Chapter 1

INTERNATIONAL SCIENCE AND TECHNOLOGY CO-OPERATION FOR SUSTAINABLE DEVELOPMENT: BACKGROUND AND ISSUES[1]

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Introduction

The importance of science and technology in enabling sustainable development was affirmed at the World Summit on Sustainable Development (WSSD) in 2002 and especially at one of its major parallel events, the Science and Technology Forum on Sustainable Development, the conclusions of which[2] were reflected in the Johannesburg Plan of Implementation (JPOI). In this plan, the participating governments acknowledged the essential role of science and technology in generating solutions to environmental and developmental issues. Most notably, the document stressed the importance of enhancing development and transfer of technology to the developing countries, building capacities in science and technology so as to allow access to international research and development programmes, and building partnerships and networks among public and private actors in science and technology including knowledge institutions such as centres of excellence.

NEPAD (New Partnership for Africa's Development) is an initiative in a similar spirit to the WSSD. It is an attempt to apply the recommendations implied in the JPOI to the specific context of the African continent. Its strategy aims "to help eradicate poverty in Africa and place African countries, both individually and collectively, on a path of sustainable growth and development and thus halt the marginalisation of Africa in the globalisation process". One of its goals is the implementation of national strategies for sustainable development. Its priority areas include energy, water, human resources development including reversing the brain drain, and health and agriculture.[3] Its *Africa's*

1. The chapter has benefited from the comments of the members of the OECD-CSTP steering group set up to organise this workshop. The section devoted specifically to issues in the areas of water and energy is entirely based on drafts provided by the members of this steering group.

2. The ministerial session of the forum adopted the *Ubuntu Minute on Science and Technology for Sustainable Development.*

3. Quotes from NEPAD (2001).

Science and Technology Consolidated Plan of Action (NEPAD, 2005) puts emphasis on "developing an African system of research and technological innovation by establishing networks of centres of excellence dedicated to specific R&D and capacity building programmes". Its goals are to "enable Africa to harness and apply science, technology and related innovations to eradicate poverty and achieve sustainable development; and to ensure that Africa contributes to the global pool of scientific knowledge and technological innovations". The Plan enumerates specific flagship R&D programmes including in the areas of water and energy.

The aims of these initiatives have been to meet the Millennium Development Goals (MDGs). However, the progress made by the developing countries in implementing the MDGs has been slow and uneven, as reflected in the country reports to the United Nations Commission on Sustainable Development (UNCSD), responsible for monitoring the progress made in the recommendations included in the JPOI. One of the obstacles to progress is limited research and access to technologies. More science and innovation capacities in human resources and physical infrastructure need to be built. Knowledge and technology need to be brought to places where they are needed the most. The key role of science and innovation for development in meeting MDGs is well argued in the UN Millennium Project report on science, technology and innovation (UN Millennium Project Task Force on Science, Technology and Innovation, 2005).

International science and technology co-operation for sustainable development

International co-operation is an effective tool for building scientific and technological capacities. Moreover, the aim of that international science and technology co-operation should be "sustainable development" rather than "development". The manifestation of a number of environmental issues at the global level, such as climate change, implies that further development anywhere in the world, especially in the developing countries, needs to be "sustainable".

Many industrialised countries (most belonging to the OECD) underwent "development" without paying due attention to its "sustainability" (*i.e.* maintaining the balance between environmental, social and economic components of development). The lack of recognition of the environmental and social impacts of industrialisation has resulted in serious negative environmental legacies, social inequities and economic disruptions since the 19th century. The increasing awareness of the global environmental issues in the second half of the 20th century (*e.g.* climate change and loss of biodiversity) has finally begun to steer the policies of the industrialised countries towards sustainable development. The so-called Brundtland report (World Commission of Environment and Development, 1987) and the Rio Earth Summit have been instrumental in setting this new direction.

Attempts to change the course of economic development policies towards a sustainable development path did not come by easily. Until recently, it has been thought that environmental sustainability can be achieved only at the cost of economic growth. Current mindsets emphasise the sustainability of a development path if its impact on economic growth is positive. But for this, there is unequivocal agreement on the pivotal role of science and technology. The OECD work on sustainable development has indeed developed such a perspective (*e.g.* OECD 2001a, 2001b). Increasing economic output per unit of energy consumption in recent decades in the OECD countries and the decreasing emissions of environmental pollutants in the context of economic growth indicate that economic growth can be "decoupled" from the exertion of negative environmental effects. Such trends were brought about by the implementation of appropriate public policies (*e.g.* regulatory regimes) accompanied by rapid technological advances in energy conversion and use as well as increasing efficiency in industrial production.

These trends suggest that developing countries can benefit significantly from working together with OECD countries in developing technologies for sustainable development, and sharing experiences on developing appropriate policies for planning and managing key resources, such as energy and water. The *systemic* nature of the science and innovation enterprise in OECD countries has been revealed in recent OECD work (*e.g.* OECD, 2002). It is not investments in research and development alone that enhance the innovation capacities of a nation. It is the co-ordinated interplay between the different actors including the government, universities and other educational and research institutions, businesses and other entities such as intergovernmental organisations (IGOs) and NGOs supported by appropriate framework policies and conditions that enhance the scientific and technological capacities of a country. In other words, linking science to innovation requires effective interactions between different actors that constitute an *innovation system.*

Building research and innovation systems should lie at the base of international science and technology co-operation. Only a well-functioning innovation system can translate the fruits of scientific research into concrete benefits for all in the developing countries. The existence of such a *national system of innovation* enables a country to participate and benefit from the ongoing economic globalisation and the accompanying globalisation of science and innovation systems. Therefore, international science and technology co-operation should involve building partnerships and networks with different stakeholders, both in the developed and developing countries, and including governments, business, trade unions, academia, IGOs, NGOs, and local communities.

Based on above insights, in January 2004, the OECD Ministers of Science and Technology adopted the *Declaration on International Science and Technology Co-operation for Sustainable Development*[4] at the ministerial-level meeting of the Committee for Scientific and Technological Policy. The ministers reaffirmed "their commitment expressed at the WSSD to the promotion of sustainable development through the application of science and technology by strengthening national innovation policies and programmes and by enhancing existing global collaborative networks". They also stressed "the importance of international co-operation in science and technology to sustainable development, notably by transferring knowledge and technology among (OECD) member countries to less developed ones."

In the declaration, the ministers invited countries and relevant stakeholders to convene an appropriate event to further enhance the consensus of the WSSD. Former Science and Technology Minister Ben Ngubane made an offer for South Africa to host this event. During the WSSD, South Africa played a key role in bringing science and technology to the forefront of the development agenda. As custodians of the WSSD, South Africa has an important role to play in ensuring the successful implementation of the targets set out in the JPOI. South Africa's Department of Science and Technology shares the responsibility for continuously reaffirming the roles of science and technology in furthering the development agenda.

4. Available at *www.oecd.org/cstp2004min*

Objectives and themes of the workshop

The workshop is aimed at fostering closer collaboration and networking between the OECD and developing country partners involved in science and technology for sustainable development. Specific aims are:

- To identify good practices in international science and technology co-operation between OECD and developing countries, aiming at fostering capacity building in science and technology, facilitating effective diffusion of scientific knowledge and technology transfer, and at developing knowledge infrastructure and networks, in order to meet sustainable development objectives at national and global levels. Such good practices include highlighting concrete and efficient solutions that have been implemented in the areas of water and energy.
- To consider possible indicators of good practices in international science and technology co-operation for sustainable development and to evaluate international science and technology co-operation initiatives.

Two sectoral themes have been chosen, energy and water, in line with the work plan of the UNCSD so that the insights gained in this workshop can contribute to the work of the UNCSD.[5]

Needs and challenges for international science and technology co-operation

However desirable and urgent it may be to build effective research and innovation systems, the realities in developing countries, especially in Africa, suggest that this is a daunting task. In many countries, the elements that make up an effective research and innovation system do not exist or are in insufficient state. In addition, the institutions that steer development towards sustainability, such as effective public regulations or economic incentive schemes as well as other framework policies, are not in place.

Innovation requires well-trained scientists and engineers, including women. There is increasing evidence that less than satisfactory progress is being made in producing scientists and engineers in the developing countries. There is little emphasis on science subjects at school level and this reduces the participation of youth in science and technology-related courses at the tertiary level. There is a need for a number of policy schemes (*e.g.* student exchange programmes at school and tertiary levels, post-doctoral fellowships and internships.) to strengthen the transformation of science and technology capacity to achieve increased numbers of people working in fields that are key in the future (Government of South Africa, 2002).

Widespread poverty means that the economic base for building a research and innovation system is weak. This implies inadequate investments in research and innovation, weak infrastructure support for these, and fewer opportunities for children and youth to achieve higher levels of education and to become scientists and engineers. The small pool of the highly qualified human resources who have secured positions in their countries of origin confront meagre resources and facilities needed for research and innovation. Such a discouraging environment results in the brain drain of the valuable human resources for science and innovation.

5. CSD 12 and 13 in 2004 and 2005, respectively, have dealt with water, sanitation and human settlements. CSD 14 and 15 in 2006 and 2007 deal with energy for sustainable development; industrial development; air pollution/atmosphere and climate change.

The absence of innovation systems also implies the weak networks of agents that participate in the innovation process, especially local businesses and communities. This suggests that the knowledge and technology transferred from industrialised countries are not necessarily appropriate for the needs of the people who need them the most. The efficient flow of information and active participation of all those concerned, especially on the demand side, enables the innovation system to deliver needed knowledge and technology.

A weak economic base, a lack of capacities and disconnectedness bring about a spiral-down effect in terms of sustainable development. The lack of capacities, framework conditions and knowledge networks results in the persistence of unsustainable modes of production and consumption that increase social, economic and environmental fragility. Poor governance, incorrect institutional set-up or inappropriate choices of technology hinder innovation systems to function. International co-operation is needed to stop such negative downward spiral.

Developing countries face serious challenges in the areas of energy and water that effective international science and technology co-operation can address. There is sufficient supply of both, but the quality of the essential services is not conducive to sustainable development. The use of these resources can be greatly enhanced through co-operative development of science and technology. This applies to the Nile River, whose water cannot be used for human consumption due to lack of technology to improve water quality. The meagre supplies usually do not reach the poorest. International science and technology co-operation brings about appropriate knowledge and innovation to improve the situation considerably. It can develop efficient and cost-effective ways to deliver and use sustainable water and energy resources by tapping knowledge available to the global community of practitioners of science and innovation.

The internationally agreed development goals, including those contained in the Millennium Declaration, Agenda 21 and JPOI, will require significant increases in the flow of financial resources as elaborated in the Monterrey Consensus, including through new and additional financial resources, in particular to the developing countries, to support the implementation of national policies and programmes, improved trade opportunities, access to and transfer of environmentally sound technologies on a concessionary or preferential basis, education and awareness-raising, capacity-building and information for decision-making and scientific capabilities (WSSD, 2002).

Improving and enhancing international science and technology co-operation

Experiences in international science and technology co-operation

A large number of international science and technology co-operation programmes have attempted to address the above issues. Some of the well-known initiatives illustrate the key elements of effective international co-operation and collaboration.

Millennium Science Initiative (World Bank)

Launched in 1999 and aimed at nurturing world-class science and scientific talent in the developing world. It seeks to do this through integrated programmes of research and training planned and driven by local scientists. These programmes are linked by partnerships with other programmes, local governments and the international scientific community. The MSI programmes have various forms; some take the form of one or more

"MSI institutes" that function as centres of excellence, others consist of small groups or individual researchers.

The World Bank makes use of its existing lending instruments in this initiative, and they are designed to support projects that award large multi-year research grants to top researchers, through a transparent and highly selective competition. MSI projects aim to stimulate a part of the national science and technology 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 improve considerably (Holm-Nielsen, 2001).

MSI projects provide targeted support focusing on research excellence, human resources training, and linkages to partners in the international science community and the private sector. The expected direct and indirect benefits include:

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

Since 1999, MSI programmes have been initiated in Chile, Brazil, Mexico, Vietnam and Africa. In Chile, the programme created competitive grants and three MSI institutes; it also provided advanced training opportunities to PhD and post-doctoral students. As a result, research productivity and international collaboration increased, as did monitoring, evaluation and accountability in scientific research. The Uganda programme provided pre-university science education, and promoted research in new universities outside Kampala. It assured coherence with health, agriculture and environment policies, and focused also on engineering, and strengthening undergraduate education.

Consultative Group on International Agricultural Research (CGIAR)

It is not directly concerned with water or energy, but this is a long-term international co-operation initiative that has produced concrete advances in putting results of agricultural research to provide concrete solutions in the developing countries. These include:

- Developing New Rice for Africa (NERICAs), a new strain of rice adapted to the conditions in West Africa, and the spread of its planting has enabled significant rice imports in countries such as Guinea.
- Integrating aquaculture/agriculture techniques resulting in increased rice and fish production in Asia through new strains of tilapia that grow 60% faster.
- Adoption of zero or low-till farming practices in Africa and Asia, minimising soil erosion and boosting farm incomes and productivity.

The CGIAR was established in 1971 and is a strategic alliance of countries, international and regional organisations and private foundations supporting 15 international agricultural centres that work with national agricultural research systems and civil society organisations including the private sector. There are approximately 8 500 CGIAR scientists and staff working in over 100 countries. CGIAR research scope is broad and mobilises agricultural science to reduce poverty, foster human well-being, promote agricultural growth and protect the environment. Its research portfolio has evolved from the original focus on increasing productivity in individual critical food crops. Today's approach recognises that biodiversity and environment research are also key components in the drive to enhance sustainable agricultural productivity. The fundamental belief of the programme is that agricultural growth and increased farm productivity in developing countries creates wealth, reduces poverty and hunger, and protects the environment (CGIAR, 2005).

Towards more effective international science and technology co-operation

The issues involved in making international science and technology co-operation effective are multi-faceted. This implies both the importance and difficulty of building up effective research and innovation systems in the developing countries.

A fundamental component of a research and innovation system is human resources. Well-educated scientists and engineers and other specialists constitute a major part of the necessary capacities. Enhanced enrolments in primary and secondary education constitute the base of scientifically literate human resources, but attention should also be paid to the tertiary level as well as specialised training in specific areas of scientific research or technological development. In the African context, the recent report of the Commission for Africa emphasised improving Africa's capacity, "starting with its system of higher education, particularly in science and technology" (Commission for Africa, 2005). This is probably the reason that the international science and technology co-operation initiatives often integrate training. The advantage of international co-operation as a means of training and human resource development is that it takes place within the context of a network of international specialists in the specific science or technology area. This means that, not only training, but also international exchange of scientists and engineers is also a part. This provides for controlled flow of scientific talents that include brain "return", not just brain "drain".

Science and technology capacity building also includes the "hardware" --the various infrastructure components for research and innovation activities. These include research institutions and industrial testing and standards centres, the suppliers of scientific instruments and tools, and the scientific and engineering information centres that provide updated information and data, which is becoming increasingly dependent on advanced ICT and the Internet. Given the realities in many of the developing countries, especially in Africa, building such infrastructure in the numerous fields of science and innovation is a long-term challenge. In the meantime, cost-effective solutions need to be found. Particular focus on building centres of excellence that bring together researchers and engineers from different countries to conduct scientific research or innovation jointly is one solution. Initiatives in many cases involve building or strengthening such centres of excellence. G8 leaders at the Gleneagles Summit in 2005 explicitly pointed to the focal role that centres of excellence could play in "helping develop skilled professionals for Africa's private and public sectors, through supporting networks of excellence between African and other countries' institutions of higher education and centres of excellence in science and technology institutions" (G8 Gleneagles, 2005).

International co-operation will not deliver concrete results if the required knowledge and technologies are not delivered to those places in the developing world where they are needed the most. In the OECD countries and in the developing world, the needed knowledge and technologies are held by businesses, governments, international institutions and universities. These resources need to be tapped into and harnessed for the needs of developing countries. Collaboration with the private sector, international co-operation between universities and science councils, and networks that promote international collaboration are key in international science and technology co-operation.

In order for science and innovation to alleviate poverty and bring about equitable economic development, required knowledge and technology should reach the local communities. This means that solution-focused research and innovation need to be conducted in close collaboration with 'local' stakeholders and decision makers. Co-operation initiatives need to be bottom-up and demand-driven. This means that smaller projects that cater for local needs should have priority over large development projects that have been agreed between decision makers at the national level.

Moving rapidly towards a sustainable development path implies deploying more of the advanced knowledge and technology that can be transferred or innovated in the developing countries. Rather than those technologies that have been available for decades which in many cases are no longer environmentally sustainable, more recently developed ones may better be suited to meet sustainable development requirements in the developing countries. This implies both opportunities and the imperative to "leapfrog." Developing countries may be the best places to diffuse technology and innovation based on advanced scientific knowledge such as ICT, biotechnology and nanotechnology. Cell phones that bypass the necessity to build landed cable infrastructures are a case in point.

Searching for suitable advanced knowledge and technology underlines the importance of creating knowledge and innovation networks globally. This is a key role that international science and technology co-operation can play. The actors in the national innovation systems need to be linked to their counterparts as well as other stakeholders in the industrialised as well as developing countries. Integration in global knowledge networks facilitates participation in the globalisation process itself.

Finally, if successful international co-operation initiatives have been long-standing initiatives, long-term sustainability of such initiatives is key to building national science and innovation systems. This does not necessarily mean detailed long-term planning and funding, but the willingness to let co-operation and collaboration activities evolve and adapt to changing conditions and the changing physical and social environments. Sustaining efforts to build science and innovation systems lead to sustainable development.

Specific issues in the areas of water and energy

Water

Introduction

The WSSD and the 3rd World Water Forum 2003 highlighted the importance of the UN Millennium Declaration and the MDGs. Water is vital for all human development and is a crosscutting issue for most of the eight MDGs. The JPOI recognises the role of science and technology in meeting water goals by committing governments to "improve water resource management and scientific understanding of the water cycle through co-operation in joint observation and research, and for this purpose encourage and promote knowledge-sharing and provide capacity-building and the transfer of technology, as mutually agreed, including remote-sensing and satellite technologies, particularly to developing countries and countries with economies in transition.". The Plan also recognises that affordable rural water technologies will be required to ensure that adequate clean water is available to marginalised communities.

CSD 13 (2005) further acknowledged the role of science and technology, emphasising implementation to:

- Develop and strengthen human and institutional capacities for effective water management and service delivery.
- Expand and improve wastewater treatment and reuse.
- Support more effective water demand and water resource management across all sectors.
- Develop and transfer low-cost technologies for safe water supply and treatment.
- Develop and strengthen national monitoring systems on quantity, quality and use of surface and groundwater resources.

Also recognised is that an interdisciplinary approach is required for the successful management of water resources. Insight into the multitude and complexity of the water management challenge are discussed below. Priorities for international co-operation in water research are highlighted, including mechanisms for such co-operation.

Endowment opportunities and threats to water resources

Life on earth would not exist without water. It is essential for the development of life, the functioning of ecosystems and preservation of the environment. A safe and stable water supply is also of vital importance for human, social and economic development. Water is globally distributed by the hydrological cycle, which is driven by the energy cycle. The circulation of water powers most of the other natural cycles and conditions the weather and the climate.

There is extreme variability in the distribution of world water resources. Africa's renewable water resources average 4050 km^3/capita/year – significantly less than the world average of 7000 m^3/capita/year (UNEP, 2002). The spatial and temporal distribution of water resources also vary. There is contrast between the arid regions and rain forests; on smaller spatial scales, contrast exists between opposite sides of a mountain range, *e.g.* the south and north flanks of the Himalayas. High variability exists on time scales of hours to decades, from short, high-intensity precipitation to marked differences between seasons in precipitation and inter-annual and inter-decadal variation (UNESCO-WWAP, 2003).

Despite the spatial and temporal variability, significant progress has been made in harnessing water resources for economic and social development. Its use in industry, mining, hydropower generation, and transport provides economies with export earnings. Water use in agriculture, livestock production, fisheries and tourism has created employment. The provision of safe water supply and sanitation is a social good – necessary for reducing morbidity and mortality rates caused by waterborne or water-related diseases such as cholera, diarrhoea and malaria. Access to safe water is inadequate but a pre-condition both for health and for fighting poverty and hunger in the poor communities in the developing countries.

For economic security and social well-being, the water resource base requires protection. Environmental degradation is inextricably linked to poverty, hunger, gender inequality and health. Water needs to be supplied while sustaining healthy, functional ecosystems. For this, integrated water resource management (IWRM) framework approaches are required. Climate change and variability, population growth and increasing water demand, over-exploitation and environmental degradation continue to contribute to complexity of water resource management. Extreme events also have an impact on the aquatic and terrestrial environments. Conflicts, misuses of water resources and poor water management practices have often resulted in depleted supplies, falling water tables, shrinking inland lakes, destruction of ecosystems, human and ecological disasters and pollution of water. Human (industrial) activities also cause widespread water pollution, further decreasing the quantity of water suitable for sustaining life.

Research has generated new knowledge to remedy some of these issues. Progress has been achieved in better understanding the functioning of the ecosystem as carrier of all life, with water playing vital roles, but many questions remain. Water is managed in too fragmented a way. Surface water and ground water are often considered separately without due recognition of their interdependence. Water and land resources in many places are still not managed in conjunction. Water supply schemes are usually designed, especially in developing countries, without the required matching with drainage networks and waste water treatment facilities. Quantity and quality are managed separately, so are water science and water policy. More efficient management of water resources and more accurate knowledge of the hydrological cycle require implementing a *system* approach, encompassing the social and economic dimension of sustainable development.

Strategies for international co-operation

As water resources are often a primary limiting factor for development in many regions and countries, in particular developing countries, more emphasis should be given to stronger interlinkages between scientific research, application and capacity building. Filling the gap between policies and alleviation of poverty, science and the transfer of knowledge is at the centre of achieving sustainable development in many developing as well as industrialised countries.

Capacity building and international co-operation is required to address issues such as developing:

- Scientific understanding of the water cycle in order to promote a systematic assessment of the quantity and quality of water available for development.
- Tools and methodologies for managing the impacts of climate change and human interventions in the hydrological cycle.
- Appropriate technologies for water treatment, sanitation systems and water conservation including the application of enhanced agricultural technologies and their application.
- Good practice models of linking these technologies to appropriate institutional mechanisms, such as catchment-level agencies.

Partnerships are increasingly adopted to foster international co-operation. The partnerships represent complex inter-linkages among a wide range of enterprises and are designed to reduce the risks associated with the development of new products and facilitate exchange of information. The partnerships help provide funds through licensing and upfront fees for R&D, reimbursement of expenses for products and services, royalties, profits, and other "success fees" associated with the achievement of certain milestones (UN Millennium Project Task Force on Science Technology and Innovation, 2005). South/south collaboration also creates opportunities for partnerships.

Focal issues

As a follow-up to CSD 13, the focal issues here include exploring north/south and south/south interaction and best practices for (regional) strategic planning, technology options and methodologies in the area of water science and technology. Good practices in order to find solutions for addressing water management for developing countries need to be discusses and shared. These practices should ensure a sufficient and good-quality water supply, adequate water (hazards) management, and efficient use of and sustainable access to safe water and sanitation, in particular for the poor. Proposals for successful research collaboration, including north/south partnerships, in pursuit of increased knowledge, capacity building and technological innovation in developing countries should be put forward. Integrated water resource management (IWRM), water hazards management; and capacity building for water management should be discussed.

Representation of developing and emerging market economies will ensure focusing on the needs and scope for country/region specific actions. Possible joint research efforts between developed and less developed countries, strengthening research outcomes with stake-holder training, and activities that raise awareness of the need for capacity building should be identified. Ways to improve access to data, information and knowledge and public involvement should be sought so that the transfer of knowledge and technology will be more beneficial for both the water specialists and the general public.

Issues in energy efficiency, climate change and sustainable industrial production

Introduction

The WSSD highlighted the centrality of water and energy service delivery to the goals of sustainable development. In the two formal outcomes, the JPOI and the public-private partnerships, the two themes were prominent as being necessary for economic and social development throughout the developing world. Their importance was formalised in the UNCSD work plan. However, to date, work fulfilling the objectives of the JPOI has neglected the value of energy efficiency in science and technology collaboration. The gap needs to be filled by linking efficiency programmes to climate change and industrial development and by demonstrating their contributions to sustainable development.

Endowment opportunities and threats regarding energy supply

Demand for energy is growing worldwide and the projected rate of growth in developing countries over the next 15 years far exceeds that of the industrialised nations. The Energy Information Administration estimates that the developing world's energy consumption will increase from over 100 quadrillion BTUs in 1999 to over 264 quadrillion BTUs by 2020. By 2020 it is also expected that the developing world will overtake the industrialised world in carbon dioxide emissions (EIA, 1999, 2001). Further increases in energy demand are expected if access to modern energy services is to be extended to the over 1.6 billion unserved people. While additional supply sources will form an essential component, energy efficiency in end-use applications is a critical element to ensure a cost-effective, long-term sustainable path that reduces greenhouse gas (GHG) emissions and contributes to sustainable industrial production.

The way in which we generate our energy also relates to energy efficiency. An alternative to the construction of new power plants that produce harmful emissions is to improve the efficiency of current sources of energy production. Energy efficiency technologies and practices are warranted both on the supply and demand sides. It makes little economic sense to increase power generation capacity unless it is generated efficiently.

Inefficient use of energy degrades the environment, slows economic growth and wastes precious natural resources. Improving the efficiency with which we generate, transmit, distribute and use energy is the surest way to ensure the sustainability of the energy system and catalyze economic and social development. Improving energy efficiency reduces infrastructure and investment requirements, enhances energy security by reducing fuel imports, frees up capital for other social and economic development needs, increases national and industrial competitiveness through more sustainable industrial production, and reduces air pollution and greenhouse gas emissions. Energy efficiency is among the most cost-effective options to address climate change.

Energy, environmental, and industrial policies and programmes have traditionally undervalued the contributions energy efficiency practices and technologies can make. The World Bank has recently recognised the need to scale-up energy efficiency investments and policy dialogue in order to overcome these global trends, and it has articulated a commitment to *i)* reduce the average energy consumption per unit of GDP in developing countries to 0.24 toe/USD 1 000 compared to 0.27 toe/USD 1 000 in 2001; and *ii)* reduce CO_2 emission intensity of energy use to 2.75 tons/tons of oil equivalent (t/toe) compared to 2.90 t/toe in 2001 (Saghir, 2003).

The primary drivers of energy use in many developing countries are urbanisation, industrialisation and rising incomes. Industrial end-use applications account for approximately 40% of global primary energy demand and roughly the same share of CO_2 emissions. The technical potential for energy saving ranges from 30% to 50% in existing operations, to as much as 90% in new buildings and operations, with concomitant reductions in greenhouse gas emissions. In many developing country industries, the costs of reducing energy and other input costs through more efficient practices and cleaner production options can be lower than the costs of increasing supply through new production facilities. By implementing technically advanced energy systems, developing nations could leapfrog the world's existing energy infrastructure in efficiency and sustainability. An extensive body of knowledge and history of experience in S&T collaboration exists in this field and can inform policy makers in developing countries in designing and implementing their development agenda. Unfortunately, lack of awareness and expertise, high perceived technical risks, low energy pricing, high up-front and project development costs, underdeveloped markets due to historically low supply/demand, and a lack of affordable financing have contributed to underutilisation of energy efficient technologies.

There are a number of international partnerships, initiatives and networks that have flourished in the last decade, promoting clean energy, sustainable development and the way to ensure energy services for the 1.6 billion people that do not have access. For example, for over 30 years, the International Energy Agency (IEA) international technology collaboration framework has provided a structure for governments to leverage and strengthen their national research and deployment programmes. Its 40 Implementing Agreements cover all new key technologies in energy supply and end use. Similarly, there are numerous bilateral S&T relationships that involve national laboratories and private sector R&D activities that cover energy and development issues from basic research to commercialisation.

Focal issues

The two fundamental components of science and technology collaboration--technologies and technology diffusion mechanisms (networks, partnerships, initiatives) --will be addressed. Technology issues will be thus be complemented by international co-operation mechanisms, including successes/failures of these efforts.

Technologies for energy efficiency

Selected production efficiency and end-use applications (*e.g.* power plants, industrial motors, commercial building lighting, pulp and paper, appliances) will be discussed. The technological solutions that have been implemented in the selected supply-side and end-use areas resulting in measurable efficiency gains in greenhouse gas abatement, environmental and economic benefits will be highlighted (*e.g.* industrial process upgrades and optimisation, improved lighting systems, codes and standards, motor and drive system improvements). There is a stress on the importance of integrating disparate efficiency technologies in a systemic fashion. The policies (*e.g.* energy pricing, incentives/penalties, standards/benchmarking, energy auditing) and institutional/financial arrangements that facilitate the adoption of the efficiency technology or improvement are to be examined. Solutions that have not only demonstrated their cost-effectiveness and commercial viability within a given market, but also their ability to be adopted on a sustainable, scalable and replicable manner will be highlighted. The results of energy efficiency programmes introducing new technologies that have resulted in substantial efficiency gains on the supply and/or demand side will be discussed from a **technology perspective**. Both bilateral and multilateral energy efficiency programmes will be presented.

International initiatives and partnerships for energy efficiency and renewable energy

From the point of view of **international co-operation in energy efficiency and renewable energy,** different types of initiatives/organisations will be discussed, *e.g.* partnerships launched at the WSSD, the US Clean Energy Initiative's Efficient Energy for Sustainable Development, and the Mediterranean Renewable Energy Program. Similarly, specific technology-focused partnerships such as the Collaborative Labelling and Appliance Standards Program (CLASP) and Watergy, a partnership designed to provide efficiency savings in both water and energy use, are discussed to show the various diffusion models for energy efficiency, renewable energy and climate-related technologies. Why the project/programme was launched; the programme goals; how the project/programme addresses capacity building, technology transfer, network building; aspects of success/failure; lessons learned; who are the stakeholders that participate (in developed and developing countries) will be discussed.

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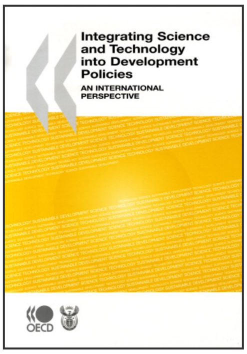

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