a number of OECD countries in addressing transport efficiency concerns. Generally, it is now recognised that competition is the most effective way of securing efficiency. Experience has shown that it is difficult, if not impossible, in the absence of competition to ensure efficient transport outcomes and provision of the services required by users. Governments therefore now generally favour competition policy approaches and new roles for themselves as competition policy and safety and environmental regulators, rather than as owners and operators of commercial or potentially commercial transport infrastructure and transport operations.

Transport efficiency can be improved to meet current and future needs by adopting:

- *Pro-competitive regulatory frameworks.* There is scope for further road transport reform and substantial rail transport reform to allow these modes to better respond to market demand. For rail, this means liberalisation to allow more competitive and commercial operations.
- *More commercial infrastructure approaches.* These approaches focus on better use of existing infrastructure, including through intelligent transport systems applications. Once infrastructure is commercialised, improvements can be funded on a user pays basis.

Policy concerns relating to transport safety

Transport safety – particularly road safety – is another major issue of current concern. It is the area where transport arguably has the greatest impacts, in terms of the human cost of fatalities and injuries. Establishing safe transport systems now also means sustainable safety in the longer term. Driver behaviour remains a high priority – as does vehicle safety. Transport policy approaches may need to lift the bar higher to dramatically improve road safety outcomes. Policy approaches could focus on:

- Blood alcohol content – a level of 0.02% or less (instead of 0.08% or even 0.05%) would have a major impact on fatalities and injuries on the roads.
- Urban residential speed limits – 50 km/hr or less.
- Widespread enforcement of laws on speed, alcohol and drugs– applied on a consistent basis.

Ten transport policy options

Ten possible transport policy options are presented below which could make a significant difference to transport sustainability outcomes over the medium and longer term. The policy options are not prescriptive and there is no suggestion that they should all be applied in any country or in each location. Rather, they encompass measures that have been tested and found effective in some locations and have been proposed in different locations because of their potential.

1. Supply-side agreements with manufacturers on fuel intensity/fuel consumption

The ACEA voluntary agreement concluded with the European Commission (and equivalent EC voluntary agreements since reached with Japanese and Korean car makers) was based on improving the fuel intensity and reducing CO_2 emissions from new vehicles by 25% (or more).

2. Intervene in new vehicle markets selectively

Market intervention would allow governments to sharpen the distinction between low- and high-fuel consumption vehicles at the time of vehicle purchase. Intervention could take the form of fuel-based vehicle registration fees (like the Vehicle Excise Duty in the United Kingdom) or revenue-neutral "feebates", which make fuel-efficient new cars less expensive and other new cars more expensive.

3. Identify the portion of existing fuel taxes intended to internalise the costs of CO_2 emissions

This clarification would allow progress towards more appropriate charging and taxing regimes, especially for road-based transport. At present, transport users – especially motor vehicle users – receive unclear messages about the external costs they generate. Road taxing and charging frameworks need to be much more sophisticated to be able to provide the correct signals to users.

4. Apply electronic use charges to long-distance road transport services on major routes

In conjunction with clearly defined emissions taxes, development of charging systems based on electronic use charges applied to long-distance road transport services on major routes will help ensure that road freight transport meets its fair share of costs on a location-specific basis.

5. Urban land use and transport programmes - on a user pays basis where appropriate

The aim should be to make cities attractive places to live and work with fewer cars. Transport administrations should steer away from transport projects which increase travel speeds in ways that facilitate urban sprawl – without achieving lasting travel-time savings. Given the importance of public acceptability for any measures proposed, the public should be given the opportunity to identify the improvements they are seeking. These will most likely include more opportunities for public and active transport (walking and cycling) which will also contribute to improving public health.

6. Improve road transport management programmes

The development and operation of roads need to be better managed if transport administrations are to be able to contain congestion and facilitate reasonable traffic flows. Measures could include giving priority to higher volume road users and ensuring that users meet the costs of their usage of the road system. Satisfactory outcomes in the longer term are likely to require more commercial approaches to road management.

7. Vehicle emission inspection and maintenance programmes

Noxious emissions remain a key issue in many urban areas, especially in developing countries. Research suggests that a relatively small proportion of vehicles contribute disproportionately to noxious emissions. Inspection and maintenance programmes need to be undertaken selectively to ensure they are targeted at high-risk vehicles (*e.g.* over 5/over 10 years old) and are cost-effective.

8. Competitive transport services

Consistent with revised policy frameworks, which facilitate replacement of public or private monopolies with competitive transport services, transport policy reforms could include:

- Reform of road transport operational regulations.
- Reform of rail service /ownership – opening rail to competition from private sector operators.
- Liberalisation of air cargo services.

9. Improve the use of existing transport infrastructure

There is considerable scope for achieving better use of existing transport infrastructure by improving information provided to users, smoothing traffic flows, applying intelligent transport systems and implementing demand management schemes.

10. Optimise safety outcomes – especially road safety

As indicated above, transport policy approaches may need to lift the bar higher to dramatically improve road safety outcomes. Policy measures could focus on:

- Driver behaviour programmes.
- Safety technologies, incentives.
- Enforcement of laws relating to alcohol, drugs and unsafe speed.

Transport policies – a reality test

The policies outlined above are indicative of changes that could be expected to make a significant difference. In a sustainable development context, policies are expected to be cost-efficient in their contribution to the required economy-wide improvements.

Importantly, of course, policies must be able to be marketed. There is little value in proposing policy measures which are not publicly acceptable. Equally important is the need to respect democratic realities: to be fully effective, policies need to offer individual incentives to achieve community benefits.

Developing countries' special needs

Much of the above discussion is relevant to transport in both developed and developing countries. Developing countries are likely to have greater need for transport policies and measures that contribute to:

- Integrated policy frameworks.
- Vehicle technology/emissions reduction.
- Meeting access needs/containing congestion.
- Better land use/transport integration.

International technical co-operation and assistance may help with some of these issues. Many organisations are active in this field. Sources include the private sector, more developed countries in the region, international aid and technical assistance bodies and international organisations such as the World Bank. The OECD is, of course, a good source of reports and advice on matters covered in its work programme. However, in some cases, developing countries would probably be well advised to not adopt precisely the same approaches as those pursued by developed countries. The following sections on urban congestion and emissions suggest some reasons for this.

Urban congestion

Urban congestion is expected to increase considerably in many large cities over the next ten to 20 years and when it does, there will be consequences for emissions, amenity and efficiency. Land use patterns, density and transport integration can, of course, be quite different in different countries. The World Bank cites as an example Bangkok, where some 11% of the area of the city is devoted to transport; for major cities in developed countries, the figure is typically closer to 25%. In many cases, it will simply not be possible to accommodate OECD rates of car ownership in existing urban areas in developing countries. Alternative policies are required to counter congestion, improve use of all available forms of existing transport infrastructure, spread demand for passenger and freight movement and maintain amenity in urban areas. In these circumstances, transport administrations in developing countries will most likely need to take more decisive action – which could include more effective charges and taxes in relation to access, parking and road use – to address congestion and environmental externalities.

Vehicle emissions and noise

Many urban areas in developing countries have serious air quality and emissions problems. As income levels increase and motor vehicle ownership grows, increasing demand, relatively slow turnover of vehicles in vehicle fleets and congestion are likely to outweigh the benefits generated by the new vehicles introduced into vehicle fleets which have the latest fuel and emissions technology. Targeted inspection and maintenance programmes will be important in dealing with noxious emissions and noise. It will be important for metropolitan and local planning authorities to exert sufficient control over land use densities and the spatial distribution of development to ensure transport flows can be handled efficiently. Again, decisive action will be required if the outcomes in the longer term are to be more rather than less sustainable.

Conclusions

Sustainable development agendas reinforce traditional objectives and priorities in meeting current needs. The longer-term issues associated with sustainable development, particularly the environment, emissions and public health, ensure that increasing sustainability will remain a major preoccupation for transport-related policy work. Clearly, sustainable development presents significant challenges for transport over a broad range of transport activities. International co-operation between OECD and non-OECD countries will be essential to achieve the global improvements required.

Clearly, sustainability will not be achieved by adopting a "business as usual" approach. More challenging policy measures along the lines outlined above appear likely to be required – and likely to be effective – both in developed and in developing countries. Given that sustainability is a longer-term agenda, it is important that policy measures should not be overly bound by existing constraints.

Chapter 21

RECENT AND FUTURE TRENDS FOR CO_2 EMISSIONS BY ROAD TRANSPORT: TECHNOLOGICAL SOLUTIONS TO INCREASE FUEL ECONOMY FOR PASSENGER CARS AND TRUCKS

by

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Introduction

Global emissions of CO_2 are the result of natural life but also arise from human activities: industry, households, transport, etc. Today, the human contribution to greenhouse gases is becoming increasingly large. Therefore, in line with the decisions taken at the Kyoto Conference, and in some cases even earlier, significant reductions in CO_2 emissions are now being implemented or have been proposed:

- In some countries, steel manufacturers have an obligation to reduce their global emissions of CO_2 by 12% between 1990 and 2000.

- In electricity production, coal-using thermal power stations are being replaced by high-efficiency natural gas turbines.

- In the road transport sector, some countries have installed regulations such as CAFE (corporate average fuel economy) regulation for passenger cars in the United States, while the European car-makers (ACEA) have agreed to reduce CO_2 emissions to the mean value of 140 g/km in 2008 and 120 g/km in 2012, with the promise to produce as low-emission models as possible. Japanese and Korean car-makers have signed the same agreement for the European market, although its application has been postponed for one or two years.

With the implementation of the above measures, it is hoped that a reduction in CO_2 emissions can be achieved as called for in the Kyoto Protocol.

Recent trends for CO_2 emissions from road transport

In fact, recent and short-term trends are not moving in this direction. Many countries have to stabilise or reduce their CO_2 emissions by 2010 compared to 1990 levels, but this goals now seems to be unattainable. There are many reasons for this failure to comply with the Kyoto commitment, all of

which can be laid at the doorstep of the high levels of economic performance currently experienced by the industrialised countries, particularly in Western Europe and the United States, where economic growth has become a permanent feature since 1994.

One of the most important reasons is the permanent and constant increase in fuel consumption by road transport, which is totally dependent on oil. At the beginning of 1990s, the share of CO_2 emissions from road transport in global emissions ranged between 17% and 35%, depending of the country considered. As of 1990, this share has been increasing slowly but surely in all countries. Absolute values, in millions of tonnes of CO_2 – the most important of the greenhouse gases – are also on the rise. Between 1990-95, the share of the increase attributable to road transport (measured in tonnes of CO_2), represented 1% per year in all the industrialised countries; since 1996, the share has risen to more than 2% per year in the same countries due to economic growth. And, in some developing countries, the increase is even more significant.

For the foreseeable future, there appear to be no available solutions which would allow a reduction in CO_2 emissions from road transport.

Factors influencing global road emissions

Global road emissions of CO_2 result from several factors. For passenger cars, these include:

- Unit fuel consumption (in litres/100 km or in mpg).
- Mean value of kilometres per year.
- Number of vehicles in use.

Kilometres per year

The number of kilometres driven each year by each passenger car has remained relatively stable in the United States since 1990, while it has increased in all the European countries by nearly 0.8% per year. For Europe, the reasons for the increase include factors such as:

- Vehicles are increasingly comfortable.
- Vehicles are able to attain higher speeds than in the past.
- New highways have been brought into service.
- The relatively low cost of fuel, compared to the price during the 1980s.
- The development of individual housing in distant suburbs.
- Increases in the standard of living, etc.

Number of vehicles in use

The density of vehicles per thousand inhabitants is growing, even when the increasing populations in all the industrialised countries are taken into account. This is the case in Western Europe, Japan and even in North America, where it was forecast that the number of vehicles per thousand inhabitants would approach saturation point during the 1980s. Growth is also very high and fast in many other countries, such as Korea, Turkey or Poland, with increases of more than 200% in Korea, 140% in Turkey and 70% in Poland during the last ten years (CCFA, 2000).

It is clear that the density of vehicles will continue to rise in the industrialised countries to approach the current level of the United States. Over the short term, the potential growth rate is very high in some large countries such as Brazil, Argentina, Mexico, and perhaps in China and India in the long term.

Unit fuel consumption (or unit CO_2 emission)

When compared with passenger-cars of the 1980s, car-makers today have made important progress in reducing fuel consumption, particularly in the case of European, Japanese and Korean manufacturers. These advances were obtained without the application of stringent regulations. In the United States, CAFE regulations were applied to classical passenger-cars as from the mid-1970s in an effort to limit unit fuel consumption. However, the introduction of the sport utility vehicle (SUV) category, which is not covered by strict CAFE regulations, has pushed the unit fuel consumption of this category to high levels. During September 2000, in spite of the climbing price of gasoline, the SUV category accounted for 50% of all vehicles sold in the United States. Many SUV are equipped with V6 or V8 gasoline engines, and have a maximum weight of 1.5 or 2 tonnes; they are very bad on fuel efficiency.

In Europe, the mean CO_2 emission level for passenger cars sold during 1999 was nearly 175 g CO_2 per kilometre, compared with 186 g in 1994-95. Progress has been made, but several factors need to be taken into account:

- The mean value results from measurements taken along an “official cycle”, which is the same for all models of cars (*i.e.* it does not include high accelerations or heavy loads).
- During the cycle, the cars are driven without energy-consuming accessories such as front lights, air conditioning, etc. It should be noted that more than 50% of new vehicles purchased in 1999 were equipped with air conditioning, compared to less than 10% in the early 1990s.
- Customers buy vehicles with increasingly powerful engines.

This last point is very important. In Europe, the mean value of engine power increased from 51 kW to 60 kW between 1980-90 in seven countries; for 1999, this value is now 70 kW for the same seven countries. A detailed analysis of these recent trends in some European countries is available (CCFA, 2000).

Vehicles are becoming more and more powerful in all countries: between 1996-99, mean engine power increased by 6 kW in the United Kingdom, 7 kW in Germany and 8 kW in France. These vehicles can attain high speeds and have very high acceleration, generating high CO_2 emissions in real use.

Trends in freight transport

Freight is carried by road, rail and waterway. For the last 30 years, global traffic has increased throughout the world and the percentage of freight carried by road has also increased, even in industrialised countries, in spite of the existence of very dense and up-to-date railway systems. The reasons for this trend are clear: just-in-time management, door-to-door delivery, flexitime, stocks inside trucks, competitive prices, etc.

In Europe, the share of freight transport carried by road during the 1980s was 60%; it is now close to 75%, and the absolute volume of freight is climbing by 4-5% per year. Some indicators forecast growth of more than 100% for road freight between 1995 and 2010 in Europe (in billions of tonnes per kilometre).

A number of countries have decided to modify this trend. Switzerland is a very interesting case: because of the very stringent limitation of 28 tonnes total weight for road trucks, all the heavier European trucks are obliged to use rail to cross Switzerland (for example, from Germany to Italy). Therefore, an important railway network was set up. However, even with this system, the results were not evident:

- The share of national freight traffic carried by rail decreased to the benefit of road.
- International road freight traffic, limited by the 28 tonnes maximum authorised weight, surged from 7% of global freight traffic (rail + road) in 1984 to 26% in 1994.

For the future, Switzerland has decided to progressively adopt a maximum authorised weight of 40 tonnes for trucks, with a toll for international traffic (free circulation with toll in 2005). Initial evaluations suggest that even with a toll, hauliers find it more profitable to travel by road than by rail because of just-in-time. It is envisaged that through road traffic will increase very significantly.

Technical parameters influencing fuel consumption

Vehicle forward motion and priorities

Four resisting forces must be overcome in order to move a vehicle:

- Rolling resistance.
- Aerodynamic resistance.
- The force of inertia during acceleration.
- The force of gravity on a slope.

Sensitivity analysis provides the order of priorities required in order to drastically reduce fuel consumption, and CO_2 emissions:

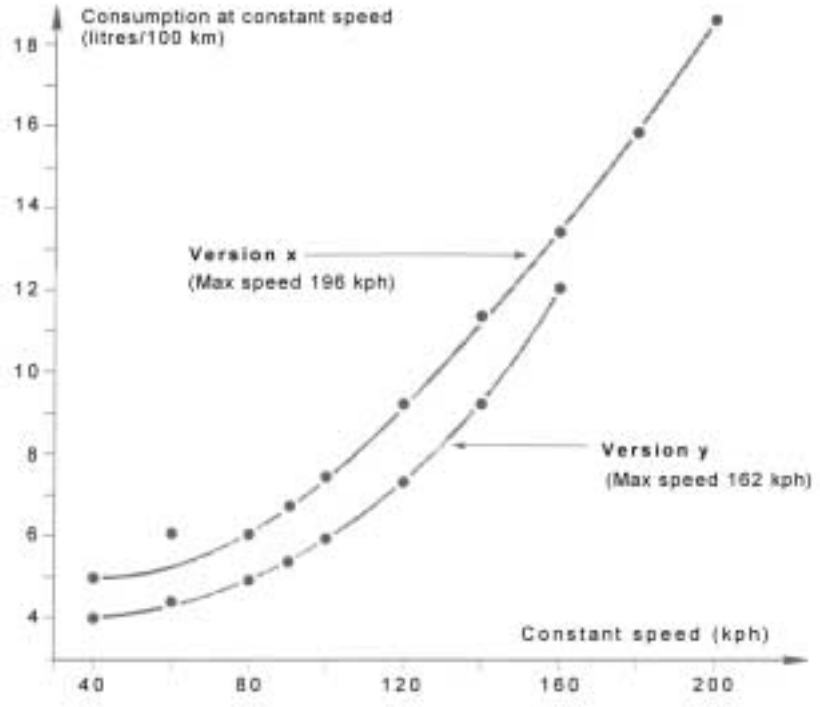
- *Highest priority:* increase the efficiency of the engine (and the transmission).
- *High priority:* reduce the weight of the vehicle.

- *Priority:* reduce the aerodynamic drag.
- *Low priority:* reduce rolling resistance (need to maintain safety).

The current situation

In fact, today, all the car manufacturers are producing vehicles which are increasingly heavy and have more and more powerful engines. This tendency has a very strong influence on fuel consumption, both at constant speeds and in urban traffic conditions. Some examples are reported in Figures 1 and 2.

Figure 1. **Fuel consumption at constant speeds for the same model of car equipped with two different engines**



In Figure 1, at constant speeds, the same model of vehicle is equipped with two engines, able to attain (on high-speed routes) 162 kph or 196 kph, respectively, and the fuel consumption values at constant speeds are reported. The model able to attain 196 kph uses 1 or 2 litres/100 km more all along the range of speeds from 40 to 160 kph, although the two vehicles are aerodynamically identical.

In Figure 2, in urban traffic conditions, the fuel consumption of 41 models in urban use are reported in function of the maximum speeds that each of these vehicles is able to attain. The differences are very important and can exceed 4 litres/100 km between vehicles which are able to attain only 170 kph and vehicles able to exceed 200 kph.

The values of urban fuel consumption of four recent gasoline models existing in different versions and sold in Europe are reported on Table 1, in function of their maximum speed. These four models occupied 35% of the European gasoline market at the beginning of 2000.

Figure 2. **Urban fuel consumption vs. potential maximum speed for 41 gasoline models**

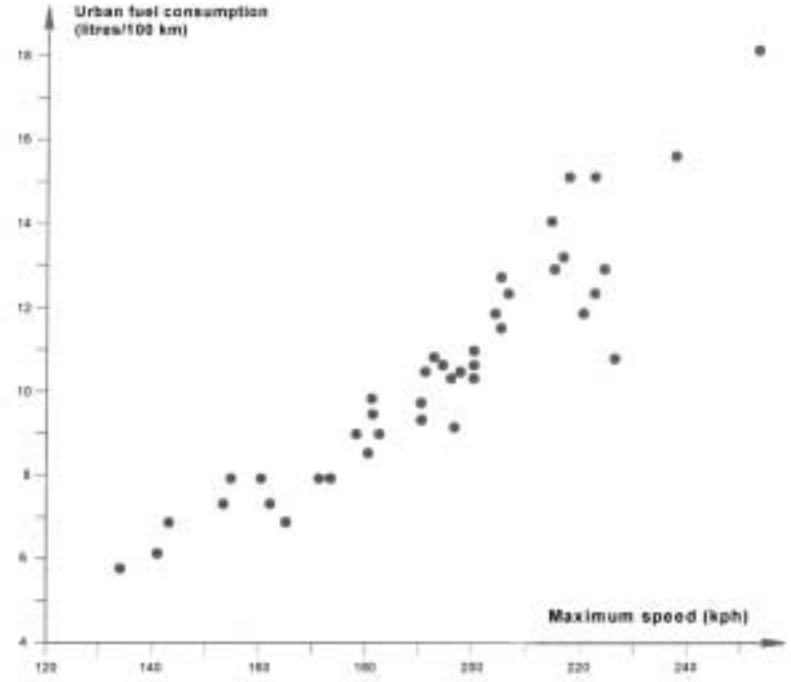


Table 1. **Fuel consumption in urban use with respect to engine type for four widely available gasoline models in Europe, 2000**

Model of car	Version	Maximum speed (kph)	Mass (kg)	Urban fuel consumption (litres/100 km)
A	1	164	840	8.0
	2	178	865	9.4
	3	205	950	11.4
B	1	158	930	8.2
	2	170	980	8.9
	3	185	1 055	9.4
	4	210	1 050	10.9
C	1	173	1 235	9.7
	2	185	1 250	9.6
	3	196	1 290	10.8
D	1	171	1 126	8.5
	2	192	1 149	9.3
	3	216	1 280	10.9
	4	235	1 440	15.3

The same comparison is reported on Table 2 for two diesel passenger cars existing in different versions (all with new direct injection technology).

Table 2. **Fuel consumption in urban use with respect to engine type for two diesel models available in Europe, 2000**

Model of car	Version	Maximum speed (kph)	Mass (kg)	Urban fuel consumption (litres/100 km)
E	1	180	1 241	6.5
	2	195	1 280	6.9
F	1	166	1 677	8.0
	2	181	1 678	8.3

It should be noted that in urban use, diesel vehicles present better fuel economy, even when the different fuel densities are taken into account. For example, in urban use with the same mass and same performances, diesel vehicles (direct injection) use 5.5 kg of fuel per 100 km (170 g CO_2 per km) vs. 7.2 kg of fuel per 100 km (220 g CO_2 per km) for gasoline vehicles. The advantage of diesel engines is thus confirmed, especially in urban use.

Actual mass and power incidence on fuel consumption

Analysis performed on fleet of vehicles of various masses allowed an accurate assessment of mass incidence. A 100 kg increase in mass leads to an increase in consumption ranging from:

- 0.3 to 0.8 l/100 km under urban use conditions.
- 0.3 to 0.7 l/100 km under average urban-road/highway use conditions.

Over a vehicle's lifetime (150 000 km), a 1 kg weight increase corresponds to an increase in gasoline consumption of 3.4 to 7.9 kg, and/or an increase in diesel fuel consumption of 3.7 to 8.7 kg.

In the same way, an analysis of vehicles representative of all the vehicle ranges led to the following conclusion relating to power incidence. For a given model of car, a 10 kph increase in potential performances at maximum speed leads to an increase in actual fuel consumption of:

- 0.4 to 0.7 l/100 km under urban use conditions.
- 0.2 to 0.3 l/100 km under road conditions.

This corresponds to an increased fuel consumption ranging from 300 to 500 kg over the whole lifetime of the vehicle. These evaluations are always verified with the different models, gasoline or diesel, present on the market in 2000.

Technological progress

A good number of technological advances have been made and applied by all the car-makers on classical engines, gasoline and diesel. Other examples of progress are now possible or are currently being researched.

Classical engines

For gasoline engines, the development of multivalve systems and modifications to the combustion chamber have led to fuel savings of nearly 10%, even under urban use conditions, while increasing engine power (Table 3). The use of direct injection gasoline engines, although currently limited to only a few models, could lead to savings of some 10% to 15% compared with classical gasoline injection engines.

Table 3. **Evolution in gasoline engines and fuel consumption on the same passenger car**

Medium size, upper part

	1999 model (1.8 l – 8 valves)	1999 model (1.8 l – 16 valves)	2000 model (1.8 l – 15 values)
Power (kW)	67	81	85
Maximum speed (kph)	181	192	197
Urban fuel consumption (litres/100 km)	11.8	11.9	10.6 (-11%)

For diesel engines, the recent use of direct injection (for example, with common rail solution) has led to savings ranging from 13% to 19% in urban use conditions, compared to indirect diesel injection on the same models. In 2001, all diesel passenger cars will be equipped with direct injection.

All these gains are obtained with 50 to 100 kW engines. By down-sizing, it will be possible to obtain gains of 30% to 40%, without important modifications to technologies:

- With a four cylinder 800 cm^3 or 1 000 cm^3 model, or even more so with a three cylinders 900 cm^3 model (combustion problems occur with too-small chambers) in gasoline or diesel.

- With turbo-charge, etc.

New technologies

Several solutions are now being researched or have been produced in small quantities:

- *Camless engines:* a gain of 5%-6% is possible, although the gain in actual use would certainly be higher because of the possibility to pilot the valves in line with the driver's power requirements.

- *Turbo-charging controlled by an electric motor:* a gain of 5%, particularly during acceleration.

- *Air-conditioning:* with a new concept to reduce the power requirements, a savings of 5% on fuel consumption compared to the situation today.

- *Hybrid vehicles:* using a combination of classical engine (gasoline or diesel), electric generator and electric motor, it is possible to optimise the global energy consumption of the

vehicle. Two or three models of passenger cars using this technology are now available on the market; savings on fuel consumption amount to 10% to 20%.

However, these are first-generation solutions and are reserved for medium-to-large vehicles. With other technologies, it will be possible to obtain more significant savings, especially on small vehicles. A number of possible solutions propose "smooth" hybridation using a 5 kW electric motor or "large" hybridation using a 50 kW one. With 5 kW, the electric motor is used only to start the car during stop-and-go urban use, while with 50 kW, all the power is supplied by the electrical system, even during road use. A potential gain of 20% to 30% could be attained compared to in-use vehicle, and this gain could be even more significant depending on the size of batteries installed to stock electricity and on the strategy used to pilot the energy group.

- *Electric vehicles and fuel cells:* the gain in global fuel consumption, and in CO_2 emissions, will depend on the origin of electricity for electric vehicles and the origin of the fuel for the fuel cells (methanol from natural gas, hydrogen from electrolysis or from cracking of natural gas?).

Targets for passenger cars and trucks

With the exception of very small vehicles reserved for urban use, it will be possible to produce two ranges of passenger cars with the following parameters:

- A small-size model: 650 kg, power limited to 25-28 kW, with CO_2 emissions of 70-80 g/km on the official cycle (90 to 100 g/km in real use), with an advanced hybrid system, it could be possible to attain 60 g/km.

- A medium-size model: 850-900 kg, power limited to 40-45 kW, with CO_2 emissions of 120-130 g/km (130 to 140 g/km in real use).

These models could use new diesel engines (very high pressure), a hybrid system, advanced batteries to stock energy, etc.

For trucks, the models produced in 2000 are extremely fuel efficient (32-33 l/100 km for a 40 tonne truck with a maximum commercial speed of 70 kph); technological progress is always possible (combustion chamber, injection, turbo-compound system, electric transmission, etc.), although the target of 29 l/100 km seems to represent the absolute limit.

Conclusions

The analysis indicates that there are strong trends towards growth in road transport which will lead to a significant and continuous increase in CO_2 emissions from road transport, at least for the next ten years. It would be difficult, and perhaps impossible, to modify these trends in the short term. For passenger cars, customers are looking for more powerful vehicles equipped with options for added comfort (air-conditioning, guidance screens, etc.).

The density of vehicles is growing in all countries and is unlikely to slow down in the near future – except, perhaps, in the United States.

The reasons underlying these developments are clear: greater distances between home and workplace, lack of public transport, particularly in the suburbs, commercial centres in easy reach by car, and relatively low priced energy (even with taxes).

Technological innovations will lead to low-fuel-consumption vehicles, although the renewal of the fleet will take a long time – nearly ten years, and it is not clear that customers will want to purchase such low-performing vehicles in a free market.

In terms of freight transport, the advantages of road transport (just-in-time, door-to-door, fuel efficiency, etc.) are so evident that, even with regulatory constraints (on safety, pollution, noise, etc.) and specific constraints (for example, tolls), the share of road transport will continue to increase in all OECD and non-OECD countries.

In the face of high and sudden economic growth, road transport alone is likely to become efficient very rapidly. In fact, rail needs important investments which are long to implement and which are geographically fixed. Technological innovations to reduce fuel consumption of trucks are possible, but the possibilities are limited.

It is clear that, due to the above trends and in spite of the introduction of new technologies, compared to 1990 emissions, CO_2 emissions by passenger cars and trucks in the OECD countries will not be reduced by 2010-15; instead, they are forecast to increase very strongly in some OECD countries and non-OECD countries.

Non-technical measures which could be implemented include:

- Taxation of each litre of fuel.
- Taxation of parking spaces at the workplace.
- Town and country planning.

However, all of this calls for long-term involvement and it would be necessary to run simulations with models to analyse the impacts of new taxes, new regulations or new town and country planning on reducing CO_2 emissions by road transport.

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Chapter 22

ENVIRONMENTAL IMPACTS RELATED TO TRANSPORT IN MEXICO WITH SPECIAL EMPHASIS ON HIGHWAYS

by

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Introduction

The communications and transport sector plays an extremely important role in Mexico since the necessary infrastructural work for the country's development have been carried out through the implementation of various action programmes. This sector includes the highway, railroad, maritime and ports, air, communications and administration sub-sectors. The first four of these are directly related to transport, defined as "the movement of people and goods within and without a nation's borders".

Transport activities are the foundations of a society's economic, political and cultural behaviour and make it possible for human communities to interrelate. The evolution of highway and railroad networks, and sea and airport systems, has had a major bearing on the location of industry, urbanisation and human settlements.

The 1995-2000 National Development Plan states that basic infrastructure and communications and transport services should be adequate, modern and efficient in order to render the economy more competitive and productive, promote regional development, and ensure the integration of markets, with a view to improving the quality of life of the Mexican people. The 1995-2000 Communications and Transport Sector Development Programme comprises a detailed diagnosis of the situation of the sector as of the beginning of the current period of government, the main problems and challenges faced by each mode of transport, the goals to meet, and the strategies and action lines necessary in each case.

In Mexico, most people and goods are transported on the national system of paved and unpaved highways which is made up of some 48 103 km in the federal network, 63 405 km in the state network, 158 285 km of rural roads and 53 062 km of improved unpaved roads, a total of 322 856 km. In turn, the federal network is divided into some 6 276 km of toll roads and 41 827 km of freeways. Every year, the transport system moves more than 2.6 billion passengers and around 600 million tons of freight in 9 million vehicles.

As far as passengers are concerned, over 2.6 billion use motor vehicles; 7.2 million use the railroads; 4.7 million use maritime transport and 29 million use the air transport service. In terms of

freight, 60% (356.5 million tons) is moved on the highways; another 31.2% uses maritime transport (185.4 million tons) and the remaining 8.8% uses the railroads (52.1 million tons).

An additional aspect considered in the Communications and Transport Sector Development Programme concerns multimodal transport, which has yet to be fully developed in the country. Suitable strategies and action lines must be established to make freight movement faster and more efficient by integrating the different modes of transport in a way that ensures the appropriate linkages.

The most important activities carried out by the Secretariat of Communications and Transport include the modernisation and maintenance of existing works and the construction of new works.

Modernisation refers to widening the cross-section of existing roads to increase capacity. According to the 1999 publication, "Modernisation of the Main Highway System", the current administration has undertaken the modernisation of some 4 700 km of federal highways.

As regards maintenance, around 41 000 km of the federal freeway network are repaired each year; while some 1 200 km of roads and more than 150 bridges are rebuilt. Maintenance programmes have been implemented for more than 6 000 km of toll roads.

New roads comprising two or four traffic lanes have been constructed, and bypasses of the main cities along the ten main highway corridors have been planned; these will facilitate long-distance national and regional traffic by allowing it to avoid congested urban areas.

In developing countries such as Mexico, full consideration must be given to such important factors as the economy. Faced with insufficient public funds, the federal government has implemented a programme to build and operate new four-lane toll highways, some of which were leased to the private sector and to Mexico's state governments.

Projections made before 1994 for the highway kilometres needed by the country and the investments required to build them have not been met, partly due to the economic crisis which began towards the end of 1994. Construction costs exceeded forecasts, tolls charged by lessees were very high and traffic flows turned out to be much lower than forecast. Once again, the federal government had to take charge of these highways to avoid damage and to promote use by drivers. Against this background, it is understandable that priority is now being given to what are considered strategic projects.

New schemes must also be developed for road infrastructure financing. These schemes must include both private and public funds to support and complement the annual federal budget that provides the majority of funds for all types of road infrastructure investment.

Public-private participation through concessions can play an important role in certain cases. The new concessions will be based on a rigorous project preparation, including thorough traffic studies; complete project design; right-of-ways acquisition prior to construction; environmental impact studies and marketing analyses to set tolls at levels that users can afford.

In its target vision for 2001-10, the Secretariat of Communications and Transport has identified a set of feasible projects that can be developed. Actions should focus on allowing the ten main highway corridors to offer the travelling public a safe, efficient and well-connected road system. The projects include the bypasses needed around the country's most important cities.

Environmental impact assessment in Mexico

Mexico is a North and Latin American country with several years' experience in the application of federal, state and municipal government environmental policies at different levels. Progress has been made in mitigating environmental impact, mainly due to the fact that preventive policies have been recognised as an important tool in the correction of existing environmental imbalances.

Environmental impact assessment for major federal development projects existed in the country as early as in the mid-1970s, but became official practice in 1980 when the Public Works Act and its regulation stated for the first time that public works must take necessary steps to avoid damage to the environment. Private sector project assessment dates from 1982.

In Mexico, the General Ecological Balance and Environmental Protection Act (1988) underwent amendments, additions and abrogations to several of its provisions in December 1996. The Environmental Impact Regulation Act (1988) also underwent amendments in May 2000. These specify the types of projects and activities for which project proponents must present environmental impact statements. Highways, bridges, tunnels, ports, railroads and airports are communications and transport projects that must be analysed to anticipate the environmental impacts that would be generated by their construction and operation.

The Federal Highway Bureau of the Secretariat of Communications and Transport is responsible for carrying out environmental impact statements (EIS) for proposed projects and integrating them into the environmental impact procedure of the National Ecology Institute, a decentralised body of the Secretariat of the Environment, Natural Resources and Fisheries. New guidelines for EIS for this kind of project have been recently issued.

The personnel of the Bureau of Environmental Impact, backed by other bureaux in the National Ecology Institute, are responsible for reviewing statements and issuing technical reports approving, applying conditions or rejecting projects.

The project proponent must execute the mitigation and other measures proposed in the study and the recommendations and/or conditions established by the authorities in the report. The Federal Attorney General for Environmental Protection must ensure that the project proponent complies with the terms of the report. In this case, the Federal Highways Bureau carries out a system of internal oversight to verify that works constructors quantify the cost of each project's mitigation measures and any conditions imposed at the time of approval, and implement them.

Apart from Environmental Impact Statements carried out by the Federal Highway Bureau, the Mexican Transport Institute has an environmental department within the Infrastructure Co-ordination, which in recent years has concentrated on reinforcing actions to protect the environment. For example, in the field of highway planning, the Institute has a document that establishes the need to consider environmental aspects in the process of planning highway infrastructure from the beginning until work execution. Among other actions, this process must include the proposal of improvements in the management of traffic and public transport on existing highways, and improvements to the design of projects, including routes that do not affect important or fragile natural resources and areas, to name but a few.

In terms of field research, a pilot study was recently performed to study noise levels on some of Mexico's highways, and the recommendation was made to continue assessing suitable values so that an official standard can be issued aimed at limiting the noise levels generated by vehicular traffic during the operation of highways.

Moreover, the Institute's Standards Co-ordination is in the process of issuing official standards and procedures manuals related with the environmental studies that must be performed as part of the environmental impact statements for highways.

Environmental impact of the construction and operation of highways

The studies leading to the various environmental impact statements for sections of highways throughout the country have allowed the individual environmental impacts of these works to be identified. Although the types, characteristics, scale and importance of the impacts vary according to the project in question and its corresponding local environment, in general terms they cover the following:

- The socio-economic impacts of damage to common and private land within the rights of way.

- The impacts on climate, air, soil, surface water, geomorphologic dynamics, plant and animal life, landscape and human populations of levelling and clearing, taking such diverse forms as changes in microclimate, suspended particles, increased soil erodibility, an increase in suspended solids in watercourses; an increase in the intensity of the action of erosion and sedimentation, loss of existing vegetation, direct destruction of wildlife habitats, visual impact, and a reduction in surface areas dedicated to other productive activities.

- Impacts on the air and health of workers and inhabitants of the area due to the transportation of materials, to the presence of suspended particles and dust and the generation of gases, smoke and noise.

- Impacts on soil, surface water, plant and animal life, and landscape due to cuts which change the original topography and stability of the land; damage the pattern of natural drainage; create barriers to wildlife and cause major visual impacts in mountainous areas due to the height of the sides of the cuts.

- The creation of dumps increases sedimentation and silting when material is deposited on surface watercourses within a project's bounds and area of influence. They can affect springs, vegetation, wildlife habitats and landscape.

- Impacts on soil, surface water, geomorphologic dynamics, plant and animal life, landscape and human populations due to the exploitation of quarries, in the form of increased soil erodibility; damage to natural drainage patterns; an increase in suspended solids in watercourses; an increase in the intensity of erosion and sedimentation, loss of existing vegetation and direct destruction of wildlife habitats; the visual effect of the devastation of land due to the extraction of materials, and changes in land use on common or private land.

- The operation of crushing and asphalt and hydraulic concrete producing machinery and equipment generate impacts mainly related to the emission of gases, particles and noise; changes in soil quality due to spills of fuel, and visual damage due to the operating yards.

- Impacts due to incorrect handling and disposal of waste during construction from camps and/or work fronts, that can cause soil, surface and underground water pollution.

- Atmospheric and noise emissions produced by traffic during the highway operation.

The identification and assessment of the environmental impacts caused by the construction and operation of highway sections has allowed the definition of the places and times at which such impacts occur, and the proposal of measures to prevent, minimise and/or compensate for them. In all cases, reforestation programmes and mitigation measures have been designed and must be undertaken by project proponents, who must comply with the ruling issued for each project by the federal environmental authority.

Despite the efforts that the Secretariat of Communications and Transport has dedicated to environmental impact statements for proposed projects and the commitment to environmental, the implementation of environmental protection and restoration programmes is not carried out in a regular fashion, due to lack of budget, supervision and follow-up.

With respect to environmental impact assessment practices in Mexico, significant progress has been achieved in recent years but much remains to be done in certain areas. For example, assessments must be made in parallel to the planning of projects in order to integrate environmental protection measures and to estimate their potential monetary costs. This goal seems unlikely to be attained in the near future because projects are usually analysed in the final stages of their design.

In addition, in accordance with the Public Works Act which governs highways and other federal works, both the contracting of environmental impact studies and the construction of the works themselves are subject to restrictions imposed by the Act which mean that works are granted to whoever guarantees the all-too-often incongruous factors of quality and a low price tag. Moreover, to date, the Secretariat does not have a table of unit prices for environmental protection and restoration measures so contractors do not consider them in their budgets.

Together with the lack of budget, some local site supervisors do not have the environmental impact reports during construction and are unaware of the measures that must be taken. Even where they are aware of environmental protection and restoration measures and programmes, the construction companies that are contracted have not always included the costs of carrying them out in their budgets and they are simply left undone.

Another failing involves the lack of an appropriate definition of the times to be assigned for the follow-up of results in terms of implementing environmental protection and restoration measures if, indeed, they are carried out at all. Thus, for example, when planting is done, the new stands should be nurtured for a given period of time in order to guarantee the survival of the plants and ensure the desired effects in stabilising cuts, avoiding erosion and slides, and properly integrating the highway into the surrounding countryside.

Mexico in the international context

Over the last 15 years, Mexico has acquired important international commitments including the free trade treaty with the United States and Canada, and free trade agreements with other Central and South American countries, Israel and the European Community. In 1994, it joined the Organisation for Economic Co-operation and Development (OECD) and the Asia Pacific Economic Conference (APEC). It also participates in the European Reconstruction and Development Bank.

In addition, as far as environmental aspects are concerned, Mexico has signed such international agreements as Agenda 21, the Biodiversity Convention, the Montreal Protocol and the Convention on Climate Change.

In the field of vehicle transportation and in the framework of NAFTA, agreements were established on penetration by international transport companies into areas beyond the national, state and provincial borders of Mexico, the United States and Canada, and also on the permissible degree of foreign investment in transport companies.

In addition, new sections of high-specification highways were built during the period 1989-94 to provide Mexico with the infrastructure considered necessary to permit a rapid opening up of the economy.

Moreover, since it joined the OECD, Mexico has assumed a range of technical commitments related to environmental protection, including the prevention and control of water, air and soil pollution, the correct handling of chemicals and the drafting of housing, transport and energy consumption policies aimed at sustainable urban development.

Where transport is concerned, the Secretariat of Communications and Transport participates in the OECD's Highway Transport Research Programme. For example, in June 1997, Mexico hosted the OECD Seminar on Intermodal Transport Networks and Logistics in Mexico City. The main objectives of the Seminar were to:

- Present progress and experience on intermodal transport highlighted through OECD reviews and actual cases worldwide.

- Contribute to the development of policies and strategies of intermodal transport systems with a view to the roles and responsibilities of public and private entities at the national and regional levels.

- Promote new public private partnerships to develop transport infrastructure and financing systems.

- Develop an international network of professionals active in intermodal transport and logistics.

In November 1999, the first OECD seminar on Transport Information and Documentation for Latin America was held in Acapulco. The main objectives included the dissemination among members from the participating countries of methods to access information and documentation on transport.

Conclusions

The environmental impact assessment of highway projects in Mexico has been carried out in recent years to foresee the environmental damage of their construction and operation, and to propose measures to avoid, minimise, correct or compensate for environmental impacts.

The presentation of environmental impact statements for highway sections has allowed the study of the environmental characteristics of the areas in which they are built, and the identification in each case of the specific potential impacts of future works. However, there has been no holistic appreciation of the cumulative impacts that these sections have had on the environment.

In recent years, budget limitations and the short construction times of many highway sections have not permitted the proper implementation of environmental protection measures, and the effort invested in environmental impact assessment is not evident in finished and operating works.

Recommendations

In order to avoid and minimise the environmental impacts caused by the construction and operation of communications and transport works, especially highway infrastructure, and to ensure sustained growth in the sector, the following recommendations are proposed:

- The next federal government sectoral programme should not only mention the need to carry out environmental impact studies for infrastructure works but should also include in its diagnosis recognition of the environmental problems caused in the recent past by the over-sizing of certain sections of highways that has unnecessarily damaged large areas of land. In addition, in the part dealing with strategies and action lines, the need to improve the design of projects by taking into account the environment in which works will be developed must be reiterated.

- The planning and design of future highway projects must include environmental aspects from the early stages of preparation. For this purpose, it is suggested that the Secretariat staff who develop projects include professionals trained in and aware of the variables of the particular environment to be subject to field and desk studies. The standards and manuals to be issued by the Mexican Transport Institute must be taken into account.

- Unit prices must be established for environmental restoration actions so that contractors of future highway works can include them in their budgets and provide the necessary funds to carry them out. This will guarantee that affected areas will not be left abandoned without the implementation of the restoration and reforestation programmes proposed in environmental impact statements. Such unit prices could also be used when federal funds are available to carry out works, in the event of highways granted in concession, and when there is financing from international organisations.

- There must be supervision and follow-up actions within the Secretariat through close co-operation between the Federal Highways Bureau, responsible for carrying out environmental impact statements, and the different centres located within the states of Mexico. To this end, suitable time periods must be established and the technical capacity of local personnel reinforced so that they can oversee the implementation of mitigation measures and environmental restoration actions.

- It is recommended that decision makers in communications and transport policy in Mexico consider other ways and means of moving passengers and freight, giving priority to those options that cause less pollution, such as railroads, and discouraging the use of private vehicles. In the short and medium term, this measure would lead to savings of fossil fuels and reductions in emissions of atmospheric pollutants and noise.

The following recommendations are made in the field of international co-operation:

- More detailed information should be provided on the experiences of OECD Member countries and other nations in the design of highway infrastructure works in cases that include environmental protection forms and elements, and earth stabilisation techniques and materials that minimise erosion, avoid long-duration conservation work and integrate highways naturally into the landscape.

- Obviously, their application would have to be assessed and would depend on the particular characteristics of Mexican natural environments, the budget available for works and the will to carry them out in new ways.

- There must be promotion for the holding of courses, workshops and seminars where such experiences can be explored, and advice must be provided in applying environmental technologies in pilot projects and evaluating their results in different Mexican environments, so that they can be applied on a large scale where appropriate.

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Chapter 23

THE SOUTH AFRICAN-NETHERLANDS TRANSPORT FORUM: AN EXAMPLE OF INTERNATIONAL CO-OPERATION ON SUSTAINABLE TRANSPORT

by

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Introduction

South Africa and the Netherlands have long-standing bilateral relationships. This is reflected, among others, in the fact that the Netherlands is currently South Africa's sixth largest trading partner and ranks among the top ten foreign investors in the country.

From the perspective of sustainable development, South Africa, like other developing nations, faces many problems. In addition, South Africa is confronted with the legacy of apartheid. In a way, this represents a double challenge: how to enhance material welfare while minimising environmental degradation, and at the same time promote black empowerment in the socio-economic system. One of the conditions for successfully dealing with this challenge is an efficient, safe and sustainable transport system.

Currently, however, the efficiency, safety and sustainability of the South African transport system is not adequate, at least compared to the international standards in more developed countries. The South African Government fully recognises this situation and in 1999 presented its long-term vision of improvements to the transport system in a document entitled "Moving South Africa – The Action Agenda". In order to implement the Action Agenda, the Republic of South Africa has sought co-operation with several countries. One of these is the Netherlands, both because of the historical relationship linking the two countries and because of the good reputation of the Netherlands in the field of sustainable transport policies in general, and in the ports and maritime sector in particular. Furthermore, it was recognised that in spite of the enormous differences in the two countries' transport situations, there are great similarities in policy vision and strategy.

Against this background, the Minister of Transport of the Republic of South Africa, Mr. A. Omar and the Minister of Transport, Public Works and Water Management of the Netherlands, Mrs. T. Netelenbos agreed in September 1999 to develop a joint action programme to intensify bilateral co-operation in the domain of ports, transport and infrastructure development. This was laid down in a protocol which was signed in January 2000. The South African-Netherlands Transport Forum (SANTF) was established with a view to the implementation of the protocol.

The focus of the Forum is not directly aimed at typical pollution and cleaner technology issues. The Forum has chosen a wider perspective: co-operation to promote a more efficient, safe and sustainable transport system which can contribute to a better competitive position on the world market, and can also bring about improvement in the domestic situation of South Africa.

In order to determine the priorities of the Forum, an assessment was made of the current transport issues and areas in which international co-operation would provide added value.

Three priority areas were formulated: ports and infrastructure; human resource management (education and training); and transport safety, in particular road safety. It was expected that in these areas mutual benefits could be achieved, both on the government level and on the private sector level. For a proper understanding of these choices, some background information on the South African transport situation is presented below.

The transport situation in South Africa today and tomorrow

The political and social reforms which were initiated after the apartheid period by the new democratic government have created the conditions for sustainable development. The desired enhancement of material welfare for the black population provides, in the long run, a better basis for the adoption of environmental goals (emissions, safety, better use of space, etc.). However, improved material welfare can lead to higher pressures on the environment in the short run. The forecasted increase in income per capita will substantially increase the demand for transport services. Consequently, it is important to achieve at least a better environmental performance per unit of product or per head of the population – even if this mean that, in some areas, increased total pressure on the environment has to be accepted.

Looking at the environmental situation, it is noteworthy that South Africa ranks as the third most biologically diverse country in the world and as such is of major importance for biodiversity conservation. For example, there are 18 000 vascular plant species within South African boundaries, of which 80% occur nowhere else, and the country hosts 8% of bird species, and 16% of the total number of marine fish species in the world. A substantial proportion of the natural habitats of these flora and fauna is threatened by agriculture, urban development, deforestation, mining and dams.

Passenger and freight transport are not in themselves the major threat to the natural environment for wildlife and for people, but they do contribute indirectly to the burden on the environment through their role as enablers of economic growth in various sectors (*e.g.* manufacturing industry) which affect the environment more directly. In some cases, however, transport represents a direct threat. For example, the marine habitat can be directly affected by marine pollution, in particular in the case of disasters involving oil tankers.

In terms of passenger transport, South Africa is confronted with the legacy of apartheid. Of the roughly 41 million people in South Africa, 77% classify themselves as black Africans, 11% as white, 9% as coloured and 3% as Indian/African.

Many black people have to travel long distances on foot. The urban transport system was set up primarily to carry large volumes of inexpensive labour (*i.e.* black commuters) over long distances. The bus fleet is very old (13 years) and cost recovery of buses and rail modes is low (50% and 30%). The main mode of public transport – taxi mini buses – carries over half of the urban commuter traffic. The taxis are barely regulated, and are unsafe, relatively old and polluting. The average age of the existing taxis is nine years and the accident rate is increasingly high.

In the field of freight transport, the system was designed to support an import-substitution economy and worked against the export competitiveness of high value-added products. Pricing policies in the ports were intended to penalise certain imports and encourage exports of bulk commodities such as coal and iron ore.

The document "Moving South Africa" (MSA) describes a failing rail service and inefficient port system with one exception: South Africa has world-class bulk freight systems in the ports, particularly Richardsbay.

Freight transport operations were in the hands of a few monopolistic parastatal organisations, *i.e.* Portnet (which controls seven important ports) and Spoornet, part of Transnet which supervises all the parastatal bodies in the transport field. This situation had led to a relatively inefficient freight transport system which was inadequate for the needs of the future.

The MSA vision recommends a number of measures aimed at improving the national transport system. Transport should function as a generator of national integration. Furthermore, transport is viewed as an enabling industry, a critical input to other industries in service of the needs of the nation. The external costs are expected to rise sharply. In urban areas, the trend is towards increasing congestion and the private car fleet is forecast to increase by 64% by 2020. MSA concentrates on explaining the measures which need to be implemented; data on actual emissions and quantitative information on pollution are not published in the document. It was recognised that the current external costs – congestion, pollution, accidents and infrastructure damage, etc. – are not paid for by users, particularly in the case of road transport users. In the case of passenger transport, this situation needs to be changed through measures aimed at:

- Achieving density in corridors and nodes; in this way the dispersal of urbanisation and traffic can be halted.

- Improving modal economics and the quality of the service of the various modes; this has to be achieved by market segmentation, corridor supportive investments such as dedicated busways and tough road-space management such as peak pricing externalities.

- Enhancing performance at the firm level; this has to be achieved by tendering services to the private sector, further environmental safety regulation and the reduction of operating subsidies.

In the field of freight transport, the MSA strategy aims at:

- Building densities by focusing freight flows in a select number of transport corridors.

- Making more effective use of the various modes of transport in such a way that they function as integrated links in a seamless logistical chain; furthermore, by promoting competition between modes.

- Improving firm-level competitiveness by means of: education and training; restoring price signals and, in particular, lowering the levy on high-value export products; removing bottlenecks such as the lack of cooling facilities for fruit; and reducing monopolies. The latter is, for example, the background behind the splitting up of Portnet into a Port Authority Division and a Port Operations Division; this will address many of the firm-level performance and productivity issues raised in the MSA report.

It was agreed between South Africa and the Netherlands that a three-year co-operation programme could lead to economic and operational improvements which would (directly or indirectly) enhance black economic empowerment (BEE) and sustainable economic growth.

The South African-Netherlands Transport Forum (SANTF)

SANTF aims to further strengthen, implement and co-ordinate all areas of co-operation as set out in the protocol "Bilateral Co-operation in Fields of Transport and Infrastructure Development", at both government and private sector level. SANTF initiates bilateral activities to the mutual benefit of the countries at the level of the two Ministries of Transport, and endeavours to create conditions which allow the respective private sectors to engage in mutually beneficial financial, commercial and investment activities. The protocol has indicated the following areas of co-operation:

- Government to government.
- Ports and infrastructure development.
- Road safety (in conjunction with the activities of the Global Road Safety Programme in South Africa).
- Education and training/human resource development (including BEE).

The financial and organisational arrangements are as follows. The government steering committee assumes overall managerial responsibility for the activities of SANTF. Furthermore, SANTF facilitates a number of sectoral working groups for companies and intermediary organisations operating in the designated fields of co-operation within the South African and Dutch business communities. Working group themes include: ports and maritime; road safety; training and education/human resource development.

The working groups serve as specialised discussion platforms for exchange of information, discussions on bottlenecks in bilateral trade, SA-NL exports and investment and transport sectors in both countries, as well as initiating joint studies and seminars. The working groups report to the government steering committee on activities, developments and recommendations.

The steering committee is co-chaired by two high-level officials of the South African and Dutch Ministries of Transport. The sectoral working groups are co-chaired by two private sector representatives from South Africa and the Netherlands. In the start-up phase, only those participants were recruited who already had relations with counterparts in South Africa or the Netherlands.

The first meeting of SANTF took place in the Netherlands in May 2000. From the South African side, 15 officials participated. From the Dutch side, 25 officials (government, private sector) were present. During this session, project proposals by the three working groups were presented to the steering group. Shortly after the first meeting, 14 projects were approved and set in motion. Some of the projects received financial support of up to 50% of total costs.

All SANTF projects are envisaged to be finalised by December 2001. Examples of the current project initiatives include:

Ports and maritime

- A feasibility study on coastal feeder services in South Africa.
- Development and establishment of a small-scale warehousing project in the port of Richardsbay for general cargo, similar to the warehouse area in Amsterdam's Westpoint.
- Preparation of an investment in a Vertical Reefer Stack for containers in the port of Cape Town, which can also serve as a wind-wall.
- A study on the optimisation of the South Africa-Netherlands cold supply chain for the exports of deciduous and other fruits between South Africa and the European consumer market via the Port of Rotterdam.
- The transfer of knowledge from a Dutch to a South African R&D institute with respect to a transport economic-environmental model ("SMILE").

Training and education/HRD

- A three-day workshop on human resource development, involving 80 representatives of all stakeholders in the transport chain: small businesses, R&D and training institutes, government agencies and unions; this should lead to a permanent round table on transport in South Africa.
- The design of a fruit-scenario for the existing Transport Chain Simulator computer learning machine followed by a train-the-trainer course, in order to prepare the hard- and software installations in South Africa.
- A study on total knowledge infrastructure in South Africa for the transport chain.

Road safety

- A review of road accident reporting and accident data management systems in South Africa, in order to formulate recommendations for South African national safety policies, as well as for provincial road safety action plans.
- A demonstration of professional drivers' training.
- A review of the legislation and execution of vehicle condition inspection systems.
- A review of driver education and examination systems.
- Human capacity building and management in enforcement, in order to improve the effectiveness of traffic law enforcement.

In the meantime, a second Forum meeting was held in Pretoria in October 2000. This was opened by South African Minister Omar and the Dutch Deputy Prime Minister and Minister of Economic Affairs, Mrs. A. Jorritsma. On the South African side, 30 officials were present, on the Dutch side,

20 officials attended. During the seminar, two private sector agreements were signed as a direct result of contacts within the SANTF framework:

- Eggerding & Co Group, an Amsterdam-based mineral-processing company, signed a co-operation agreement with Future Bound Holding (a BEE holding in Durban).

- The Rotterdam company, Smit Internationale, signed an agreement with Dudula Shipping Co Holding (a BEE company in Cape Town).

During the second Forum meeting, additional ideas for projects were identified. These will be taken aboard in the programme for 2001. Some examples of successful projects implemented in 2000 include:

- In the education and training activities field, over 150 South Africans (government and private sector) participated in various HRD workshops and training programmes.

- The Dutch Ministry of Transport assisted in capacity building and support in policy development within the South African Department of Transport.

- Implementation of BEE objectives in existing and new Dutch-South African co-operation agreements.

- Closer co-operation between Dutch and South African companies and intermediary organisations in optimising the total logistic fruit and cold supply chain by expanding the number of companies involved with new SANTF stakeholders.

- Investment initiatives in cooling facilities and warehouses.

Experiences and lessons

The Forum mechanism has proved to be an effective instrument for international co-operation. Although the projects are not specifically focused on environmental issues or environmental technology, the Forum encourages more efficient and advanced transport practices with positive indirect impacts on the environment. For example, better cooling facilities prevent wastage of fruit, while better use of trucks means less transport per unit of product.

The Forum is set up as a public-private partnership because in South Africa a massive restructuring process is underway towards a democratic, market-oriented economy. In such a situation, close relations between government and private sector are indispensable in order to be able to discuss and deal with challenges and bottlenecks as they arise. To enable difficult and sensitive subjects to be placed on the agenda, government steering needs to function in a climate of mutual trust and openness. Furthermore, strong support at the political level is essential for successful cross-departmental co-operation, such as between the ministries of Trade and Industry, Public Enterprises and Economic Affairs.

The effectiveness of the Forum is very much a question of serious and persistent efforts on both sides to identify and develop win-win situations. It requires time and regular personal contacts. The preparation and follow-up to Forum meetings represents a great deal of work. It is particularly noteworthy that the activities have led not only to win-win situations between South African and

Dutch partners, but also between national partners in the same transport chain – for example, the agro-logistics chain.

Now that co-operation has become the accepted mode of operation, it is time to decide on the strategy for the future: what should be the final results? In the case of SANTF, the following objectives have been formulated:

- Wherever possible, the results of the projects should be embedded in self-enforcing structures. This is the case in the field of education and training. The so-called TETA framework can make use of and build on the SANTF project results; this is why the TETA project leader participates in the SANTF education and training working group.

- Some projects should lead to continued, structural co-operation between South African and Dutch partners in their own right; that is, independent of the SANTF framework. For example, this is the objective of the co-operative project between the key knowledge institutes CSIR and TNO . Once the projects have illustrated that there is a good basis for long-term co-operation, they can make further arrangements themselves.

- Some of the projects are one-time actions. In these cases, the role of SANTF ends once the projects have been successfully completed. For example, a capacity-building workshop was held in South Africa in November of this year.

Three years after its launch, the results of SANTF will be evaluated. Based on the evaluation, the Transport Ministers of the two countries will decide whether there is a need for continuation or not. The ambition of the steering group is to achieve its objectives in such a way that the SANTF renders its existence superfluous.

Chapter 24

TRANSPORT AND ITS KEY CHALLENGES

by

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Introduction: The role of transport in the economy

Transport is central to economic and social development. Access to markets and resources is critical to opening possibilities for trade and economic growth. Physical mobility is considered a personal prerogative and influences the quality of our life. Transport is an important economic activity in its own right, representing some 4-8% of GDP and employing 2-4% of the labour force.

In the European Union, for example, recent data (1998) show that commercial transport services account for approximately 4% of GDP. If own-account operations and private transport are included, this figure rises to some 7% of GDP – more than the contribution of the Community's agricultural or steel sectors. Some 6 million workers are employed in the transport service sector, more than 4% of all employed persons. In addition, more than 2 million are employed in the transport equipment industry and another 6 million in transport-related industries. In 1998, investments in transport infrastructure amounted to an estimated total of around USD 70 billion, or more than 1% of total GDP.

In North America and Asia, the economic importance of transport is of a similar magnitude. Over the five-year period from 1993-98, trade between the United States and Canada increased from USD 211 billion to USD 340 billion, while US-Mexico trade over the same period increased from USD 81 billion to USD 173 billion. The majority of these increases are due to the dismantling of trade barriers under NAFTA. In North America, truck transport is the dominant mode of transportation for trade, carrying 80% of US exports to Canada and 60% of Canadian exports to the United States. Approximately 75% of Canada-US trade (by value) moves by truck, with 17% by rail, 6% by air and 2% by ship.

Overall, there is a strong positive correlation between economic growth and growth in demand for transport. In times of economic prosperity; transport demand increases for both passenger and freight.

Developments of the various modes of transport

A brief look at the various modes of transport shows the following picture. Demand for freight transport has grown more or less continuously over the last three decades in most OECD countries.

Since 1970, growth in road freight (around 4% per annum), measured in billion tonne-kilometres, has been greater than that of rail (around 2% per annum), and freight carriage by truck now exceeds freight carriage by rail for most OECD countries. However, over the same period, freight movement grew strongly by rail as well as by road on the North American continent; Europe saw some decline in rail carriage; and there was only marginal growth in rail carriage in South-East Asia/Australia, while road movements increased progressively. These trends are expected to continue in the short term, with road-based freight expected to increase more rapidly than rail in most OECD countries.

Air transport has grown tremendously in the past 30 years, by about 9% per year for passengers and approximately 11% for cargo. Some industries are now highly dependent on air cargo, such as tourism and the machinery, plastic and electronics industries, as well as producers of cut flowers, live trees/plants, fish, crustaceans, etc. Air transport of both passengers and freight is continuing to grow rapidly and is improving its competitive position *vis-à-vis* road-based and rail modes over medium travel distances for high-value, time-sensitive products. At the same time, air cargo represents a very small proportion of the total freight market (in tonnes).

Maritime transport is used predominantly for freight transport and is continuing to grow more slowly, but on a larger base. The transport of dry and liquid bulk cargoes grew by some 90% during the last 30 years, while general cargoes, primarily containerised cargoes, were up by some 260%.

During the 27 years from 1970-97, passenger travel generally increased continuously, especially on the North American continent and in Europe – where the rate of increase was particularly high (more than doubling over the period) – and South-East Asia/Australia, albeit from a lower baseline. Travel by private car is now the major form of passenger transport in OECD countries. The number of passenger vehicles is increasing by around 3% a year, and average trip lengths are becoming longer.

As to the future; overall demand for transport operations is expected to continue to grow in line with the rather favourable medium- and longer-term growth projections for the world economy. All regions and modes of transport will participate in this growth; however, increases in freight will be significantly greater than in passenger transport. For example, in Europe, freight is expected to increase by 86% until 2020, compared to an increase of 38% for passengers. Elsewhere in the world, similar movements are foreseen.

Key challenges

Trade liberalisation and globalisation of the world economy are having significant impacts on international transport and on trade relations. Communication technologies and containerisation have altered trading arrangements and influenced the entire production-transport-distribution chain. Improved transport efficiency has become increasingly important due to the nature of value-added goods, which require faster transit times.

New developments in information technology and e-commerce are likely to have major impacts on the ways in which business is conducted, with uncertain implications for transport demand. However, early signs suggest that travel represents a key growth area, particularly when coupled with the age distribution in OECD countries.

International trade and tourism are key “drivers” of transport demand, and increasing trade and tourism means more international transport services. In many *regional* locations around the world, increasing demand is likely to require expanded capacity at airports and ports, often in environmentally sensitive locations. Associated increases in land passenger and freight transport

movements could, in many locations, impact adversely on local communities. Unless growth in these facilities is handled sensitively, major port and airport facilities could become impediments to – rather than facilitators of – the efficient movement of international passengers and freight.

Government infrastructure funding is an area in which there is some tension between development and transport and where sustainability issues are emerging. Budgetary and environmental considerations have led to governments becoming less willing and less able to make the substantial investments required to meet expected future demand (*e.g.* investment in urban road infrastructure improvements and expansion to meet growing road-based freight and passenger movement demands). Alternative ownership structures and funding arrangements are under consideration in some cases. However, continually adding to the stock of roads infrastructure is becoming increasingly difficult in some countries in the face of tightening budgetary and political constraints. Within many *urban* areas, it will become increasingly difficult to cater for the forecast increases in transport demand, as there are physical limitations on the space available for transport improvements.

The OECD recognises that the organisation of transport activities has moved from a largely modal approach to one where transport is seen as a seamless system. The development of transport logistics and multimodal shippers means that research for the advancement of effective transport policies to promote sustainability necessitates a broader perspective than that traditionally bound within any single transport mode. Further, the generation of impacts on society by transport requires governments to develop integrated solutions that reflect the strong inter-relationships that exist within the transport sector and between this sector and other sectors of the economies of Member countries.

In many OECD Member countries, transport policy has progressed beyond modal reform and modally based issues. Transport agencies are now grappling with the broader challenging issues of intermodal linkages, infrastructure funding priorities and financing mechanisms, transport safety, sustainable transport development and the effective deployment of advances in communications technologies, which stand to revolutionise the business of transport.

At the same time as globalisation has created international pressures for transport regulatory reform, liberalisation and efficiency, there has been a growing awareness of other emerging global pressures, which also cannot be ignored. There seems to be little doubt that human activity, in all its forms, is impacting on the global environment and resources, as well as on communities themselves, in ways that are not sustainable.

At a *global* level, the transport sector is a major contributor, along with the energy sector, to CO_2 and other greenhouse gas emissions. Transport is a major consumer of energy (particularly fossil-fuel) resources. Transport can also have wide impacts on air and water quality more generally. Climate change related to “greenhouse gases” and the use of fossil fuel at a faster rate than the development of alternative energy sources are outcomes that do not sit well with sustainability concepts. While motor vehicles are a prime cause for concern in these respects, aviation and other transport modes are also important contributors. Although some uncertainties remain, recent work on CO_2 emissions in particular indicates that there is no room for complacency. Transport accounts for about 25% of total CO_2 production, of which road transport’s share is approximately 75%. Several OECD Member countries expect an increase of 10% in CO_2 emissions from road transport by the year 2010. Congestion costs include delays, increased costs to industry and the consequent impacts on competitiveness.

With the projected increases in demand for transport, safety will remain a key challenge. In 1998, over 130 000 people are estimated to have lost their lives on roads in OECD countries, a decline of about 6% relative to 1997. The total annual economic loss resulting from road deaths and injuries is

estimated to have exceeded USD 452 billion in 1996, equivalent to 2% of GDP in OECD countries. For a number of OECD countries, however, there have been little or no reduction in road fatalities, and in some cases, the numbers are increasing. A few countries reported that even after correcting for the effects of improved economic conditions for 1998, there was still a rise in fatalities by comparison with 1997 (economic recovery in many countries led to an increase in travel). However, these direct costs of road safety do not include the indirect costs of transport emissions on health.

Some of the impacts are well known. For example, communities are well acquainted with transport "externalities" (such as noise and emissions) and have sought protective actions where the effects are severe. Transport practitioners have long argued that transport users should be required to pay the full costs, including externalities, of their use of transport systems. In a number of countries, "internalisation" of these "external" costs has been proposed.

More recently, however, community and policy attention has shifted to broader economic, environmental and social impacts of human activity and the concept of sustainable development. Member governments of the United Nations adopted in 1992 a blueprint for achieving sustainable development, described as *meeting present economic, social and environmental needs without compromising the ability of future generations to meet their own requirements.*

In this context, there is now increasing focus on the interactions between transport and sustainable development.

Policy approaches

Governments in developed and developing countries have an important role to play in dealing with sustainable development concerns at a global level. There is a need for consistent international approaches which can only be achieved through international co-operation in the fields of science and technology. Governments have already made some progress (*e.g.* through Kyoto) towards ensuring that appropriate policy frameworks are put in place; however, more remains to be done.

Transport policy has always required achieving a balance between competing objectives, such as efficiency, community development, environmental responsibility and safety. There seems little doubt that a new balance will be required in the future, which gives greater and more appropriate weight to sustainable development objectives. With an appropriate global framework and a new balance in transport policy objectives, the transport sector will be better able to make an appropriate contribution to more sustainable outcomes.

In this context, it will also be important for government, industry and the general public to work together to address the range of sustainability concerns related to transport. In broad terms, this co-operation will need to encompass:

- The *private sector* becoming fully involved in the new policy directions and receiving the right market signals while shaping and responding to consumer and business demands. In this respect, the private sector cannot be expected to take appropriate decisions, from a sustainability viewpoint, on matters such as location and product distribution or passenger services, unless the costs of the alternatives under consideration fully reflect transport costs, including externalities and sustainability impacts.

- *Consumers* being better informed of the impacts and motivated about the consequences of their individual choices relating to transport use. Like business, consumers will need the

right policy framework, supported by incentives, where necessary, to favour sustainable choices.

- *Transport practitioners* being armed with evaluation methodologies which ensure that the myriad planning, operational and infrastructure decisions reflect the wider objectives of the new policy framework and consequently the weightings to be attached to more sustainable development.

Co-operation

These new patterns combined with significant increases in international trade cannot be solved by one government alone, they require international co-operation and new policy considerations in order to improve economic efficiency while at the same time contributing to sustainable development.

Globalisation of economic activity has accelerated the agenda for addressing common issues through a co-operative approach to avoid a patchwork of different measures based on different technologies that could lead to cross-border difficulties. This approach is required on both the input side, with transport becoming an integrated supplier of transport services, as well as on the output side, with transporting contributing some 25% of CO_2 emissions.

The requirement for seamless transport across modes, ports and terminals, and across national boundaries, has placed demands on national governments to embark on comprehensive economy-wide reforms. ICT, coupled with the increased mobility of people and freight, has put the spotlight on protectionist policies and the need for greater harmonisation of approaches.

With this has come the recognition that the spill-over effects of policies that run counter to sustainable development objectives are not contained within national boundaries. The problem of global warming transcends the policy initiatives that any one government or organisation may undertake – it is the externality problem in its broadest and truest sense.

Reflecting the political priority attached to the reduction of greenhouse gases by most governments, policies and actions need to focus on improvements in motor vehicle fuel consumption to reverse the current strong growth in transport-related CO_2 emissions. The development and diffusion of environmental technologies as well as international co-operation in this area will be crucial to achieving this goal. Similarly, international science and technology co-operation involving both the public and private sectors will be of key importance for other measures necessary to achieve a sustainable development of transportation.

How can we achieve such co-operation between developed but also between developed and developing countries? Information-sharing related to various transport issues like environmental technology and infrastructure is certainly one way to promote co-operation, as is the provision of expertise in relation to infrastructure development, road safety, education and training/human resource development. Joint technical assistance action programmes involving not only governments but also the private sector are another potential path. These and other promising measures deserve detailed discussion.

Chapter 25

TRANSPORTATION-RELATED AIR POLLUTION REDUCTION STRATEGIES AND THEIR APPLICATIONS IN SEOUL

by

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Introduction

Urbanisation combined with rapid industrialisation, has been particularly pronounced in Korea over the past 40 years. In 1998, the population of Seoul was some 10.3 million (about one-quarter of the total Korean population) for an area of just 0.6% of the total surface of the country. This imbalance illustrates well the massive economic and demographic transformations which have taken place in Seoul. As a consequence of these transformations, since the 1960s the city of Seoul has suffered from unhealthy air. Residents of the city are aware of the fact that they breathe the most polluted air in the country.

A recent survey indicates that of all urban air pollutant emissions generated in Seoul in 1999, 85.4% were induced by motor vehicles, 12.7% by heating, 1.7% by industry, and the remaining 0.2% by power-generation. Thus, air pollution will continue to worsen as a result of the increasing number of road vehicles and vehicle-kilometres-travelled (VKT). This implies that automobiles are now the dominant source of urban air pollution, as is the case in most large cities. An interesting finding arising from serial data analysis carried out on Seoul City in 1961-95, is that, in terms of reducing air pollution, it would appear that the primary policy target should be the reduction of VKT, rather than the restriction of car ownership (Kim, 1997).

In line with the concept of sustainable transportation, this chapter presents an overview of Seoul's air pollution problems and discusses current and ongoing measures aimed at reducing transport-related air pollution. The analysis looks at both "how to control transport?" and "what kinds of technology are required?", two notions which, taken together, may be able to help improve air quality in Seoul. Finally, some recommendations are proposed for environment-friendly transport planning and policy analysis for better decision making.

Transportation-related air pollution

Since the early 1960s, the rapid economic growth experienced by Korea has resulted in large increases in demand for transport services and the private ownership of vehicles. In the early 1970s,

Seoul numbered only 60 000 cars but over the past ten years, growth of car ownership has risen by a factor of about 3.5 (*i.e.* by 1980, there were some 210 000 cars on the road).

Towards the end of the 1980s, the number of cars increased tremendously, reaching the one-million-car level in January 1990. In the 1990s, the annual average rate of increase slowed gradually, yet this still represented an increase of about 200 000 vehicles each year. At the end of 1999, the number of cars in Seoul reached 2.2 million.

Table 1. **Car ownership in Seoul**

Year	Total	Car	Van/bus	Truck	Other
1997	2 248 567	1 776 377	149 925	320 033	2 232
1998	2 289 642	1 762 824	197 846	326 841	2 131
1999	2 198 619	1 732 632	154 283	309 556	2 148

This huge increase in motor transport has substantially outstripped the capacities of the road network, resulting in traffic congestion. In return, congested traffic conditions generate considerably more vehicle pollution than free-flow conditions and there is, therefore, an urgent need to introduce transport policies with a particular emphasis on fostering public transport modes and managing the demand for private transport modes.

As shown in Tables 2 and 3, transportation contributes the largest share of air pollutants to the urban environment in Seoul. In addition, diesel vehicles account for a greater share of vehicle population and VKT than in any other major city, and contribute substantially to NO_x and PM10 emissions.

Table 2. **Annual trend of transport emissions in Seoul**

Thousand tons and percentages (in brackets)

Year / Source	1992	1993	1994	1995	1996	1997	1998	1999
Total	760 (100)	534 (100)	455 (100)	422 (100)	396 (100)	388 (100)	334 (100)	325 (100)
Transport	462 (60.8)	383 (71.6)	351 (77.1)	341 (80.6)	326 (82.3)	331 (85.3)	280 (83.8)	278 (85.4)

Source: Korea MOE (2000).

Moreover, roadway monitoring data shows that pollutants such as NO_x and PM10 combine to generate a secondary noxious form of suspended particular matter. For this reason, the Seoul City Government should focus on establishing strategies for reducing diesel vehicles' PM10 and NO_x emissions.

Table 3. **Air pollutants by source in Seoul, 1997**
Tons/year and percentages (in brackets)

Pollutant / Source	CO	SO_2	TSP	NO_2	CO	HC
Total	388 342 (100)	22 514 (100)	14 895 (100)	106 191 (100)	215 211 (100)	29 531 (100)
Transport	332 649 (85.7)	4 049 (18.0)	13 110 (88.0)	85 783 (80.8)	201 007 (93.4)	28 700 (97.2)
Heating	39 646 (10.2)	10 668 (47.4)	1 168 (7.9)	13 678 (12.9)	13 382 (6.2)	750 (2.5)
Industrial	12 707 (3.3)	7 793 (34.6)	599 (4.0)	3 646 (3.4)	598 (0.3)	71 (0.3)
Power generation	3 340 (0.8)	4 (-)	18 (0.1)	3 084 (2.9)	224 (0.1)	10 (-)

Source: Seoul City Government (2000).

Seoul City Air Quality Management Plan

Overview

In 1997, the central government recognised the deteriorating environmental conditions in the Seoul metropolitan area and requested the local government to prepare a comprehensive environmental improvement programme for the metropolis. After a two-year research project, a number of integrated environmental strategies were prepared with detailed action plans and/or programmes for reducing emissions in the short and long term.

The Korean Government approved the Seoul City Air Quality Management Plan (SCAQMP), designed to improve air quality in the Seoul metropolitan area. The strategies comprised a number of proposed policies and measures to support the necessary changes and required action plans.

These incorporate aspects of both “how to control transport?” and “what kinds of technology are required?” which, taken together, may be instrumental in improving air quality in Seoul. The first aspect includes transport control measures such as the “traffic congestion management plan” (TCMP), the introduction of an emission tax, and a public-private coalition campaign (“Sib Bu Je”), etc. The second aspect involves new vehicle management with green car certification, inspection and maintenance (I/M) of old vehicles, provisions of clean fuel, and new efforts to develop low-emission engines such as compressed natural gas (CNG) buses, diesel particulate filter (DPF) and exhaust gas re-circulation (EGR) devices.

Objectives

The Seoul Metropolitan government will implement mid- and long-term plans to meet the WHO’s recommended air quality standards by the year 2005:

- Long-term Comprehensive Plan for Environmental Protection.
- Measures for Reducing Seoul’s Air Pollution Level in the 2000s.

Strategies for reducing transport-related air pollution

Traffic Congestion Management Plan (TCMP)

The handling of emissions from road traffic has been given high priority. In order to deal with traffic congestion, five special districts have been declared "traffic congestion management districts"; these are managed through the enforcement of one-way streets, parking restrictions, etc. Traffic speed, which is currently only 13.9km/h is estimated to rise to 17km/h in 2002 and 23km/h by 2007.

Emission tax

Since transport-related air pollution can be regarded as a negative externality of transport, a major concern is to introduce measures aimed at the reduction of vehicle emissions, particularly through the adoption of the "polluter pays principle". Based on Seoul's short-term congestion management programme (SCMP), three modules are analysed: *i)* zero emissions; *ii)* less than KRW 500; and *iii)* less than KRW 1 000 per litre emission tax plus gas tax. From the empirical application in Seoul City, one of the most exemplary findings of the SCMP is that an emission plus gas tax can provide a very useful tool for reducing vehicular emissions since it allows major pollutants to be targeted differentially rather than dealing with all pollutants collectively. However, policies such as fuel price/tax control, aimed at reducing emissions need to carefully consider the possible side-effects, such as raising other prices through the increase of transport costs.

Public-private coalition campaign

A co-operative effort is being undertaken by the government, the public and non-governmental organisations to restore the quality of the air in Seoul. One such project is the "Sib Bu Je" campaign launched by a public-private coalition. This campaign encourages drivers to refrain from driving their cars on days when the last digit of their licence-plate number matches the last digit of the date. "Sib Bu Je" is a voluntary campaign and has successfully contributed to reducing automobile usage by up to 10% a day.

New vehicle management with green car certification

Reducing vehicular emissions has two aspects: first, it is necessary to identify more-polluting cars; second, it is necessary to force them to produce lesser emissions. The first aspect is dependent on the existence of a well-organised detection system such as the remote sensing device (RSD), together with a periodic and/or on-road inspection system. The inspection system determines whether or not the polluting car should be sent to the maintenance shop. The introduction of "green car certification", covering both used-vehicles and new-models meeting emission standards, will bring about a reduction in average emissions per vehicle.

Inspection and maintenance (I/M) of old vehicles

Recent studies show that emission levels are not equal, even among cars of the same model and year. Instead, emission levels are drastically skewed. Thus, it is clear that policies which deal with all vehicles equally or which target new vehicles, are less likely to be cost-effective than those which recognise the importance of I/M programmes and those that target poorly maintained vehicles. In order

to achieve benefits by reducing pollutant emissions from such badly maintained old vehicles, a old-vehicle retirement programme (*i.e.* a scrapping programme) should be considered.

Provision of clean fuel

Like many other major cities, the air pollution problem in Seoul is partly associated with the use of fuels in the transport sector. The types and amount of air pollutants emitted are closely related to the fuel quality, or to which pollutants are contained in the fuel and at what levels. Thus, better fuel quality leads to less pollution.

CNG buses

Since in 1995, diesel-fuel vehicles accounted for 80% of NO_x and 99% of PM10 in Seoul, emission-reduction targets for diesel-fuel vehicles are restricted to these two pollutants. Among the strategies for reducing pollutant emissions from diesel-fuel vehicles, high priority is given to the adoption of CNG buses. The Seoul Government's ten-year CNG buses operating plan is referred to below in the section on new measures for cleaner transport.

Diesel particulate filter (DPF)

Koreans today are increasingly worried about the impacts of PM10 pollutants on human health and on the urban environment. This concern is backed up by increasing scientific evidence. In 1997, road transport, one of the major sources of urban air pollution, accounted for around 67.2% of all PM10 emissions in Seoul. Without dramatic reductions of PM10 emissions from transportation sources, the ongoing "Walkable City Movement" will not be successful. One way of dealing with PM10 emissions is to equip buses with a diesel particular filter (DPF). Even though there is some debate as to the efficiency of DPF devices, controlling PM10 emissions depends on the use of such filtering devices.

Exhaust gas re-circulation (EGR) devices

One effective method for dealing with NO_x emissions is exhaust gas re-circulation (EGR) devices; these are already in use in gasoline engines. Up until now, EGR was being experimented for large diesel-vehicles. In the near future, more refined control devices will be needed to eliminate PM10 and NO_x emissions.

Other strategies

The implicit notion behind the reduction of transportation-related air pollution is that the primary policy target should be the reduction of all polluting emissions. Other strategies which are currently implemented or are planned to be implemented include more stringent emission standards for both new gasoline/diesel vehicles and motor cycles, mandatory production of low-emission vehicles, preparation of an ordinance limiting idling time, adjustment of a long and curved bus lane, extension of warranties on emission-related spare parts, on-road vehicle emission regulations, etc.

Constraints and issues

The major weakness of the SCAQMP strategy was that it did not sufficiently identify or address the capacities and institutional relationships of the responsible agencies. Insufficient capacity of many of the institutions responsible for air quality management, combined with the lack of well-designed communication and co-ordination mechanisms for sector dialogue, is the major shortcoming which needs to be tackled urgently if air quality management is to become more meaningful.

Another important constraint for air quality management is the absence of a multi-sectoral forum where air pollution issues can be tabled, discussed and analysed. In addition, due to insufficient data, the SCAQMP strategies did not include detailed plans to address the importance of mixed plans.

Strategic plans for sustainable transportation

Background

Concerns about clean air quality are not new, but never has the demand been so urgent as at present. To face this challenge, Seoul City requires innovative combined urban transport-environment policy alternatives as well as analytical tools that can implement/evaluate the wide-ranging impacts of possible strategies on air quality.

Unfortunately, the role that could be played by current urban clean-air conservation programmes in addressing Seoul's current air pollution problems remains unclear. Due to the increasing rate of car ownership and the relatively higher contribution of automobiles to urban air pollution, careful consideration should be given to investigating how appropriate transport measures could help to improve air quality in Seoul.

Meanwhile, there is growing interest in sustainable development. Hundreds of articles, reports and books have been published dealing with sustainability issues, and many communities are involved in sustainable planning projects. Seoul City is no exception to this worldwide trend.

Sustainability requires rethinking how we measure transportation. Transport planners often treat vehicle movement as an end in itself. Sustainable transport planning, however, needs to focus on both the enhancement of accessibility and the reduction of transport-related emissions. In this sense, sustainability requires a comprehensive decision-making process that takes into account the indirect and interrelated impacts. The following notion of "sustainable transport" planning envisions "what and how Seoul City can put in place to deal simultaneously with transport-environment issues":

Sustainable transportation can be described as: i) moving people and goods in cleaner, greener, healthier, safer, more equitable ways; and ii) where appropriate, not moving people and goods.

With the introduction of this new paradigm which mixes transportation demand and environmental values, there is a need to identify ways of sustainable transportation which lead to better air quality. These involve the new deal for cleaner transportation described below, a new paradigm for sustainable transportation, and a shift towards sustainable transportation, calling for a mix of policies.

The new deal for sustainable transportation

New efforts towards cleaner transportation: CNG buses

The rapid increase in automobile use has meant that the motor vehicle has become the largest contributor to air pollution in large cities; in Seoul, it accounts for about 85%. Although heavy-duty vehicles account for only 4% of the total motorised vehicle fleet, they are responsible for 43% of total motor vehicle emissions.

In accordance with the surge of global interest in reducing motor vehicle emissions and mitigating greenhouse gases, the Korean Ministry of Environment is actively promoting and initiating the replacement of the current fleet of some 20 000 diesel-powered buses with CNG buses (MOE, 2000).

Starting in 2000, the Seoul Government is also planning to fund the replacement of current diesel-powered buses with CNG buses. The plan is to replace all city buses by 2007. As a first stage, 2 000 buses will be replaced by early 2002.

CNG buses, compared to their diesel-powered equivalents, can drastically reduce particulate matters (PM), which are believed to cause lung cancer. They can also reduce ozone-depleting substances by up to 70%. CNG vehicles therefore hold the promise of contributing to a more pleasant urban atmosphere and helping to preserve global air quality.

The new paradigm for sustainable transportation

The main aim of traditional transport planning is to estimate the maximum amount of traffic that a given facility can accommodate. Such capacity analysis would be severely limited, however, if this were its only focus. Traffic facilities generally operate poorly at or near capacity, and facilities are rarely designed or planned to operate in this range. Capacity analysis also attempts to estimate the maximum amount of traffic that a facility can accommodate while maintaining prescribed operational facilities.

The professionals that implement transport policies under capacity constraints – transport planners and traffic engineers – tend to measure vehicle movement, using indicators such as level of service (LOS), volume per capacity (V/C) ratios, congestion delay, and average vehicle speeds. However, these indicators are inappropriate because:

- It is impossible to build sufficient urban road and parking capacity to satisfy potential demand.
- Motor vehicles impose significant economic, environmental and social costs.
- Some people cannot own or drive a motor vehicle.

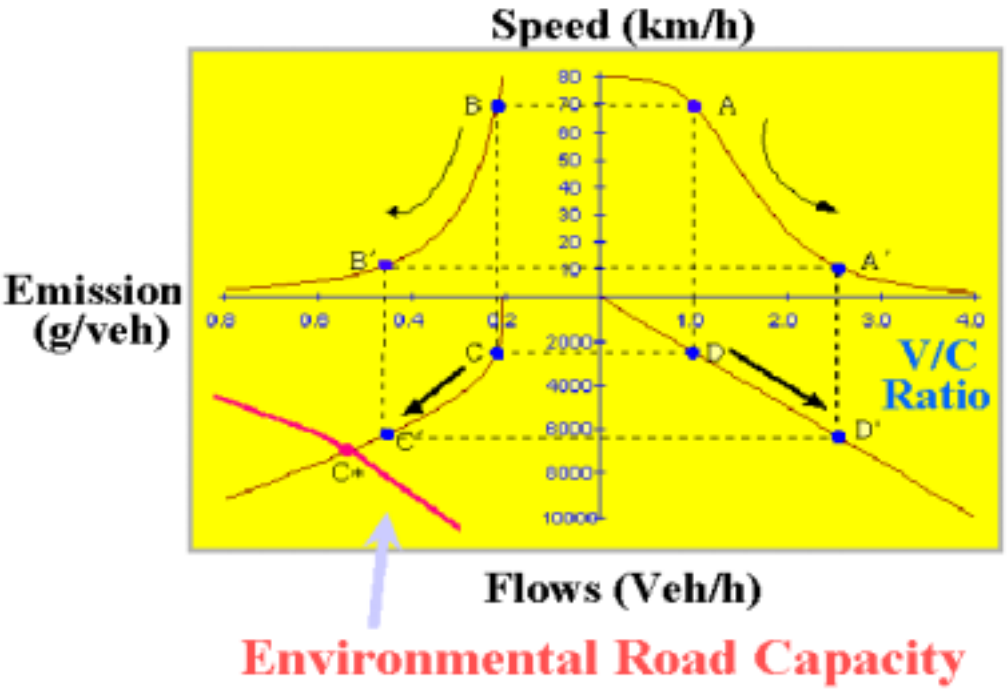
Meanwhile, emission system component failure, lack of proper maintenance, tampering and the normal deterioration of emission control system performance all act to offset the benefits to be had from progress in reducing emissions from new vehicles. Today, we need to adopt a more sensible paradigm that can explain the interactions between transport and the environment, and reasonably implement actions for the common good.

The shift towards sustainable transportation

It is evident that environmental issues have come to play a central role in transportation planning and policy. However, two factors such as environment and transport are not easily combined. With the application of the integrated paradigm, the pursuit of a single objective such as minimising travel time is no longer a primary concern in the decision-making process. Instead, a search for a suitable balance between transport costs and compatibly configured environmental planning is desirable.

One possible way to achieve this goal is through the application of the "environmental road capacity" concept in the traditional transport planning (Figure 1).

Figure 1. **Environmental road capacity with traffic flow**



Based on empirical applications to explain interactions between traditional transportation planning and environment-capacitated planning (*i.e.* "environmental road capacity" is embedded in transport planning), a number of implications can be drawn (Kim *et al.*, 1998). One of the most exemplary findings is that, notwithstanding the fact that total travel time increased by 38.9%, the average NO_x concentration level decreased by 87.9%. It is crucial that traditional transport planning be properly co-ordinated to achieve simultaneous improvements in travel cost and air quality.

Conclusion

Concerns about clean air quality are not new, but clean air has never been in more urgent demand. The tremendous economic and demographic transformation which Seoul has experienced in such a short time have changed the urban environment and resulted in worsening air quality. And air

quality is obviously going to become still worse in the face of increasing numbers of road vehicles and VKT.

To deal with these problems, Seoul City has prepared a comprehensive ten-year air quality improvement plan (SCAQMP), comprising detailed action programmes. However, more innovative combined urban transport-environment policy alternatives are required as well as analytical tools that can implement/evaluate the broad-ranging impacts of possible strategies targeting air quality improvements.

Maintaining Seoul's sustainable transportation programme calls for the creation of a multi-sectoral forum where air pollution issues can be tabled, discussed and analysed. In addition, sustainable transport requires rethinking how we measure transportation and involves a paradigm shift from road capacity to environmental road capacity.

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PART VIII

PARALLEL SESSION 3

WATER AND SUSTAINABLE DEVELOPMENT

Chaired by Manuel Dengo
United Nations Commission on Sustainable Development

Chapter 26

CHINA'S WATER SECURITY OPTIONS: A COMPREHENSIVE SOLUTION INVOLVING TECHNOLOGY, ECONOMICS AND BEHAVIOUR

by

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Introduction

Industrialisation and urbanisation have been taking place in China at a rapid pace since the country opened to the world and began the transition from a planned to a market economy. Over the past 20 years, the GNP of industry and the number of cities and towns have increased three-fold. The combination of high pressure of population growth, rapid economic development and a strong desire to improve life quality, fragmented institutions and low eco-awareness in policy making are threatening water availability and water security.

Water security can only be assured through a human-ecological understanding of the complex interaction of environmental, economic and social/cultural factors and through comprehensive planning and management grounded in ecological principles. In dealing with this critical issue, a transition from physical engineering to ecological engineering, from reductionism to holism, and from man domination to man-nature harmonisation is called for. Therefore, increasing people's understanding of the eco-sphere of "the man-water complex", probing scientific mechanisms and methods for addressing water problems, and searching for effective technological instruments for sustainable water use are key to China's sustainable development.

Water issues

China has abundant water resources. There are more than 1 500 water catchments, each with an area of more than 1 000 km^2. There are 17 major rivers, each with an annual runoff exceeding 50 billion m^3, and 130 lakes, each with surface area exceeding 100 km^2. Total surface and groundwater resources amount to some 2 800 billion m^3; China ranks sixth in terms of the world's water resources.

China has the largest population in the world, with 1.24 billion inhabitants in 1997. Water resources per capita are estimated at 2 245 m^3, or one-third of the global average; China's per capita water resources are among the lowest in the world. Water resources per hectare of land are 2 871 m^3, corresponding to two-thirds of the world's average value. With 7% of global total fresh water resources, China has to support more than 21% of the world's population.

The main characteristics of the water issue in China are the extraordinarily uneven geographical distribution of the country's water resources: 80.2% are located in the Yangtze River basin and its southern area (15 south provinces), an area which accounts for only 58% of the total population and 40% of the total land area. Per capita water availability in southern China is three times that of northern China and, per hectare, water resources are six times more abundant. In southern China, 60% of the annual precipitation occurs in the April-July period, while 80% of the annual precipitation in northern China falls in July-September. Available water per capita in the Huaihe, Haihe and Yellow River basins is below 1 000 m^3, the internationally accepted definition of water scarcity. The runoff in the Haihe River basin, for example, is particularly low, at only 245 m^3 per capita.

Water for river and wetland ecosystems in northern China falls far short of requirements. In 15 of China's northern provinces, total water availability is only 962 m^3 per hectare, while in the 15 southern provinces, it is 5 829 m^3. This explains why water shortages are one of the main factors explaining the weak functioning of river and wetland ecosystems in the north. If we take 1 500 m^3 per hectare – one-quarter of the average level of water available in south China – as the minimum level for the correct functioning of the river and wetland ecosystems in north China, water reserves need to increase by at least 470 billion m^3.

In China, 10 000 m^3 of water serve 4.46 persons. Using this average, the seven provinces in northern China can support 75 million persons, a mere 23% of the current population. The overload of the water-carrying capacity of northern China is therefore three times the national average. In 1997, the northern region used about 70% of available water resources, while in the south-west region, only 6% of the available resources were used.

Water stress

The driving forces behind the water issue include: high population growth, rapid economic industrialisation and urbanisation, a strong desire for a better quality of life, fragmented institutions, and low eco–awareness in policy making; these pressures threaten both water quantity and quality. Uncontrolled water usage has led to severe qualitative and quantitative water shortages, with inappropriate hydrological and anthropological processes leading to an acceleration of flooding and drought, desertification, soil erosion, loss of biodiversity, and a decline in ecosystem services. Natural ecosystems provide man with many essential goods, including seafood, game, fodder, wood for fuel, timber, and pharmaceutical products, and perform fundamental life-support service, including purification of air and water, detoxification and decomposition of wastes, regulation of climate, regeneration of soil fertility, and production and maintenance of biodiversity.

During the last 50 years, the population of China has doubled while water use for human purposes has multiplied by a factor of 4.5. The agricultural water consumption ratio in 1949, 1965, 1980 and 1997 was 97.1%, 92.7%, 88% and 70.4% of total water use, respectively. Over the past 50 years, agricultural, industrial and domestic water consumption has increased 3, 46 and 41 times, respectively.

Average agricultural water use efficiency in China is about 0.4–0.5. In northern China, for example, the irrigation quota is 7 500–12 000 m^3/hm^2– 2–5 times more than actual crop needs. If technological progress enables average efficiency to increase to 0.65, thus reaching the level of advanced areas in China, 130 billion m^3 of water could be saved each year in northern China.

Irrigation works in China were mainly built between the 1950s and the 1970s; they have now been in use for some 30–40 years. The works have seriously deteriorated due to lack of maintenance.

Three-quarters of the large and medium-sized reservoirs are considered to be dangerous and sedimentation is very severe. According to a study of 231 large reservoirs, for example, the average annual sedimentation rate is 2.3%, while cumulative sediment represents 14.3% of total capacity.

In 1997, 54.6% of total wastewater drainage was of industrial origin, while 45.4% was domestic sewage. The current urban domestic sewage treatment ratio is only 13.6%, with most sewage being discharged directly into rivers and lakes without any proper treatment.

China has 7.9 million factories. In 1997, the total amount of industrial wastewater discharged amounted to 22.7×10^9 tons. Industries at the county level and above discharged 18.8×10^9 tons, while town and village industries discharged 3.9×10^9 tons. At county level or above, the share of discharged wastewater which meets quality standards was 61.8%.

Furthermore, the increasing use of chemical fertilisers and pesticides, the raising of livestock and discharges from heavily polluting rural industries have accelerated water pollution and the deterioration of the ecosystem. This non–point source pollution accounted for 70% of the total pollutant load in China's water reserves.

Chinese rivers are heavily polluted. According to a national water-quality survey carried out in the 1990s, fish had become extinct in 45% of the surveyed rivers due to water pollution, while water from 23.3% of the rivers could not be used for irrigation. This means that 68.3% of surveyed rivers were very severely polluted. The main pollutants included organic matter, ammoniac nitrogen, petroleum chemicals and heavy metals.

Over–exploitation of groundwater and the rapid decline in the water-table have become a critical ecological issue in many parts of China. In north China, about 87% of water resources were drawn from groundwater, leading to over–exploitation of some 30 billion m^3 of groundwater a year. The total area affected by the decline of the groundwater-table in northern China was over 23 000 km^2, and groundwater resources in some regions are now exhausted. Since the groundwater-table decline was the result of over–drawing of groundwater, seawater intrusion and land subsidence has occurred in 75% of coastal cities and surrounding areas.

Wetlands and lakes have been completely lost over the last few decades due to water-resource exploitation and land-use change. About 800 lakes, a total of 13 000 km^2, have disappeared since the 1950s. Especially in western China, water-resource exploitation is usually the main cause of lake degradation.

Since the 1990s, river dry up has attracted increasing attention and is now considered a critical ecological problem in China. When rivers dry up, the natural habitat is completely destroyed and wetlands related to the rivers disappear. River dry up has occurred not only in north and west China, but also in south China. The Yellow River, the second longest river in China, dried up in 1972 for the first time. The annual average dry period was 13 days in the 1970s. In 1997, the dry period lasted 226 days and the length of dried river was 700 km: the duration and length of dry river has risen extremely rapidly.

Urban drinking water is taken from rivers, lakes and reservoirs, of which 90% are polluted. Another 145 million citizens in small towns have no access to a safe water supply. Dongting Lake was the largest lake in China. The area of the lake has shrunk from 4 350 km^2 in 1949 to 2 691 km^2 in 1978, with water capacity decreasing from 29.3 billion m^3 in 1949 to 17.4 billion m^3 in 1978; this represents reductions of 38.2% in area and 40.6% in terms of water capacity. On average, the bed of the lake rose by 3.6 cm per year, and the area covered by beaches amounted to 120 000 hm^2, with an

annual increase of 666.7 hm^2. With sand deposits, and as land is enclosed for cultivation, loss of water capacity represents one-fifth of the total water reserves of the lake, thus enhancing the risk of flooding.

Water security modelling

Water security

"Compound water security" in China covers food security, life security, environmental security, economic security and social security. Compound water security issues will become a critical issue in China in the 21st century:

- *Food security:* To satisfy a growing population and its increasing demand for food quantity, quality, sufficiency and accessibility. China has 80 million poor people, whose income and living conditions are below the national poverty level.

- *Life security:* To provide all citizens with access to sufficient clean water supplies, to protect them from the risk of flooding and drought, from water-borne diseases and the plague.

- *Environmental security:* To maintain the eco-integrity of the water eco-sphere, including landscape, water and soil conservation, watershed management, and the balance of water metabolism, to enhance the nature service function so that the viability of the natural ecosystem is guaranteed and biodiversity conserved.

- *Economic security:* To raise the efficiency of water use so that it can sustain stable growth of the national economy and to reform production structures to safeguard high productivity per unit of water.

- *Social security:* Sufficiency of working opportunity per unit of available water; to fairly compensate those who are adversely affected by water control and conservation projects, and to reduce water-induced social conflicts, water-induced outside dependency and water-disaster-incurred refugees.

Driving forces

Population growth: Medium-term growth projections indicate that China's population will reach 1.39 billion in 2010 and 1.521 billion in 2025. The annual population growth rate will continue to decline over the next 25 years, the modelling time period. The majority of the population increase will affect rural areas.

Urbanisation: Today, some 0.3 billion people live in the cities and it is expected that by 2025, about 0.76 billion people, half the total population of China, will live in urban areas. Much of this urban growth will be the result of internal migration, as rural citizens, and especially the younger generations, leave the traditional rural life for the cities and rural industrial development, further accelerating the expansion of the already fast-growing small towns of rural China.

Economic development: As the most populated developing country, the income of nearly 30% of the population does not exceed USD 1 per day, the United Nations lowest level of poverty. China is coming under very high political and economic pressure to speed up her economic development. It is predicted that the country will continue to experience high growth rates for the next 25 years.

Technology: China, like other parts of the world, will experience rapid developments in the fields of information, communications and biotechnology. Biotechnology will likely furnished seeds with a higher yield potential and improved resistance to drought, tolerance of saline water and soil, and better resistance to pests and diseases. Information on markets, weather and new technologies will be more widely available, enhancing the ability of producers and water users to make sound management decisions. Improved water and land management technologies will become more accessible and affordable, especially for smallholders due to cheaper production costs and open markets, thus increasing the productivity of land and water.

Market economics: As the Chinese economic system shifts towards market economics, there will be a tremendous surge in the privatisation of state-run organisations delivering agricultural and other services such as electricity and water, and the prices of these services are expected to increase. Farmers will have greater choice of higher-value crops and more flexible cropping strategies, enabling them to respond speedily to changing market and water conditions. The water-consuming industry will become more flexible and better able to adapt to changes in water resources and prices.

Environmental awareness: Increasing awareness of the importance of natural ecosystems to future development and continued life on Earth will generate pressures to improve the quality of return flows to rivers, lakes and wetlands. This will lead to a demand for larger in-stream flows in many rivers, such as the Yellow and Haihe Rivers. Many of these changes will be accomplished through enforcement of regulations and through changes in behaviour.

System model and simulation

Based on water security and driving force analysis, the related quantified index and variables were defined, the relationships between these variables formulated, and the model constructed. The model was validated using current data. The system model comprises five main feedback processes: population growth, urbanisation, improvements in living standards, technology development and increased environmental awareness.

The scenarios: towards sustainable development

Business-as-usual (BAU) scenario

The Chinese economy will continue to grow during the next 25–30 years; total GDP in 2025 will be 6.1 times that of 1997, industry output in value terms will be 7.7 times that of 1997, and the grain yield will increase by 31.8%.

Population growth is a critical factor with regard to demand for water. The population will continue to increase, reaching 1.54 billion by 2025. In the meantime, nearly one-half of the population will reside in cities and towns; with the urbanisation ratio growing from 29.2% in 1997 to 48.8% in 2025.

Cultivated land in China will be about 91×10^6 hm^2 in 2025, about 3.91×10^6 hm^2 less than the area cultivated today. In the meantime, irrigated areas will represent about 56.34×10^6 ha in 2025, an increase of 19.8%. By that time, irrigated areas will account for 62% of total cultivated land, 12% more than in 1997.

However, this rapid economic development comes at a price and will lead to increased water stress and a high degree of vulnerability. Forecasts point to a water shortage of 96.8 billion cubic meters and a grain shortage of 48.1 million tons. Under this scenario, by 2025, the water sector would most likely be facing a serious crisis.

This water shortage will be increasingly severe during the period from 1997 to 2015 as the demand for water for economic development will exceed water supply. However, the stress will slightly improve after 2015 thanks to significant social, economic and technical progress.

The expected increase in water demand over the next 25–30 years will come mainly from industry and households. The share of demand for agricultural water in total water demand is forecast to fall from 70% in 1997 to 53.5% in 2025, while the absolute figure remains fairly stable, increasing by only 3.7% (from 421.6×10^9 m^3 in 1997 to 437.5×10^9 m^3 in 2025). Other demands will double over the next 28 years, with industrial demand for water increasing from 126.7×10^9 m^3 in 1997 to 270.8×10^9 m^3 in 2025 and demand for domestic water rising from 53.9×10^9 m^3 in 1997 to 108.6×10^9 m^3 in 2025.

Led by the thermal power industry, six industries (papermaking, chemicals, metallurgical, printing and dyeing, and food and drink), are the most intensive users of water in China. The proportion of high–water–consumption industries will decline in the next 25–30 years, although the decrease will be limited.

The conclusions presented here are based on the average hydrological regime. If a large–scale drought were to occur in China, water shortages would be critical and the grain yield would fall below the security line, with an import share of more than 10% of total grain production.

Under the BAU scenario, China faces serious water and food shortages in the next 25–30 years. The Chinese Government needs to take effective measures to ensure that the country's economic development is consistent with its water-resource capacity; only such action will guarantee water security and sustainable development.

Towards sustainable development scenario (TSD)

Current irrigation efficiency in China is only 40%–50%, compared to 80%–90% in some industrialised countries. If the ratio were to increase to 65% by 2025, the area of irrigated land would increase by 7 million hectares with no need for additional water.

The current average ratio of cereal yield to water in China is only 1.17 kg/m^3, much lower than that of the industrialised countries. If it were to increase to 1.59 kg/m^3 by 2025, which is still only 80% of the current level in advanced countries, 51.8 billion m^3 of water could be saved in 2025.

If the annual increase rate of grain yield were to rise from 1.3% to 1.5% due to technological and ecological improvements, the grain yield would attain 6 639.7 kg/hm^2 and total grain output would rise to 684.36 million tons in 2025.

Compared to developed countries, the water–saving potential in China is huge. The water reuse rate could rise to 57.29% in 2010 and to 68.28% in 2025.

If the water-consumption coefficient were to decrease to 25.60 m^3 per CNY 10^4 of industrial output in 2025, industrial water demand would decrease by 44.6 billion m^3.

Irrigated land could account for 51.80 and 57.93 million hectares in 2010 and 2025, respectively. In this case, the share of irrigated land in total arable land is forecast to rise from 56% in 2010 to 64% in 2025.

If the proportion of cereals, cash–crops and feed crops is gradually modified from 5:3:2 in 1997 to 4:3:3 in 2010 and to 3:3:4 in 2025, and grain consumption per capita and grain for industrial use are maintained at 1997 levels, the amount of grain available for feed will increase by 140 million tons. This is equivalent to 45 million tons of additional meat production, *i.e.* a per capita increase of 30 kg. Furthermore, roughly 400 million hectares of pastures, grasslands and arable desert lands in China are not appropriately exploited or managed (of which 30% are of high quality, 30% of average and 40% of bad quality). Each year, 600 million tons of crop stalks/straw and other alternative biomass could substitute for grain in livestock raising and industrial production.

In the TSD scenario, the ratio of high–water–consuming industries would decrease from 74% in 1997 to 68% in 2010 and 64% in 2025. The demand for industrial water is forecast to decrease to 203.4 billion m^3 and 236.3 billion m^3 in 2010 and 2025, respectively. This implies that water savings could amount to 18.5 billion m^3 in 2010 and 24.5 billion m^3 in 2025. Water use per CNY 10^4 of industrial output in 2010 and 2025 would decrease to 55.58 m^3 and 27.09 m^3, respectively.

If the structure of domestic livestock were to shift from mainly grain–fed to herbivorous, and alternative protein were produced without the consumption of such large amounts of grain (*i.e.* through the feeding of insects, mushrooms and other micro–organisms), meat production would increase four-fold compared to the 1997 level.

If the water-use quota and reuse ratio are maintained at the same level as in the BAU scenario, but industrial growth is assumed to slow down from 13% in 1997 to 7% in 2010 and to 5% in 2025, industrial water demand would decrease to 209.7 m^3 in 2010 and to 255.5 m^3 in 2025. That is, there could be water savings of some 12.2 m^3 and 15.3 m^3 in 2010 and 2025, respectively. The corresponding industrial output values would be CNY 34.60 trillion in 2010 and CNY 82.29 trillion in 2025.

In terms of total grain production, the share of grain for food would fall slightly, the share of grain for feed would increase, and that of grain used in industry would decrease, with substitution by other kinds of wild biomass. According to our estimations, the share of food, feed and industrial uses are 50%, 30% and 20%, respectively, at present.

Per capital grain demand would be 428.6 kg in 2010 and 420.8 kg in 2025, while total grain demand would be 581.5 and 668.9 million tons in the same years. That is, about 6.8 and 26.8 million tons of grain or about 4.76 billion m^3 and 17.99 billion m^3 of water could be saved according to the corresponding grain–water equivalent.

In 2010 and 2025, respectively, per capita domestic water use is estimated to be 230.0 litres/day and 255.3 l/day in urban areas, and 100.5 l/day and 122.0 l/day in the countryside. Domestic water demand would thus increase from 74.9 billion m^3 in 2010 to 105.3 billion m^3 in 2025. Thus, about 1.1 billion m^3 and 3.3 billion m^3 of water could be saved in 2010 and 2025, respectively.

Water exploitation from alternative resources, such as salt and rain water, could amount to 36.1 billion m^3 in 2010 and 59.0 billion m^3 in 2025; 512.4 billion m^3 and 566.0 billion m^3 could come from surface water in 2010 and 2025, respectively.

Saving one ton of grain is equal to saving 1 000 tons of water; switching 1 000 tons of water from agriculture to industry will create 50–70 times more GDP than that arising from agriculture, *i.e.* some CNY 50 000. Saving or substituting 100 million tons of grain is the equivalent to tapping 100 billion tons of additional water and creating CNY 5 000 billion of GDP. At the same time, 20 million hectares of cropland, or one-fifth of total cropland in China, could be returned to grassland, forestry or wetland, significantly enhancing the nature service function.

In the TSD scenario, we aim to keep three-quarters of total cropland, or 100 million hectares according to the current official statistic, for grain production, which is equal to raising productivity by one-third, and to transfer the remaining quarter, around 30 million hm^2, to other types of ecologically sound biomass production; this shift is already occurring in the upper reaches of the Yangtze and Yellow Rivers.

Conclusion

The word "crisis" (*Wei Ji*) in Chinese has both the meaning of risk (*Wei*) and opportunity (*Ji*). With its long tradition of sustainable water management and human ecological philosophy, China's vision for water has both optimistic and pessimistic perspectives. Although the per capita water resource in China is only 35% and 75% of the world and Asia average level respectively, the spatial and temporal distribution is extremely uneven. Human activities are threatening regional food, health, life, economic, social and environmental security, but there are also promising opportunities for the exploitation of alternative water resources and for water saving. By adopting the strategies described above, by 2025 China will be able to feed its 1.54 billion inhabitants and guarantee them an improved quality of life with limited water resources but without having to resort to significant imports of grain (although a small amount, say less than 7%, of grain imports would be beneficial both for China and the world). The key to successful adaptation lies in technological innovation, institutional reform, changes in lifestyle, water diversion, ecological engineering and intelligent governance. Today, China is a crossroads and must choose between a miserable or a prosperous future – its water-related fortune is in its own hands.

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Chapter 27

SCIENTIFIC AND TECHNOLOGICAL CO-OPERATION FOR SUSTAINABLE WATER RESOURCE MANAGEMENT

by

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Introduction

This chapter is a compilation of ideas and personal thoughts, some more formal than others, based on our experience in dealing with integrated water resource management (at the political and technical co-operation levels), and discussions with colleagues in DESA and other UN agencies on water-related issues. I also include general views emanating from positions of the Group of 77 and China on questions referring to technology transfer. They are particularly relevant to and address the main focus of this Conference: scientific and technical co-operation for sustainable development. The terms of reference for Session III, which I had the pleasure to chair, have been delineated along the following lines:

To secure safe and sufficient supply, water resources need to be efficiently managed:

- Developing countries often lack the local capacity.
- Developing countries often lack the technology.

To promote the scientific and technological co-operation aspects of integrated water resource management, it is necessary to overcome barriers that limit the sound transfer of technologies and scientific knowledge, in the following areas:

- Financial aspects.
- Institutional structure.
- Human resources.
- Information management and flow.

Two important elements for the background of our deliberations are the views of developing countries on these issues as well as the new trends within the UN system for establishing working

partnerships with the private sector, non-governmental organisations and other groups of civil society. These elements exemplify the new openings and opportunities which are being created to bring together all those interested in the issues of scientific and technological co-operation.

The view from the developing countries

Some of the main issues for developing countries in terms of implementing sustainable development targets are to find appropriate mechanisms to ensure social integration, including capacity building, development of technical knowledge and transfer of technologies, as well as the mobilisation of financial resources to assist developing countries in achieving these targets.

Developing countries agree that South – South co-operation should be viewed, not as a substitute for, but rather as a complement to, North-South co-operation, and in that connection, there is a need to effectively promote, *inter alia*, triangular approaches to facilitate South-South programmes and projects.

The following paragraphs are excepted from a recent intervention of the Group of 77 and China in the Second Committee of the General Assembly. They are not directly related to integrated water resource management but, in my opinion, they are of the utmost relevance to the aims of this Conference and to the future of sustainable development:

> *"As we enter a new century, on the wings of the various forces of globalisation, it is certain that the primary challenge before the international community is how to ensure that globalisation benefits humanity as a whole, and not just a few industrialised countries. Thus efforts should be focused on how the main instruments of globalisation, namely, international trade, international financial transactions, foreign direct investment and information and communication technology (ICT) can help integration of the world economy in such a way that developing countries can take advantage of the opportunities inherent in this phenomenon.*
>
> *The international community, especially the United Nations, has a special obligation to assist developing countries to be part of the digital revolution. In particular, it can provide the platform to other members of the international community to work in close concert with national governments, private global sector and civil society, to assist developing countries in this endeavour, as recommended by the panel of experts. In addition, the G77 is of the view that the following recommendations of the panel are worthy of consideration and implementation accordingly:*
>
> - *proclamation that the right to universal access to ICT services such as the Internet is an important new component part of the United Nations principles and conventions on human and development rights*
> - *creation of a Task Force to bring together multilateral development institutions, private industry, foundations, and trusts to facilitate investment and the expansion of the market for ICT in developing countries*
> - *establishment of a Fund which will be leverage and additional sources of resources to assist developing countries to implement their own ICT programme".*[1]

1. Statement delivered by H.E. Mr. J.K. Shinkaiye, Ambassador of Nigeria, on behalf of the G77 on Globalisation and Interdependence, in the Second Committee of the 55th UNGA, New York, 24 October 2000.

The Global Compact

As an example of the trend towards involving members of civil society in activities of the UN system organisations, I will refer briefly to the Global Compact as a possible basis for the establishment of partnerships.

At the Davos World Economic Forum, on 31 January 1999, UN Secretary-General Kofi A. Annan challenged world business leaders to "embrace and enact" the Global Compact, both in their individual corporate practices and by supporting appropriate public policies. The principles cover topics in human rights, labour and environment:

Human rights

The Secretary-General asked world business to:

- *Principle 1:* support and respect the protection of international human rights within their sphere of influence; and
- *Principle 2:* make sure their own corporations are not complicit in human rights abuses.

Labour

The Secretary-General asked world business to uphold:

- *Principle 3:* freedom of association and the effective recognition of the right to collective bargaining;
- *Principle 4:* the elimination of all forms of forced and compulsory labour;
- *Principle 5:* the effective abolition of child labour; and
- *Principle 6:* the elimination of discrimination in respect of employment and occupation

Environment

The Secretary-General asked world business to:

- *Principle 7:* support a precautionary approach to environmental challenges;
- *Principle 8:* undertake initiatives to promote greater environmental responsibility;
- *Principle 9:* encourage the development and diffusion of environmentally friendly technologies.

How to transform principles into management practice

There is no one way for a company to incorporate the Global Compact principles into its business activities. Rather, there are a variety of approaches that can be used. How a company decides which approach to take depends on the business sector in which the company is located, its management structure, its outputs, its stakeholders, etc.

Intrinsic elements of DESA's approach to integrated water resource management

I would like to mention a couple of important elements of our work in the Department of Economic and Social Affairs (DESA) on integrated water resource management. Our activities are two-fold:

- We provide coverage and service the political debate for UN bodies such as the Commission for Sustainable Development (CSD) on water/natural resource issues.

- We execute a broad programme of technical co-operation projects in developing countries, with integrated water resource management being the major component of this work.

Thus, we have both: the field expertise and the normative/political experience. This combination of activities allows us to inform the political debate with inputs coming from our real-world experience and, at the same time, we try to put into field practice the main elements emanating from such multilateral forums as the CSD. It is an important strategic position from which we can watch both developments in the political arena and the direct actions and reactions at the country level.

From this strategic position, we recognise the following as being some of the main areas where scientific and technology transfer for sustainable water resource management can make a difference:

- *Sustainability*. There is a need to recognise water as a social and economic good with a vital role in the satisfaction of basic human needs, food security, poverty alleviation and the protection of ecosystems. The principle of sustainability underpins the integrated approach to managing freshwater resources in order to maintain and extend the benefits derived from natural freshwater systems.

- *Management* of the demand for and the allocation of water resources should be based on the principles of equity and efficient use to promote sustainable development, including health, the satisfaction of basic human needs, food security and environmental protection.

- *Capacity building.* Institutional and human capacities at the national and local levels need substantial strengthening for integrated water resource management to happen. The need to strengthen capacities at the local level is especially strong. Training of local entrepreneurs plays an important role in implementing actions. There is a need to promote indigenous technologies and knowledge and to transfer appropriate technologies.

- *International co-operation.* International co-operation and partnership in support of national actions are essential for achieving sustainable development, particularly in the water sector. In particular, there is a need for mobilising resources, capacity building, transfer of technology, scientific research and information exchange.

- Management of demand is a key part of policy, focusing on water conservation through recycling and reuse and by the adoption of best practices and technologies.

- Adoption of technologies combining indigenous and modern techniques, especially for water conservation, reuse and improved efficiency in irrigation and other sectors.

- Improve local institutional capacity and promote human resource development to strengthen community participation, taking into account the role of women.

- Strengthen capacities to plan and implement programmes for capital investment, delivery of services, maintenance of systems, and monitoring and regulation of water quality requirements.

- Support recent national and international initiatives to expand sanitation coverage through information sharing among governments, communities, no-governmental organisations and the international community.

In performing our work on integrated water resource management, we look at two main large areas:

Sustainable management of the water resource base (quantity and quality; surface and sub-surface waters). This is carried out at three levels:

- Micro level (village, city, irrigation schemes, factories, etc.).

- Meso level (river basin , aquifer, province, etc.).

- Macro level (policy and regulatory level).

Sustainable development and management of water systems infrastructure (to be carried mainly at the micro level, but assessed through two different points of view):

- Urban and industrial water supply, sanitation and treatment (piping systems, networks, utility management, municipalities, etc.).

- Rural water supply (local water point, community management, local authorities, etc.).

Our programme places special emphasis on capacity building and transfer of knowledge, since these elements bring sustainability to the results obtained by the different technical co-operation projects. Capacity building is a major goal of our technical co-operation activities. The above components provide ample opportunities for the inclusion of elements of scientific and technological co-operation/transfer, at all levels.

Recent developments in information and communications technologies (ICT) are fundamental for the dissemination of scientific and technological knowledge. Bridging the digital divide is key to the exchange of scientific and technological knowledge on all aspects and levels of water resources, in particular, and sustainable development, in general.

Equally important is to strengthen South-South co-operation schemes, taking advantage of all new openings, developments and opportunities for co-operation among governments, the private sector, NGOs, multilateral organisations and communities.

Final remarks

Scientific and technological co-operation at the international level poses a challenge to both developed and developing countries. In assessing the many components of this challenge, we have to recognise that no matter how complex the scientific and technical solutions to sustainable development problems, they are the easy part of the equation. The difficult part is synchronising the political, policy, legal, financial and social mechanisms necessary to bridge the gaps between scientific knowledge and the appropriate technologies that will make the sustainable development goals more attainable.

In looking for solutions to facilitate this process, there is only one path to follow: be innovative and open to all options. I am sure that many interesting ideas for improving scientific and technology co-operation for sustainable development will be presented during this Conference.

Chapter 28

PROMOTING INTERNATIONAL SCIENTIFIC AND TECHNOLOGICAL CO-OPERATION IN SUSTAINABLE WATER AND SANITATION FOR PEOPLE

by

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Introduction: the challenge

The conventional approach to providing water and sanitation for people in the context of sustainable water resources is changing. The long-accepted pattern of governments serving their citizens through the direct provision of water and sanitation to ensure the "merit good" of public health has not achieved the desired benefits, particularly in the middle- and low-income countries (MLIC). For the most part, government provision has failed to break through the performance barrier of a mediocre, supply-driven approach. New approaches are being considered as to who should be providing what services, as well as to the most suitable technological approach to ensure sustainability.

Water service coverage has shown significant growth over the past 30 years, reportedly reaching 71% in rural areas and 92% in the urban areas of MLICs. There is dramatically lower coverage for sanitation, 31% rural and 81% urban. Whatever the successes, this means that there are over 1 billion people still without access to clean water and 2.5 billion without sanitation (DFID, 2000). The low sanitation coverage is of particular relevance for environmental health.

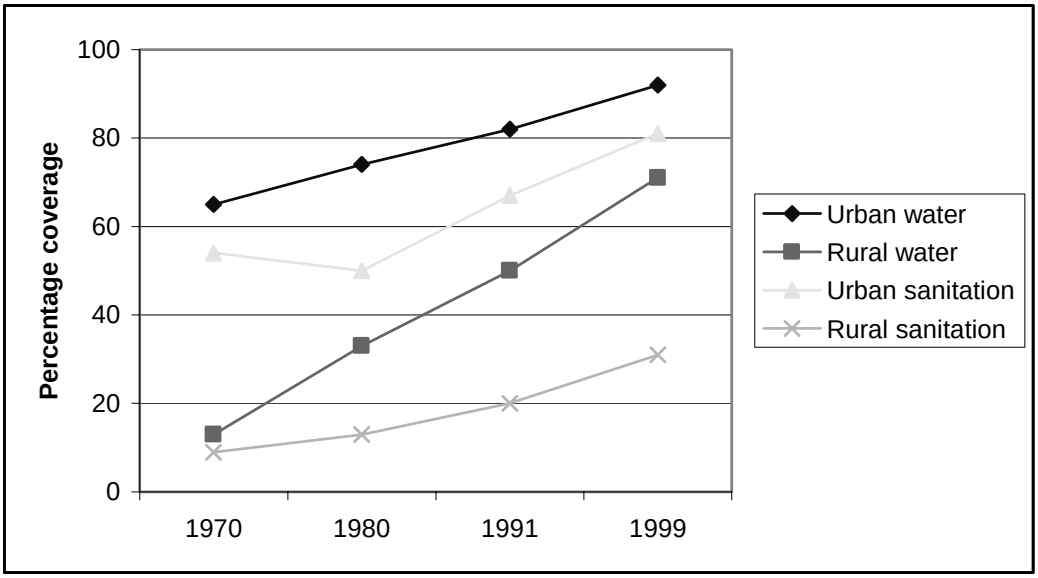
Notwithstanding the increase in coverage, the service provided is often seen to be unsustainable. Prices charged for water can be one-third of the level of costs, but these (sometimes unintentional) subsidies to ensure access for all have most often gone to the rich, not the poor. The urban market has been growing at a rate of 1 million people every seven days but too many people, if they receive water at all, receive it at limited pressure and then perhaps for only a couple of hours per day, with women in particular having to wait for hours for their turn to fill a container.

In addition, there has been environmental unsustainability in that the ineffectiveness (or lack of reach) of centralised supplies has led to local groundwater mining, and also in that the partially centralised collection of wastewater has led to untreated discharge of concentrated wastes.

This chapter focuses upon water and sanitation for people. The related aspects of unsustainable use of water resources for irrigation (approximately 80% of water use) have to be addressed through ensuring a move towards economic pricing of water and power for pumping. The environmentally

unsustainable discharge of industrial wastewater has to be addressed through cleaner production and on-site treatment.

Figure 1. **Drinking water and sanitation coverage, 1970-99**



Source: DFID (2000).

To consider how to promote scientific co-operation in solving the challenges of effective, efficient and sustainable water and sanitation service for all, it is necessary to ensure a common understanding of the meaning of science, technology and sustainability.

The emphasis of the title of this Conference implies that science and technology play a vital role in the objective of facilitating sustainable water and sanitation for all. Clearly, technology has a role to play but I would like to emphasise the word "science" in the title, using a dictionary definition of science as "knowledge or skill based on study, experience and practice". This chapter will be considering the scientific knowledge we have gained as a result of the most recent decades of experience. Similarly, the word sustainable must also be clarified – to ensure a safe supply of drinking water supported by the necessary sanitation naturally requires sustainability, but a definition of sustainability perhaps beyond the environmental aspects implied in the Conference outline. Scientific co-operation in MLICs over a number of years has taught us that we need to consider sustainability under the headings of:

- **S**ocial sustainability.
- **H**ealth sustainability.
- **T**echnical sustainability.
- **E**conomic sustainability.
- **F**inancial sustainability.
- **I**nstitutional sustainability.
- **E**nvironmental sustainability.

And that even this long list of *SHTEFIE* has to be subsumed within the overall demand for *political sustainability*.

In the higher-income countries, we have been fortunate in that we have matched our technological progress with our economic progress. In effect we have only invented a new technological process (or it has only been accepted in the professional domain) when there has been a clear demand to solve a problem, when the wealth needed to support it and make it work became available and as the institutional framework developed to manage it.

The challenge for the MLICs is far greater because in co-operation we have to facilitate the transfer of science that enables governments and peoples to appropriate the most sustainable technology to meet their needs at this time, matching their particular political, economic, socio-cultural and technological conditions.

So, the delivery of water and sanitation has to be in a manner that people (at all levels of income) want (*social*); that produces the desired health benefits, particularly for children (*health*); that can be operated and maintained effectively for the desired period with the available skills and access to materials and parts (*technical*); that matches people's and government's willingness to pay for those resources (*economic*); that ensures, with perhaps the appropriate use of subsidies, that the direct providers can pay for the cost of capital invested *(financial*); that uses the most efficient combination of public, private and community organisations to deliver these services (*institutional*); and that ensures there is no significant degradation of the environment in the process (*environment*).

This is a more difficult task than that faced by the pioneer public health engineers of the rich country past. The science, the knowledge of experience as to how to deliver this complex package of outputs may best be described as "programme management". The definition of this general term used here is "the co-ordinated management of a portfolio of projects to achieve a set of specific objectives", this definition reinterpreted from the five offered by Reiss (1996).

The science of programme management, of achieving *SHTEFIE* sustainability is science indeed, often stretching the skills of the rich countries and therefore even more necessary to share with the lower-income countries. Clearly, this is going beyond the challenge of transferring the knowledge of how to replicate the most recently invented treatment technology, and hence faces even greater difficulty.

Programme management means having an overall objective and then using the skills of conventional project management allied with an understanding of operations, financial and marketing management as well as the leadership skills of strategic and change management. This is the science that we need to explore together in co-operation if we are to achieve our objective.

The objective is clear: water and sanitation are critical for life. The WHO tells us that "Every eight seconds a child dies, every year 5 million people will die from water and sanitation and 'environmental' diseases and there are 1 billion diarrhoeal disease episodes per year" (WHO, 1999).

In terms of focusing upon objectives, it could therefore be argued that developing sustainable water and sanitation services for health for all might have a greater priority than ensuring immediate environmental sustainability. There are environmental problems associated with water and sanitation as mentioned earlier. However, in recognition of the fact (perhaps exceptional) that Brussels, the city at the heart of Europe, is only now constructing its first wastewater treatment plants, it is necessary to be realistic in our desire for a sustainable "water for people" environment (recognising again the caveat regarding industrial wastewater).

Present practice

The preferred scientific and technological practice to meet the needs for water and sanitation for several generations has been the supply driven "predict and provide" approach. Planners determine the population size, estimate the population growth, estimate the growth in demand and then design and construct a "latest technology" water treatment works to deliver that level of production. However, they omit to recognise that the distribution network usually does not extend to the informal housing areas where the need for the water supply to promote public health is greatest. They omit to recognise that perhaps half the water put into the distribution system will be lost through leakage or illegal connections. And they omit to recognise that the prices paid for the water that does reach the elite, being subsidised in support of the merit good of public health, can never pay for the expensive new investments. Only rarely is there sufficient cash generated to pay for leak detection and extension of the services to the poor.

This experience has now taught us that the best way of achieving the objectives of *SHTEFIE* sustainability is by turning away from a conventional supply-driven, centrally planned approach towards a demand-driven, "demand-responsive approach"; that is, by finding out what people want and are prepared to pay for. This approach is diametrically opposed to the traditional "product-driven or supply-driven" approach; that is, a top-down, "knowing" what people want and then giving it to them, irrespective of actual demand. However, recognising that where the sector now emphasises bottom-up, demand-responsive, community involvement approaches, there clearly remains a vital professional, scientific role in responding to a dynamic demand. This is what has been described as "bottom-up, top-enabled".

Therefore, we have to investigate what is the science and technology that enables this to be achieved.

How to integrate the skills of the design and construction engineers, the economists, the sociologists, the financiers, the operations managers, the water quality specialists and the hygiene motivators? We have to look especially carefully at technical co-operation when the imbalance of economic wealth is so great.

It is relatively straightforward to transfer technologies between partners with equal riches. However, when the "modern equivalent asset value" of, for example, the fixed assets of the privatised English & Welsh water companies is USD 2 000 for water, USD 3 760 for sewerage per person and the privatised industry is continuing to invest at USD 100 per person per year, it may be necessary to question the appropriateness of high-income country co-operation with the MLICs (Table 1).

Table 1. **High-income country co-operation with low- and lower-middle-income countries**

Population and wealth	High income	Upper middle income	Lower middle income	Low income
Population, million (WDR, 1999)	885	588	908	3 515
GNP per person (WDR, 1999)	USD 25 510	USD 4 860	USD 1 710	USD 520
Affordable water and sanitation investment per person per generation at 5% of income (includes for O&M)	USD 7 420	USD1 480	USD 520	USD 160

For the 3.5 billion people in the low-income countries, affordability for water and sanitation is extremely restricted. Therefore, the objective has to be to prioritise co-operation in the science of

achieving service coverage for health objectives (programme management), matched with the science of economic sustainability, not necessarily the science of new technological developments for environmental sustainability.

Science and technology for future sustainability

Quoting in full a statement from the recent eConference on water supply and sanitation:

I think there is a general awareness that technology is not the answer, and that it is getting the institutional side of things right that counts. However, having said that, there are times that technology does matter, a lot, and that the right technology can make the right things happen. What is important is that the institutional environment allow technology to play its proper role, and that the institutional 'vision' drives a search for the right technology (not the other way around). (Brocklehurst, 2000)

To meet the *SHTEFIE* criteria for sustainability requires careful segmentation of potential customer beneficiaries and then careful differentiation of the technical means for supplying their demands at a price at which there is willingness to pay.

For example, parts of the world can still benefit significantly from the development of deep hand-dug wells that have very low technological demands for operation and maintenance. More sophisticated techniques of radial drilling from dug wells can complement this approach in particular ground conditions. Continuing the inputs into improving hand pumps and, for example, hand-powered drilling rigs manageable by local enterprises, for hundreds of millions of people, are equally critical for sustainability in other hydrogeological and/or economic settings.

Rainwater catchment, as well as the recycling of grey water, can be critical for smaller communities in low-income countries just as they are increasingly recognised to be of relevance for rich countries (a delegation from the United Kingdom has been visiting Japan recently to study this subject).

For urban areas, where economies of scale and density of population demand a piped approach, the adaptation of reduced pressure systems with ground tanks in peri-urban areas, matching the service with customer's willingness to pay a reduced tariff, as has been experimented with in Durban, can promote long-term sustainability. Another example is the provision of water mains in low-income areas with batteries of water meters at intervals from which each householder makes his own plastic connection above ground, as in Quezon City (Mathys, 2000). With the introduction of piped supplies comes the possibility to continue the most immediately sustainable forms of sanitation, that is on-plot and on-site excreta disposal through improved pit latrines and septic tanks. For this generation, sustainability could well mean that it is more effective and efficient to pipe clean water into a peri-urban community and accept limited pollution of immediate groundwater (always recognising the need to be aware of any particular ground conditions).

As wealth and demand increase, there is the potential to invest in reduced-cost (condominial) sewerage with its own particular science and technology before looking at constructed wetlands and waste stabilisation ponds for treatment as economic wealth allows.

This is not to say that there is no need for high technology, but it has to be within the demand-responsive approach for sustainability. For example, one manufacturer has suggested that its "ultrafiltration" units, packaged within a standard 20-foot container, can be converted into a water

treatment kiosk to ensure clean water for vending in a low-income housing area. “The treatment kiosk avoids contamination from the distribution system by treating water at the point of consumption. Both the installation and maintenance of kiosks can be self-financing with the support of local water traders operating as franchises to collect income.” (Aqua Technique, 2000).

However, recognising that possibility does not demand the wholesale transfer of rich-country technology when the bulk treatment of water in many locations can be managed through the use of stilling basins and slow sand filters, for example. Criticism of this latter technology as being land- and therefore capital-intensive has to be matched with its reduced requirements for operating expenditure (and chemicals and power) which might well lead to enhanced sustainability. And adopting this option always leaves open the possibility of reassigning the land for more intensive use when economic conditions make that sustainable.

This brief reminder of just some of the technical options for water and sanitation is designed to indicate that the goals of sustainability may have to be approached from unconventional starting points – hence the need for the science of, for example, programme management, being the overriding capacity requirement to be shared. It is more complex to deliver “household-centred environmental sanitation”, optimising the range of possible inputs to match demand to achieve the objectives of public health and convenience for all, than it is to design and build a new wastewater treatment works. However, this is the objective that we believe many countries are looking towards and for which they would value co-operation.

This approach to the knowledge required for sustainable service delivery was summed up in a report to the UK DFID (Franceys, 1996), proposing a prioritisation for scientific research and applications towards:

- “Effective customer use of engineered services.
- Supply to peri-urban areas and secondary towns then rural areas before conventional urban areas.
- Integrating the known elements before over-refining individual aspects.
- Sanitation then water supply.
- Institutional and financial development then technology choice before technology development.
- Distribution and collection then treatment.
- Optimisation and rehabilitation before technology design for new capital works.
- Discovering and documenting and disseminating what is happening presently.
- Project and service delivery-oriented.
- Research-supported demonstration projects in target areas.
- Using (and therefore developing) local research capacity.”

Refocusing co-operation

This Conference raises the question as to how this scientific knowledge of programmes to deliver sustainable water and sanitation might be shared.

Nick King, Director of the International Water Association Foundation suggests that there are three main barriers to co-operation: barriers to transmission from a country, problems with transmission and reception and, thirdly, problems with acceptance in the new location.

In my view, you have to fully understand the concepts, both the technical and the wider system of which it is part before you can adapt it to your own particular circumstances. It's one thing to produce the material and send it half way round the world, by paper or electronically. It's quite another to truly understand the concepts from just reading the text so that you can apply the concepts in practice effectively. For example, the writer will have taken for granted many of the things the reader needs to know because they are such a sub-conscious part of the writer's daily life. This is where richer forms of information exchange such as training, exchange visits, etc., come in. (King, 2000)

The science of programme management to deliver sustainable water and sanitation is complex and multi-disciplinary. It is necessary to share not only knowledge but also skills and attitudes. There are many barriers to its successful implementation in terms of willingness to consider alternative technological and institutional approaches as well as in the capacity to deliver. Perhaps the most significant barrier to transmission has been the accepted paradigm of what constitutes the technology of environmental engineering, water supply and sanitation. We have simply not been transmitting the required knowledge, often through our own misconceptions of what is required.

For example, the *ASCE Journal of Environmental Engineering* (Dentel, 2000) describes four categories of research frontiers in environmental engineering: sustainable environment, complex environmental systems; analytical tools in molecular sciences; and process technologies. However valid these are for rich countries, it is a mistake to perceive them as being of immediate priority in low-income countries. As ASCE recognises, commenting that "use of local materials and low technology is essential in some regions". But, by default, it tends to be the more challenging technological development that sets the perceived co-operation agenda at the level of the high-income countries, rather than appropriate delivery of services to all. In addition to the attractions of new technology acting as a barrier to transmission, it is perpetuated by the conventional high-income country engineering training that focuses upon science and technology design and construction rather than delivery of environmental and sanitary services.

There is also the barrier of some countries allegedly using co-operation as a means of supporting "high-technology programmes which benefit [national] industry" rather than being focused upon delivering "the most profitable investment for sustainable development" (World Bank, 2000).

To overcome this natural bias, advocacy programmes are now challenging these problems with knowledge generation, transmission and reception. Advocacy for sustainable "watsan" ideas is being undertaken in a whole range of international settings, such as the Second World Water Forum, The Water Supply and Sanitation Collaborative Council, the eConferences in the sector (already quoted twice as examples of the approach) as well as this OECD Conference. Similarly the Internet is becoming a critical tool, with for example, the Global Applied Research Network for water and sanitation mailing list with respondents available to share knowledge and experience.

Changing the emphasis of the core subject area towards service delivery is one reason why IHE, Delft, in addition to its full range of scientific and technical water programmes, has developed a new Water MBA programme (www.water-mba.com). This programme focuses upon management of "watsan" provision in all its various forms, attempting to break through the barriers of a traditional engineer's training, preparing personnel to understand and manage the broader definitions of sustainability.

Also focused upon transmission and reception, with the support of the Netherlands Government IHE, Delft has for several years been establishing capacity-building projects in partner universities, for example Cali, Columbia; Harare, Zimbabwe; Sanaa, Yemen; Birzeit, Palestine; and Kumasi, Ghana. Although established as technical collaboration, this programme is increasingly been broadened to include the management aspects of achieving sector objectives. The most recent partnership is with Parahyangan University (UNPAR), Indonesia, which will comprise students beginning their studies in Urban Infrastructure Management in Indonesia for the first semester, before transferring to Delft to undertake specialist modules in the Netherlands – a more balanced form of scientific co-operation.

Increasingly, other forms of knowledge transfer through distance learning are also playing their part in the sector. Since moving into the general environmental field, Wye College, University of London, has developed one pattern of programmes in the agricultural sector. This approach has been emulated by WEDC, Loughborough, who offer a range of distance-learning modules for water and sanitation that have at their heart the understanding of sustainability.

Now the World Bank Institute, through its many programmes, and the World Bank Global Development Learning Network suggest that:

Distance learning is more than a means of extending educational opportunity based on traditional models. It is about access and interaction. It allows us to construct entirely new learning environments and relationships, using processes that are only possible with the new technologies. Distance learning fosters unique ways of communicating and collaborating. At the World Bank, these new dynamics are bringing people together to learn, discuss, debate and ultimately to take action on the Bank's mission to eradicate poverty.

Recognising that the third barrier to co-operation is acceptance of ideas in the new location, there is a range of initiatives to ensure ownership of concepts where they can best be used. The Water Utilities Partnership (WUP) is a:

Partnership for Capacity Building in Africa . . . a joint Programme initiated by the Union of African Water Suppliers, CREPA, Burkina Faso and TREND, Ghana, to build a partnership among African Water Supply and Sanitation Utilities (WSSUs) and other key sector institutions, to create opportunities for sharing of experiences and capacity building. (WUP, 2000)

A similar Water Utilities Partnership is now being developed for South Asia.

Another type of co-operation to promote acceptance is the Change Management Forum (CMF) for Sustainable Water and Sanitation in India, supported by the Ministry of Urban Development and DFID, with its partner Management Development Programme for Senior Public Health Officials (MDSUPHO). This programme gives senior sector staff the opportunity to see first hand what is happening in other parts of the world (to date in Europe). It then demands that they then put this knowledge and experience into practice through fieldwork in a "neutral Indian city" (*i.e.* not their own) to deliver local acceptance. Participants then return to their place of work with a detailed personal action plan and are brought back together again six months later to report on their progress and to reinforce the key learning messages. It is a sophisticated and relatively expensive programme but experience suggests that this level of input is required to overcome the traditional barriers to co-operation and acceptance.

As is also demonstrated in the co-operation through the "Streams of Knowledge" initiative, facilitated by IRC Delft, with the mission of developing a global coalition of resource centres in the water and sanitation sector (CINARA, Colombia; CREPA, Burkina Faso; IWSD, Zimbabwe;

NETWAS International, Kenya; PCWS - ITN Foundation, Philippines) to help to close the gap on unmet needs by: "organising Streams of Knowledge, achieving equitable access to information, focusing knowledge where it can help to build capacity, and promoting action learning, whereby people benefit from their own experiences" (IRC, 2000).

With appropriate research and consultancy being undertaken nationally, many of the difficulties of transmission, reception and acceptance are overcome.

Notwithstanding these various patterns of formal knowledge co-operation, the modern fashion for "learning organisations" replicates the long-standing professional responsibility to stay up to date through membership of a Professional Association. For too long it could be argued that in the water and sanitation sector, such associations have been dominated by the conventional technological approach.

For wider sustainability, water and sanitation professionals need an association which is not engineer-biased but is one where all professionals in the sector can share openly and not feel excluded for being a sociologist or pit latrine promoter but are similarly welcomed for their commitment to the overall objective.

There are hopes that the new IWA and its International Water Association Foundation might begin to become an ongoing scientific forum for developing all our capacities *(SHTEFIE)* to deliver the programme objectives. In this context, Nick King of IWAF asks whether: "There is a place for the traditional professional association role of publishing technical standards and design codes which give more weight to a concept, such as small-bore sewers, so as to help make them more acceptable to traditionally trained engineers?"

Co-operation through public-private partnerships

However, in addition to enhancing mechanisms for co-operation through revitalised human resource development, the objectives may also be met through enhanced co-operation with the private sector, both foreign and national, large and small. One of the unexpected routes to sustainability in the larger cities has been through the present move towards public-private partnerships (PPP), as can be seen in Table 2 (Franceys, 2000). This data is summarised from the 638 contracts detailed in the IHE-WEDC PPP database (as at July 2000).

Table 2. **Public-private partnerships**

Public-private partnerships	Capital expenditure (billion USD)	Utility purchases (billion USD)	Population served (millions)
Total reported/planned	149.82	34.65	384.9
Total operational	111.7	33.7	304.3
MLIC reported/planned	66.2	3.7	222.3
MLIC operational	30.8	3.0	156.6

Figure 2 illustrates the growth in these partnerships around the world, Figure 3 the present distribution. Irrespective of the doubts many have about giving such large responsibilities for public health to the private sector, that same private sector, driven by the need to make profits, has to be able to deliver the contracted objectives in the most efficient and effective manner. This has been demonstrated in the most recent European experiment in privatisation in England and Wales. To quote

(approximately) a reported conversation between a French utility Director and a British Director: "Why do you use second-rate technology?", British Director: "Because it does the job effectively and more cheaply."

The private sector, in search of a reasonable profit, is less likely to be seduced by the latest technology, as shown by the examples of Buenos Aires and El Alto, where technology is being adapted to meet the needs of the poor and significant extensions of service coverage are being achieved by the private contractors.

Figure 1. **Announced water and sanitation public-private partnerships**

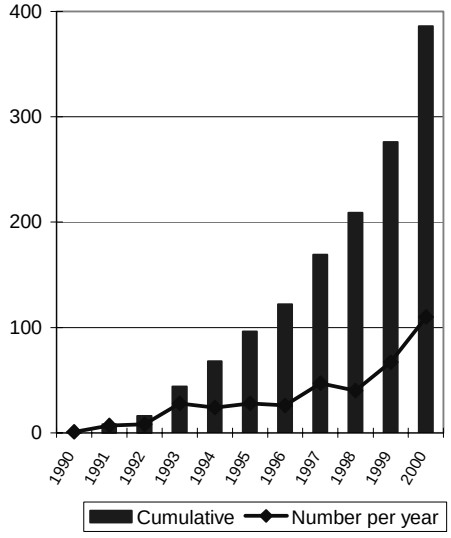
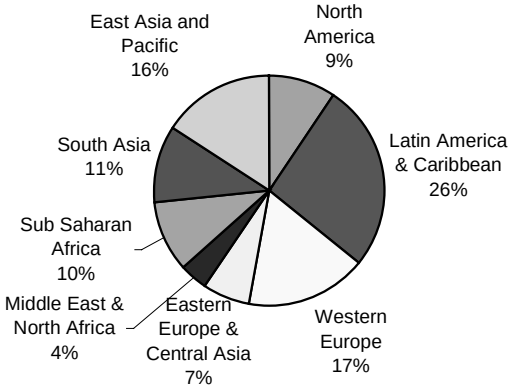


Figure 2. **Percentage of announced public-private partnerships by region, 1990 to July 2000**



The rate of adoption of PPP is increasing and, although there is a definite bias towards upper-middle-income economies (and metropolitan areas in those countries), it has proved far easier to induce a foreign multinational to respond to the demands for wider service coverage (albeit at a price and with delayed environmental sustainability), than it has for conventional government direct providers. To promote scientific co-operation further (and to emphasise co-operation rather than "foreignisation", 70% of the major PPPs include foreign contractors), it is possible to demand additional requirements such that international providers match each expatriate brought into a country with a national manager becoming an expatriate learner manager in another country. Or to require that "localisation" of management is completed within a specified time frame. It is notable that private (foreign) companies are already taking their human resource development responsibilities very seriously as evidenced by, again for example, Lyonnaise des Eaux's training centres developed at its major concessions ("100 000 hours per year of training in Buenos Aires") and now with its virtual university for water.

The international community is also now co-operating with the private sector through, for example, the Public Private Infrastructure Advisory Facility of World Bank that has been established to "channel technical assistance to governments in developing countries on strategies and measures to tap the full potential of private sector involvement in infrastructure and identify, disseminate and promote best practices on matters related to private sector involvement" (PPIAF, 2000).

Similarly, to support the move towards PPP, (you cannot have privatisation without regulation) the International Forum for Utility Regulation (IFUR, 2000), has been:

Established on an informal and voluntary basis (World Bank supported) to serve as both umbrella and catalyst for the new category of professional – the specialist utility regulator, charged with administering regulatory frameworks that seek to balance the interests of consumers and investors in technically complex and politically sensitive industries. [Regulation] can have a major impact on the performance of privatised firms, on the cost of investment capital (and thus on infrastructure tariffs), and on the sustainability of reforms.

And, demonstrating the understanding of the need to promote local acceptance of ideas, SAFIR (South Asia Forum for Infrastructure Regulation) has also been established.

This overview of co-operation in the sector is not meant to be comprehensive but rather illustrative of the range of ideas currently being attempted to enhance co-operation in the science of delivering sustainable water supply and sanitation. There is no single solution to scientific and technological co-operation. All of these approaches are required. To overcome the ultimate problem of "acceptance in the new location", Brocklehurst (2000) recommends:

A major part of this is encouraging innovation. Engineers need to have the freedom to experiment, and particularly to adapt new solutions from examples in other places. We hold an obligation to find out what is happening elsewhere, understand it, and make it work in our particular situation. [In] Durban … all sorts of things are being tried to extend services to previously unserved peri-urban areas. All the engineers …. said that having a Water Services Director who expected them to innovate and encouraged them (even when things went wrong!) was what made the difference. This included developing "sub-optimal" engineering techniques - mixing high tech with low tech when that fitted the need.

Conclusion and recommendations

In conclusion, to achieve water and sanitation service for all, we need to understand the holistic meaning of sustainability to be achieved through the science of programme management, recognising the key objectives, delivered by a demand-responsive approach.

We need to develop and support a range of mechanisms to research, transmit, aid reception and acceptance of this scientific knowledge through innovative learning programmes supported by international and national conferences and associations.

We need to seize the opportunities offered by the best public-private partnerships, for scientific and technical co-operation as well as for accelerated service delivery for all.

Ultimately, we need scientific professionals (traditionally engineers, but increasingly less so), public or private who are enabled and encouraged (through international co-operation and local demands for innovation) to respond to the demands of customers for sustainable (in all meanings of the word) water and sanitation by following the mantra of Stiglitz (1999) to: "scan globally, reinvent locally". It is one of our tasks to ensure that the whole range of knowledge for sustainability is available for scanning to enable local reinvention.

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Chapter 29

TECHNOLOGY DEVELOPMENT IN RURAL WATER AND SANITATION IN DEVELOPING COUNTRIES

by

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Introduction

For many of the world's poor, the first health requirement is not for cleaner water but for more water – whatever its quality – to keep things clean. Ready availability of adequate water is still a dream in many parts of the world in spite of decades of investment in water supply and sanitation infrastructure. It is estimated that in the developing world some 40% of the rural population still lack an adequate water supply and 60% are without adequate sanitation. In the World Water Forum concluded in the Hague in March 2000, it was stated that over 1.5 billion people have no access to safe water. For many developing countries, this may be an understatement taking into consideration that data collection is still poor in many developing countries.

The target set by governments of many developing countries of "water for all by the year 2000" has been a failure in most of them. The lesson emerging from these failures is that the goal of universal coverage of water and sanitation services will be unattainable as long as governments in developing countries, facing severe economic pressures, continue to plan in the belief that their resources, and those provided by donor countries, will be sufficient. Communities themselves will have to carry some of the cost of service provision. Similarly, investment in capital cost is only the start of the process. The real problems lie in operation and maintenance. Many water systems are not operational in a number of developing countries for reasons that include inappropriate technologies, inadequate maintenance and poor management by governments and their agencies. The need to empower communities to take responsibility for their own service provision is inevitable.

Development approaches and demand-responsive approach

The past decades have seen the emergence of principles that guide work in the provision of water and sanitation in many parts of the world. One of such principles has been a call for water to be treated not only as a social good, but also as an economic one that should be managed at the lowest appropriate level. This has seen more emphasis being given on consumers' engagement in the process of selecting technologies, financing, implementing and managing systems that meet their demands. This calls for systems that not only meet their demands but are affordable in terms of what they and their governments can pay. Other key supporting principles have been the need to adopt a holistic

approach to the use of water resources, and to acknowledge the importance of the role of women in the selection of technology and management of water.

While there is broad consensus around these general principles of community approaches, the World Bank is now advocating for the concept known as the "demand-responsive approach" (DRA). Differences have, however, emerged as to the details of implementation and, more importantly, around the longer-term vision of where the DRA should lead to. Agencies such as the World Bank interpret DRA in the context of their own vision of the new global economic and political trends, while many other role players, notably NGOs and governments, have embraced a somewhat different philosophical and practical interpretation of the approach. The Bank has popularised the term "demand responsiveness" because it is a term used in market economics, and emphasises the Bank's view of water as first and foremost a commodity. The term is, however, causing a great deal of misunderstanding among practitioners in the sector, most of whom do not have an economics background. Many have interpreted "demand" to mean the expression of expectation of delivery of a right, which is a completely different type of demand from that of DRA concept. Demand responsiveness should be placed more on the willingness to take responsibility and pay for something.

Technology development and transfer in community water supply

Technology today is a major cultural determinant, shaping human life to a greater extent than philosophy, religion or sociology. The effects of this influence are felt even more in the developing world where, due to poor economic development, citizens are ill prepared to cope with the positive and negative implications of technological innovations. Technological innovation has been institutionalised by organised research and development in the developed world, where there is heavy investment in big R&D laboratories. Similar levels of investment in technological innovations are not possible in developing nations because of their weak economic bases. The water and sanitation sector has not been spared in this aspect: components used in the sector are developed in industrialised countries and shipped to developing countries where they work with limited degrees of success.

At the global level, technology development is uneven and has contributed to the widening gap between the rich and poor nations, thus increasing international tensions. While the opposite view holds that only through technology can the less-developed countries improve their lot, this is only possible if the more advanced nations use technology to help the less-developed countries rather than to hold them in thrall. Supplying the products of technology is one way of providing help, especially if these products are appropriate to the recipients' needs. Complicated water supply systems are of no use in a region in which settlement is at a bare subsistence level.

A more effective way of transferring technology to the developing nations is through the provision of blueprints, models, design, patents and know-how. The establishment of workshops, factories, training programmes and colleges would facilitate the transfer of knowledge needed in developing nations. The past has seen the support of technology transfer by governments of most developed nations, who hope to gain not only relaxation but also an enlargement of their own economic, political and cultural spheres. A new dimension has emerged in technology transfer in the water and sanitation sector over the past decades. Businesses now look for possible partners in other countries in the hope of penetration of overseas markets, but tend to forget the valuable aspect of knowledge and skills development to sustain the technology. Stalled water supply systems in many developing countries bear witness to this kind of arrangement that does not incorporate the development of the skills needed to sustain a technology.

Low-cost technology development

Because of its naturally good quality, technology development in water supply in the past decades concentrated on groundwater. Emphasis was placed on the development of low-cost technologies as these were seen as the only hope for developing nations for the attainment of the goal of water for all. However, confusion emerged in many countries because of the rush to become industrialised. This shifted attention from the development of low-cost technologies to the adoption of conventional systems found in developed countries, as the development of water systems for urban centres became a priority issue. This has meant that the development of water and sanitation systems takes place in the urban centres, leaving rural areas unattended. Conventional systems have not worked well in most urban centres: the systems are either too expensive and operate below capacity or the local people lack the skills to run them. Because of different institutional requirements, the same technologies have been found to be inappropriate in a rural environment. The pace of technology development for rural areas has been overshadowed by the emphasis on urban development. The development of simple technologies for poor urban settlements has not been completed and the situation is nearing crisis level, with more and more settlements gaining urban status in many countries. Sharing of information and knowledge, supported by field trials, can make a big contribution to decisions on the appropriate technologies for the urban and rural poor.

Hand pump development

Because groundwater became almost the only choice for community water supplies, development of the hand pump took the centre stage of technology development in water supply. The hand pump is seen as appropriate and has gained popularity with many donors and development support agencies. This has resulted in the mass rooming of different designs and models of hand pumps supported by various donors. To avoid confusion, many countries went into standardisation of the hand pump – and even standardisation has not improved the quality of the pump. If anything, quality is likely to go down as manufacturers become complacent once their pump is standardised in a country. More often, standardisation trials do not fully incorporate what the target beneficiaries need, would require and are willing to pay for. If this were done, there would be no need for standardisation as only good pumps that meet users' needs would survive. Many hand pumps are stalled all over the world because what planners thought was good for the people has failed to fulfil their desires. The lesson to be learned here is the importance of incorporating indigenous knowledge of local people in low-cost technology development in water and sanitation initiatives. Technology development should take place at the closest point to the end users.

Technology development in environmental sanitation

Technology development in environmental sanitation remains a global challenge. Sanitation poses the greatest danger to the lives of many people in the developing world. Every year, 2.5 million children die from diarrhoea that could have been prevented by good sanitation. Poor sanitation has led to the infestation of nearly 1 billion people, largely children, with a variety of worm infections with corresponding costs in health and energy. Human excreta are responsible for the transmission of schistosomiasis, cholera, typhoid and many other infectious diseases affecting hundreds of millions of people. Heavy investments have been made in water supply since l980, but the resulting health benefits have been severely limited by poor progress in sanitation. Besides this toll of sickness and disease, lack of sanitation is a major environmental threat to water resource systems and a fundamental denial of human dignity.

The sanitation problem

Despite years of rhetoric, good intentions and hard work, little or no progress is being made at current rates of "sanitation provision", the number of people without sanitation will not change in the many years to come. A staggering 2 billion people in the world are without any form of sanitation. This is astonishing, given the human capacity to solve the problem, the fundamental nature of this basic need and the enormous suffering caused by our failure to meet it. Those of us working in sanitation agree that, with some notable exceptions, we are either losing ground or basically simply holding the line.

Through previous research findings and field experience, we can group the barriers to progress in technology development and sanitation improvement:

- *Lack of political will.* Currently, there is little political incentive for governments to deal with this problem. Politicians and administrators come under pressure from people when there is no water. Political commitment is needed to create an environment in which demand for sanitation can grow, which in turn can strengthen political will. Political will is thus both a cause and effect of other problems, and a key to successful sanitation promotion.

- *Low prestige and recognition.* Low-cost sanitation facilities and hygiene promotion campaigns have never been prestigious to the elite members of many communities. Among the professionals, the best and the brightest avoid low-cost sanitation as a low-status, low-pay career, particularly as it is more difficult and demanding than high-status, high-tech engineering or medical approaches. Among consumers, low-cost sanitation suffers from a lack of prestige in comparison with "conventional" water-borne sanitation, as used by the industrialised world and by the economic elite of the developing countries.

- *Poor policies.* In general, ineffective and counterproductive policies exist at all levels. These pay too much attention to water supply at the expense of sanitation. They have a focus on short-term outputs (hardware) rather than on long-term behaviour change. They offer subsidies that favour middle- and higher-income communities and leave out the very poor who need sanitation facilities. Philosophical approaches for sound policies are lacking.

- *Poor institutional framework.* Many more actors could be involved in the promotion of sanitation than is witnessed today. The institutional frameworks in place in many countries fragment responsibilities among government departments. These responsibilities ignore the poor people who are most vulnerable and ignore the powerful role that NGOs and the private sector can play in sanitation improvement. Governments and existing institutions need to give more voice and power to the most vulnerable to enable them to express their desires and aspirations.

- *Inadequate allocation of resources.* Most often, sanitation does not attract a fraction of the resources needed to do the job. It is a more demanding problem but receives fewer resources than is put into water supply. An increase in the resource allocation to sanitation is needed given the growing populations and rising urbanisation which make the hazards of poor sanitation even more acute in the developing world today. When resources are allocated, too much goes into hardware and very little to mobilisation and hygiene promotion.

- *Inappropriate approaches and technologies*. In many areas where sanitation promotion programmes are attempted, the approaches taken are often wrong. Planners take time to find simple universal solutions – which then fail because they ignore the diversity of needs and

contexts. Very little consideration is given to the fact that urban needs often differ from rural needs, the technological options offered are limited and inappropriate. Critical issues of behaviour are ignored or handled badly. Often, sanitation improvement fail because they are badly defined or are applied too broadly or too narrowly within a specific environment. For instance, the scope of environmental protection and pollution control becomes so broad that the focus on basic household excreta management is lost. In other cases, a narrow focus on pit latrine installation that ignores local drainage needs could exacerbate disease transmission during floods. The approaches used give very little attention to transition as a goal. Current approaches are also manipulative and lead communities to accept what agencies are willing to support. They stifle innovation and undermine the confidence of the most vulnerable.

- *Neglect for consumer preferences.* Many programmes sell what people don't want or can't afford. In many communities, low-cost technologies are seen as low-status technologies. Many appropriate technologies in the market today are well beyond the economic reach of the most needy. Much of the hygiene promotion conducted is based on messages which ignore existing knowledge, beliefs and experience of the local people.

- *Low public awareness.* In general, people don't want to talk or think about faeces, so selling the idea of sanitation is difficult. Those responsible for selling sanitation are often unaware of effective promotional techniques and continue with top-down approaches that alienate "target populations" by denying their voice, desires and involvement in the process. The adoption of social marketing and participatory approaches to sanitation is promising, but is still in its infancy.

- *Low involvement of women and children.* Many programmes fail to recognise that women are potential agents of change in hygiene education, and children are the most vulnerable victims. Women often need privacy and security in sanitation more than men, yet are unable to express these needs effectively in many societies. Women and children – who have the most at stake – have the weakest voice at the sanitation decision-making table. Their inputs should be considered in technology development to guarantee sustainability.

- *Creating and understanding demand in sanitation.* There is currently very little effective demand for sanitation improvement. Problems of sanitation are more often expressed as constraints upon supply. We also need to think about the factors which limit economic or political demand. Some may want sanitation facilities but not at the available price; others may not want the available "improvements" at any price. Where sanitation is poor, we need to understand why the effective demand is low, to determine whether it is most amenable to political, financial, technical or informational change. Technologies can then be developed to take care of the identified issues.

Investment efficiency

Investment efficiency has not received much attention in technology development in water and sanitation. Investment efficiency should advise planners on the level of service suitable for a given community, based on their level of development. Service levels desired in the developed countries may not be relevant in the developing countries. The development of systems for developing countries needs to take into consideration their pace of development and their ability to cope with the capital and investment costs.

Technology assessment in water and sanitation

The real dangers of technology development, such as irreversible ecological damage, can be dealt with if the dangers are known in advance. This is made possible in developed countries through well-established technology assessment centres. Such centres do not exist in developing countries or, where they do exist, are ill equipped and suffer from a lack of skilled personnel. There is increasing exposure to the dangers of technology development among developing nations: what they really need is not only the establishment of assessment centres but also support in the development of the relevant skills desired in technology assessment. Water and sanitation sector would enjoy greater benefits from technology assessment if an impartial body able to lay aside all vested interests were involved. This is where independent research institutions that can give frank and open information on research findings have a role to play in quality assurance.

Groundwater quality monitoring

The promotion of hand pumps as the technology of choice for rural water supplies has led to massive exploitation of groundwater through the sinking of wells in developing countries. While this is going on, very little is being done on monitoring or assessment of groundwater ability to cope with this increased demand. We are not sure if enough water is being left in the ground to support the ecosystem. Neither are developers bothered with the quality of groundwater. The measure of success is based on coverage, in terms of the number of wells drilled. Because attention is not being given to quality at the construction stage, abandoned wells are a common occurrence in many villages in developing countries. There are increasing reports of cases of harmful chemicals in groundwater in many parts of the world – indicating that a problem exists. Water-quality monitoring efforts are often frustrated by lack of skills and tools in many countries. The development of simple methods that can enable rural communities to monitor the quality of their water sources can be achieved through cross-border co-operation in scientific and technological research among the world's nations. Countries in which these systems have already been developed should disseminate them widely for the benefit of the poor people of the world.

Measuring community health

In public health, basic epidemiological techniques to measure and evaluate community-wide health problems are not well developed in many developing countries. Because of this, public health assessment records are not readily available, making it difficult for planners to choose interventions that target the real needs of communities. This fact contributes significantly to sustainability problems in many water and sanitation programmes, especially in areas where the intervention was not tailored to people's real needs.

Collapsing systems in developing countries

The identification of microbes as causative agents of disease allowed public health workers during the late 19^{th} and early 20^{th} centuries to develop specific methods of prevention. Mass immunisation programmes were initiated and public health laboratories were founded to test the purity of water, food and milk, as well as to diagnose contagious diseases. The benefits to human life brought about by these innovations may be lost as systems collapse in developing countries. Public health laboratories are collapsing in many developing countries, making even water-quality testing near

impossible. The sophisticated laboratory techniques, diagnostic equipment and in-the-field surveillance enjoyed in developed countries need to be spread equally among the nations of the world.

Threat from pollution

When industrialisation was in its infancy, the impact of pollution was localised and minimal. With rapid worldwide industrialisation using petrochemicals as an energy base, toxic pollution has increased to global proportions. The stress placed on fresh water sources by pollution has far-reaching effects and constitutes a grave crisis. While attempts have been made in many cities to establish sanitary engineering departments responsible for garbage collection and sewage treatment, the situation in rural areas is still left to chance and could be linked to many diseases that affect the rural poor in developing countries. Rural communities are under greater threat from pollution than their urban colleagues. Industries discharge effluents into rivers that are used downstream for domestic purposes. Groundwater is not spared either. In many places groundwater recharge is rainfall-dependent, chemical fallout from the atmosphere could be fixed by rainfall into groundwater reserves. Developing countries may not be equipped at this stage to carry out assessment. Empowerment and co-operation between international and national environmental protection agencies is needed to protect public health by controlling air and water pollution and by regulating the production, use and disposal of toxic chemicals.

The critical need in Africa

Despite huge investments in water and sanitation in Africa, very little impact has been realised in technology development. The problems in Africa today are caused by a combination of natural and man-made factors. These factors range from mismanagement of resources to bad governance. Lack or shortage of financial resources makes Africa perhaps one of the most backward regions in terms of coverage in the areas of water supply and sanitation. Different statistical records show that over 46 million people do not have access to safe water and over 50 million do not have access to adequate sanitation. Africa needs cost-effective and sustainable technologies, coupled with local capacity building, to be able to overcome its water supply and sanitation situation that is nearing crisis. In Sub-Saharan Africa, less than 40% of the rural population have access to safe water and less than 32% have access to adequate sanitation.

The ever-increasing population is adding further strain to already stretched resources in Africa. The effects of this are decline of life expectancy and high infant mortality rates. Most of the children who die of diarrhoea live in Africa. Many young children cannot go to school, not only because their parents cannot pay school fees but also because they are kept at home to help in fetching water and other household chores. The African girl-child is a victim of this situation.

Past technology development approaches in Africa have failed to carry out many of their promises and even stand accused of having made matters worse. Policies imposed from above by international agencies and central governments have been at great variance with the needs and aspirations of ordinary people. The new world order of globalisation poses great threats to technology development in Africa. Governments charge very high tax rates on local goods to raise revenue, making it quite difficult for local goods to compete with imported goods. Governments of developed countries subsidise their manufacturers who can afford to sell their products at lower prices abroad. This luxury is not available to the local manufacturers in Africa. The cost of the hand pump remains high, even with local manufacture.

The need to recognise indigenous knowledge

Indigenous knowledge is needed for technology development in Africa. Africa needs support in adaptive research that incorporates the wishes and the aspirations of the local people in technology development. Promotion of participatory approaches in research that work from below and enable local voices be heard more effectively is the way forwards for Africa. Efforts of central governments and support agencies will not lead to the development of sustainable technology in Africa unless the targeted communities are allowed a seat at the decision-making table. The water and sanitation crisis will not be solved without involvement of people at grassroots. Africa needs technology development that can provide a response to the issues of high drilling costs, expensive hand pumps, quality and adequacy of groundwater and falling sanitation standards. Only with investment in low-cost technology – not in systems that support conventional technologies – will Africa be able to solve its water and sanitation needs. We may be able to see the light at the end of the tunnel if we can gain support and co-operation from agencies with experience in adaptive research in technology development to support Africa. Access to water and adequate sanitation for all will only be realised with the development of cost-effective technologies affordable to the African poor.

Lessons learned over the past decades

Investment in water and sanitation over the past decades has brought with it many lessons that need to be followed and further researched in order to make interventions more sustainable:

- There still exists no universal criterion for determining the right technology in community water supply and sanitation. What succeeded in one community may not be the right choice for another. Engineers and planners are faced with greater challenges in deciding technological options due to lack of data. Assumptions made by engineers and planners are often not the situation on the ground. Faced with a situation of inadequate information and fear of failure, designs are over complicated, resulting in high technical estimates that fail to attract donor support. This has been the greatest constraint in the development of solar-powered water systems. Capital costs are high and the project is therefore seen as inappropriate even in places where a solar system provides the only hope. Scientific and technical co-operation is needed among nations in the collation of information and data on solar energy.

- There is a need to research and develop suitable sanitation options for developing countries. The mass rooming of poorly planed urban centres has worsened the sanitation situation in most countries. Now is the time to take the decision if the situation is to be arrested. The pit latrine concept is becoming more and more inappropriate in many communities. The right size and depth of a latrine is an issue that needs addressing. Users do not agree with the scientific methods used by designers in determining the depth of a latrine. A very deep latrine instils fear in people and discourages use. Many users feel strongly that the best depth of a latrine is one that would easily allow the recovery of a victim in the event of an accidental collapse. It has become more clear that the use of social marketing techniques that promote the use of the indigenous knowledge of the target population stand a better chance of success in latrine promotion.

- The first step in sanitation promotion should be the creation of community demand. Programmes have to be financially self-sustaining, even if only in part. Sanitation systems and hygiene practices have greater longevity when communities design, manage and finance the services from which they benefit. Affordable technologies with creative arrangements for

credits and revolving funds that enable producers and users to make the necessary investments in the technologies should be encouraged.

- Communities have to identify their needs and manage the direction of their solutions if concrete steps are to be made in improving access to water and adequate sanitation. Development supporters need to facilitate an environment where:

  - Communities initiate and make informed choices about service options, based on their willingness to pay for the service and an acceptance of their responsibilities for subsequent operations and maintenance.
  - Communities contribute to investment costs relative to level of service and have significant control over how funds are managed.
  - Communities have adequate flow of information, as well as procedures for facilitating collective action decisions.
  - Government has a facilitative role, sets clear national policies and strategies and creates an enabling environment (including the legal framework) for participating groups.
  - The community (or representative legal body thereof) owns and is responsible for sustaining its facilities.
  - Community capacity should be appropriately strengthened to cope with the challenges in developing and maintaining water and sanitation projects.
  - Innovation is promoted, the need for flexibility and the role of indigenous knowledge are recognised.

- Agencies investing in water and sanitation development should include training in functional literacy in their packages. Users need education in functional literacy if they are to follow the operation manuals that accompany many technologies. Village-based artisans cannot follow plans or maintenance manuals, thus contributing significantly to the failure of many water schemes.

- Most of the work in water and sanitation in developing countries is done by NGOs. Capacity of local NGOs in developing countries to conduct training in low-cost technologies is lacking. Many NGOs are not able to attract and retain skilled personnel because of weak financial bases. Partnership with international NGOs is the way forward if local NGOs are to make any significant impact in community water supply and sanitation development.

- There is varying level of consensus that basic social services, including water and sanitation, are not fundamental human rights like individual liberty and freedom of expression. They are conditional on the ability to pay. Policy objectives should therefore not be based on providing a particular level of technology and service, even if it is considered to be the basic minimum required for health and human dignity, but rather on what consumers can afford to pay. Government should move away from financing operation and maintenance costs if they do not have long-term plans for sustainability.

- The economies of developing countries are too weak for governments, even with donor support, to be able to make enough financial resources available for the infrastructure required to enable all their citizens to have access to basic services. Consumers must

therefore pay a significant part of the cost of the provision of services. A technology should be termed as low-cost, based on the economic status of a particular community. No one universal approach is right.

- Consumers respond only to economic incentives and disincentives. Treating services as a commodity to be supplied in accordance with the rules of the "market" is the best way to achieve efficiency and cost-effectiveness. Sustainable technologies and services are those for which consumers can afford to pay the full economic cost.

- Over-subsidised services to the poor are not beneficial if the supported governments cannot afford them. Even if they can afford them now, due to of economic pressures on many governments, the support may not be relied on for any length of time. Subsidised systems often fail when the subsidies are withdrawn, leaving communities in a worse situation. It is estimated that more than 80% of the stalled water systems in many developing countries were initiated and operated on subsidies at the beginning.

- Service provision to rural communities needs to be approached in a fundamentally different way to urban services. Institutional support in rural areas is very weak and is unlikely to improve in the foreseeable future. In any development programme, communities must be encouraged to take the leading role in service delivery and management. In essence, rural development planners should make it clear to communities that they are on their own and have to solve all their own problems.

- Most rural communities will remain outside the formal or mainstream economy for the foreseeable future. Rural local governments are not prepared and will not be able to adopt and afford technologies suitable for urban dwellers for the provision of water and sanitation. Even if they did, they may not able to play a significant, or at least not a reliable or sustainable, role. Access to water and sanitation for all remains a dream for many of the world's poor. Further studies and experience sharing among participants in the water and sanitation sector all over the world are called for if we are to come up with options that would enable all world's poor to have access to water supply and adequate sanitation.

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Chapter 30

ENVIRONMENTAL INDICATORS TO MONITOR THE SUSTAINABILITY OF PIG FARMS

by

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Introduction

In 1998, the OECD published a report on the use of environmental indicators to achieve sustainable development in the agricultural sector. The report ranked Korea in fourth place among the OECD countries in terms of livestock densities, at 4.8 head/hectare. In terms of the application of nutrients to agricultural land, Korea ranked third, with 177 kg N/ha and 80 kg P/ha in 1995.

This chapter looks at pig farms. In 1998, there were about 7.4 million pigs in Korea. Each pig produces about 346.2 g biochemical oxygen demand (BOD) per day, the equivalent of seven people. Thus, the pig population is roughly equivalent to 50 million people; the total population of the country contributing to water pollution is then 100 million. This suggests the significance of waste from pig farms in Korea. Unless full consideration is given to the proper management of such waste, optimal water quality will not be possible and the goal of clean water supply will not be achieved in the near future.

In this regard, the Korean Government has invested some USD 1 billion. About 80% of the total investment was earmarked for the construction of reuse plants for livestock waste, such as compost and liquid fertilisation plants, while the remaining 20% was used for the construction of community plants for the treatment of the livestock wastes prior to their discharge. However, the investment programme was only partially successful. The Korean Ministry of Agriculture believed that reuse of livestock waste on agricultural land provided the most desirable method of disposal and was useful for crops, but it did not take into account the effects on the waters receiving the waste, such as streams, reservoirs and groundwater reserves. Large amounts of solid waste from pig farms intended for land application were transported to the community plants, often upsetting the normal operation of the plants. The concentration of the influent waste had to be increased four-fold compared with the concentration under normal operating procedures. This suggests an important point: demand for pig farm waste as fertiliser is not as high as expected and the land application of waste is not economical.

Reservoirs are the major source of water in Korea. Most reservoir water is in an eutrophic state, with a relatively high TN:TP ratio of 84 to 362 (Kim, 1996). Table 1 illustrates the current regulatory effluent limits for pig farm waste. As can be seen from the table, the effluent limit for pig farm waste is comparable with the limits for municipal sewage and night-soil treatment plants regardless of the

influent characteristics. This chapter emphasises the role of nitrogen as an environmental indicator because nitrogen is one of the major pollutants depleting dissolved oxygen, creating eutrophication, and reducing the quality of drinking water through the presence of NH_4N. In addition, nitrogen removal is an indicator which ensures complete carbon removal in the biological wastewater treatment of pig farm waste. The amount of nitrogen discharged with other pollutants, its applicability to agricultural land, the currently available treatment technologies and its economics are discussed below in relation to the environmental sustainability of Korean pig farms.

Table 1. **Current regulatory effluent limits in Korea**

In mg/litre

Constituents	Farms for which a permit is required: > 715 pigs		Farms for which a report is required: 35 to 715 pigs		Community livestock wastewater treatment plants	Municipal sewage treatment plants	Night soil treatment plants
	Special areas	Others	Special areas	Others			
BOD	50	150	150	350	30	20	30
COD_{Mn}	-	-	-	-	40	40	40
SS	50	150	150	350	30	20	30
TN	260	-	-	-	60	60	60
TP	50	-	-	-	8	8	8

The composition of waste

Each pig produces about 2 kg of faeces and 4 litres of urine and wastewater per day. The chemical oxygen demand (COD) and nitrogen loads are respectively 853.4 g COD/head/day and 124.9 g N/head/day, as shown in Table 2. The concentration of pig farm waste varies according to the amount of faeces discharged into the liquid stream. If the totality of faecal matter is discharged into the liquid stream, COD concentration can attain 140 g/l and nitrogen concentration can attain 20 g/l. If the faeces are properly separated, the COD and nitrogen concentrations would be respectively around 8 g/l and 2.5 g/l. However, these concentrations can be influenced by the amount of water used for cleaning the pig pens. The amounts of water used vary according to the season, with usage in the summer months about 100% higher than during the winter months.

Table 2. **Unit pollutant discharges from pig farms**

In g/head/d (70 kg average live weight per head)

Constituents	Total	Faeces	Urine + washing water
COD	853.4	805.5	47.9
BOD	346.2	322.2	24.0
Nitrogen	124.9	109.6	15.3
Phosphorus	30.9	30.1	0.8
COD/TKN	6.8	7.4	3.1
COD/TP	27.1	26.3	62.5

Conventional pig pens allow the faeces to be separated manually, thus minimising the concentration of wastewater. However, the slurry type pig pens operate without solid (faeces) separation, resulting in higher concentrations. The scraper type pig pens which operate with mechanical solid separation generally give concentrations which include about 20% of the faeces generated.

Nitrogen loads to agricultural area

Reuse plants

Conversion to compost and liquid fertiliser have been used as reuse technologies for agricultural land application. Conversion to compost requires limiting the water content and must be preceded by solid separation. However, liquid fertiliser (bioliquid) does not require separation of the solid, and this technology is now becoming more popular. As shown in Table 1, liquid collected from smaller farms operating with between 35 and 715 animals is transported to the community plants.

Nitrogen applicability

The pig population in Korea amounts to 7.4 million head, with a total of 1.9 million hectares of agricultural area, resulting in 3.87 pigs/ha. Nitrogen production is 45.5 kg/head/year as shown in Table 2 and the Korean Ministry of Environment reported that about 81% of pig farm waste is applied to agricultural land after conversion to compost or liquid fertiliser. It was estimated that about 20% of the nitrogen discharged is lost during processing, resulting in a nitrogen load to agricultural area of 113 kg N/ha/year. It should be borne in mind that the OECD (1998) reported 177 kg N/ha/year (including that produced by other animals besides pigs) for Korea. In addition, 180 000 tons/year of chemical nitrogen were applied as fertiliser (Ministry of Agriculture, 1999), equivalent to 94.2 kg N/ha/year. The resulting total nitrogen load is thus 271.2 kg/ha/year.

Nitrogen requirements vary from 55 to 400 kg/ha/year according to crop grown, type of soil, SiO_2 and organic content (Hanrim Journal Co, 1998). On the basis of an organic content of 2.5% in a typical soil containing 72 ppm of SiO_2, the computed nitrogen load to agricultural area (in this case rice paddies) represents 109 kg N/ha/year. The Ministry of Agriculture recommends 152 kg N/ha/year.

The actual nitrogen load according to Ministry of Environment (2000) therefore significantly exceeds both the computed and the recommended loads. The excess nitrogen will be discharged into the receiving waters, resulting in depleted dissolved oxygen, eutrophication and increased nitrogen concentration in the water sources.

OECD countries generally limit nitrogen application to between 170 and 250 kg N/ha/year, although this limit will be lowered to under 170 kg N/ha/year as of 2003. However, the permissible application rates in Korea are between 210 and 340 kg N/ha/year (Ministry of Environment, 2000).

Wastewater treatment technology

As of 2000, 41 community plants treat a total of 7 380 m^3/day of pig waste. Ten of the plants treat a total of 2 960 m^3/d, while the remaining 31 plants are under construction and are expected to be able to handle 4 400 m^3/d, according to the Ministry of Environment. In general, larger plants use the anaerobic process followed by the aerobic process, while smaller plants use the aerobic processes combined with additional physical and chemical processes. Some joint plants exist with the treatment of municipal sewage. The pig wastewater treatment plants follow a three-stage process: pre-treatment, followed by the main and polishing stages.

As indicated above, the characteristics of wastewater vary according to the amount of faecal material included and the amount of water used for washing down the pig pens. At the planning stage for the implementation of community plants, the Ministry of Environment estimated that the wastewater concentrations would be about 5 000 mg/l BOD, on the assumption that the faeces were mainly separated for the production of compost. However, in practice, the concentration turned out to be nearly 20 000 mg/l, because the solids to be composted were discharged into the liquid stream. As a result, the community plants were overloaded; their capacity is currently being expanded to enable them to treat the increased concentrations.

Depending on the faeces content, the efficiency of treatment will vary. Without the faeces, TCOD:TKN ratios were much lower and were difficult to denitrify because of the carbon limitation. To maximise denitrification, the TCOD:TKN ratio must be greater than six.

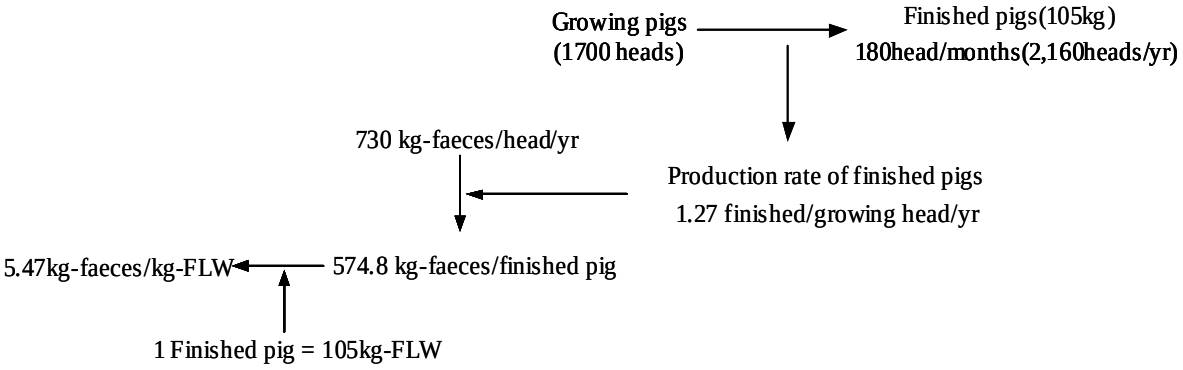
The efficiency of COD removal was not sensitive at temperatures of between 15 and 48°C, although NH_4N removal efficiencies fell from 66% to 99.9% with night soil (Oa, 1995). The critical temperature for nitrification is around 35°C. This suggests that complete nitrification would not be achievable during the summer months.

Economic analysis

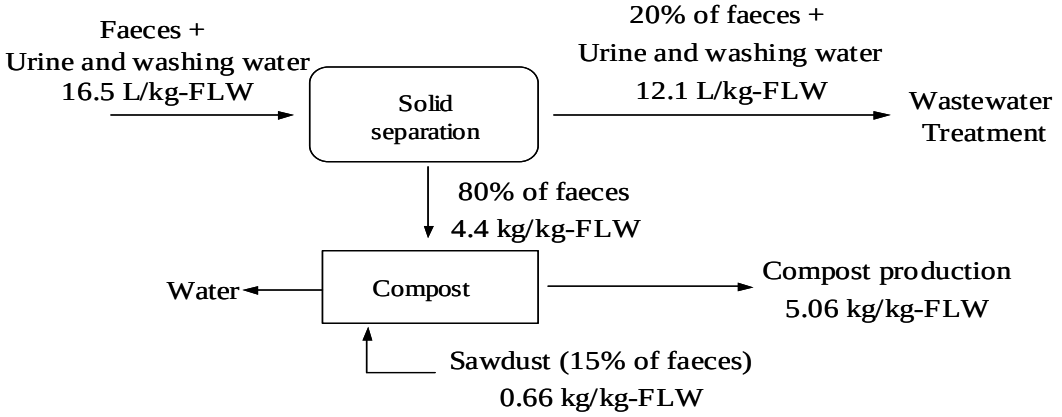
Figure 1 illustrates the basic material flow for the production of pigs, compost and liquid fertiliser in finished live weight (FLW) equivalent. The average live weight of pigs on the farm is about 70 kg/head; pigs weighing around 105 kg/head will go to market. A farm operating with an average of 1 700 animals produces some 2 160 animals per year. It is estimated that 574.8 kg of faeces will be produced per 105 kg live animal (*i.e.* 5.5 kg faeces/kg FLW). The production of 1 kg FLW generally requires 3 kg feed, and discharges a total of 12.1 l of wastewater and 5.5 kg of faeces. If the price of live pigs is KRW 1 700/kg and KRW 400/kg feed is required, the net gain will be KRW 500, including labour, operating cost and benefit. The estimated treatment costs for the waste generated from pig farms based on FLW are listed below:

Figure 1. **Material flow based on FLW**

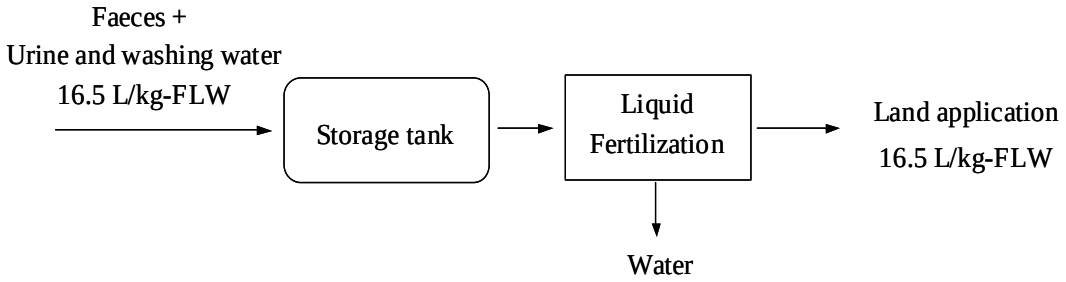
a). Finished pig and waste production



b). Compost production



c). Liquid fertiliser production



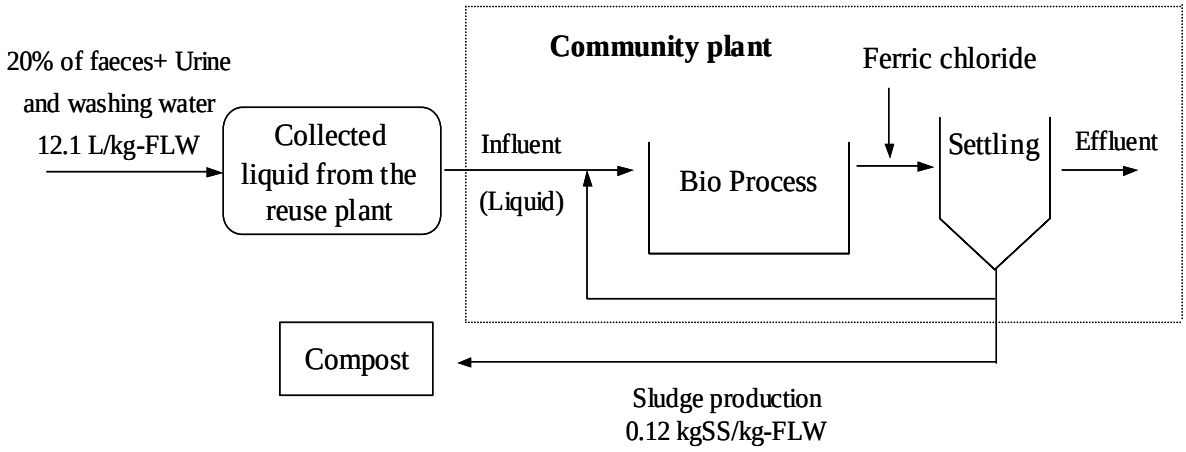
- *Compost:* The unit price per kg of composted material is approximately KRW 115. If this unit price is converted into the FLW, it represents KRW 582 per kg FLW. Compost materials is reported to cost KRW 3 850/kg, with sawdust supplied free of charge (Y. farm, 2000). If the earnings from resale of the composted material are considered, the net cost for compost would be around KRW 20/kg FLW to produce KRW 389/kg FLW.

- *Liquid fertiliser (bioliquid):* Fertiliser use is estimated to represent KRW 11 000/m^3. If all waste from a pig farm is converted to liquid fertiliser, a total of 16.5 l/kg FLW could be produced at a cost of KRW 182/kg FLW.

- *Ocean disposal:* Ocean disposal has been used in the coastal regions of the country. The cost is reported to be KRW 13 000-KRW 14 500/m^3 of waste (Ahn, 2000), equivalent to about KRW 230/kg FLW.

- *Wastewater treatment:* The regulatory effluent limits vary across the regions as shown in Table 1. The cost analysis was made on a basis of community plants where nitrogen control is required. Figure 2 shows the flow scheme used for cost analysis: solid waste separation for the manufacture of compost; biological process for organic and nitrogen removal, and chemical treatment for the removal of phosphorus, colour and the enhancement of solid separation. The influent characteristics used for the cost analysis were 35 000 mg/l COD, 18 000 mg/l BOD, 5 200 mg/l TN and 720 mg/l TP. The treatment cost was computed to be KRW 39 577/m^3, equivalent to KRW 479/kg FLW, including KRW 20 625 for chemicals, on the basis of a 20-year duration at a 5% interest rate.

Figure 2. **Community plant for cost analysis**



Discussions on sustainability

Table 3 presents a comparison of the treatment costs of unit processes. The composted materials could be sold at between KRW 2 222 and KRW 3 850, equivalent to KRW 562-KRW 971/kg FLW. If demand for composted material is greater than production, the overall treatment cost decreases. However, the reality is that the production of composted material seems not give a substantial benefit. Farmers actually changed their plant from the composting to the liquid fertilisation. The estimated total cost including the composting was KRW 104 to KRW 513/kg FLW. The cost difference was attributed from the sale price for the composted material. As mentioned earlier, the demand of the

composted material is not as great as expected and the total cost for pig waste would be increased to KRW 1 075/kg FLW in future.

Table 3. **Costs for the unit processes of pig waste treatment**

Items	Composting of faeces	Liquid fertilisation (including faeces)	Ocean disposal	Wastewater treatment (excluding faeces)	Composting + wastewater and sludge treatment
Production per kg FLW (kg, l)	5.06	16.5		12.1	17.28
Cost per m^3 (ton) (KRW/m^3)	115 000	11 000	14 000	39 577	62 210
Cost per kg FLW (KRW/kg FLW)	582	182	231	479	1 075

As shown in Table 3, the most economical way to handle pig farm waste would be through liquid fertilisation. However, this process requires the land area to be cultivated. The minimum area requirements per head are 340 to 640 m^2 depending on the type of land (Ministry of Environment, 2000), although the estimated area requirements are to be 1 900 to 2 600 m^2 per head. In short, the policy makers did not specify where the end products of treated pig farm waste should be used in an economically viable way. In addition, the lakes which supply water in Korea are in an eutrophic state which is threatening the sustainability of pig farms. To ensure an environmentally sound and sustainable development of pig farming, a proper waste management programme must be implemented.

Further questions which need to be solved in the near future include:

- What would be the appropriate amount of nitrogen applicable to the agricultural area when the use of chemical fertilisers is taken into consideration?

- What would be the realistic effluent regulations for small farms operating with less than 715 animals? Are levels of 350 mg/l BOD and SS attainable? Why 715 head? Does the regulation consider the amount of water used? Water demand has been reduced.

- Would medium-sized farms with more than 715 head be able to achieve the effluent limit of 150 mg/l BOD and SS, 260 mg/l TN and 50 mg/L TP?

- Legislation for the community plants targets an effluent quality of 30 mg/l BOD and SS, 60 mg/l TN and 8 mg/l TP. Is this possible without dilution? What about the refractory COD remaining in the effluent? Is this achievable without dilution? The effluent limit is 40 mg/l COD_{Mn}, which is equivalent to about 100 mg/l COD from influent concentrations of between 12 and 140 g/l. The same effluent regulations apply to municipal night soil plants, but dilution (x 20) is permitted.

Because of the more stringent effluent limit imposed on larger farms, it is likely that the number of smaller farms is on the increase. It would therefore be more efficient if the regulation targeted the total amount of discharge rather than attempting to limit the concentrations. Furthermore, the easiest way to confirm whether the effluent meets the standard would be to check the process rather than measuring the effluent concentrations. For this, the regulatory agency needs to know in advance which processes are applicable. However, it appears that they were unable to describe the applicable processes and probably could not explain the reason why the current effluent limits had been set at those specific levels of concentration. If the effluent limits are not economically attainable, the pig farms will not be sustainable. If they are sustainable, our water resources will not be sustainable.

Each year, Korea imports some USD 20 billion to USD 30 billion of agricultural products for human and animal consumption. As pointed out above, the excess fertiliser has to be used somewhere. One possibility would be to export the fertiliser (or chemical fertilisers) to countries from which Korea purchases agricultural products. Korea has a great deal of experience in handling waste such as human excreta (night soil), including pig waste. The stringent regulatory effluent limit has stimulated technical progress in this area. The Korean people appear to be ready to share their technologies with others where required.

Summary and conclusion

Korea ranks in fourth place among the OECD countries in terms of livestock densities. Pig production generates roughly the same amount of pollution as 50 million people. This means that the equivalent of 100 million people discharge pollutants into the countryside. In the absence of a proper policy on treatment of this waste, the national goal of a clean water supply will not be achieved. Land application has been used as the major reuse technology, based on conversion to compost and liquid fertiliser. However, using nitrogen load to agricultural area as an environmental indicator, production already seems to have exceeded demand. The current load, including chemical fertilisers, is 271.2 kg/ha/year, compared with an optimum load of 109 kg/ha/year computed, or 152 kg/ha/year as recommended by the Ministry of Agriculture. The nitrogen concentration in the country's water resources has deteriorated the quality of our drinking water. Appropriate nitrogen loads with chemical fertilisers must be established prior to continuing the reuse practice. If the nitrogen load to agricultural land is too high, nitrogen removal technologies must be applied. Cost analysis indicates that composting is then no longer an economically viable option.

If nitrogen has to be removed, the treatment cost based on the current regulatory effluent limit has to be increased to KRW 479-1 075/kg FLW depending on how the solid (faeces) is handled. The faeces improve the TCOD:TKN ratios of the pig waste and reduce the cost of nitrogen removal, but too much faecal matter increases the cost of carbon removal. The current cost of finished pig production is about KRW 1 200/kg FLW, excluding labour and other costs. The treatment cost exceeds the expected benefit to be obtained from rearing the pigs. The current regulation does not appear to be realistic: limiting the effluent COD concentration will further increase the cost of treatment for an unknown environmental benefit. The legislation does not even take into account the fact that water consumption has been reduced and the allowable effluent concentrations should therefore be increased. The Korean Ministry of Agriculture and Environment must provide a solution to this problem in order to ensure the sustainable growth of the pig farms and the sustainability of our water resources.

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PART IX

PARALLEL SESSION 4

CLEANER TECHNOLOGY AND INDUSTRIAL SUSTAINABILITY

Chaired by Daniel Malkin
Science and Technology Policy Division, Directorate for Science, Technology and Industry, OECD

Chapter 31

OBSTACLES TO THE TRANSFER OF CLEANER PRODUCTION TECHNOLOGY

by

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Introduction

Environmental development in transition countries: the case of Hungary

In view of Hungary's accession to the European Union, the country is expected to carry out a number of expensive environmental projects in spite of the fact that, in many respects, its environment could be in a better state than that of many Western countries (the EU often sets targets without taking into consideration the state of the environment in the country concerned). Over the next few years, Hungary will have to invest some USD 3-4 billion in waste water management in order to fulfil EU requirements, although the soil and the ground water bed is in fairly good condition. A differentiated approach is needed which would allow the same environmental safety levels to be attained, but at lower cost.

It is clear that these practices are often motivated by economic reasons: waste water treatment equipment and waste incinerator manufacturers, as well as others in the environmental industry, have a vested interest in capturing a share of the market in the West so they move to the East to access new markets.

The development of environmental infrastructure is an expensive proposition, placing enormous pressures on the economy, while offering mainly deferred and indirect benefits: healthier natural surroundings leading to a general improvement in the health of the population. In comparison, firm-level environmental protection in developed Western countries, while placing some burden on the firm through the introduction of eco-taxes and other elements of environmental policy, actually increases the competitive advantage of companies since better resource management and the development of environmentally friendly products bring conventional economic advantages.

In terms of the development and implementation of environmental policies, diverse geographic, social and economic conditions render indispensable the consistent application of the principles of *regionalism.* Regional inequality in environmental quality is closely linked to other socio-economic differences, suggesting that a well-conceived *regional and municipal development strategy* can play a crucial role in preventing the degradation of the environment. Some existing environmental problems can be explained by the undeveloped infrastructure in certain countries while, at the same time, the

potential negative environmental effects of economic growth can be offset by integrating environmental concerns into regional development plans and projects.

Environmental protection and *nature conservation* are interdependent and complementary areas where there is an urgent need for harmonisation of responsibilities. The sustainable utilisation of resources and the preservation of our natural heritage are not only a moral obligation, they are in the best interest of the country's long-term economic and social interest as well.

Environmental investments related to EU membership and paid primarily by central government, will be spent on air quality and pollution control, safe waste disposal, waste water treatment and the overall improvement of monitoring infrastructure.

To my knowledge, research in environmental and other fields has so far ignored the potential effects of outlays for environmental investment projects on income redistribution.

The issue of income distribution can be analysed at several levels. This chapter presents a brief overview of two aspects. The first involves the consequences of redistribution across the different sectors of the economy. While certain sectors carry the direct financial burden of achieving more efficient environmental performance, others clearly benefit from the meeting of environmental requirements (Kerekes and Kiss, 2000).

Sectors carrying the burden of ever-increasing requirements	Sectors enjoying the benefits of higher requirements and improved environment
Energy industry	Tourism
Chemical industry	Sectors of the environmental and construction industry
Metallurgy	Bank and insurance services
Transportation	Health insurance
Light industry (textiles, leather, paper, etc.)	Education
Mining	Local governments
	Public administration

Environmental policy tied to the EU accession places obvious demands on the players at one end of the economic playing field while creating new business opportunities for the others (*e.g.* growing markets for the construction and environmental industries; increased demand in days spent in Hungary for tourism; improvements in the health of the population, thus favouring the health insurance industry – even if in the latter two cases the benefits only become evident over the long run). These factors must be taken into account when financing environmental projects. In other words, the cost of environmental development cannot be shouldered by the polluting industries alone.

Obstacles to West-East environmental technology transfers

Cleaner production is, by definition, more efficient than end-of-pipe technologies in terms of both environmental and economic efficiency. It is therefore difficult to understand why the dissemination of these preventive technologies is so slow. This chapter will focus on obstacles drawn from market analysis and, to a limited extent, on aspects of environmental policy. Three types of problems can be highlighted:

- Shortage of funds available to SMEs.

- Lack of public and regulatory pressure.

- Contradictions in the demand for and supply of environmental technologies.

Obstacles to investments in cleaner production by SMEs

The large majority of small and medium-sized enterprise (SME) owners in the transition countries became entrepreneurs out of necessity. Having lost their jobs during the recession which accompanied the transition process, many people were obliged to try their fortune as entrepreneurs. This explains why the majority of SMEs are characterised by:

- Lack of financial capital for green-field investment.

- Low profitability of current inefficient technologies, often characterised by internal bottlenecks and over-capacity.

- A high discount rate, reflecting the perceived riskiness of small businesses.

The majority of SMEs in the developing countries are short of capital. With the exception of the hotel industry, new entrepreneurs tend to start up their activities with "second-hand" equipment, even in the case of green-field investments. These older but "cheaper" technologies and equipment are inefficient both economically and ecologically and, as a consequence, the profitability of these industries is very low. Obsolete technologies with high maintenance costs are also inappropriate in terms of energy efficiency and emissions. Due to their low profitability, SMEs are very often forced into liquidation. Banks ask high interest rates or are unwilling to grant loans. SMEs very often improve their production lines step by step, financing the improvements from their own savings. This step-by-step investment creates three types of problems:

- The production line consists of different units according to the age of the equipment. Some elements are obsolete, others less so, but they are never at the same development level.

- Merging the different units into a single production line is extremely difficult as they vary not only in terms of age but in production capacity as well.

- Economies of scale are unlikely to benefit SMEs in environmental terms. For some technologies (such as painting), the cleaner, more efficient and more quality-oriented solutions become economically viable only once a certain capacity level has been reached. (In some instances, it was suggested that the entrepreneur would do better to outsource this type of activity, but they usually insisted on developing their own capacity.)

This "step-by-step" development increases production costs and decreases material and energy efficiency – and creates additional pollution, as well. Some elements of the production line might be state of the art, but even those elements are often combined with inappropriate fittings, etc., which spoils the overall environmental performance.

Cleaner production solutions reduce unit costs, but tend to require higher investments which are not affordable for SMEs because of the conflict between their short-run and long-run interests.

Lack of public and regulatory pressure

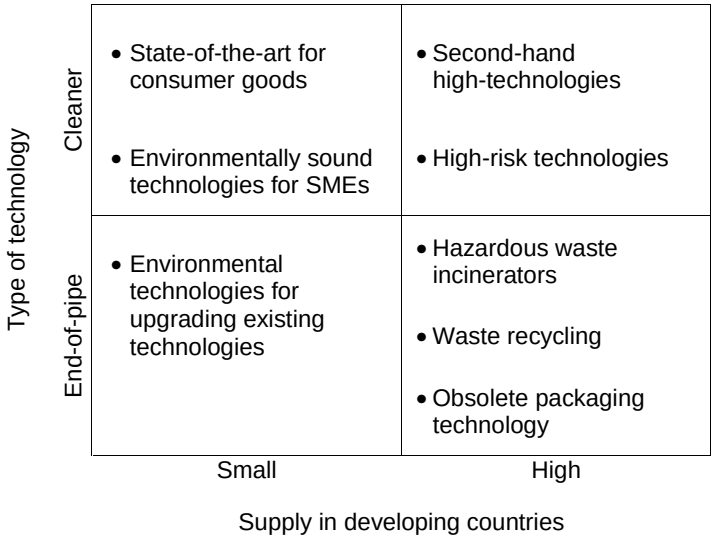
SMEs are mainly diffuse polluters, which explains why there is no regulatory or public pressure forcing them to implement environmental measures other than economic rationality in the form of cost reduction.

No data are available to show the contribution of SMEs to total pollution in Hungary. Even in the OECD countries, these data are hard to come by. Existing monitoring systems cannot handle this problem. The contribution of SMEs to environmental pollution is much higher than their contribution to GDP, although their pollution damage escapes control. Policy makers do not pay attention to this sector as it represents a very difficult task: transaction costs are very high and public support is low because of the large numbers of people who stand to be adversely affected by tax or cost increases.

Unmatched demand and supply for environmental technologies

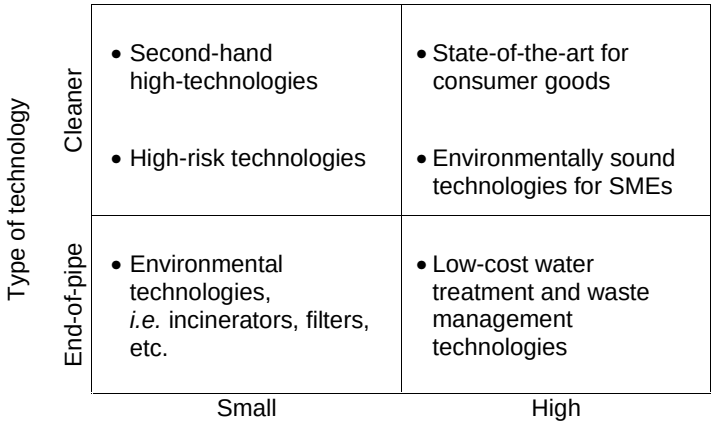
In recent years, the Hungarian Cleaner Production Centre has organised several conferences and workshops with the aim of bringing together Hungarian and foreign entrepreneurs. While these events were quite successful, the expected results very often flow away. One of the main obstacles is that supply from the West does not meet internal demand. Michael Porter's famous strategic grids are used below to demonstrate this discrepancy. Figure 1 illustrates the technologies offered by US or Western Europe on the Hungarian market. Typical technologies available in the market tend to be end of pipe technologies. The most prevalent are waste incinerators, sewage treatment facilities, soil clean-up technologies and waste management technologies. These are the "industries" in which new entrepreneurs are sought out by foreign investors or where technology and equipment can be purchased at favourable financial terms. This market is totally supply-driven. Among the supporters of these investors, we find multinational consultancy companies and the producers of these technologies who seek to attract or establish SMEs in this business. On the other hand, the contractors are typically local governments or the Ministry of Environment with whom it is not easy to do business. Other types of technology frequently offered on the market include second-hand technologies or high-risk technologies.

Figure 1. **Supply of different kinds of technologies in the market**



Demand follows almost the opposite pattern as shown in Figure 2. SMEs represent a huge demand for small-scale technologies and for low-cost end-of-pipe technologies. In addition, there is strong and growing demand for state-of-the-art technologies for the production of consumer goods, *i.e.* food products.

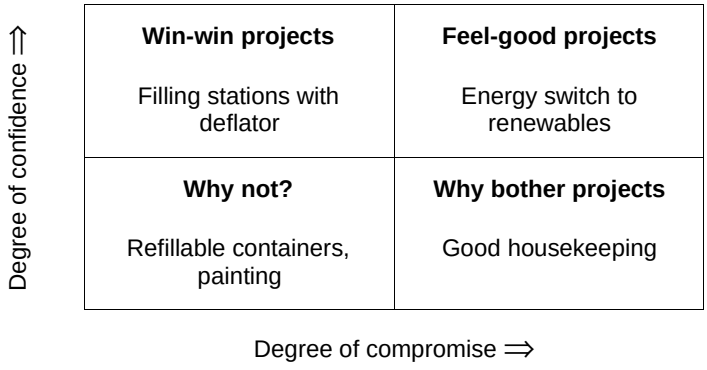
Figure 2. **Demand for different kinds of technologies in the market**



This discrepancy between supply and demand also exists in the consulting business. With the unique exception of energy, where some positive examples exist, experts from the United States and Western Europe are specialists in end-of-pipe rather than cleaner production technologies.

In our experience, typical approaches to cleaner production such as the Graz Ökoprofit model which start with so-called "good housekeeping", are often not completely successful because they require too great an effort from the organisation in terms of changing human behaviour. In Figure 3, we use the same grids to cluster different types of CP technologies. The diagram shows that for a CP project to be successful, not only is it important to undertake awareness raising activities, the consultant must also tackle the problem of organisational change. In the case of good housekeeping, for example, the consultant has to understand that it calls for "sacrifices" by employees (as they have to change their everyday behaviour), and instead of telling them that such solutions are easy and cheap, it is better to explain that it is more difficult to switch off the light when not in use than to pay the costs of a sensor.

Figure 3. **The cleaner production perception matrix**



It is true that the "low-hanging fruits" provide the cheapest and most cost-efficient environmental *protection* solutions – but they do not necessarily act as stepping-stones towards pollution *prevention*.

While environmental protection solutions imply the adoption of energy- and material-saving measures, and thus lead to reductions in pollution and costs, their use tends to highlight management deficiencies at the company level, often stirring up opposition from the technocrats who are unwilling to accept any form of "criticism".

Our analysis shows that it is easier to implement cleaner production when a polluting technology is replaced by a cleaner one. Examples include using sensors to turn out lights, replacing the rotating grids in incinerators by a fluid bed, or replacing the mercury cathode alkali chlorine electrolysis process by ion exchange membrane methods.

While firms tend to be reluctant to adopt organisational changes, they are generally more open to technological innovation – the good consultant should start with the latter, even if it is more expensive.

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Chapter 32

KOREA'S EFFORTS TOWARDS CLEANER PRODUCTION

by

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Introduction

Environmental policy in Korea has been shifting from a focus on "end-of-pipe" treatment to cleaner production technology. Because of high energy consumption and a weak environmental infrastructure, more sustainable business practices, including cleaner production, have become necessary. In Korea, to implement the International Declaration on Cleaner Production, a series of efforts have been made such as strengthening of environmental standards, reinforcement of the Preliminary Discussion System, substitution of the Extended Producer Responsibility for the Deposit-refund System, and effective implementation of the Environment Home Doctors System, the Green Building Certification System, and the Environmentally Friendly Enterprise Certification System, and the Environmental Labelling System.

Korea has also been strengthening its efforts to contribute to cleaner production through bilateral co-operation, regional co-operation, and co-operation with international organisations and participation in international meetings with a particular emphasis on technology transfer. Bilateral and regional co-operation has been pursued with Asian countries such as China, Vietnam, and Malaysia. Korea's efforts to deepen its co-operation with international organisations include, *inter alia*, organising international meetings such as the UNEP Cleaner Production V Conference and the 6th AEETC PPGG Meeting, dispatching of environmental experts to international organisations such as AEETC, as well as financial and personnel contributions to international joint research projects.

Implementation of new systems for cleaner production

Revision of the Environmental Policy Act

According to the revision and proclamation of this Act in December 1999, the Preliminary Discussion System (PDS) was reinforced. The Preliminary Discussion System had previously been regulated by individual acts and by the Prime Minister's Decree, but has now been incorporated into the Environmental Policy Act. Private development projects and administrative plans that had not been subject to preliminary discussion are now included. Also, documents, procedures and methods that had not been specified in the individual acts are now specified. In the revised Environmental Policy Act, environmental standards for SO2, PM10 and Pb were strengthened as well.

Environment Home Doctor System

The Environment Home Doctor System is similar to the P2 Program in the United States. The Ministry of Environment (MOE) designates environmental specialists or environmental consulting companies as Environment Home Doctors to advise specific businesses that are concerned with pollution generation.

The MOE: *i)* inspects businesses; *ii)* identifies those companies which need improvement; *iii)* designates a home doctor which then inspects the business's practices and technologies; *iv)* establishes improvement plans and consults with the selected businesses on improvements including financing, etc.; and *v)* lastly, the business implements the agreed-upon improvement plans.

The MOE links and co-ordinates guidance and control, technology assessment and development, and monitors the effectiveness of improvement work. Under guidance from the MOE, regional environmental offices, cities, provinces, and regional environmental technology development centres, the Environmental Management Corporation, the Environmental Technology Centre, and the Energy Management Corporation are participating in the Home Doctor System.

To encourage positive co-operation from businesses, various incentives and public campaigns have been promoted. The message given to companies is that process improvements require considerable initial expenses, but in the mid and long-terms, productivity will be increased through the process improvements. The MOE also offer incentives such as exemptions of guidance and inspection. Pilot research projects are on-going at a regional environmental technology centre in Yeosoo. By implementing the step-by-step approach and the interim review, 1 000 businesses out of the 73 000 businesses that discharge pollutants will be subject to the Home Doctor System.

Green Building Certification System

In Korea, due to the rapid development of new cities, new construction and reconstruction of existing buildings is very active and thus environmentally-friendly preliminary considerations have become quite necessary. This system certifies the environmental performance of buildings through review of the factors that affect the environment, including energy efficiency and resources conservation, reduction of pollutants, ambient environment and comfort, harmonisation with the surrounding area, etc. This system targets the entire life cycle of buildings, including production of construction materials, design, construction, maintenance, demolition, etc. Evaluation items for Green Building Certification are shown in Table 1.

Green buildings are evaluated on a scale from 0 to 5. Buildings that comply with the minimum legal standards for the items mentioned above are given no points; those buildings that comply to the maximum extent possible are considered "ideally environmentally friendly buildings" and are given five points. In particular, if a building receives three points or more (or at least which is 60% of the level of an ideally environmentally friendly apartment) on its evaluation, it is certified as a green building.

Table 1. **Evaluation items for Green Building Certification**

Sectors	Items
Consumption of resources (20%)	Energy use for operation, maximum demand for electricity, maximum demand for heat, building site ecosystems, water conservation plans, plans to minimise scrapped materials, use of environmentally friendly products, etc.
Environmental load (20%)	Air pollutants (CO_2, SO_2, NO_x, particulates), solid waste, sewage, other loads.
Indoor environment (20%)	Ambient air quality, temperature, visibility, noise control, etc.
Durability (5%)	Adaptability for alteration, etc.
Process management (15%)	Waste treatment during construction, reduction of particulates, reduction of noise and vibration, supply of documents for operation and guidance, etc.
Surroundings (20%)	Proximity to public transportation and service facilities, distance from facilities which could be harmful to juveniles, conservation plans, etc.

Extended Producer Responsibility (EPR)

While consumer and local governments greatly contribute to separated collection and assortment of waste, producers do not play an important role (except to partially cover charges like deposits). The EPR system places responsibility for waste recycling on producers and allows them to create organisations to manage the collection and recycling of waste.

To create favourable conditions for recycling, the government has determined the level of recycling that producers must meet, supervises compliance and levies recycling charges on producers who do not comply.

The existing Deposit-refund System is being replaced by EPR. Target items are those subject to the existing Deposit-refund System (TVs, refrigerators, washing machines, air conditioners, computers, audio equipment, tires, waste oil, batteries and fluorescent lamps), as well as wrapping materials. In the case of wrapping materials, EPR will be implemented incrementally across businesses above a certain scale.

Producers can either become a member of the Recycling Business Mutual Aid Union and pay a share of expenses or submit independent recycling plans and recycle waste individually. If neither option is chosen, a recycling charge is levied.

If a business voluntarily makes a contract with government and establishes a waste collection recycling system, the deposit will be exempted. For home appliances, EPR will applied to refrigerators, washing machines, TVs and air conditioners in 2001, and to personal computers and other large electric appliances in 2002. For fluorescent lamps, EPR will be applied in central Seoul in 2001, in the Seoul Metropolitan Area in 2002, and nation-wide in 2003.

Environmentally Friendly Enterprise Certification System

The Environmentally Friendly Enterprise Certification System (EFECS) is a voluntary approach which sets environmental quality targets through contractual agreements between enterprises and the government, and encourages enterprises to implement their own environmental improvement plans. The system requires that participating enterprises conduct environmental impact assessments (EIA) for

their entire production process and set their own environmental quality targets. The MOE certifies an enterprise as environmentally friendly if it contributes to environmental improvement through significant reductions in pollution, reductions in resource and energy use, improvements in the environmental performance of products, and other environmental protection activities.

EFFCS has been operational since July 1996 and is used as the basis for establishing a systematic environmental management system. As of June 1999, a total of 110 enterprises had been certified as environmentally friendly.

To achieve environmentally friendly certification, an enterprise first submits an application. A Screening Committee conducts an examination of the enterprise's performance and improvement plans, and a final decision on certification is made.

Once certification has been obtained, the MOE annually conducts a performance review of the firm's environmental improvements and collects and inspects the pollution generated. The MOE then decides whether the firm can continue to benefit from the environmentally friendly enterprise certification.

Benefits provided to certified enterprises include exemption from regular monitoring and inspection, replacement of permits for emission and effluent treatment facilities with a simple reporting system, and financial grants for small and medium-sized enterprises.

Environmental Labelling System

Before 1990, the regulation of pollutants discharged from working areas was the major environmental policy tool. With the emergence of stronger global environmental preservation efforts, environmentally friendly consumption is now recognised as a key component of environmental protection.

The Environmental Labelling System provides information to consumers on environmentally friendly products. It is essentially a preliminary prevention system, abating pollution by inducing consumers to choose environmentally friendly products over competing products that are considered more damaging.

The International Organization for Standardization (ISO) classifies the Environmental Labelling System into three types: Type I is known as the Eco-mark Programme; Type II is based on corporate self-reporting on environmental performance; and Type III is an environmental performance marking programme.

In Korea, Types I and III are carried out by the MOE, while Type II programmes are carried out by the Fair Trade Commission.

Type I: The Eco-mark Programme

With the introduction of the Eco-mark Programme in 1992, Korea joined over 30 programme participants, including Germany, Canada, the United States, Chinese Taipei, Japan, New Zealand and Singapore. The Eco-mark is placed on products which meet the programme standards, offering consumers greater choice by considering environmental friendliness as part of the purchasing decision. The Korea Environmental Labelling Association sets the standards and grants the Eco-mark for

environmentally friendly products that generate less pollution in their production, consumption and when discarded, tend to require fewer resources and lower amounts of energy compared to competing products. As of June 2000, 147 products in 49 categories have been granted the Eco-mark.

Type II: Self-reporting Programme

Enterprises participating in this programme supply with their products a brief report on the environmental impacts. Certification by a third party is not required. Type II aims to encourage demand for and consumption of services and products that have a lesser environmental impact by improving the available information on such services and products. The objective is to stimulate market-led environmental improvements.

The main advantage of this programme is that it offers greater variety of information compared to Types I and III. However, since the information comes from the enterprise itself and is not certified by a third party, it can be deceptive. Therefore, many countries have enacted legislation which makes companies accountable for the dissemination of false or misleading information.

Type III: Environmental Performance Mark Programme

Type III encourages producers to provide transparent environmental information on their products. Standardisation for an environmental performance marking programme is currently being discussed by ISO. ISO decided to establish international standards for the Environmental Performance Mark Programme in Kyoto, 1997, and at the Stockholm Conference in 2000, case studies from various countries were presented. Using the Life Cycle Assessment method, the total amounts of natural resources used across all product stages, the total amounts of pollutants generated, and their impacts on the global environment are to be declared by means of numbers and graphics.

In Korea, a research project was performed to develop operational methods and procedures. As the basis for the programme's implementation and operation, Korea revised the Act on Environmental Technology Assistance in February 2000. Detailed enforcement regulations are currently being revised and will come into effect after February 2001.

Voluntary Agreements and Design for Environment

The Voluntary Agreements (VAs) programme is a system which aims to manage pollution at minimum expense, utilising self-regulation, originality and diversity of businesses, based on a formal partnerships between an enterprise and government. Initially, VAs will be introduced in weak areas such as those with a concentration of pollution sources, heavily polluted areas, areas prone to environmental accidents, and areas that frequently do not meet environmental standards. The basic plan for VAs is currently being prepared in Korea through close collaboration between enterprises and government.

To encourage the effective use of resources and reductions in pollution, environmental quality should be considered at the initial stages of product design, referred to as DfE (Design for Environment). In developed countries such as Germany, the United States, Denmark and the Netherlands, DfE is established at the national level and contributes significantly to the international competitiveness of products. In Korea, however, a theoretical basis and systematic methods for DfE have not been prepared and product designers are not educated to meet this emerging situation.

Therefore, measures to encourage DfE are called for. Assistance for DfE is currently being prepared, and practical guidelines will be developed in 2001.

International co-operation and strategy

Bilateral co-operation

Korea has co-operated with China, Vietnam and Malaysia on the exchange of environmental technology. To promote environmental research, and the exchange of environmental technology and information, the Korea-China Environmental Technology Exchange Centre was established in 1999 at national institutes of environmental research in the two countries. These centres will hold periodic academic events, conduct joint research and facilitate information exchanges between universities, enterprises and local governments.

In August 2000, the first Korea-Vietnam Environmental Ministerial Meeting was held to discuss co-operation between the two countries. The two ministers agreed to designate organisations that would be responsible for co-operation on environmental technology and industry, assistance for technology study tours and exchange of information necessary for the development of related businesses. In addition, co-operation plans for an Eco-city construction project in Haiphong were discussed. Significantly, an MOU on environmental co-operation was signed. The two ministers also discussed plans for a meeting on Korea-Vietnam Environmental Industry and Technology. Korea is currently applying efforts to establish similar co-operative projects with Malaysia, and will continue its efforts to pursue co-operation on environmental technology with South-East Asian countries.

Korea signed an MOU for environmental co-operation with Canada in September 1995, which was extended in May 2000. According to the MOU, the two countries co-operate on environmental technology and industry, one example of which is the ETV (Environmental Technology Verification) programme. In 1997, Korea implemented ETV, using the Canadian ETV as a model.

Multilateral co-operation

Korea has been actively participating in and contributing to regional environmental meetings such as NEAC (North-East Asian Conference) and NEASPEC (North-East Asian Programme on Environmental Co-operation), which serve as venues for discussing environmental issues in the North-East Asian region. In these meetings, major issues include co-operation plans for environmental technology transfer between developed and developing countries. A frequently discussed issue is the sharing of publicly owned technologies.

Notably, Korea, China and Japan hold an annual Tripartite Environmental Ministers Meeting (TEMM) to discuss co-operation at the government level. The first TEMM, which was held in Seoul, established co-operation on environmental technology and industry as a priority area. At the second TEMM held in Beijing, the ministers agreed to open a Roundtable for Environmental Industry, co-organised by the three countries. The first roundtable will be held in Seoul in June 2001 and will discuss co-operation between industries, institutions and governments in the three countries.

Co-operation with international organisations

Korea has organised a number international meetings for cleaner production, most notably the Cleaner Production V Conference, co-organised with UNEP. This conference, held in Pyonchang in December 1998, launched the International Declaration on Cleaner Production. In July 2000, Seoul hosted the 6th AEETC PPGG Meeting, co-organised with AEETC.

Korea actively participated in the establishment of AEETC, initiated by ASEM, to promote environmental technology exchange between Asia and Europe. In particular, Korea dispatched a high-level officer as Vice-Chairman in March 1999 (when AEETC was established) and provided funding for personnel expenses to assist environmental technology transfers and co-operation between Asia and Europe.

Korea has also initiated and is conducting international joint projects to promote environmental technology transfer between Asia and Europe. The following international joint projects are funded by Korea:

- Korea is preparing an MOU with AEETC for "Air Pollution in Mega-cities in Asia" with the aim of identifying effective air pollution management methods for Asia.

- Korea and AEETC will sign an MOU for "Survey and Research on Environmental Technology and Markets in Asia" that aims to specify areas in which mutual co-operation and technology transfers are possible. Korea will invest USD 50 000 in this project between December 2000 and November 2001.

- "The Green Tax Symposium", organised by the Korean Environment Institute and Japan's IGES with support from AEETC, will establish plans to implement a pollution prevention system.

Strategies for international co-operation on cleaner production

In terms of cleaner production and environmental technology levels, Korea is situated between the developed and the developing countries. Korea is focusing on introducing systems and technologies from developed countries and transferring the acquired knowledge to the domestic context. The country is also active in exporting domestic technologies to developing countries. To help facilitate these efforts, Korea has been preparing strategies for international co-operation in environmental technology, and developing mechanisms for joint research between advanced and developing nations.

For the effective transfer of environmental technology, the specific expertise and technologies possessed by each country need to be identified and prioritised. In Korea, there is no list of targeted environmental technologies; therefore specific technologies which need to be imported or exported are not referenced. A system in which such information can be organised and clearly presented would greatly assist transfers between Korea and the rest of the world.

To address this issue, the MOE established the Korea Environmental Technology Information Centre, which is managing the ongoing Yellow Page Project. This project collects and organises data on Korean environmental technologies and environmental industry. The centre plans to introduce Korean environmental industry and technology abroad and establish a basis for transferring

environmental technology by preparing a database in English with 60 000 items. Korea also has plans to designate the centre as a clearinghouse for clean technology.

As part of the mechanism for joint research between advanced and developing countries, a clean technology centre was established at the Korean Production and Technology Institute in the beginning of 2000. This centre has a KRW 30 billion budget for clean technology development and was designated as the National Cleaner Production Centre by UNEP.

The centre now plays the role of international clearinghouse for cleaner production. For example, in March 2000, the centre signed an MOU on environmental technology transfer with the US State of Rhode Island.

Conclusion and recommendations

Korea is introducing a variety of systems for cleaner production, including a number of systems from advanced countries. The systems are then adapted to meet domestic requirements. The most important factor in the implementation of new environmental technology policy is mutual understanding between government and the private sector. In implementing systems for cleaner production, Korea has been pursuing a win-win strategy. Private businesses generally assume that new systems for cleaner production will increase their load and bring about new environmental expenses. To counter these assumptions, the Korean Government highlights the fact that new systems will help reduce the overall environmental load and emphasises that the benefits accruing to firms will actually increase in the long term. The government also encourages enterprises to adopt new systems through various incentives including financial support.

In implementing new systems for cleaner production, Korea acts as an intermediary between the advanced and developing countries. If systems developed and operated in developed countries are modified in an intermediary country like Korea, the possible negative impacts arising from the implementation of new systems in developing countries could be avoided or reduced.

Korea has also introduced case studies on cleaner production systems through bilateral and multilateral co-operation channels and in international conferences.

Technology transfer from developed countries to developing countries is an essential factor in the wide dissemination of cleaner production methods,. Technology transfer is a win-win strategy in that developing countries can introduce technology from advanced countries while avoiding costly and inefficient trial and error, and advanced countries can take advantage of opportunities to enlarge their markets. In the case of publicly owned technologies which do not have intellectual property right implications, transfers should be pursued as quickly as possible.

Korea has been making efforts to absorb environmental technologies from advanced countries and export domestically developed technologies through bilateral and multilateral co-operation agreements. Korea is of the view that publicly owned environmental technology should be transferred rapidly and widely and has thus been preparing systems and organisations to facilitate this.

One of the major outcomes of the 2nd ASEM Meeting, held in Seoul in October 2000, was the agreement to establish an ASEM Environment Ministerial Meeting. This meeting should provide a formal channel for practical co-operation between Asia and Europe. Korea will work hard to achieve this goal and the ASEM Environment Ministerial Meeting is expected to generate significant

momentum and assistance for environmental co-operation between advanced countries and developing countries.

There are a number of recommendations that could help achieve the goals and concerns outlined in this report:

Promoting the development of clean technology

- Prepare and distribute a comprehensive list of the technologies available in each country. This will help prevent duplication in technology development and dissemination efforts.
- Encourage the OECD to prepare R&D guidelines. This would aid in co-ordinating R&D efforts across countries and organisations, and help to create a common set of standards that would facilitate the dissemination of cleaner technologies.
- Establish a centre for the international exchange of technology. The centre would serve to focus and prioritise efforts, and accelerate the sharing of new approaches, ideas and techniques.

Securing financial assistance

- Establish a clearinghouse for financial information. By channelling those seeking or providing funds to a "one-stop shop", efficiencies will be realised.
- Conduct research on evaluation and classification of existing technologies.
- Encourage the OECD to play a key role in establishing a new technology fund offering low-interest loans to developing nations. Such a fund would accelerate the adoption of new technologies in developing countries and enable them to leapfrog environmentally costly technologies.

Target transfers of publicly owned technology

- Publicly owned technologies that have demonstrated a clear contribution to environmental performance should be shared without hesitation. Institutional barriers to the adoption of these technologies should be dismantled.
- Governments should have primary responsibility for overseeing such transfers.

Clearly defining the role of the OECD role in cleaner production efforts

- Expand understanding of cleaner production and related issues through various discussion channels including international forums.
- Form partnerships and enlarge co-operative programmes with non-member countries. By increasing the number of participants in cleaner production efforts, the potential market for new technologies can be expanded, thereby introducing greater economies of scale for bringing new technologies to market and helping to create momentum.

Chapter 33

CLEANER TECHNOLOGIES AND INDUSTRIAL SUSTAINABILITY

by

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Introduction

This chapter will focus on international co-operation to diffuse cleaner technology, mostly applied to mature industries. The term "cleaner production (CP)" is defined to include cleaner technology (hardware) and the management of the technology (software).

UNEP has defined cleaner production as "the continuous application of an integrated preventive environmental strategy applied to processes, products and services to increase eco-efficiency and reduce risks to humans and the environment".

The CP concept is inherently a preventive strategy, as opposed to pollution control (end-of-pipe) strategies which accept waste, emissions and effluents as "given" and attempt to find ways to handle them or minimise their effects. There are three main reasons why end-of-pipe solutions should be avoided: *i)* end-of-pipe solutions are normally considered to represent a cost to companies; *ii)* end-of-pipe solutions generally reduce pollution in one media by displacing the problems to another media (from air pollution to water pollution; from water pollution to waste pollution, etc.); and *iii)* end-of-pipe solutions require maintenance, which has a tendency to become less effective after some years of operation, resulting in reduced efficiency and increased emissions.

CP is primarily characterised by the integration of environmental considerations in the process (technology) and the management: prevention is better than cure.

In the last ten years, various tools have been developed for implementing CP strategies at plant level; these include generic manuals as well as sector-specific manuals edited in several languages.

The World Cleaner Production Society (WCPS) is a Norway-based group of consultants working in a number of countries on CP programmes mainly funded by NORAD and the Norwegian Ministry of Foreign Affairs.

Our first CP programme was launched in Poland in 1990 and was later extended to other Central and Eastern European countries. Based on the experience gained in Poland and the Czech and Slovak

Republics, we were asked by the OECD to draft a report that was later published as *The Best Practices Guide for Cleaner Production Programmes in Central and Eastern Europe*.

In line with to the "Best Practices Guide", CP programmes have since been implemented in north-west Russia, Lithuania, Tunisia, Zambia, Indonesia and China (Beijing and Hunan). Programmes are currently running in Russia, Tanzania and Pakistan. Some experiences and results from the projects in Tanzania and Pakistan will be presented below.

Training by doing – the Norwegian approach

The first CP training programme outside Norway was initiated and implemented on a trial basis in Poland. At the same time, a campaign for CP assessments was organised in Norway. In the period 1991-95, 300 CP assessments were carried out in Norwegian companies. In addition to the environmental and economic benefits for the companies, expertise was gained in implementing CP at company level. This expertise has been utilised in Poland and other countries. The approach is very practical and applies the following principles:

- In-plant training.
- Training by doing.
- Training the trainers.

An important objective is capacity building in the recipient country. Once the assistance programme has finished, trained local experts should be able to carry on the training process.

The training is organised as a combination of classroom training (lecturers and group work) where the participants are trained in how to implement the CP strategy at their plant, and project work at the plant at which the participants are employed. The course consists of four plenary classroom sessions and three intermediary sessions with project work. The trainers (advisors) visit the plants twice between the plenary sessions. The contents of the plenary sessions include:

Plenary session 1

Objective: Familiarisation with CP as a method for increasing the profitability of waste and energy reduction at source. Preparations for company work for the first intermediary session.

- *Day 1:* Introduction to the CP method, familiarisation with the results achieved in other CP projects, introduction to flow-charts and mass- and energy-balance as a tool for CP.
- *Day 2:* Training in data capture and evaluation, introduction and training in preliminary cost assessments, familiarisation with success criteria and barriers/obstacles to CP, training in presentation techniques.
- *Day 3:* Training in problem-solving methods, generation of options (ideas), introduction to environmental management systems (EMS) as a useful steering system for the company, familiarisation with the elements in project presentation, training in presentation techniques, understanding of the basic principles of CP organisation, policy formulation, goal and objective setting.

- *Day 4:* Organisation of a CP project, construction of a preliminary plan for organising the CP project in the participant's own company, elaboration of a work plan for the first intermediary session in participant's own company, elaboration of work methods for the first intermediary session.

Plenary session 2

Objective: Report results from first intermediary session. Prepare for second intermediary session. Introduction to the principles for strategic planning and business analysis.

- *Day 1:* Report results from intermediary session 1, introduction to environmental policy, project objectives and organisation, mass and energy balances, discussion of success criteria and obstacles and barriers in start-up phase, and mass and energy balances.

- *Day 2:* Identification of options from assessment phase, training in feasibility studies (economic, technical, environmental).

- *Day 3:* Training in different methods of project evaluation, introduction to the principles for strategic planning and business analysis.

- *Day 4:* Clarification of work plan for intermediary session 2 with report format.

Plenary session 3

Objective: Report results from the second intermediary session. Preparations for third intermediary session. Preparations for follow-up plan two years ahead.

Plenary session 4

Objective: Assessment of candidates for the CP Assessment Certificate.

Day 1-2: The candidates for the course certificate present a company report focusing on:

- Process and main waste streams.
- Material or energy balances for the most important unit.
- The housekeeping options implemented.
- Immediate (short-term) and long-term implementation options.
- Implementation transferred to waiting box (major investments)

Candidates are expected to identify major events, and describe the barriers encountered in carrying out the project and how these were overcome. They present a strategic follow-up project plan. Award of diplomas.

In general, engineers from 10-20 different firms participate in the programmes. In addition, participants include representatives from local governmental agencies, business associations and local consultancy companies. Through the practical project work, participants from the participating organisations play a key role in achieving commitment from key stakeholders to the CP strategy. This commitment is crucial for the transformation from supply- to demand-driven activities.

Often, awareness-raising seminars are organised as a way of recruiting companies for a CP programme. Local institutions – CP centres – are responsible for setting up these seminars. Cleaner production assessments help to identify three main types of action:

A. Housekeeping actions, including minor investments with a few months payback on investments.

B. Short-term (< one year) investments to be financed from operating budget or by small loans.

C. Long-term (>one year) investments, requiring external loans.

Actions of type A and, partly, B can normally be financed out of the enterprise's operating budget. Financing for actions of type C and, partly, type B has to be obtained from external sources, either as a commercial loan or through soft loans.

Examples from Tanzania

Table 1 summarises the results of the latest programme in Tanzania, in which eight companies took part. Most of the measures are of type A, with a few type B actions. All the measures listed have been implemented. This programme is organised by the Cleaner Production Centre of Tanzania (CPCT) in close co-operation with the Norwegian National Institute of Technology, and is the first of a series of programmes which will be undertaken over the next five years.

The results are quite typical of what can be achieved by implementing the approach described above. Several hundred similar case studies are documented by UNEP, Division of Technology, Industry and Economics (UNEP TIE) – International Cleaner Production Clearinghouse.

The challenge is to go beyond "picking the low-hanging fruits" and to organise continuous improvement processes. One option is to link the experiences gained from CP assessments with the introduction of environmental management systems (EMS) – in particular, ISO 14001.

CP assessments are an excellent platform for introducing and strengthening EMS. Housekeeping measures do nothing more than help firms to strengthen existing management routines and/or develop new routines and are elements of EMS, CP assessments with material balances as a platform for developing a company environmental policy.

Access to loans

The UNEP TIE project "Strategies and Mechanisms for Promoting Cleaner Production Investments in Developing Countries" is closely linked with a DANIDA supported CP Programme in Zimbabwe and the CPCT organised CP programme in Tanzania supported by NORAD.

A list of potential investment projects resulting from CP assessments shows that most of them are type B and some are type C.

Table 1. **Summary of results from a CP programme in Tanzania, April 2000**

Firm	Measures implemented	Investment (USD thousand)	Savings (USD thousand)	Environmental impact
Pharmaceuticals	Increased boiler efficiency	0	4.7	7 000 l reduced oil consumption
	New equipment for waste reduction	13	6.3	95% waste reduction
	Reduced steam leakages	3.2	2.5	Reduction of oil consumption by 5 000 litres
	Product reformulation	0	1	Reduction of ethanol consumption by 1 000 litres
Soap production	A number of house keeping measures	2	33	50% waste reduction
	Process optimisation and improvement in recycling	72	58	70% reduction in effluents (BOD)
Edible oil	A number of housekeeping measures	17	35	Waste reduction (not quantified)
Textiles – A	Change of production	0	25	85% reduction in waste (yarn)
	Repair of water leaks	0.6	3.7	
	Process optimisation	0	95	66% reduction in fuel costs
	Reduced packaging	0	13	From five to two bales
	Redesign of trolleys	1.3	1.7	Waste reduction
Textiles – D	Repair of water pipes		98	97% reduction in water leaks
	Reduction of steam leaks		12	55% reduction
	Recycling of caustic soda		5	
	Proper waste separation and handling		160	8% waste reduction
	Summary investment	5		
Brewery	Rehabilitation of decanter	17.4	50	46% waste reduction; improvement in product quality
Tyre manufacture	Fixing water leaks	0	1.9	
	Repairing water systems + spares	0.9	7.8	15% reduction in water consumption
	Insulation steam pipes	2.5	10.8	1.7% reduction in oil consumption
Soap production	Repairs and sealing of leaking pipes, valves, etc.	Minimal	6	Not quantified

Table 2. **Distribution of recent investment proposals, Zimbabwe and Tanzania**

Thousand USD

Investment required	Number of proposals
5 - 50	7
50 - 100	2
100 - 200	3
200 - 300	3
> 300	1

Note: More than half of the investment options are under USD 100 000.

Loan applications for the investment options in Tanzania have been submitted to commercial banks. For various reasons, none have as yet been approved. The brewery investment is too small to attract interest from finance institutions; it may be implemented using the company's own funds. On the other hand, several commercial banks have shown interest in the edible oil investment proposal and the final decision will probably depend on the banks' confidence in the borrower.

The proposal for methylene chloride (an ozone-depleting substance) replacement has relatively low profitability, in addition to the fact that the firm's equity is rather small. In sum, it would appear difficult to obtain an ordinary bank loan, although it may be possible to attract interest through UNIDO and/or through Montreal Convention facilities.

The waste-recycling project is only marginally profitable, with the internal rate of return very close to the current interest rate charge on commercial loans in Tanzania. However, there are some possibilities for improving the project and discussions with a local bank which has an agreement and funds with the European Investment Bank have proved quite promising.

The glycerine-recycling plant will need to install equipment from an European machinery exporter who may be able to attract interest from national authorities for parallel financing. However, other options are being evaluated, based on funding from multilateral institutions. Finally, the last textile company is being considered for funding from a donor country.

These cases from Tanzania illustrate the difficulties in attracting loans from commercial banks for reasonably profitable investments.

UNEP TIE planned to present all the investment options at the UNEP Finance Initiatives Annual Roundtable Meeting in Frankfurt on 16-17 November 2000. At this meeting, representatives of some 200 banks and other financial institutions will be informed about the emerging demand for CP bankable investment proposals. Signatories of the UNEP Statement by Financial Institutions on the Environment and Sustainable Development will be invited to consider the proposals prepared by the UNEP teams in Zimbabwe and Tanzania and to review upcoming projects in these countries and in Guatemala, Nicaragua and Vietnam which are also participants in the UNEP project. In the case that no interest is shown, they will be invited to explain why the projects are not of interest to them.

The establishment of a soft loan facility (revolving fund) would make it easier and faster to attract interest in improvements to the environmental and at the same time serve to increase demand for CP investments. This could be one solution for building up demand for such types of investment.

Barriers to the introduction of cleaner production at plant level

At a recent plenary session, three groups (which comprised among them eleven Tanzanian firms) were asked to list the most severe barriers to the implementation of cleaner production improvements at their companies. The following results were collected:

Group 1

- Inappropriate decision-making process at plant level.
- Financial constraints.
- Management conservatism.
- Lack of transparency (insulation gap between management and junior staff).
- Communication barrier between top management and staff.
- Employment of unskilled labourers.
- Lack of space for installation of new recycling equipment.

Group 2

- Financial constraints.
- Lack of trained personnel.
- Lack of commitment from top management.
- Too heavy work load.
- Poor administration.
- Lack of commitment from workers.
- Lack of protective gear.
- Lack of motivation among workers.
- Requirement to stop production while new equipment is installed.

Group 3

- Fear of the investment cost of cleaner production improvements.
- Resistance to change (attitude).
- Lack of motivation of workers.
- Under-valuation of ideas from workers by top management.
- Lack of technical know-how.
- Lack of communication skills.

In my opinion, the most significant barriers can be summed up as:

- Poor management.
- Training – especially lack of skills among workers.
- Lack of financial resources.

Participants at a recent training session for tanneries in Pakistan were asked to list barriers to the introduction of cleaner production at plant level. Participants included representatives from 22 tanneries – owners as well as production managers – and representatives from local government and local experts; altogether, 32 persons attended.

A brain storming session was set up at which potential barriers were listed. The next step was to evaluate the barriers. Each person was asked to appoint five points to the most serious barrier, four to the next most important, three to the next, etc. The most important barriers are ranked in Table 3.

Table 3. **Barriers to the implementation of cleaner production**

Barriers	Points
Lack of management / commitment	90
Lack of education	86
Lack of technology for effluent disposal	50
No local technology information	40
Low awareness on safety equipment	34
Lack of skill of workers	31
No laboratory facility	31
No money for new machinery	30
No information on eco-friendly chemicals	27
Taboos / old ideas / conservatism / no R&D	18
Lack of time to access information	12
Duties on imports	7
No Internet access	5
Small building – no space	4
Lack of openness / exploited by the government	4
No skilled local consultancy companies	0

The mini-survey shows that the key barriers to the introduction of CP are: management, information and training. Access to technology and financial resources should not be underestimated, but appears to be less important than might be expected.

Conclusions

Cleaner production initiatives are typically supply-driven – government-supported programmes in OECD countries and donor-supported programmes in the Central and Eastern European countries, the New Independent States and developing countries have been instrumental for implementing CP activities. The introduction of EMS (ISO 14001 and EMAS), in combination with supply chain management strategies, has led to small changes, mainly due to pressure from the European Union. I believe that there are three major conditions for demand-driven CP activities in the CEE/NIS and developing countries:

- Regulatory and institutional infrastructure.
- Training – management and information.
- Financial resources.

Chapter 34

TECHNOLOGY INNOVATION AND CLEANER PRODUCTION

by

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Presented by John Arseneau

Introduction

Cleaner production (CP) is increasingly recognised as essential for reconciling environmental and economic goals at the global, national and even the local level. This is because international organisations such as UNEP, OECD and APEC, national governments and agencies, industry associations and environmental groups continue to build awareness of CP not only as an issue but also as a call to action. Information products such as the excellent International Cleaner Production Information Clearinghouse (ICPIC) (UNEP, 1999) now provide almost instant access to a wide range of information on CP networks, publications, conferences, case studies and technologies.

One key prerequisite for CP is the recognition by stakeholders that the status quo is not satisfactory, that change is necessary and that innovation rather than retrenchment is required. However, innovation should not be taken to mean only technological innovation.

For example, ICPIC provides a series of very useful case studies showing how companies and other organisations have developed and implemented cleaner production and what were the environmental and economic benefits. A few practical conclusions can be drawn from these and similar case studies:

- Simple, intelligent techniques, such as improved "housekeeping", can be very effective for achieving CP as well as significant cost savings; and these should be explored first: *technology is not always the answer*.

- Appropriate adaptations of existing technologies will often provide significant benefit in a short time at relatively low cost: *unnecessary technological sophistication or complexity (technology "overkill") can be counter productive and wasteful*.

- In many cases, available techniques and technologies are inadequate and solutions must be found through scientific research and experimental development. For effectiveness, this must be closely linked with technology assessment and appropriate feedback throughout the research/design/development process: *technology innovation supported by simultaneous assessment and effective policies can be a very powerful tool to achieve CP*.

This chapter aims at establishing the role which biotechnology and innovation can play in achieving CP and, beyond that, sustainable development, while nevertheless recognizing that technology innovation is only one of the driving forces for CP.

Understanding the driving forces for CP: technology is not sufficient

The OECD (1995; 1998) has identified three inter-related macroeconomic driving forces for cleaner products and processes:

- Market demand.
- Advances in science and technology.
- Government policy.

The analysis carried out by the OECD leads to the conclusion that these driving forces must work in concert to advance the adoption of CP by industry.

Market forces can provide very powerful incentives for achieving CP because they affect the profitability of companies and, therefore, strongly influence company behaviour. They allow for great flexibility in designing responses to publicly determined environmental objectives so that industry can meet the requirements by changing manufacturing processes or feedstocks, by modifying the product or by adopting/developing entirely new technology.

Advances in science and technology open up new opportunities and options for achieving CP. The private sector often has difficulty making the investments necessary for developing and incorporating CP technologies into existing systems unless the benefits to be obtained are proven. This is because it is usually easier to measure the costs of technology innovation than the benefits, which may be complex and long-term. Achieving greater penetration of CP into industrial production will require joint R&D and demonstration efforts by government and industry.

Government policies to enhance CP can be the single most decisive factor in the development and industrial use of cleaner technologies. Legislation, regulation, guidelines, standards, government procurement, government support for R&D and human resource education/retraining can encourage or discourage, accelerate or delay the use of CP by industry, depending on their orientation or manner of implementation. Obstacles can arise from the absence of policy or its enforcement, insufficient international harmonisation, policy uncertainties and contradictions as well as policies that ignore the particular conditions of individual sectors. Government policies should promote the best technologies and encourage their wide dissemination for industrial use.

While there is some understanding of macroeconomic drivers for CP, more study is needed at the microeconomic level to understand the motivation of companies that embark on CP initiatives. It is clear from CP case studies that a culture of innovation is a more important factor than in-house technological expertise in determining whether a firm undertakes to develop/implement CP and persists to achieve this goal (Wolf, 2000). At the level of the firm, the microeconomic driving forces for CP map approximately onto the macroeconomic driving forces; but, they are somewhat different and expressed as the need for:

- Improved/sustained profitability/competitiveness and consumer good will (market forces).

- Greater control of production and product quality (science and technology).

- Reduced environmental liability and risk management costs (government policy).

These three microeconomic driving forces must also work in concert to advance CP within the firm. Environmental benefits alone are generally not sufficient to motivate the selection of CP by a firm since their customers are usually reluctant to pay more for products manufactured using CP.

CP trends in selected sectors

Much has already been written on pollution reduction and CP in a number of sectors. The intent in this section is to provide some highlights and trends rather than a comprehensive review of the field. Also, where possible, mention is made of biological approaches to CP as biotechnology holds great promise for achieving sustainable industrial development.

Chemicals

The chemical industry is key to advancing CP because chemical products and processes are used as inputs in so many other sectors. It is estimated that the chemical industry has reduced the overall waste produced per ton of product approximately five-fold from 1975-95 (OECD, 1998, p. 32). However, this has been offset somewhat by the two- to three-fold increase in production and the increasing use of commercially produced chemicals in developing countries which occurred over the same period.

The reduction in waste per ton of product has been accomplished by approaches ranging from improved housekeeping to improved processes and process control, development of new less-polluting products as well as more efficient utilisation of by-products. Technology innovation has occurred in the areas of catalysts, sensors, reactor design as well as materials and separations technologies. Recently, the concept of "green chemistry" (Anastas and Warner, 1998) (or environmentally benign chemistry) has shifted the focus to reducing the hazard of chemical products and processes in addition to controlling emissions and exposure (see discussion below).

Biotechnology has begun to play an important role in the synthesis of fine chemicals to the extent that biocatalysis is becoming part of the general tool kit used by synthetic organic chemists. In 1996, the top 21 journals used by synthetic organic chemists and three more specialist journals contained over 1 400 articles in which biocatalysis was a major feature (Roberts, 1999). Many of these articles reported on environmental benefits. For example, BIOCHEMIE, a subsidiary of Novartis, has reported that for the production of one ton of cephalosporin the conventional chemical process resulted in 31 tons of wastes that require incineration while its new enzyme biocatalysis process resulted in only 0.3 tons of such wastes (OECD, forthcoming). On the horizon are bioprocesses to produce a number of bulk and commodity chemicals as well as plastics utilising biomass as a renewable feedstock (US Research Council, 1999).

Pulp and paper

The pulp and paper industry has made significant progress in decreasing its consumption of energy, chemicals and raw materials per ton of product. Waste biomass is often burned on site to produce steam and electricity and this has reduced the requirement for energy from fossil fuel or

hydroelectricity. In some cases, pulp mills are net producers of electricity and the excess is sold into the power grid. Improved treatment of process wastewater is reducing the amount of water and chemicals used in the pulping process per ton of product and a number of operations now use closed-loop systems where all the process water is recycled (El Haji *et al.*, 1998).

Traditionally, pulp bleaching has been carried out using chlorine and this has led to concerns over chlorinated organic chemicals which are persistent in the environment. Newer systems for bleaching pulp use enzymes such as xylanase and laccase to reduce the requirement for chlorine and, in other cases, technologies for producing ozone or hydroxyl radicals are used to eliminate the use of chlorine. Efforts have also focused on deriving value-added products from pulp and paper waste biomass. Chahal and Chahal (1998) provide an excellent review of this field.

Recycling of used paper products, especially newsprint, has been adopted in a number of countries because it helps reduce the volume of municipal solid waste. One of the main drivers for paper and cardboard recycling has been the setting of minimum recycled fibre content for certain types of paper, especially newsprint. This has stimulated development of ink-removal technologies, including the use of enzymes to reduce the requirement for strong chemical treatments which themselves cause environmental problems. The development of less toxic inks using soy oil base and organic pigments replacing those containing heavy metals such as cadmium has also been stimulated by the move towards recycling of paper.

Textiles

Some progress has been made to reduce or replace toxic chemicals used in the dyeing process. For example, dyes based on plant-derived chemicals are used in some cases to replace dyes based on coal-tar or heavy metal compounds. Bioprocessing, especially the use of enzymes, is also beginning to make a contribution to CP in the textile industry (OECD, 1998, pp. 40-44). For example, the enzyme catalase is used to remove residual peroxide from the pre-treatment process before dyeing. This saves a rinse step and reduces time and cost as well as the volume of wash water that is used and subsequently treated. In another process, the enzyme amylase is used to remove sizing from cloth.

The trend towards increased use of natural fibres has opened up additional opportunities to use enzymes to modify the look and feel of cloth made from cotton, hemp or wool. This can help to avoid the use of strong acid or alkali treatments while producing a control over the look or feel of the cloth that could not be achieved using conventional chemical treatments.

Food processing

The major challenge for CP in the food processing industry is that conventional processes often result in the production of large volumes of dilute organic by-products that cause major environmental problems if disposed on land or in water. For example, in starch extraction, 30-50 m^3 of wastewater is produced per ton of starch (Rakshit, 1998) and in cheese production, 9 kg of whey is produced per kg of cheese (Tyagi and Kluepfel, 1998). Process improvements can increase the efficiency of converting raw materials into final product and decrease the amount of waste produced (for examples, see case studies in OECD, 1998).

Food-processing by-products usually contain substances that could be used as food additives, feed or industrial chemicals and result in additional revenue streams. Therefore, much of the focus on CP in this sector has been on waste utilisation by separation and/or conversion by fermentation

(Kroyer, 1998) into food additives, animal feed or specialty chemicals and feedstocks for producing certain industrial chemicals.

Food-processing companies may need strategic alliances with chemical or biotechnology companies to develop the waste utilisation technologies and to market the resulting specialty chemicals.

Energy

The current predominant source of energy is from fossil carbon, specifically, oil, natural gas and coal. Examples of measures to achieve CP in oil refining range from improvements in housekeeping to development of new catalyst technologies (see case studies in OECD, 1998). The industry has invested for decades and continues to invest in technology to divert/convert more waste into product as well as to replace polluting chemicals and to develop new more environment-friendly products.[1]

Bioremediation and end-of-pipe technologies such as biofilters for contaminated air or water have been used extensively by the industry. However, with few exceptions, biotechnology has had little impact on CP in the energy industry:

- Biological removal of sulphur from oil and natural gas can save energy and cost compared to the conventional process which uses hydrogen at high temperature and pressure; however, this process is still in the developmental stages (OECD, 1998, p. 55).

- Production and use of biomass as a renewable energy feedstock (either by direct combustion, pyrolysis or bioconversion into fuels) is being explored and several pilot projects are under way; this is described in an excellent monograph by Klass (1998).

- Ethanol produced by fermentation from agricultural or forest biomass is used in a 10% ethanol/gasoline blend as an octane-enhancing additive; recently several car manufacturers have begun to produce vehicles which can run on an 85% ethanol/gasoline blend.

Fuel-cell technology is developing rapidly and promises to provide clean, highly efficient power units for both stationary and mobile applications, including replacement of the internal combustion engine. However, at present the fuels for fuel cells still come from fossil carbon sources. In future, ethanol or, in the longer term, hydrogen derived from biomass could provide a renewable energy source for fuel cells.

Technology and CP

Level 1 – reduce waste at source

- Good housekeeping.
- Process modification.
- Product modification.
- Change of materials.

Level 2 – recycling of waste

- Internal recycling.
- External recycling (among different organisations – industrial ecology).

Level 3 – use of renewable resources

- Biomass as a renewable feedstock for energy, fuels and chemicals.[2]
- Other sources of renewable energy: solar, wind, tidal, small-scale hydroelectric.

These approaches involve a combination of technology (processes and tools) and techniques (ways that technology is used). Technology and technique are mutually supporting in delivering CP as can be seen in case studies. Performance assessment is the guide to determining the optimum combination of the two.

Most, if not all, technologies can be relevant to CP. A treatise could be written on the application of each field of technology to CP. The following list provides a sampling of this wide scope:

- *Sensors:* A wide range of chemical, electrochemical and biosensors provide the means to measure the concentrations of chemical reactants and products, control processes and detect products or pollutants in real time.

- *Informatics*: Information technologies can be used to design equipment and processes as well as to control processes in real time at the site or from a remote location. Process design and simulation technologies can help with analysis and optimisation of complex industrial systems as well as their impacts on the environment.

- *Materials:* Materials technologies include abrasion and corrosion resistant coatings; powder coatings which do not require solvents; and light weight composite materials which save energy when incorporated into cars, trucks and aeroplanes.

- *Nanotechnology:*[3] Nanotechnology is the ultimate in materials technology. It is the fabrication of devices or products with atomic- or molecular-scale precision. Some of the first examples of this technology are mirrors that don't fog, biomimetic paint with a contact angle near 180 degrees, gene chips and fat-soluble vitamins in aqueous beverages. While the field is still in its infancy, there is great interest in its potential to create entirely new products as well as to contribute to CP.

- *Energy:* Energy-related technologies have received much attention since the oil "shock" of the 1970s. The efficiency of electrical technologies, specifically of electric motors, has increased significantly over the last few decades. More recently, fuel-cell technology has developed sufficiently that it is now possible to use them to provide stationary sources of electricity and to power motor vehicles. This latter application will greatly increase the energy efficiency of such vehicles while also eliminating the air pollution associated with internal combustion engines. As the energy densities of fuel cells increase, the cost will become more competitive with conventional sources of power. Hydro and wind power and solar-cell technologies continue to improve in efficiency and cost effectiveness. There is continued R&D on reducing the cost of producing renewable fuels such as ethanol and methane generated by pyrolysis or bioprocsssing from biomass as well as biodiesel from waste oils and lipids. In future, ethanol or some other product derived from biomass may be used in powering some types of fuel cells. Research is also focusing on biological production of hydrogen which would be the ultimate clean fuel.

- Chemical technology: Chemical technology has increased in efficiency, with decreased waste as a secondary benefit, and this has largely been driven by competition and regulation. However, it is only more recently that a fresh look has been taken at incorporating environmental considerations in a comprehensive manner into the selection of chemical

inputs and the design of chemical processes. The result has been "green chemistry":[4] the design of chemical products and processes which are more environmentally benign. A major effort is under way, led by organisations such as the US Environmental Protection Agency, the OECD and other organisations to advance education, training and technology in this field. Industrial biotechnology (see below) can be viewed as a subset of green chemistry which involves bioprocesses that are more eco-efficient and biologically derived chemicals that are more biodegradable than their conventional chemical counterparts.

- *Biotechnology:* Biotechnology embodies a group of technologies which harness the chemistry of life forms to develop products and processes. Biocatalysis involves the use of enzymes or micro-organisms to synthesise or modify molecular structures with great efficiency and specificity. Many reactions utilise naturally occurring enzymes or micro-organisms. Others make use of enzymes or micro-organisms that have been modified using mutation and selection techniques, including high-throughput screening. More recently, genetic engineering has been used to produce micro-organisms that contain all the steps for a particular series of reactions in one cell ("metabolic engineering"), in effect turning the cell into a miniature chemical factory. For example, Genencor has used this approach to develop a highly efficient process for producing vitamin C. A number of organisations are currently involved in bioprospecting, that is exploring nature's biodiversity for micro-organisms and plants that have novel traits and catalytic activities coded for by genes which may have industrial utility. Enzymes have also found use in producing single isomers of optically active compounds in high purity through selective degradation of the other isomer. This enzyme-based process uses much less energy and auxiliary solvents than the conventional separation processes which involve repeated recrystallisation or chromatography. Bioprocesses naturally lend themselves to processing of biomass, a major renewable resource, into fuels (*e.g.* methane, ethanol) and chemicals (*e.g.* acetone, butanediol). The application of biotechnology for CP has begun to grow in a number of key industry sectors and this has recently been reviewed extensively by the OECD (1998). The OECD Task Force on Biotechnology for Sustainable Industrial Development is developing a collection of case studies highlighting the environmental and cost benefits of bioprocesses compared to conventional process technologies.

The importance of technology assessment

It is essential to measure environmental performance of products, processes and the technologies embedded in them, if CP is to be achieved. Measuring performance of a technology includes consideration not only of the technology but also of how it is used and how well it is used. Tools such as life-cycle analysis (LCA) have been developed to systematically measure the environmental impacts of products and processes and the technologies embedded in them.

LCA is an excellent tool at the microeconomic level for designers in individual companies to examine the environmental consequences of their decisions broadly and beyond the "plant boundary". LCA measures a range of environmental impacts, *e.g.* one software (Simapro 4 developed by PRé Consults B.V. in the Netherlands) used in LCA includes the following parameters: eutrophication; carbon dioxide emissions; energy consumption; winter smog; summer smog; solid waste production; acidification; carcinogenic substances; heavy metals; and ozone depleting substances.

Case studies using multi-parameter measures indicate that, in many cases, improvements in technology that move towards "cleaner" in terms of one parameter may simultaneously move away

from “cleaner” in terms of another parameter. Thus, there are potential trade-offs which may have to be made or additional redesign undertaken to implement the technology.

Techniques such as LCA cannot readily examine society-wide macroeconomic issues such as sustainable development. This is because LCA answers the question “is it cleaner?” while for sustainability the question is “is it clean enough?”. However, it is possible to arrive at an estimate of what is “clean enough” based on present conditions and some simple assumptions. The question then becomes:

If one is to approach environmental sustainability while achieving sustained economic growth, what should be the environmental performance targets for technology undergoing R&D today relative to the performance of current industry-standard technology?

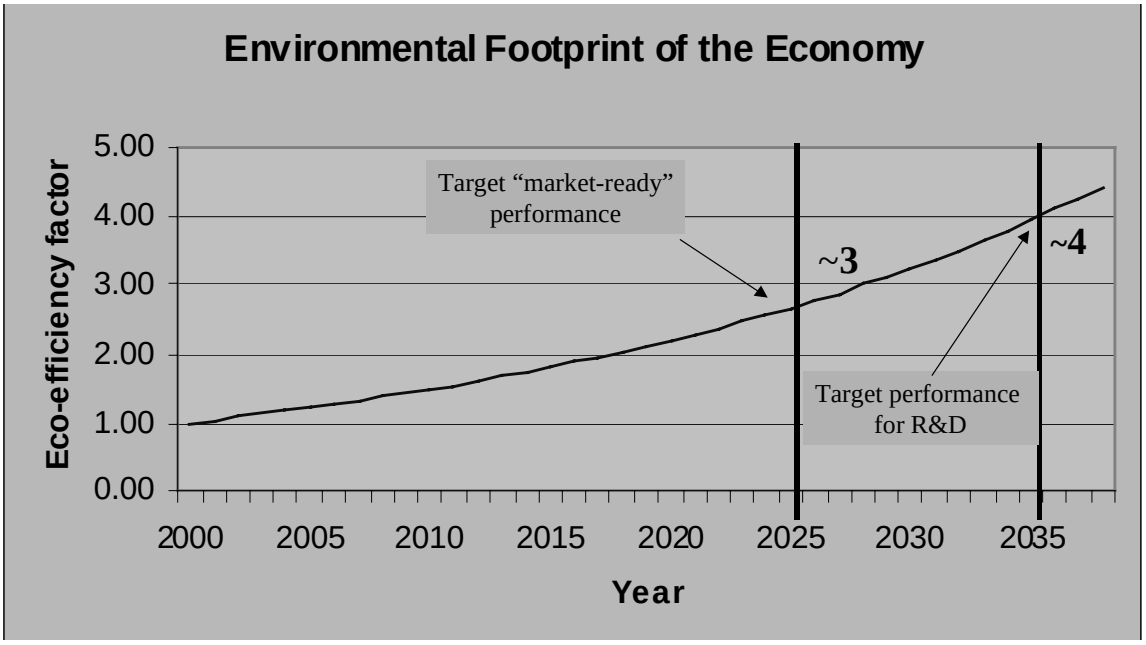
To answer this question, it is necessary to determine what environmental performance will be required to keep the environmental “footprint” of the economy at a constant level. An equation that describes this is:

$$GDP(t) / F_e(t) = \text{Constant}$$

Where, GDP(t) is the gross domestic product (global or national) and $F_e(t)$ is the eco-efficiency of the economy (*i.e.* the average environmental performance of the economy), both as a function of time.

The following assumptions are built into the case shown in Figure 1: environmental impacts are proportional to economic activity; economic growth for sake of argument is set at 4%; increased eco-efficiency decreases the environmental impact of a given level of economic activity; if newly developed technology is now beginning to be introduced into industry, it will take an average of 25 years for it to become the average performance of the industry as a whole; technologies at the R&D stage today will take an average of ten years to achieve market readiness.

Figure 1. **Eco-efficiency of the economy to keep the environmental footprint constant**



The line in Figure 1 represents the rising environmental impact from 4% economic growth without any changes in the environmental performance of the technology used. It shows that in order to bring the environmental impact back to its original level:

- Technologies that are ready for market today (and that take an average of 25 years to become average industry practice) should have an environmental performance at least three times better than the current industry average (*i.e.* emissions only 33% of present levels).

- Technologies that are at the R&D stage today (and that will take an average of 35 years to become average industry practice) should have an environmental performance at least four times better than the current industry average (*i.e.* emissions only 25% of present levels).

If the present environmental impact is not sustainable, then the environmental performance targets for new technology to help address this will have to be raised even higher. It should be noted that a factor of four improvement is not a particularly aggressive target. For example, the Netherlands has established a sustainable development technology research initiative with a factor of 20 improvement as the goal and the BIOCHEMIE example cited earlier achieved a factor of 100 improvement for reduction of hazardous waste.

Developing an integrating principle for CP

At present, the application of a wide range of technologies for CP is occurring across industry as "a thousand points of light", *i.e.* without an integrating principle. Such a principle is needed to avoid wasting resources on incremental improvements in the cleanliness of industrial production systems which will never make it to "clean enough", *i.e.* sustainable. The need to shift towards an economy based on renewable carbon because of the eventual depletion of fossil carbon resources does provide such an integrating principle. This provides a means of setting global and national priorities for research and technology development as well as for allocating our scientific and financial resources accordingly.

As can be seen in Table 1, continued use of conventional processes and non-renewable feedstocks result in continued pollution and exhaustion of resources. If conventional processes that are not eco-efficient are used on renewable resources they will likely lead to resource depletion as the global economy grows and demand increases. If cleaner production processes are used on non-renewable resources they will extend the lifetime of those resources but this is only postponing the inevitable. Sustainability is to be found in utilising renewable resources through cleaner processes that are eco-efficient. The present level of global energy consumption, production and industrial growth is ultimately not sustainable because it is only made possible by continued withdrawals from the stored "bank" of fossil carbon which is finite and not renewable.

Table 1. **Choice of process and feedstock: environmental impacts**

	Conventional processes	Cleaner production
Non-renewable feedstock	Status quo – pollution; rapid exhaustion of resources	Extended life of resources – "postponing the inevitable"
Renewable feedstock	Depletion of renewable resources	Sustainable

Developing an economy based on renewable carbon (a "biobased economy") means that the strategic technology challenge for the 21st century is:

To use cleaner production as the means of establishing a sustainable linkage between the carbon cycle in industry and the carbon cycle in the environment.

The life sciences, and in particular biotechnology, will play a prominent role in making this a reality. In fact, the life-science revolution will lead to a convergence of industry sectors, including agriculture, chemicals, pharmaceuticals, forest products and informatics as well as a period of economic growth surpassing that brought on by the informatics and telecommunications revolution. This is eloquently described by Enriquez and Goldberg (2000).

Making the life-science revolution sustainable provides a robust integrating principle for cleaner production technologies. The *Vision* (US Dept. of Energy, 1998) and *Technology Roadmap* (US Dept. of Energy, 1999) *for Plant/Crop Based Renewable Resources 2020* provides a view of how this integration can be conceived, planned and executed through targeting the development of technologies in the near, medium and long term for:

- Developing value-added plant varieties for food feed and industrial applications.
- High-yield, sustainable crop production.
- Eco-efficient processing.
- Sustainable utilisation of the resulting products.
- Closing the loop back to the environment.

Opportunities and constraints

The vision of CP in the service of a biobased economy offers hope for both developed and developing countries. For developed countries it presents the opportunity to use their technological abilities to head off the major economic and social disruptions which will be caused by fluctuations in the price of energy and petrochemicals as the supply of these finite, non-renewable resources continues to diminish. For a number of developing countries, it provides the opportunity to potentially leap-frog the age of fossil fuels and petrochemicals to the age of biofuels and biochemicals which are less toxic and more easily biodegradable[5] and which can be derived from locally grown feedstock, leading to local self-sufficiency. There are major challenges to overcome if these opportunities are to become realities:

- *Price:* The historically low price of petroleum-derived chemicals and development of product standards based on these types of products makes it difficult for alternatives based on renewable feedstock to compete on an equal footing in the marketplace. The recent increase in the price of oil may help offset this disadvantage as can policy measures which reduce the cost of innovation and help develop the large-scale infrastructure required for processing renewable bio-resources.

- *Lack of interdisciplinary expertise:* The integration of CP into the biobased economy will require cross-sectoral and cross-disciplinary research, technology development/transfer and implementation on a very broad scale. The linkage of microbiology with chemistry and engineering and other relevant disciplines has yet to be made across a range of industry sectors. Networks such as the Cleaner Production Centres can play a major role in this area.

- *Long lead times for CP technology development:* Long lead times require careful selection and planning of investments in technology to ensure that as far as possible they pay off. In some cases, development of CP technology can be done in phases so as to lower the overall risk of the project. Initiatives such as "technology roadmaps" can also lower the risk by helping to identify market-driven priority areas for development of technologies as well as the relevant research disciplines and industry/university/government networks to undertake the research, development, scale-up and technology demonstration.

- *Lack of financing:* CP often results in sufficient cost savings that the payback period for investment in CP technology innovation may be a few years or less. A key element for bringing in financing, whether it is from the company's own resources, from the government or from a financial institution, is building awareness of the economic benefits of CP and the costs of continued pollution of the environment in the organisation providing the financing. In this regard, tools such as life-cycle analysis and environmental accounting can be useful. The use of environmental management systems (EMS) can also provide comfort to investors that the objectives of CP technology development will be met.

- *Lack of private sector entrepreneurs:* Many CP technologies are commercialised by firms that specialise in technology development. These firms service the technology needs of other firms that are users and adapters of technology but not developers. Some researchers in university and government and industry laboratories may have promising ideas for CP technologies which are not of interest to their current employer but could provide the basis for starting a new company. Some universities, government research agencies and companies have begun to provide flexible leaves of absence and even incubator facilities for researchers who want to spin out a company. Another factor in stimulating the flow of entrepreneurs is examples of entrepreneurs who have been successful and have benefited financially from their efforts.

- *Lack of government support for this kind of research:* Government is one of the prime sources of funding for fundamental and applied research which has potential benefits for society, such as that on CP. Often, government priorities for supporting R&D are focused on technologies and products with commercial potential. In some cases, CP is not seen as having commercial potential and direct economic benefits. Initiatives such as those of UNEP, OECD and other international organisations can be very important in educating government policy makers and programme managers that CP can also have major economic benefits and create/preserve jobs.

- *Distrust of technology and corporations:* A number of consumer and environmental groups have developed a deep distrust of technology and many of the corporations which develop and commercialise technology. CP is seen as an imperative by many of these organisations. This may provide an opportunity to develop a constructive dialogue with them on the issues surrounding technology and CP. Consumer understanding and confidence in the performance of CP technologies is one means of stimulating the market forces driver for CP.

Conclusion

Technology innovation can be a very powerful tool to achieve CP if it is informed by effective technology assessment and supported by effective policies at the company level. A wide range of technologies and related research disciplines can contribute to CP. However, advances in science and technology are not sufficient as a driver for achieving CP: market forces and government policies must

also work in concert with technology to advance the adoption of CP by industry. Thus, a wide range of different communities representing quite different perspectives must come together to help achieve CP.

One integrating principle for CP, which focuses on sustainability is the use of CP technologies to establish a sustainable linkage between the carbon cycle in industry and the carbon cycle in the environment. Technologies based on life sciences and biotechnology in particular will play an increasingly prominent role in moving global production systems towards this ultimate goal of sustainability.

Awareness of the need for CP is growing and various communities as represented by different research disciplines, national and international agencies as well as different associations and non-governmental organisations have developed initiatives in this field. Some networks, such as that led by UNEP, have begun to emerge. As stated in the ICPIC document, *Cleaner Production: An Opportunity for Industry*,[6] the challenge for the 21st century is:

> *To link the different stakeholders relevant to the dissemination and application of this concept [CP] in order to promote concerted action.*

These stakeholders need to influence and be influenced by each other and recognise that it is in everyone's interest to develop and implement global solutions for global problems.

Glossary of CP terms

Design for the environment or "ecodesign" examines a product's entire life cycle and proposes changes to how the product is designed to minimise its environmental impact during its lifetime.

Environmental management systems (EMS) are a structured approach to planning and implementing environment protection measures that enable organisations to measure their environmental performance, and then regularly evaluate their performance and improvement.

Environmental audits are designed to identify all the environmental impacts made by a firm so that changes to processes and practices can be assessed and implemented.

Environmental accounting aims to provide organisations with the information to understand the full spectrum of their environmental costs and to integrate these costs into decision making.

Performance-based contracting is a technique under which a third-party contractor takes responsibility for the management of a specific part of the business. The contractor adopts the risk for managing that part of the business but also gains financial rewards for making it more efficient. The efficiency gains are shared between the contractor and the owner of the business.

Industrial ecology refers to the siting of symbiotic or complementary industries in the same areas. This type of development, also known as "industrial ecology parks" can facilitate improved recycling of outputs from one industry by other industries, rather than those outputs simply being treated as waste and sent to landfill. Such recycling reduces waste and increases profits, not only for the producer of the outputs, but also for the buyer.

NOTES

1. For example, see the Web site of the Royal Dutch Shell Group: http://www.shell.com/royal-en/.

2. See Web site of the Institute for Local Self-Reliance: http://www.carbohydrateeconomy.org.

3. More information is available on the Web site of *NanoTechnology* magazine: http://nanozine.com.

4. The concept of green chemistry was developed by the US Environmental Protection Agency and includes a number of partnerships with universities, industry, other government agencies, scientific societies, trade organisations, research centres and international organisations. For more information, see the EPA Web site at: http://www.epa.gov/opptintr/greenchemistry. For the 12 principles of green chemistry and related information, visit the American Chemical Society Web site at: http://www.acs.org/education/greenchem.

5. For example, d-limonene, which is derived from citrus fruit, is an excellent substitute for petroleum-derived solvents such as 1,1,1-trichloroethane in cleaning and degreasing applications.

6. Available at: http://www.emcentre.com/unepweb/RESOURCE/cp_opportunity/opr_cont.htm.

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Chapter 35

ENVIRONMENTAL CONSERVATION IN THE FERMENTATION INDUSTRY

by

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Introduction

Constant improvements in manufacturing processes have greatly increased the value of the fermentation industry to the world. In the past, the goal of the industry was simply to improve or innovate on existing technology in order to produce superior products at reduced cost, improve the quality of people's lives and enable many to enjoy economic advantages. However, times have changed and there has been a major push for the establishment of sustainable manufacturing technology in areas with environmentally sound fermentation production systems and products.

Our entire social system, including the production environment, can be divided into co-existing human and natural ecosystems. As such, these systems can be considered inter-linked to form a single circulating system and defined as an environmentally sound cycle (Hiraoka, 1992). In one possible system, materials and energy are extracted from the natural ecosystem and consumed by business and daily living activities, with a wide range of waste matter being generated. There is another system, however, in which waste matter is recycled, processed and used as a resource. By properly linking both systems and managing the resulting cycle, it is possible to conduct sustainable social and production activities. Once this type of cycle is established, production processes will naturally evolve into closed systems that generate a minimal amount of waste matter.

Culture media rich in organic matter and commonly used in the fermentation industry are first converted into bacteria, then to primary and secondary metabolites. Even in the most efficient fermentation systems, however, products only account for a small percentage of the total raw materials used. In whiskey distillation, for example, 90% of the raw materials used are not converted into the end-product. In the amino-acid fermentation industry, only 40% to 50% of the raw materials used are converted into the end-product, with the remaining materials being disposed of as bacteria, carbon dioxide and soluble organic matter. With regard to environmental protection and resource utilisation, it is very important to recycle this organic matter and reuse it in fermentation to complete a closed manufacturing system.

This chapter will review by-product utilisation in the fermentation industry as an example of the fermentation production of monosodium glutamate (MSG), an amino-acid-based seasoning, by Ajinomoto Co., Inc.

Environmental protection activities of Ajinomoto Co., Inc.

Ajinomoto Co., Inc. (Ajinomoto Co., Inc., 1999) is the world's largest amino-acid-producing company, with fermentation plants in more than ten countries. Ajinomoto produces some 450 000 tons of MSG, 170 000 tons of lysine and 9 000 tons of amino acids annually. To establish its reputation as an eco-friendly company in the 21st century, Ajinomoto has been enhancing its environmental management system to promote eco-friendly management based on the company's environmental philosophy and maximise its contribution to environmental improvements in foreign countries where the company's overseas plants are located. Many of these countries have enacted stricter environmental regulations, such as limitations on the discharge of organic matter, nitrogen and phosphorus into the water. Accordingly, Ajinomoto has been developing environmentally sound technologies adaptable to any conditions with the establishment of an eco-friendly production process in mind.

Treatment of wastewater and utilisation of by-products in the fermentation industry

MSG production by fermentation can be briefly described as follows: glutamic acid is accumulated in fermentation liquids and isolated in crystals which are then neutralised, decolourised and dried. Finally, the crystals are isolated and purified to obtain MSG (Yoshimura, 2000).

Sugarcane molasses is generally used as the main raw material of MSG. Sugarcane molasses is the residual liquor of the sugarcane refinery process, obtained after separating the sugar. It is the most economical raw material used in the fermentation industry because it contains large amounts of sugar and inorganic matter absorbed from the culture soil, and can be easily collected in bulk. In practical fermentation processes, organic and inorganic materials required for the growth and production activities of bacteria are added, while protein and various metabolites are accumulated with the proliferation of bacteria. Therefore, any discharge of the residual fermentation liquors into bodies of water will generate high biological oxygen demand (BOD). It is thus important to establish techniques to eliminate BOD, not only to ensure efficient utilisation of resources but also to improve production efficiency in the fermentation industry. For these reasons, the waste liquors are classified. For instance, the thick portion (commonly called "mother liquor") obtained after isolating the end-product is used as fertiliser and feed, while the thin portion is treated using chemical and biological methods.

Utilisation of "mother liquor"

Utilisation as fertiliser

Glutamic acid is formed in sugarcane molasses fermented by glutamic acid-forming bacteria. The residual liquor after isolating glutamic acid is known as "fermentation mother liquor", which comprises most of the fermentation by-product. Although mother liquor is difficult to process because it has colour and includes rich organic matter, its unique composition and the absence of noxious matter make it a valuable resource.

In general, the composition of mother liquor varies depending on the kinds and content ratios of raw materials used. Mother liquor consists of about 5% nitrogen and 9% various amino acids. The ash contains much P_2O_5 derived from the raw material and K_2O derived from sugarcane molasses. Many experiments have confirmed that fertiliser made from mother liquor produces a harvest yield matching that produced by rapeseed oil cake fertiliser as typical organic fertiliser. To investigate changes in the bacterial flora in fertilised soil, cabbage was cultivated in soil fertilised with other fertiliser, then bacteria in the soil was examined 20 days after planting to count the number of bacteria. As the results of these experiments show, culture media and root growth of cabbage at harvest indicate that soil fertilised with mother liquor contained more than 1 billion bacteria per 1 g of soil, which was significantly higher than in other soils. In addition, the root expansion at harvest was also greater in soil fertilised with mother liquor. These results suggest that amino acids in the mother liquor promote the growth of soil micro-organisms, which in turn alters the crumb structure of the soil to improve the root growth environment (*e.g.* air permeability, water permeability, and water retentivity).

Liquid fertilisers containing 6% to 7% nitrogen are manufactured at reduced cost at Ajinomoto factories in South-East Asia and South America. To investigate product efficiency, these fertilisers were used to grow lowland rice and sugarcane in Thailand; the results indicate that plants treated with mother liquor fertiliser had a 10% to 30% higher rice yield and 10% to 15% higher sugarcane yield than plants treated with a chemical fertiliser.

Based on these results, Ajinomoto participated in a joint project with JICA (Japan International Co-operation Agency) to restore the sugarcane fields in Pampangan province in the Philippines that were destroyed by the ash fall caused by the violent eruption of Mount Pinatubo in 1991. In this project, unproductive fields were treated with mother liquor fertiliser to improve the soil. This significantly enhanced the yield of sugarcane and consequently the production of sugarcane molasses. Because sugarcane molasses is used as a raw material in glutamic acid fermentation, a closed system is now being established.

Utilisation as feed (Yoshimura et al., 1994; Yoshimura et al., 1995; Yoshimura and Kawakita, 1995)

Since mother liquor still contains 200 to 250 g/l of crude ash after eliminating all contaminants, it must be demineralised to enable its use as feed. After examining various demineralisation procedures, the electrodialysis method was determined. The mother liquor was demineralised by electrodialysis, eliminating approximately 90% of the inorganic salt from the mother liquor. The demineralised solution was concentrated to adjust its components. The resulting concentrated demineralised solution (CDS) was examined in view of its utilisation as feed. It contained 42% water, more than 20% crude protein, 2.6% glutamic acid, other amino acids, and various vitamins. No noxious matter was detected.

The results of the digestibility test indicate that pigs fed CDS digested on average 64% of the crude protein, 39% of the crude fat and 83% of the soluble nitrogen-free extract. Because CDS contained 42% water, however, the digestible crude protein (or DCP) was 12.8%, and the total digestible nutrients (or TDN) was 37.1%. The DCP and TDN for goats (ruminants) were respectively 14.5% and 31.9%. The average digestibility of crude protein, crude fat and soluble nitrogen-free extract were respectively 72%, 56% and 47% for goats. Consequently, CDS was considered favourable as a feed.

The palatability trial of CDS was performed using weaning piglets and cows. The amount of feed with CDS consumed was 180 relative to the amount of feed without CDS, which is assumed to be 100. The consumption of feed with feed containing 3% CDS was about 1.8 times greater than that of the control group fed with sugarcane molasses. In addition, a similar test was performed using cows; the

results showed no differences in the feed intake between cows given feed containing 5% CDS and those given no CDS.

The feeding value of CDS for fattening cattle was investigated using ten-month old cows by giving them feed containing either soybean meal, urea or CDS for five months. Table 5 shows the results, which indicate that cows fed CDS showed a higher daily body weight gain, consumption and feed conversion rate than cows fed the urea and soybean cake. The cows fed CDS gained 890 g of body weight a day, while cows fed urea and soybean cake gained 710 g and 720 g, respectively, a day. This can be attributed to a preference for feed containing CDS. The feed conversion ratio of high concentrate feed was 7.9 for CDS and 8.6 for the soybean cake, respectively. The crude feed consumption was highest for cows fed CDS, and the total feed conversion rate also showed a significant difference.

Hoover and Miller (1993) report that adding mother liquor to the feed decreases the loss of nitrogen components such as ammonia in the rumen, while increasing the conversion of nitrogen into bacteria in the rumen and formation of VAF, specifically acetic acid. These findings suggest that nitrogen components of the demineralised concentrated solution added to the feed of cows within a range of 5% are effectively used (Yoshimura, 1995).

In the United States, all glutamic acid fermentation mother liquor is utilised as a feed additive for well-fed healthy cattle.

Wastewater treatment method

Wastewater with low concentrations of waste matter (*e.g.* washing water) is treated by using one of the following methods or a combination thereof. The methods selected depend on the plant location.

Physical treatment method

Solids in wastewater are mechanically separated before biological treatment to reduce BOD. Filter aids are often used to efficiently separate solids.

Chemical treatment method

Solids suspended in wastewater in the form of particles are separated by coagulation or flocculation. Ferrous chloride, ferric chloride, aluminium sulphate and calcium hydroxide are used as flocculants. These flocculants are added to wastewater in a mixing vessel to efficiently form precipitates or flocs capturing solid particles that are then precipitated and separated in the form of sludge.

Biological treatment method

Organic substances are decomposed by bacteria using various aerobic and anaerobic methods. Aerobic methods are generally based on a trickling filter, rotary table, rotary drum and activated sludge. Anaerobic methods include anaerobic digestion and filtration.

In the activated sludge method, a typical aerobic method, liquor containing organic matter is stirred while aerating to form micro-organism flocs, which are then precipitated and collected. Activated sludge looks like wastewater, but is actually a mixed culture system composed of bacteria and various micro-organisms characterised by significantly high microbial activity. When the pollution of wastewater is represented by BOD (biochemical oxygen demand), the process of BOD elimination can be broken down into the following steps:

- Elimination of BOD by biological absorption upon the contact of activated sludge with wastewater.
- Elimination of BOD increased by growing more activated sludge.
- Oxidation of intracellular substances by endogenous respiration.

Most pollutant is eliminated from wastewater by biochemical reactions, and the residual sludge is drained with effluents. The eliminated pollutant is adsorbed, oxidised, then assimilated by micro-organisms. Some absorbed organic matter is decomposed by respiration into carbon dioxide, which is used to promote the growth and activity of bacteria. The activated sludge process effectively concentrates organic matter in wastewater. With standard activated sludge process, about 40% of influent organic matter is fixed and eliminated as a micro-organism component (excessive sludge). It is necessary to utilise the excessive sludge as a raw material in fertilisers. Many commercially available solid fertilisers are produced by drying a mixture of sludge and other sub-materials.

Denitrification of wastewater

In the activated-sludge process, influent nitrogen is fixed at the ratio of only 5% of BOD, and residual nitrogen is discharged without treatment. If the nitrogen concentration is too high, nitrogen cannot be eliminated by the conventional activated sludge process. Newly developed techniques convert nitrogen in wastewater into nitrogen gas by using two types of bacteria: nitrifying bacteria, which turn ammonia into nitric acid in an aerobic environment; and denitrifying bacteria, which turn nitric acid into nitrogen gas in an anaerobic environment. However, such techniques are costly, as large quantities of oxygen, neutralisers and hydrogen donors (reductant) are required for denitrification. Generally, methanol is added as a reductant to perform denitrification of organic matter in wastewater. A new circulating denitrifying nitrification technique (BDN) has been developed in which a nitrification solution is circulated for the denitrification of wastewater containing organic matter. This is considered to be the most efficient technique because it requires significantly reduced amounts of oxygen, neutralisers and hydrogen donors. With this technique, the ratio of BOD to nitrogen in the influent is important, with BOD/N ratios of 3 to 3.5 best suited for BDN.

Anaerobic methods

Anaerobic methods convert organic matter into methane and carbon dioxide by using obligatory and facultative anaerobic bacteria. Some tanks used for anaerobic methods are as large as 12 000 m^3, and it takes 10 to 30 days to treat wastewater by anaerobic methods. The residue sludge is dehydrated and dried, then incinerated or dumped.

Anaerobic methods offer the following advantages:

- They are adaptable to heavier loads that aerobic methods cannot treat.

- Power costs for BOD treatment are low.
- Useful substances such as digested sludge and inflammable gas can be collected.
- Organic compounds are converted into more stable forms.
- The water retentivity and drying properties of sludge are enhanced.
- Less sludge is produced.
- As bacteria grow at a slow rate in an anaerobic environment, it is not usually necessary to supply nutrients to water.

However, the conventional methane fermentation process (or fluidised proliferation process) cannot maintain anaerobic bacteria in high concentrations. Thus, 20 to 30 days are required to treat wastewater. Newly developed fixed proliferation techniques utilising the agglomeration function of bacteria (granule sludge) have enabled high-speed methane fermentation processes. Such processes include the fixed bed, fluidised bed and sludge bed processes. In particular, the UASB (upflow anaerobic sludge blanket) process, in which granule sludge (that readily sediments by self-immobilisation) is formed and thus maintains anaerobic bacteria at high concentrations, can treat heavier loads. This process is becoming mainstream as it can treat heavier loads in a smaller space. It also requires no air-exposing energy and produces less sludge.

In terms of efficiency, each of these methods has its advantages and disadvantages. For example, it is difficult to treat wastewater containing high concentrations of nitrogen and organic matter using a single anaerobic method. For this reason, the most efficient combination of wastewater treatment methods was subjected to a computer simulation based on the stoichiometric formula. As a result, variations of BDN (in which anaerobic and BDN treatment are incorporated) are considered the most suitable for treating wastewater containing high concentrations of nitrogen and organic matter. BDN reactions proceed slowly, however, and are susceptible to wastewater properties. Therefore, efficient BDN requires the control of BOD/N ratios and an increased nitrification rate that often determines the rate of BOD reactions. Efficient treatment was found most feasible when used with a circulation method in which UASB is combined with nitrification tanks containing fluidised carriers to maintain high bacteria concentrations and reaction rates (Tubone and Baba, 2000). Wastewater suitable to BDN is first treated by UASB, which rapidly eliminates BOD, until the BOD/N ratio becomes about 3-3.5, then BDN is conducted using the circulation method. BDN can enhance elimination efficiency by employing this two-stage treatment. Wastewater is supplied as the BOD source (prior to UASB treatment) into the denitrification tank in the second stage, thus eliminating the need for hydrogen donors such as methanol, and reducing the cost and size of equipment.

Conclusion

Ever since glutamic acid-forming bacteria were discovered in nature, MSG production processes have been developed on a laboratory scale. The commercialisation of these processes required research into: *i)* genetic breeding of bacteria; *ii)* resolution of issues relating to raw materials; and *iii)* the establishment of industrial production processes, as well as the use of large quantities of fermentation by-product liquors. For this purpose, attempts have been made to evolve glutamic acid fermentation processes into closed systems that emit no waste matter into the environment. Since these attempts have proved successful, the concept of “zero emissions” will now reach the stage of actual implementation by the fermentation industry. In particular, the use of by-product liquors as fertiliser

and feed is the key determinant for the survival of the glutamic acid fermentation industry. Most BOD and colours are incorporated in solids and collected as by-product liquor, and low concentrations of waste liquor are collected in the form of micro-organisms, including bacteria through biological treatment to enable its use as a fertiliser. In addition, in South-East Asian countries, the fermentation mother liquor is utilised as a nitrogen source (fertiliser) for green algae, which represents the first link in the food chain for aquaculture, and the use of this method has boosted the production of shrimp culture (Lin *et al.*, 1984; Tavarutmaneegul and Yoshimura, 1985; Tavarutmaneegul, 1987).

Further biotechnological studies should be conducted on genetic breeding of bacteria to treat various types of wastewater (Iefuji and Kato, 2000), and on biological fixing of carbon dioxide produced in fermentation processes for conversion into useful resources (Kodama, 1996; Ishida *et al.*, 2000).

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Chapter 36

ENVIRONMENTAL INFORMATION SYSTEMS (EnvIS) SUPPORTING SUSTAINABLE DEVELOPMENT

by

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Introduction: information systems and sustainable development

At first view, information systems and sustainable development seem to be different worlds. If we look at the situation of environmental damage today, the following phenomena can be identified:

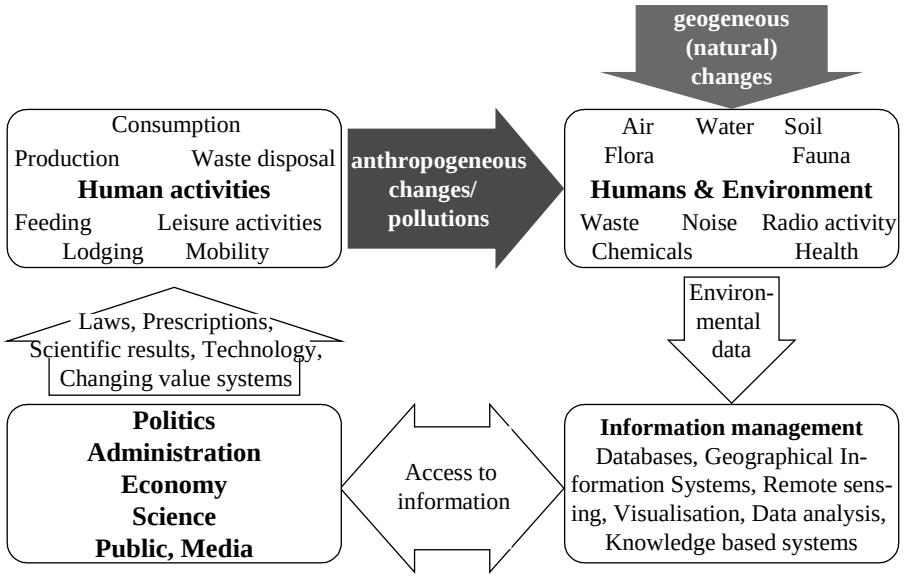
- *Developments are insidious and can only be followed over a long period:* Therefore, a long-term and global observation of environmental change needs to be established. In particular, environmental monitoring based on worldwide sensor networks and Earth observation satellites is required. For this, masses of data sets, ranging from simple measurements to complex satellite images, have to be stored, processed and evaluated. Today, the daily volume of environmental data in this field is estimated at 10 terabytes.

- *Politicians and other decision makers need clear and scientifically proven information to provide support for decision making:* Decisions regarding environmental measures are often unpopular, because they usually have disadvantageous economic consequences in the short- to medium-term perspective, although they provide considerable long-term benefits. These benefits have to be clearly identified and underpinned by "trustworthy" information.

It is clear that environmental data and information are key to an objective assessment of current and future developments. The role of environmental data and information is depicted in Figure 1 (Pillmann and Zobl, 1990). Human and geogeneous activities cause environmental damage in various fields. Environmental change is observed and, as a result, environmental data are collected. *Environmental data* directly reference properties of the air, water and soil media.In the next step, environmental information is derived from these data through the application of sophisticated technologies and techniques such as geographic information systems (GIS) databases, data analysis or knowledge-based systems. Obviously, environmental data and information have to be managed by computer-based information systems. *Environmental Information Systems (EnvIS)* are made for the investigation, reduction, avoidance or clearing of environmental pollution or damage (Page and Rautenstrauch, 2001). We define information based on environmental data assigned to space, time and a specialist context such as *environmental information* (Pillmann, 1995). This information is relevant to nearly all important groups of society. Finally, the interpretation and usage of environmental

information leads to changes in terms of legislation, science and the value system of society. In view of the current situation, these changes should focus on sustainable development in the place of today's irresponsible consumption-oriented behaviour. However, since the changes influence human behaviour in nearly all areas of life, the cycle is a closed one.

Figure 1. **The role of environmental data and information**



EnvIS: an overview

The current situation of research and development on EnvIS is documented in Rautenstrauch and Patig (2001). This following sections present the results of a worldwide survey carried out at the beginning of 2000. Based on the survey results, EnvIS can be classified as described below.

Global and multinational EnvIS

Environmental change and environmental damage do not stop at national borders. Therefore, multinational monitoring of the environmental situation is required. This has led to the elaboration of *environmental monitoring systems*.

Environmental monitoring is defined as the long-term observation, evaluation and documentation of environmental phenomena. The raw data of environmental monitoring systems are the measures and images generated by remote sensing systems. The most important technology in this field are observation satellites which permanently observe environmental developments on Earth and send back images from different spatial areas (so-called *scenes*) for further evaluation. The images are transmitted as a two-dimensional pattern of pixels, such as is used by digital cameras. Each colour defines a layer so that the scenes can be evaluated using single or multi-layer analysis. Combining different layers enables different colours to be put together, although the satellites are also able to create pictures from non-visible frequencies such as, for example, infrared. Table 1 provides an overview of the key technical specifications of current *Earth observation satellites* (Belgian Federal Government, 1995).

Table 1. **Technical specification of different satellites**

Satellite sensor	Landsat TM	Landsat MSS	NOAA AVHRR	SPOT HRV multispectral	SPOT HRV panchromatic
Main applications	Land use	Land use	Meteorology, land use	Land use	Land use
Spatial resolution	30 m	80 m	1.1 – 4 km	20 m	10 m
Surface/scene (km)	185 x 172	185 x 172	2 000 x 1 000	60 x 60	60 x 60
Repeat coverage (d)	16	16	1 – 8	3 – 26	3 – 26
First launch	1982	1978	1986	1986	1986
Number of bands	7	4	5	3	1
Spectral range (μm)	0.45 – 12.4 blue-TIR	0.50 – 1.10 green-NIR	0.58 – 12.50 green-TIR	0.50 – 0.89 green-NIR	0.50 – 0.73 green-red
Min. recorded scale	1:75 000	1:100 000	1:3 000 000	1:50 000	1:25 000
Max. recorded scale	1:250 000	1:500 000	1:5 000 000	1:100 000	1:100 000
Price/scene (USD)	4 500	800	15	3 000	4 000

Key: TM = Thematic mapper; MSS = Multi-spectral scanner; NOAA = National Oceanic and Atmospheric Administration; AVHRR = Advanced very high resolution radiometer; SPOT = *Satellite pour l'observation de la terre*; HRV = High resolution visible; TIR = True infrared; NIR = Near infrared.
Source: Günter (1998).

However, unless they are interpreted, such data are only masses of pixels which require further processing in order to tell a meaningful story. Two basic image-processing techniques are available:

- *Iconic image processing* is used to produce an appropriate visualisation by manipulation or combination of pixels. In this case, images are handled as what they are – a set of pixels.

- *Symbolic image processing* means that all graphic elements are treated as vector-based objects. For example, a rectangle can be moved, turned, elongated, etc., as a whole, whereas in iconic image processing, single pixels can be removed, added or coloured. It does nor matter whether a pixel is a part of an object or not.

Since iconic image processing allows the pictures to be manipulated so that some parts can be made clearer, further interpretation needs the support of other systems. For example, a blue line can represent a real world object like a river or can be the result of a sensor fault. Such problems are solved by the combination of images with GIS, which can be understood as electronic maps where all geographic objects from real world are represented by a vectorised object, and additional knowledge regarding the derivation of spatial information from images.

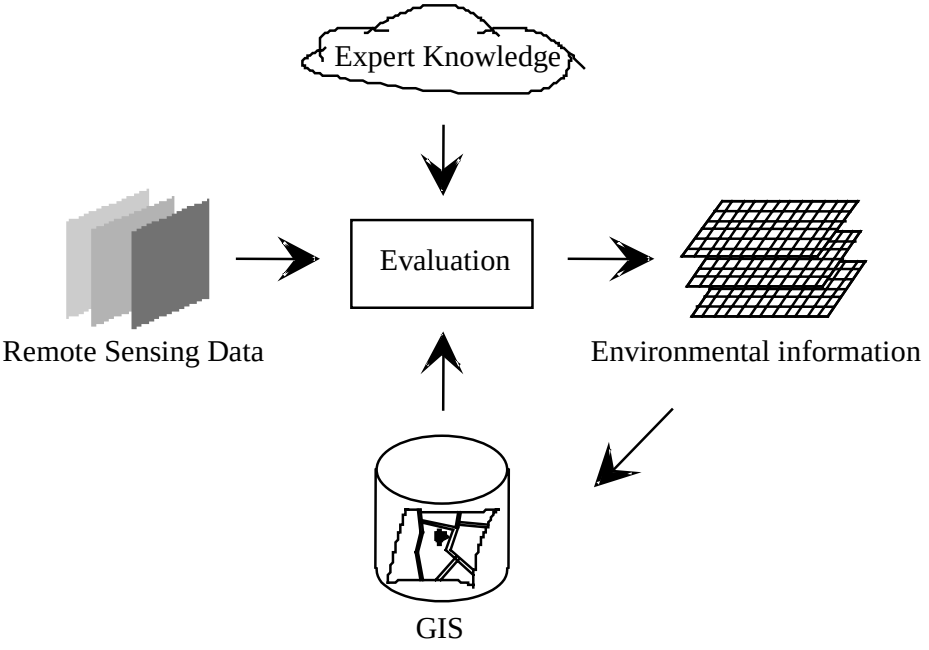
Figure 2 illustrates the relationships between the different components as implemented in the RESEDA project (RESEDA = REmote SEnsor Data Advisor) (Günther *et al.*, 1993):

- An *image processing system* supports the basic iconic manipulations as described above.

- An *expert system* manages models for the derivation of environmental information from the raw image data and maintains the knowledge required to apply the models.

- A *GIS* manages the geographic information used to support the image-interpretation process. The results of the evaluation may then be used to enhance or extend the spatial data stored in the GIS.

Figure 2. **Combination of technologies**



In practice, environmental change can be identified by comparing images of the same area at different time periods using an image-processing system. The image can be assigned to a geographic area with the help of a GIS and expert system. A further result is the derivation of environmental information based on the knowledge-based interpretation. This derived environmental information can then be depicted using GIS.

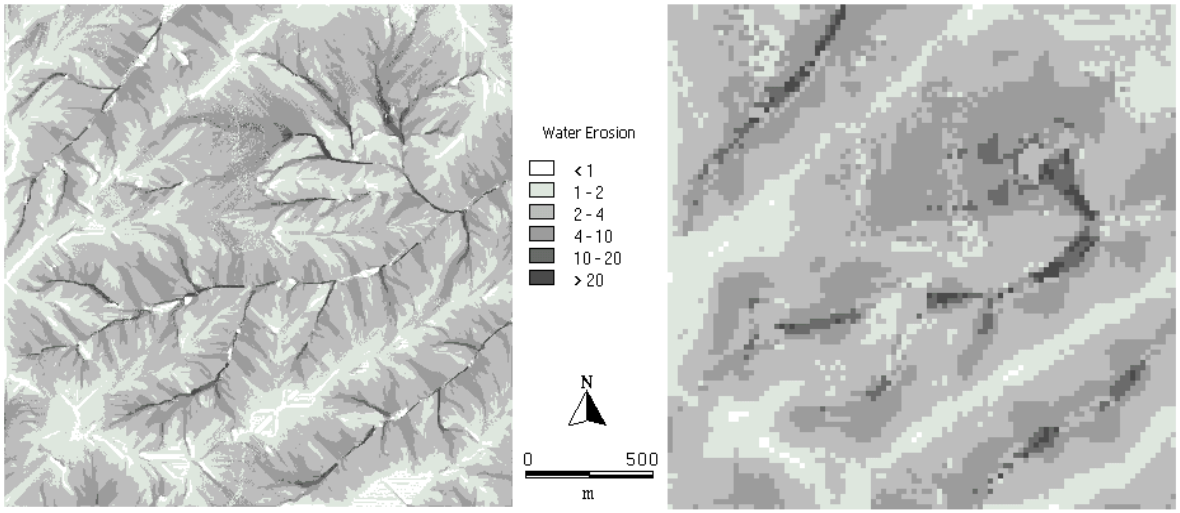
Global change databases are constructed to support the development of *global combined energy and biosphere models* (Ahamer, 2001). Since the information relevant for such databases is dispersed throughout the world and comes from different types of national or regional data sources, the creation of directories and dictionaries for the retrieval of environmental data sources in global networks is necessary. *Meta-information systems* were developed to help users find relevant environmental information, particularly on the Internet. These systems will be discussed in greater detail below.

EnvIS for the protection of air, water and soil

Although air, water, and soil are also subject to environmental monitoring, specific EnvIS, specialised in the assessment, analysis and depiction of the particular problems experienced by the different media, have been developed. For example, long-term data observations regarding soil erosion can be combined with GIS to provide electronic maps depicting the stages of erosion in specific locations. The output can be generated based on the WATEM (water and tillage erosion model), using a low-precision digital elevation model (LP-DEM) or a high-accuracy digital elevation model

(HP-DEM) as shown in Figure 3. Similar techniques can be used to depict the pollution of water and air in a particular location.

Figure 3. **Water erosion rates (Mg.ha^{-1} y^{-1})**



Note: The left-hand image shows the HP output; the right-hand image, the LP output.
Source: van Rompaey, van Oost and Govers (2001).

Urban and regional developments

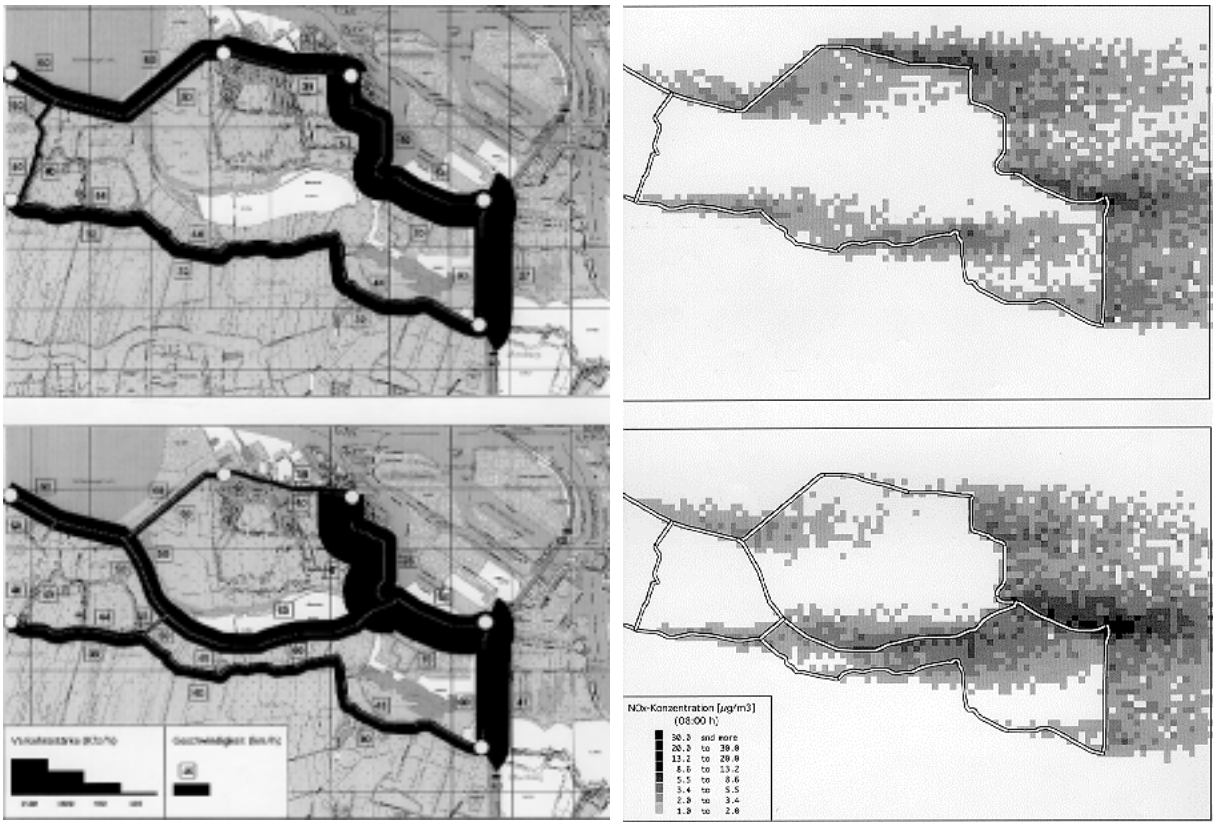
Today, urban and regional planning (also called *land-use planning*) requirements for environmental protection have to be taken into account, with a goal to achieving sustainable land-use. Expert knowledge from soil surveyors, climatologists and census offices needs to be combined in order to come up with a solution which meets the requirements of the different stakeholders. Furthermore, the information to be processed is often uncertain and vague. Obviously, this is an application where artificial intelligence techniques come into play, in particular relating to fuzzy logic or neural networks (Tsoumakas and Vlahavas, 2001).

The planning of new traffic routes is an urban development planning task. Vehicle exhaust fumes have negative effects on the quality of life. When a new road is planned, the consequences in terms of pollution have to be investigated. For this, extension models have to be developed which show the intensity of emissions depending on parameters of time, space and weather conditions. Typically, this is an application which calls for simulation models. The left-hand column of Figure 4 shows the changing distribution of emissions if a new bypass road is added (lower left-hand quadrant). The thickness of the lines indicates the concentration of nitrogen oxides. The right-hand column shows the NO_x concentrations calculated by an atmospheric dispersion model using the Lagrange particle simulation approach, taking a typical wind field and the emissions of the right-hand column as input (Hilty, Meyer and Ruddy, 2001).

Waste management and logistics

Waste – and particularly hazardous waste – needs to be observed "from the cradle to the grave". Depending on national legislation, a more or less complex set of laws and regulations has to be enforced. The handling of waste in industrial and other enterprises must be observed and precisely documented. Industrial EnvIS for waste management supports this process by recording all waste treatment processes and the generation of all required management, based on a special database containing all relevant regulations (Rautenstrauch, 1999). Such a functionality is often integrated into the Environment, Health and Safety (EH&S) modules of Enterprise Resource Planning (ERP) systems.

Figure 4. **Results of a simulation model**



Once it leaves an industrial plant, the routing of hazardous materials has to be carefully planned and observed. Global position system (GPS) technology is used for the permanent observation of such transports; the trucks can thus be re-routed as necessary. Furthermore, contingency plans for the management of environmental hazards caused by transport need to be prepared and maintained (Boulmakoul, Laurini and Zeitouni, 2001). Once hazardous materials has been delivered to the waste deposit, the final waste treatment measures have to be monitored. Particularly in the case of thermal waste treatment, the waste-burning processes are observed on a permanent basis in order to calculate the optimal conditions for the control of the burn out (Keller, Müller and Fick, 2001). In addition, waste management and regional developments intersect in planning for the allocation of waste deposits. The identification and assessment of environmental risk zones for waste deposits is supported by enhanced GIS systems (Belogurov, 2001).

Management of environmental hazards

Forecasting the behaviour of environmental hazards is a prerequisite to ensuring that the appropriate measures are implemented. For example, in the case of forest fire behaviour, a number of (simulation) models have been developed to assist in forecasting the spreading of fires (Guarnieri, Napoli and Olampi, 2001). The observations include: rate of spread; flame height; flame angle; fuel consumption ratio; fire-line intensity; radiative flux; convective flux; conductive flux; gas temperature; and solid particle temperature.

Another field of environmental hazard management is the detection of oil spills on water. This calls for the application of Earth observation and GIS technologies (Theophilopoulos and Kassomenos, 2001).

Meta data and environmental reporting

Meta data are data which describe other data. The content of *meta-information systems* serves to help users find and understand information from other data sources. A meta-information system contains directory information regarding the localisation of data elements ("which data are stored where in what format?") and dictionary information explaining the semantics of data elements. The dictionary contains textual descriptions of data elements and their relationships to other data elements. The third kind of content deals with user access privileges. For this, user models, roles and privileges are maintained as meta data so that only authorised persons are enabled to access relevant data.

An example of a multinational meta information system is the *Directory of Information Resources (DIR)* of the European Topic Centre on Catalogue of Data Sources (Pillmann, 2000). The DIR is a directory of environmental locators, pointing to environmental information sources in Europe. The content is organised along the lines of the standard data model of the *catalogues of environmental data sources* (CEDS) (Lessing, Günther and Swoboda, 1995):

- *Environmental objects* represent phenomena from the real world, such as stretches of water, biotops, plants, etc.
- *Environmental data objects* represent environmental data related to environmental objects.
- *CEDS objects* are meta data describing environmental data objects.

Access to (meta) data is organised as a *thesaurus*. A thesaurus is a graph where nodes describe concepts (so-called *descriptors*) and edges represent the relationships between them. In principle, a thesaurus is organised hierarchically, although cross references and synonyms are also possible. (Meta) data related to a thesaurus are definitions which are often based on laws and regulations, hierarchical assignments of subdescriptors and superdescriptors, non-hierarchical assignments of related descriptors (cross references) and synonyms which are relevant for navigation but not for retrieval. In this case, a thesaurus becomes a universal user interface to environmental information and has the role of a glossary for all important definitions.

Meta data can be applied to the generation of environmental reports. Based on meta data which help the user to find the relevant data sources and workflow definitions, the content of environmental reports can be "assembled" automatically (or at least semi-automatically). If the document descriptions are defined with markup languages like XML (eXtensible Markup Language), the reports can be published electronically on the WWW and on paper with identical or similar formatting.

Industrial Environmental Management Information Systems (IEMIS)

The documentation of the environmental situation and the planning, control and observation of environmental measures is supported by IEMIS. The environmental situation of a company is documented in so-called eco-balances, where all inputs and outputs of materials, substances and energy are listed. Eco-balances can refer to the whole company, processes or products (in this case they are called life cycle assessments – LCAs). The environmental impact of a company, a process or a product can be evaluated by an assessment and analysis of weak points based on the underlying eco-balance. A sophisticated method for this is through *material flow management*, which will be discussed below. Furthermore, production-related IEMIS need to support measures regarding the redesign of products and processes. This includes support of "design for disassembly" or "design for environment" approaches from engineering as well as the planning and control of recycling processes. An extensive overview of IEMIS is provided in Rautenstrauch (1999).

Technologies and techniques applied in EnvIS

From a technician's perspective, EnvIS can be characterised as high-technology applications of applied informatics. Table 2 illustrates how technologies and techniques are assigned to the different types of EnvIS described above (Rautenstrauch 2000). The different shades of gray depict the intensity of application.

Table 2. **Technologies and techniques for EnvIS**

EnvIS chapter	Data analysis	Visuali-sation	Remote sensing	GIS	Environ-mental databases	XML	Simulation	XPS	WWW and Internet	ERP systems
2.1										
2.2										
2.3										
2.4										
2.5										
2.6										
2.7										

Key: GIS = Geographic information systems; XML = Extensible Markup Language; XPS = eXPert Systems; WWW = World Wide Web; ERP = Enterprise resource planning.

Conclusions and outlook

Although it would be impossible to illustrate all the developments in the field of EnvIS in a short chapter such as this, many different facets of EnvIS have been presented, from global to industrial EnvIS, and for different applications. Furthermore, it has been shown that EnvIS are high-technology systems which combine various technologies and methods from engineering and informatics. Since sustainable development is an concept involving all parts of our global society and EnvIS have been identified as core technology for the support of sustainable development, it is obvious that their relevance is growing continuously.

While, at present, most EnvIS are used for the analysis and documentation of the environment, in the future, it will be crucial that systems be developed to actively support the reduction of environmental damage. In EnvIS, nearly all current technologies of computer science are applied. Therefore, it is necessary to bundle all these activities and bring together all the experts working in this field. For the time-being, a scientific community in the field of *environmental informatics* where

experts from different fields come together to solve environmental problems exists only in the German-speaking countries. However, as sustainable development becomes the driving force for human behaviour (and there is no doubt that this will happen), the application of EnvIS is becoming more and more self-evident. The creation of an international scientific community in the field of environmental informatics is an indispensable task for the near future.

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Chapter 37

OECD SEOUL CONFERENCE ON INTERNATIONAL S&T CO-OPERATION FOR SUSTAINABLE DEVELOPMENT: RAPPORTEUR'S SUMMARY

by

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Introduction

Economic development cannot be sustained beyond and over nature's capacity to supply resources and absorb wastes. The basic issue for sustainable development is how to enhance material welfare while minimising environmental degradation. There is no question that one of the most effective means to integrate environmental and economic goals in the move towards sustainable development is cleaner production and technology. But, as Minister Seo of Korea stated in his opening speech, however effective the new technologies may be, if those technologies are not adequately diffused and not applied at a global level, their optimal effectiveness cannot be attained. The challenge of this Conference is how to enable the developing countries to properly utilise those technologies through international co-operation.

On behalf of the Korean Government, the Korean Minister of Science and Technology, Mr. Seo, opened the Conference, stressing the importance of collaboration between developed and developing countries in addressing the international issues of environment, resources and energy, in order to pursue the common interest of maintaining a balance between industrial development and the protection of the environment. As a first shot across the bows, to trigger the discussion in the Conference, he launched the idea of creating an "International Fund for Environmental Sciences and Technology Co-operation", and suggested for the short term, rather then waiting for such an tempting Fund, to go boldly ahead and open governmental R&D programmes to mutual co-operation among countries, via the creation of a network on the Internet.

Herwig Schlögl, Deputy Secretary-General of the OECD, underlined Minister Seo's words and called for policy instruments in a coherent framework in order to decouple economic growth and environmental deterioration, including social impacts. Achieving sustainable development goals at a global level will heavily depend on the widespread diffusion and application of cleaner technologies. Numerous barriers hinder the contribution that can be made by S&T co-operation to the development and diffusion of environmental technologies. Developing countries often face difficulties in assessing appropriate scientific knowledge and technical skills. Their own knowledge base needs to be strengthened, while the qualified human resources required to develop and implement environmental technologies are insufficient. R&D infrastructure and other framework conditions such as effective research network and suitable funding mechanisms to develop and utilise cleaner technologies remain

inadequate. Although a great deal of effort has already been made at both the bilateral and multilateral level, more co-operation could occur in a wide range of areas to meet these needs. In this regard, current international S&T co-operation programmes need to be assessed from the perspective of developing countries' needs, and good practices should be identified and diffused.

The objective of the Seoul Conference was to discuss ways to promote and facilitate international co-operation in the development and diffusion of environmental technologies, in particular cleaner technologies, between developed and developing countries. To this end, the Conference aims to identify the barriers which impede effective co-operation and to propose recommendations aimed at enhancing international S&T co-operation involving both the public and private sectors to overcome these barriers so as to respond to global environmental problems while addressing the needs of developing countries.

International S&T co-operation for sustainable development

Three keynote speakers reflected on the main theme of this Conference, respectively from a developing countries' perspective, a developed countries' perspective and a business perspective. Chinese Vice Minister of Science and Technology, Ma Songde, expressed the severe environmental challenge China is facing as a consequence of its unprecedented economic growth. China's efforts on environmental S&T work are already quite substantial, but without international support it will be insufficient to satisfy China's needs to cope with their problems. He called for an increase in international funding of S&T activities, acceleration of technology transfer and strengthening of S&T absorbing capabilities. Mr. Humphrey, the United Kingdom's Ambassador in Korea, presenting on behalf of Lord Sainsbury, UK Minister of Science and Technology, spoke from the developed countries' perspective, saying that "neither government nor business can afford to ignore the environment and the challenge of sustainable development. The challenge should not be seen as a threat to business; rather, as an opportunity". He underlined the necessity of active multi-stakeholder dialogue between government, industry and NGOs, also in the international context. And he illustrated the United Kingdom's efforts with some initiatives for international co-operation; *e.g.* Joint Environmental Market Unit (JEMU) and the Technology Partnership Initiative (TPI). Perry Norling, representing Du Pont's and the World Business Council for Sustainable Development's vision on S&T co-operation for sustainable development, concurred with the preceding speakers. He analysed the problem via the basic questions of "what" and "how", resulting in a framework of six perspectives on sustainable development. The most appealing called for a concerted effort from industry: "to make sustainable development a reality, industry must lead and must innovate. Industry cannot view the environment and business as two different topics or competing topics. It is industry that can turn the technical solutions and opportunities into realities".

Development of S&T infrastructure for sustainable development

Won-Hoon Park, former President of the Korean Institute of Science and Technology, presented as his starting hypothesis that, in the transfer of environmentally sound technology (EST), developing countries face severe constraints on their efforts to advance in technology transfer and co-operation since they lack adequate financial resources and have limited human and institutional capacities. The following three key areas need priority attention in order to support the transfer of EST on terms that will promote their use and rapid diffusion: *i)* dissemination of and access to information on ESTs; *ii)* institutional development and capacity building; and *iii)* financial arrangements, technology co-operation and partnerships. He rephrased these key areas in action programmes and suggested, among others, to: *i)* set up an "Environmental Keeping Operation", in a similar vein to the UN's Peace

Keeping Operation; *ii)* establish an "Environmental Aid Programme", along the lines of Minister Seo's proposed International Fund; *iii)* strengthen regional co-operation; and *iv)* establish public-private partnership programmes for recipients of intermediate and higher technological capacity.

Yoichi Kaya of Keio University in Japan illustrated the established of international/bilateral S&T networks via the development of two types of "appropriate" technologies. The first category includes those technologies for which the bases are already developed but which need to be modified to enable them to be adapted to different regional situations. The low-cost desulphurisation units which are less water-intensive are being jointly developed by Tsinghua University of China and the University of Tokyo of Japan are a typical example. The second type of technologies reflects the idea of "leapfrogging" which requires developing countries to leave the paths that have been traced by the developed countries and build a new path towards "3E" technologies. This requires both developed and developing countries to collaborate in R&D towards frontier-type technologies. Examples are the bioremediation of polluted water (China-Japan collaboration), and the development of transportable renewable energy (Japan-United States-the South Asian countries).

Developing and diffusing cleaner technology

Frans Verspeek of IVAM Environmental Research UvA argued that since the 1992 UNCED Conference, many more or less successful initiatives had been launched to initiate and facilitate technology co-operation between developed and developing countries. Many developed and developing countries and transition economies have adopted cleaner production and eco-efficiency policies and programmes which emphasise the introduction of integrated technological solutions in production processes. It has, however, been recognised that the level and pace of technology transfer and technological transformation required to accelerate progress towards cleaner, more resource efficient systems and processes of production in developing countries and transition economies, is fairly slow, especially related to the pace of economic development. More attention has to be given, including in technology co-operation and partnerships between developed and developing countries, to the promotion and use of environmentally sound indigenous technologies and related knowledge that exist in developing countries. Joint ventures or other forms of foreign direct investments in developing countries that combine high-tech industrial knowledge of developed countries' companies with low-tech indigenous knowledge of the host countries' enterprises could become effective mechanisms for stimulating demand for ESTs and, thus, promoting their transfer to, and diffusion in, developing countries.

Rajendra Shende of UNEP's Division of Technology, Industry and Economics added to the preceding presentation from the UNEP perspective, concluding that only through the development and diffusion of cleaner technologies or environmentally sound technologies (ESTs) can irreparable and irreversible damage to the environment be prevented. Cleaner technologies embody eco-efficiency, pollution prevention and waste minimisation strategies. Agenda 21 and the Commission on Sustainable Development continue to emphasise the importance of promoting, facilitating and financing the development and diffusion of cleaner technologies through co-operation and capacity building – specifically in developing countries. The successful application of this strategy would call for a change in attitudes, behaviour and policies. A tripartite venture between government, industry and civil society operating through appropriate use of information technology is needed to translate these strategies into a sustainable future. He illustrated his presentation with several examples of UNEP's ongoing efforts to make cleaner technologies a mass movement and a way of life; *e.g.* the National Cleaner Production Centres Programme, the International Cleaner Production Declaration and the ICPIC Clearinghouse.

Woodrow Clark, visiting professor at Aalborg University, shared his research results and recommendations from an evaluation of six country studies (the United States, the United Kingdom, Germany, Italy, Japan and Denmark) on the development and diffusion of climate change environmentally sound technologies. His foremost conclusion is that government or public sector funding are typically the primary and consistent source of support for research, development, demonstration and commercialisation of ESTs. At the same time, the private sector rarely finances R&D and almost never the commercialisation of ESTs. Hence, there is a need for governments and multilateral organisations to finance ESTs in R&D and also the demonstration or commercialisation phases. This is especially true for ESTs in developing countries. Therefore, five policy recommendations should be pursued: *i)* provide a multilateral fund for the commercialisation for ESTs in the demonstration and even prototype stages; *ii)* provide an Intellectual Property Trust for new EST technologies; *iii)* actively seek emerging companies to commercialise ESTs through partnerships with "IP owner" countries; *iv)* create international partnerships, supported from a government and controlled by a firm; cash from multinational organisation; and technical support, training, and education from public-private financing; and *v)* provide a global business model whereby governments as well as firms obtain a return on their investments in terms of equity, shares and profits.

A number of barriers hinder the contribution that international S&T co-operation can make to the development by, and diffusion to, developing countries of environmental technologies. Kejun Jiang of the Energy Research Institute at the Chinese State Development and Planning Commission gave his analysis of the barriers which exist in China in relation to climate-relevant environmentally sound technology transfer, and came to a classification of five types of barriers: financial, technological, information, institutional capacities, and policies and strategies. He was of the opinion that from a developing countries' point of view, the requirements of technology transfer are: preferential terms, non-commercial, suitable for the economic level and special situation of developing countries, closing the technological gap with developed countries, facilitative of industrial progress, low cost, ease of access, ease of duplication and propagation, easy to upgrade and, in order to digest, assimilate and develop, both hardware and software shall be transferred to avoid reliance on the providers.

Philippe Bergeron, Director of the Regional Institute of Environmental Technology came, from a more regional perspective, to a fairly similar analysis of existing barriers. He grouped and phrased those barriers and the inter-related suggestions for improvement into four categories: *i)* weak enabling policy framework in developing countries; *ii)* limited S&T absorption capacity of developing countries; *iii)* lack of S&T facilitation mechanisms in developing countries; and *iv)* limited interest shown by developed countries. Barriers also exist from a developed country perspective: S&T programmes in developed countries, and especially those addressing eco-efficiency, are often viewed in terms of strategic national interest rather than as a vehicle for ODA or international economic co-operation. Bergeron stated that, in his opinion, governmental agencies dealing with S&T programmes in developed countries tend to have a weak understanding of the real S&T interests, needs and capacity of developing countries. Working in ministries with limited international economic co-operation dialogue especially towards developing countries, many S&T programme developers fail to see international S&T co-operation with developing countries as a source of mutually beneficial opportunities in terms of demand for innovation and market-making processes. To boost the facilitation of international co-operation to an higher level, Bergeron proposes, in line with the suggestion made by Minister Seo in his opening speech, the establishment of multilateral or regional initiatives and funds that can encourage multi-country and multidisciplinary teams of researchers to work together on sustainability R&D projects with mutual benefits. The objectives of such ISSTC funds could be to provide catalytic seed funding to promising S&T ideas, to lower transaction cost for multi-country R&D projects and to facilitate downstream access to traditional finance sources for creditworthy application of S&T results.

Role of financial institutions and government

Lack of appropriate financing mechanisms is often highlighted as a major obstacle for business initiatives to develop and diffuse environmental technologies. Lauritz Holm-Nielsen addressed this issue from a World Bank perspective. Through effective partnerships with other multilateral institutions, government agencies, non-governmental organisations and the private sector, the Bank aspires to apply its financial resources and extensive knowledge base towards increased efforts in the S&T sectors, which will help to create the foundations of knowledge-based economies among its borrowers. He stressed that it should be borne in mind that the World Bank's primary interest is not in the development of new technologies, but in their ability to facilitate a wider development agenda. Hence, they are usually introduced as part of a package of activities which may include policy and regulatory reform, financial or management restructuring, private sector participation and other "non-hardware" investments which may have equal, or even greater, impact on environmentally and socially sustainable development. The World Bank has been financing scientific and technological projects, and project components, since its inception. During the 1990s, World Bank support for S&T-related projects averaged USD 560 million per year. Currently, the World Bank devises a comprehensive strategy for future lending that capitalises on the pivotal role of science and technology in the development process. The lending programme for scientific and technological capacity is expected to increase as the creation and application of knowledge come to play an increasingly essential part in development efforts. These investments will focus on institutions, policy reform, self-enhancing financing mechanisms and human capital development and will make effective use of state-of-the-art technologies. In parallel with the development of an S&T strategy, the World Bank is implementing a number of innovative actions. These include projects undertaken under the aegis of the Millennium Science Initiative (MSI). The MSI uses the World Bank's existing lending instruments, but strongly emphasises the need for countries to improve the performance of their science and technology systems. MSI projects are designed to stimulate national S&T systems to function according to international best practice for research funding. Through this and other actions, the World Bank joins the international S&T community in placing high priority on the use of knowledge for sustainable development.

The second presentation on creating and accessing appropriate financing mechanisms by Mizue Tsukushi of The Good Bankers Co. was completely different in nature. Mrs Tsukushi shared her experiences as a "small", private Japanese initiative, responsible for the establishment of an investment-advisory company called "The Good Bankers Co., Ltd." which aims to introduce the socially responsible investing mechanism in Japan. Socially responsible investment, or SRI, means investing in companies whose business behaviour or products – or both – aim to influence the attainment of a sustainable world for future generations. This new investment style is rapidly spreading throughout the world. To introduce this new concept into Japan, a new mutual fund was created, the "eco-fund". Its major objective is to facilitate sustainable development in society by investing in environmentally friendly companies. Such funds are known worldwide as "green funds" or "eco-efficiency funds". The Nikko Group, Japan's prominent group of investment bankers, embraced the idea and created Japan's first socially responsible investing product, the "Nikko Eco-Fund", in August 1999. The Nikko Eco-Fund has proved to be a resounding success, collecting more than four times the projected initial sales, and reflecting stronger than expected interest among Japanese individual investors in this new investment vehicle. It is now Japan's 17th largest mutual fund and one of the largest green funds in the world. Since its inception, six more financial institutions have followed the trend, launching similar mutual funds. The total assets of Japanese green funds under management reached some USD 2 billion by January 2000, only six months after Nikko Eco-Fund's launch. The immediate popularity of these funds has caused a sensation in the Japanese financial services industry.

From a governmental perspective, Karin Refsnes of the Research Council of Norway presented Norway's ideas and initiatives on how to play an active role in international S&T co-operation for sustainable development. Norway has been very active in the last decade in promoting and supporting Cleaner Production activities in Central and Eastern Europe and, based on the successes of those programmes, similar activities have now been launched in Africa and Asia. Characteristic of Norway's approach is the fact that it is demand-driven and places a strong emphasis on local capacity building. Recent activities are investment promotion, via tailored Investment Funds (NORFUND and NEFCO), and support to the development of the private sector in developing countries, *e.g.* through pilot projects in Uganda, Mozambique and Sri Lanka. The experiences for promoting R&D for sustainable development can be summarised in the following key elements: *i)* programmes focused on environmental improvements are important for the development of tools and instruments in addition to solving specific environmental problems; *ii)* integration of environmental considerations in other industry-related R&D projects is a key strategy; and *iii)* partnerships between different governmental authorities (environment, transport, industry, agriculture, etc.) and the private sector (business associations) are important for ensuring demand-driven R&D activities.

Parallel sessions

Four parallel sessions were organised to address, at a sectoral level (energy, transport, water and industry), the issues previously raised in the plenary sessions. Each of the sessions focused on evaluating and drawing lessons from current international programmes and addressing effective ways to improve S&T co-operation in a particular sector.

Energy and sustainable development

Economic growth and the corresponding growth in energy demand are directly related. Any development process over the next 50 years will therefore see growth in the use of energy. In the next two decades primary energy demand is forecast to increase by more than 50%, and under the business-as-usual scenario, this will result in a proportionate increase in fossil-fuel use and its associated global and local environmental hazards. As several speakers pointed out during their presentations, energy use, and its related effects on CO_2 emissions and climate change, will determine the path of global sustainable development as illustrated by a quote by the German Chancellor, Mr. Schröder: "Climate change threatens the future of mankind more than any other impact on the environment". Long-term energy outlooks show that, under a business-as-usual approach, CO_2 emissions in 2020 would be 70% higher than in 1990 – clearly an unsustainable level.

Rajendra Shende of UNEP-TIE attempted to answer the question of what is required. In his view, a paradigm shift is needed in development aid for the energy sector towards support for technological innovation and away from the traditional support to proven conventional energy technologies. Aid agencies can make a significant contribution to encouraging technological "leap-frogging" by changing their practices to support the adoption of advanced technologies and by assuming some of the risk associated with making cutting-edge investments in renewable and associated R&D. The greatest challenge for this paradigm shift will be the high level of investment required. The mobilisation of domestic savings in developing countries and massive financial transfers from developed to developing countries appear to be the only available options for financing the shift away from fossil fuels. Unfortunately, R&D funding for the energy sector in the last 20 years has been decreasing. Innovations in the energy sector have been very minor and have not contributed to more rapid commercialisation or to reductions in the cost of production of renewables. UNEP projects such as the Sustainable Energy Advisory Facility (SEAF) and African Rural Renewable Energy Enterprise

Development (ARREED) attempt to catalyse policy making towards the financing of renewable energy. At the same time, international networks and collaboration among R&D institutes need to be promoted in order to reduce time and costs.

Wolf-Dieter Glatzel of the German Federal Environmental Agency underscored the need for "leap-frogging" by developing countries and warned that it was not sufficient to simply copy the experiences of industrialised countries. Technology transfer too often results in plain copying, resulting in copying errors and unsustainable structures and technologies. In his opinion, the general perception of international scientific and technological co-operation is often oriented towards one-way technology transfer or towards cost-intensive basic research. Because of the increasing necessity for global sustainable development, he emphasised the necessity of fostering and encouraging "leap-frogging" in international scientific and technological co-operation, and referred to the OECD's Climate Technology Initiative (CTI) as a good example of this type of co-operation.

Successful examples of ongoing international co-operation programmes were presented during the parallel session by Dave Howard of the National Renewable Energy Laboratory. These included the Technology Co-operation Agreement Pilot Project (TCAPP) and the Climate Technology Implementation Plan (CTIP) under CTI. Crucial components for success in these programmes appear to be: *i)* a demand-driven approach for selecting priority technologies and designing actions; *ii)* multi-stakeholder participation in the design and implementation of these actions through the involvement of the international business and investors, including donors and especially the recipient country; and *iii)* international S&T co-operation. Howard illustrated these programmes using examples of country activities in Southern Africa for CTIP and the TCAPP in Korea. TCAPP and CTIP have become leading models for implementation of technology transfer under the UNFCC. They appear to be effective because they depend on the host country playing a pivotal role in the identification and prioritisation of the technologies. A key aspect is that the pilot projects pursued under the programme are neither the goal nor the objective of the programme. Rather, they are tools for developing models which can, and will be, replicated many times within the pilot country and in other countries to ensure effective transfer of cleaner energy technologies throughout the developing world.

Hanns-Joachim Neef of the International Energy Agency, who was chairing this parallel session, summarised the common opinion of the speakers and participants, that science and technology are regarded as key factors for a sustainable energy future. National energy R&D programmes will benefit from international co-operation and are a starting point for the deployment of clean energy technologies worldwide. International exchange of lessons learned and best practices in energy technology policies, from research to deployment, will contribute to the increased use of clean and efficient energy technologies. Specifically, international collaboration on energy technology development reduces the costs of R&D by enabling the sharing of results and by avoiding duplication of efforts, and through the resulting increased rate of technological progress. International science and technology development, exchange and diffusion through public-private partnership for technology adsorption, capacity building and innovative project financing mechanisms are desirable and mutually beneficial to developed and developing countries/regions.

Transport and sustainability

Wolfgang Hübner and John White of the OECD, respectively chairman and speaker of this parallel session, positioned the role of transport in sustainable development. As is the case for energy, transport can also be seen as central to economic and social development. Access to markets and resources are critical to opening up possibilities for trade and economic growth. In the freight transport sector, freight transport and economic growth traditionally have been strongly linked. Moreover,

physical mobility is considered a personal prerogative and strongly influences the quality of our lives. At the same time, at the global level, the transport sector is a major contributor to CO_2 and other greenhouse gas emissions. In this context, there is an increasing focus on the interactions between transport and sustainable development. Hübner described new trends and patterns in transport and transport policy and argued that, combined with significant increases in international trade, the problems emerging today cannot be solved by one government on its own but demand international co-operation. New policy approaches are required to improve economic efficiency while at the same time contributing to sustainable development.

John White proposed a set of ten transport policy options which could make a significant difference to transport sustainability outcomes over the medium and longer term; these ranged from managerial or technical measures to financing schemes. Woon-Soo Kim of the Seoul Development Institute presented concrete illustrations of some of those options with a focus on the Korean/Seoul situation. The quality of the air in Seoul is deteriorating rapidly and transportation control measures are urgently called for. Seoul has launched strategies to lessen the damage from transport and to examine the types of technologies that can be developed/enforced. The first strategy includes transportation control measures such as the "transport congestion management plan", emission tax and a public-private coalition campaign. The second involves new-vehicle management with Green Car Certification, inspection and maintenance of old vehicles, provision of clean fuel, renewed efforts to develop low-emission engines, diesel particulate filters, etc. Both speakers emphasised the importance of multi-sectoral forums and multi-stakeholder discussions and participation in order to maximise the commitment of all actors in the analysis of the problems and the elaboration of possible solutions.

Jean Delsey of the French *Institut National de Recherche sur les Transports et leur Sécurité* provided some insights into recent and future trends in the development of cleaner cars and engines, placing ideas for and possible results of technology innovations in a clearer perspective. He is of the opinion that, in spite of new technology developments, it is unrealistic to anticipate reductions in CO_2 emissions by 2010-15, compared to the 1990 levels, in the OECD countries; he warned that increases have to be expected in the non-OECD countries. An analysis of recent trends indicates that very strong developments are taking place, particularly on the road transport front, which will lead to a large and continuous increase in CO_2 emissions from road transport, at least for the next decade(s). It would appear to be very difficult, and perhaps impossible, to modify these trends in the short term.

In line with the overall objective of the Conference, Fred Heuer of the Netherlands Ministry of Transport, Public Works and Water Management, described how to initiate international S&T co-operation projects. The Netherlands, via his Ministry, has established a joint action programme to intensify bilateral co-operation with South Africa in the field of ports, transport and infrastructure development, laid down in a protocol, the South African Netherlands Transport Forum (SANTF). The final results of SANTF have still to be evaluated with a view to deciding how successful the Forum was and if there is a need for the work to be continued but, in Heuer's view, so far the Forum mechanism has proved to be an effective instrument for international co-operation. As a first step towards the continuation of the project, two objectives have been formulated: *i)* to embed the results of activities into self-enforcing structures in South Africa; and *ii)* to establish structural co-operation between South African and Dutch partners, independent of the SANTF framework, *e.g.* co-operation between the key knowledge institutes, CSIR and TNO, has been initiated.

Wolfgang Hübner's summary of the parallel session discussions underscored the SANTF objectives: international co-operation should be tailored to the needs of developing countries; and the goal should be to ensure that, through empowerment of the developing countries, responsibility will be gradually taken over by the recipients.

Water and sustainable development

To secure safe and sufficient supply, water resources need to be efficiently managed. Developing countries often lack the technology and capacity for this. This session addressed issues in water resource management and treatment (sanitation) in developing countries. Two presentations from developing countries underscored this objective. Euiso Choi of Korea University explained that pig farming in Korea has become unsustainable. Korea faces the dilemma that unless effluent limits can be made economically attainable, the farms will not be sustainable. Or, if they are sustainable, this will be to the detriment of the country's water resources. Korea is currently seeking technological solutions to this problem with, as the international component, the possibility of exporting the useful by-product stemming from the treatment of pig manure. Zhiyun Ouyang, of the Chinese Research Centre for Eco-environmental Services, described the disastrous situation that will arise in China if the country continues to follow it's business-as-usual (BAU) scenario and pleaded for the adoption of a towards sustainable development (TSD) scenario, in which, in addition to technological innovation and intelligent governance, such "radical" strategies as institutional reform and lifestyle change are adopted.

Gordon Mumbo, the Ghanese representative of WaterAid, highlighted the issue of why, in spite of decades of investments in rural water supply and sanitation infrastructure in developing countries, the pressures on the already-strained resources have not been relieved. In his opinion, the key problem area has been the choice and development of technological options. In the past, technology development approaches failed to deliver many of their promises and may actually have made matters worse in the developing world. Many water and sanitation programmes fail because of bad policies and inappropriate technological systems. Policies imposed from above by international agencies and central governments have been at great variance with the needs and aspirations of rural inhabitants. He strongly recommended the use of indigenous knowledge for technology development in developing countries. In parallel, he advocated the promotion of participatory approaches in research that works from the bottom-up and allow the local voices be heard more effectively as the only way forward for developing countries. These are crucial components for international S&T co-operation initiatives.

These general recommendations were put into a more concrete perspective by Richard Franceys of the Dutch Institute of Hydraulic Engineering. He used actual examples to illustrate how the three main barriers to co-operation could be overcome. These, according to Nick King (Director of the International Water Association Foundation) include: barriers to transmission in the donor country; problems with transmission and reception; and problems with acceptance in the new location. He referred to initiatives such as the Global Applied Research Network, the World Bank Global Development Learning Network, the Water Utilities Partnership and the development of customised scientific and technical water programmes at his own institute. Furthermore, he stressed the importance of seizing opportunities of public-private partnerships for scientific and technical co-operation as well as for accelerated service delivery.

The chairman of this session, Manuel Dengo of the United Nations Commission on Sustainable Development, underscored these ideas which are in line with DESA's approach to Integrated Water Resources Management. In addition, he suggested to include and build upon recent developments in information and communication technologies (ICT), which are fundamental for new approaches to the dissemination of scientific and technological knowledge. Bridging the digital gap is key to new approaches for the exchange of scientific and technological knowledge on all aspects and levels of water resources, in particular, and sustainable development, in general.

Cleaner technology and industrial sustainability

John Arseneau of Industry Canada provided examples of industrial sectors, *e.g.* the chemicals, pulp & paper, textiles and food industries, in which technology innovation can provide a very powerful tool for achieving cleaner production (CP). However, this can only be achieved if it is informed by effective technology assessment and supported by effective policies at the company level. A wide range of technologies and related research disciplines can contribute to CP. However, he showed that advances in science and technology are not sufficient as a driver for achieving CP; market forces and government policies must also work in concert with technology to advance the adoption of CP by industry. Thus, a wide range of communities representing quite different perspectives must come together to help achieve CP.

At present, the application of a wide range of technologies is occurring across industry. This is occurring as "a thousand points of light", without any integrating principle. Arseneau argued that such a principle will be essential in order to avoid wasting resources on incremental improvements in the cleanliness of industrial production systems which will never be "clean enough", *i.e.* sustainable. He proposed an integrating principle for CP, which focuses on sustainability: the use of CP technologies to establish a sustainable linkage between the carbon cycle in industry and the carbon cycle in the environment. In particular, technologies based on life sciences and biotechnology will play an increasingly prominent role in moving global production systems towards the ultimate goal of sustainability. Minoru Yoshimura of the Miyagi Gakuin Women's College proposed several examples of biotechnology-related environmental measures to improve the food processing industry.

In the following presentations, examples of cleaner production activities, co-ordinated via the initiation of a National Cleaner Production Centre, were given. Both European speakers were critical of past and present international co-operation programmes. Uno Abrahamsen of the Norwegian National Institute of Technology, which is involved in supporting CP activities around the world, concluded that CP initiatives to date are typically supply driven, and suggested three major conditions for working towards demand-driven activities: *i)* an improved domestic regulatory and institutional framework; *ii)* a stronger training system; and *iii)* recipient financial resources. Sándor Kerekes, Director of the Hungarian National Cleaner Production Centre, described a supply-driven approach, using as an example the obstacles encountered in West-East environmental technology transfer. He also criticised the discrepancies in supply and demand that exist in the consulting business: experts from the United States and Western Europe were usually specialists in end-of-pipe technologies but not in cleaner production. Probably the only exception is the energy field, where positive examples of technology co-operation exist. Overall, they found that typical approaches to cleaner production such as the Austrian model which starts with so-called "good housekeeping" are not very successful, mainly because they require too great an effort in terms of changing human behaviour. It is true that the "low-hanging fruits" are often the cheapest and very cost efficient environmental protection possibilities, but he is convinced that they do not serve as introductory steps towards pollution prevention. While firms are mainly opposed to organisational change, they are often open to technological innovation – the good consultant should start with the latter, even if this tactic proves more expensive.

Finally, Chong-Chun Kim, of the Korean Ministry of Environment, and Young-Woo Park, of the Korean National Cleaner Production Centre, presented the efforts that have been made in Korea to shift from end-of-pipe to cleaner production over the last years. The main requirements for developing countries like Korea are an evaluation and classification system of existing technologies and the distribution of comprehensive lists, if possible electronically via the establishment of clearinghouses, of available technologies around the world. These activities should be facilitated by the establishment of a centre for the international exchange of technology and a new technology fund offering low-

interest loans to developing countries. This last measure would accelerate the adoption of new technologies in those countries where new technologies can have the greatest effect by allowing them to "leap-frog" environmentally costly technologies and thus avoid the costly mistakes of the industrialised countries.

Daniel Malkin of the OECD, who chaired this session, summarised the parallel session discussions and reported the participants' recommendations for work on capacity building, for teaming up scientists and technologists from the North and the South in programmes to develop appropriate information systems, including a clearinghouse for cleaner production technologies and practices, and reiterated the strongly felt need for better co-ordination of international scientific and technological activities.

Concluding remarks

The discussions at the Seoul Conference can be summarised as a strong consensus among all participants on the need for strengthening international co-operation to achieve sustainable development. All speakers underscored the importance of international networking and partnerships. Science and technology co-operation between developed and developing countries is not a one-way flow of resources. It works best when it builds upon sustained partnerships or co-operative arrangements in which all partners can realise their interests and share responsibilities and benefits over the entire co-operation process.

Critical remarks were made, by several speakers and also in the plenary discussions, on the overly supply-driven character of existing international co-operation and technology transfer ODA programmes. In identifying or developing technological solutions, it is essential to ensure that these solutions fit the conditions, needs and capacities of potential users and are consistent with community requirements for sustaining economic growth, lifestyles and the environment. Thus, appropriate technological solutions are often the result of merging high-technology industrial knowledge transferred from abroad with low-technology indigenous knowledge existing in the user country. In this context, some participants raised the problem of the "transfer of dirty technology", requesting international rules and procedures to avoid "dumping" of dirty technologies. Linked to this, an appeal was made to define criteria and clearing-houses for "clean(er) technology". However, there is no straightforward way to decide which technologies are dirty and should not be transferred at all. Some argue that effective and clean application depends on local circumstances – technology is not uniformly applicable.

Another issue of common understanding was the importance of capacity building; this is an old issue, but one which remains relevant. Many participants stressed that successful technology transfer involves more than the transfer of physical hardware; the skills to use the equipment are just as crucial to success. Without the education and training to enhance the capabilities for scientific inventions and technological innovation, for adaptation and absorption of technologies, sustaining sound business operations, implementing environmental and quality management systems, and maintaining the equipment, the hardware will almost certainly fail to fulfil its purpose. Technology transfer and capacity building to adapt, absorb and diffuse technologies and, finally, reach a higher level of capability for technological innovation, are two sides of the same process.

Despite the proliferation of databases, information systems and clearing-house functions – public and private, national and international – dealing with particular types of ESTs or providing technological information more generally, participants raised the issue of "information", regarding availability, applicability and/or accessibility. It appeared that Conference participants had limited

knowledge of the existence and contents of databases, and for this reason, no generally accepted conclusions and recommendations were put forward.

Finally, throughout the discussions, questions were raised by several speakers, not least by Minister Seo in his opening speech, as to "*how* to stimulate, or at least facilitate, this generally desired S&T international co-operation?" and "*who* should take the initiative?". The idea of setting up an International Fund for Science and Technology Co-operation was widely applauded. No direct commitments were made during the Conference, although one participant suggested earmarking a percentage of ODA for such a fund. This would be a worthwhile avenue to investigate and developed country governments should be asked to consider ways to create such a fund. Regarding the question of "*who?*", Conference participants agreed that all relevant players have, or should have, a role in the process, although many speakers emphasised the role for multilateral organisations such as the OECD and UNEP in facilitating/initiating/continuing the dialogue. While these organisations do not have a direct influence on co-operation processes, they can – and should continue to – facilitate such processes, both through the organisation of conferences such as this one and through the creation of networks. Several participants expressed their personnel willingness and commitment to continue the dialogue and establish initial (small) networks. Generally speaking, the Conference was felt to have been fruitful and to have made a significant contribution to the development and discussion of new concepts.

A set of policy recommendations arising from the discussions was released at the end the Conference (see page 367).

OECD SEOUL CONFERENCE ON INTERNATIONAL S&T CO-OPERATION FOR SUSTAINABLE DEVELOPMENT

POLICY RECOMMENDATIONS

Preamble

Global sustainability issues, such as climate change, demand global solutions. Rapid industrialisation is taking place in the developing countries and the economy is increasingly globalised. The shift to the knowledge-based economy implies increasing importance of science, technology and innovation to achieve sustainable growth. Governments of both developed and developing countries need to formulate and implement policies and programmes to integrate and address sustainable development issues in the national research and innovation systems. The global implications of sustainable development mean that it can be effectively addressed only through international co-operation in developing, accessing and diffusing appropriate knowledge and technology, especially for developing countries.

The Korean Government and the OECD jointly held a high-level conference to discuss these issues under the theme of "International S&T Co-operation for Sustainable Development" on 15-17 November 2000 in Seoul. Over 100 policy makers and experts from more than 40 countries participated. The following are the main policy recommendations that arose from the discussion.

Needs and objectives

Needs-driven co-operation

International co-operation to develop appropriate technologies for sustainable development should start with the identification of local needs. Appropriate technologies need to be identified and adapted. These could be simple and readily-available technologies, or the development of new innovative technology. International co-operation is the best means of identifying and adapting the right technologies.

Capacity building

Responding to local needs requires human and institutional capacities for assessing, adapting, developing and diffusing technology. These underpin the absorptive and adaptive abilities in the developing countries. This needs educational and research institutions which are the major elements of

national systems of innovation. Such capacities can best be built when there is effective participation and commitment by the domestic and foreign private sector.

Information access and diffusion

Responding to local needs through suitable capacity building requires access to and diffusion of information. Many information systems now exist, but they often are not properly interlinked or fail to satisfy local needs in developing countries. Furthermore, there is still a lack of hardware and/or capacity to access these.

How do we address these needs?

Public/private partnerships, networks of research and innovation

These needs could best be addressed through public/private partnerships. These can be international partnerships involving governments, firms and university or research institutes in different countries. In contrast to unilateral assistance programmes, partnerships stimulate participation and commitment of the stakeholders involved. Strong partnerships result from networks of researchers and other stakeholders. There is a need for more research and innovation networks with sustainable development objectives, such as that developed through IPCC, in order to build effective partnerships.

Role of public R&D in bilateral, multilateral or regional co-operation

There should be easier access to the results of public R&D, especially for firms in developing countries. National R&D programmes could be linked to each other as a means for regional/global collaborative efforts geared towards sustainable development.

Facilitating access to intellectual property

Protection of intellectual property is an effective means to promote technological development and diffusion. However, in the case of technologies contributing to sustainable development, access to these could either be facilitated through policy incentives for firms to reduce royalties or firms may be encouraged to make IPR concessions. International agreements can enhance such policies.

Role of international trade and investment

International trade and investment are the most effective vehicles for international diffusion of knowledge and technology. For that reason, international co-operation for sustainable development should be pursued in parallel with liberalisation of trade and investment regimes.

New mechanisms

Innovative financing mechanisms

Conventional loan financing is often inadequate to finance cleaner technology projects in the developing countries. Innovations in financing are also needed to develop and diffuse appropriate technologies in developing countries; these include micro-credit and “eco-funds”. Public/private partnerships in financing could leverage limited public funds for R&D and technology diffusion and stimulate private financing. Innovative financing mechanisms could be developed through

international co-operation. Governments could take policy measures to stimulate innovation in financing and facilitate the adoption of innovative financing mechanisms adapted to the needs of developing countries.

Role of government

Governments in the developing countries should strengthen regulatory and other framework conditions, so that the environmental and other sustainability issues can be dealt with under predictable and transparent conditions. Governments can facilitate well-functioning markets through these and other measures that enhance public-private partnerships, including matchmaking between demand and supply sides and among different international partners.

New institutional mechanism for international S&T co-operation

To address issues specific to sustainable development, new institutional mechanisms that facilitate international scientific and technological co-operation can be developed; one example is the proposed international fund to promote international S&T co-operation. The fund could be used to facilitate and stimulate the activities recommended above. The main functions of the fund could include:

- Conducting international programmes to combat global environmental problems.
- Co-ordinating international joint R&D programmes.
- Facilitating technology transfer.
- Providing technical and financial assistance for developing countries.
- Scientific monitoring of global environmental change.
- Policy research on prioritisation and effectiveness of international co-operation programmes for sustainable development.

Role of international organisations

International organisations can play a key role in facilitating international S&T co-operation for sustainable development. This includes:

- Compilation of data on national R&D activities and ODA devoted to sustainable development.
- Strengthening of information clearing-house functions by including international S&T co-operation activities.
- Fostering international co-operation in specific areas that contribute to sustainable development such as biotechnology and information technology.

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