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Achieving the Successful  
Transfer of Environmentally  
Sound Technologies: Trade-  
related Aspects

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**ACHIEVING THE SUCCESSFUL TRANSFER OF ENVIRONMENTALLY SOUND TECHNOLOGIES:  
TRADE-RELATED ASPECTS**

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## ABSTRACT

This report examines factors that have proven helpful in achieving the successful transfer of environmentally sound technologies (EST) to developing countries. It provides an overview of the main issues lying behind trade-related aspects of EST transfers. It then briefly examines the main channels for the transfer of such technologies and the factors which are relevant to technology transfer in general, and to EST transfer in particular. It concludes with a summary of conditions for successful EST transfers which seem to be particularly relevant in the context of trade. These include government regulation and market-based instruments, trade-related policies and practices, intellectual property rights, capacity, and financing. The report is based on the extensive literature dealing with technology transfer in general, and EST transfer specifically, and on empirical work summarised in a range of case studies.

*JEL Classifications:* F18, O33, Q56

*Keywords:* developing countries, environmentally sound technologies, technology transfer, trade

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The report is available on the OECD website in English and French at the following URL addresses: <http://www.oecd.org/trade> and <http://www.oecd.org/environment>.

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## ACHIEVING THE SUCCESSFUL TRANSFER OF ENVIRONMENTALLY SOUND TECHNOLOGIES: TRADE-RELATED ASPECTS

### Executive summary

#### *Transfer of EST: differences and similarities with technology transfer in general*

Environmentally sound technologies (EST) are those that “protect the environment, are less polluting, use all resources in a more sustainable manner, recycle more of their wastes and products, and handle residual wastes in a more acceptable manner than the technologies for which they were substitutes” (Agenda 21). Technology transfer does not just relate to equipment or “hardware”, but also to total systems and their component parts, including know-how, goods and services, equipment, and organisational and managerial procedures.

There seem to be few areas in which EST transfers differ from technology transfer in general. Those factors that seem to be more specific to transfers of EST, and, more specifically, transfers through trade, include: adequate environmental regulation, enforcement, and market instruments; the removal or reduction of trade barriers, such as tariffs on environmental goods and services; intellectual property regimes and the potential of publicly owned technologies; sufficient capacity in governments and enterprises to acquire EST; and appropriate financing mechanisms.

#### *Adequate environmental regulation is one of the main drivers of EST transfers*

Strong environmental regulation and enforcement are the main incentives for firms to acquire new technologies. At the other extreme, weak environmental regulation and enforcement are among the main obstacles to successful technology transfer and diffusion. Low environmental standards may perpetuate existing control technologies rather than supporting innovation.

The role of government in providing pathways for technology transfer has changed, and is now viewed by many as helping put in place policies and measures that promote the transfer of technologies to the private sector. Government procurement policies also have the capacity to enhance EST transfer, since governments are important purchasers of goods and services, for which, often, environmentally sound options exist. Moreover, governments, especially at regional and municipal levels, are the primary purchasers of environmental services, such as waste management and water treatment, and related technologies.

#### *Reducing trade barriers on environmental goods and services benefits EST transfer*

The impact of tariffs and other cost factors on technology transfers seems to vary across markets, and will largely depend upon the tariff levels applied. Liberalisation of goods and services trade can help remove barriers which inhibit EST transfer. Examples are tariffs on environmental goods, or restrictions on various modes of foreign service provision.

The literature suggests that subsidies that promote EST can be either an enabling mechanism or a potential barrier to EST transfer. Government support for a particular sector or industry that distorts the value of its output can blunt the incentives producers have to lessen the environmental impact of that

industry. This can make producers less likely to react to changing environmental conditions, and less receptive to EST.

*Adequate IPR regimes are necessary for the development and transfer of EST*

Intellectual property rights (IPR) may play an important role in ensuring economic returns to investors, including research and development resources that have been devoted to developing and improving a technology, and enabling its transfer and diffusion. IPR regimes that are too weak to protect initial ownership over technology can discourage transfer of EST, and thus constitute a barrier. Equally, IPR regimes that provide too extensive a monopoly on a given technology can also limit the diffusion of that technology. The actual effect of IPR regimes on EST transfers is difficult to measure, and there is a lack of empirical data to support the theoretical literature.

Much research and development of new EST is done within the realm of public institutions. However, only a small proportion of EST resulting from publicly funded R&D are patented, commercialised or transferred. A large number of EST are in the public domain. Ways of easing and fostering their transfer should be further explored.

*Lack of capacity is one of the main obstacles to the successful transfer and absorption of EST*

Capacity is necessary to adopt and enforce adequate environmental legislation and IPR regimes and to put in place investment incentives. It also includes capacity by governments and industry to understand the need for, and foster the introduction of new, more environmental friendly technologies and production processes.

Capacity is also a determinant for the absorption and diffusion of technologies. Often, environmental technologies (e.g. waste and water treatment technologies) are acquired by municipalities, and, in many cases, officials in charge of purchases have little knowledge or expertise in environmental technologies. When technology transfer is accompanied by capacity building efforts, the result is generally satisfactory, and numerous case studies show the importance of adequate training and technical assistance to enhance local capacity to absorb new technologies.

*Specific financial mechanisms are sometimes necessary*

Insufficient financial resources to acquire technologies is frequently reported as a primary barrier to technology transfer, including transfers of EST. In a number of technology transfer cases, specific financing mechanisms were developed to ensure absorption of the technology. Examples include micro-financing programmes to ensure access of the poor to the new technologies or services.

## Introduction

The potential for technology transfer to contribute to sustainable development has been recognised at the highest international levels. In the Rio Declaration, States declared that they should cooperate "... by enhancing the development, adaptation, diffusion and transfer of technologies, including new and innovative technologies". Agenda 21 devoted a whole chapter to the transfer of technology, and numerous initiatives were launched to facilitate technology co-operation and transfer between developed and developing countries. However, it has generally been recognised that the level and pace of technology transfer and technological transformation required to accelerate progress towards cleaner, more resource-efficient systems and production processes in developing countries and economies in transition has been slow (OECD, 2001; UNEP, 2003).

In the new millennium, new calls for comprehensive and targeted programmes of technology transfer have been made. The *OECD Environmental Strategy for the First Decade of the 21<sup>st</sup> Century*, endorsed by Environment Ministers in 2001, recommends, under Objective 5 (Global environmental interdependence: Improving governance and co-operation) that OECD countries "continue and improve bilateral and multilateral co-operation with non-member countries, including the transfer of environmentally sound technology and capacity building for environmental management." At the 2002 World Summit on Sustainable Development, States made further pledges to mobilise resources and contribute to the transfer and diffusion of environmentally sound technologies.

At its meeting in June 2003 the Joint Working Party on Trade and Environment (JWPTE) agreed to undertake a study to examine factors that have proven helpful in achieving the successful transfer of environmentally sound technologies (EST) to developing countries.

This report provides an overview of the main issues lying behind trade-related aspects of EST transfers. It briefly examines the main channels for the transfer of such technologies and the factors which are relevant to technology transfer in general, and to EST transfer in particular. It concludes with a summary of conditions for successful EST transfers which seem to be particularly relevant in the context of trade.

The report is based on the extensive and rich literature dealing with technology transfer in general, and EST transfer specifically, and on empirical work summarised in a range of case studies. These case studies have been drawn mainly from the International Energy Agency and Organisation for Economic Co-operation and Development's study, *Technology without Borders, Case Studies of Successful Technology Transfer* (IEA/OECD, 2001), the International Panel on Climate Change report, *Methodological and Technological Issues in Technology Transfer* (IPCC, 2000), and the Centre for Environmentally Sound Technology Transfer, *Doing business in the Chinese Environmental Market* (CESTT, 2002).<sup>1</sup> Information has also been drawn from various case studies by the World Business Council for Sustainable Development (WBCSD), including those in *Developing Countries and Technology Co-operation, 10 Business Cases* (WBCSD, 2002) and on the WBCSD's website ([www.wbcsd.org](http://www.wbcsd.org)). Finally, the report also

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<sup>1</sup> The IEA/OECD and IPCC studies focus mainly on technologies aimed at reducing GHG emissions, the CESST and WBCSD reports cover a range of environmental goods and services in the areas of air and water pollution control, solid waste treatment, water conservation and agriculture, and environmental management.

takes into account the case studies and findings of the 1992 report by the OECD, *Trade issues in the transfer of clean technologies*<sup>2</sup>, a survey to examine the role of trade-related policies and practices in the transfer of clean technologies.<sup>2</sup> Except for the examples in the 1992 OECD study, none of the case studies focussed specifically on trade issues.

## **Some key aspects of EST transfer**

### ***What are environmentally sound technologies?***

Environmentally sound technologies have been defined in Agenda 21 as follows:<sup>3</sup>

“Environmentally sound technologies protect the environment, are less polluting, use all resources in a more sustainable manner, recycle more of their wastes and products, and handle residual wastes in a more acceptable manner than the technologies for which they were substitutes.

Environmentally sound technologies in the context of pollution are “process and product technologies” that generate low or no waste, for the prevention of pollution. They also cover “end of the pipe” technologies for treatment of pollution after it has been generated.

Environmentally sound technologies are not just individual technologies, but total systems which include know-how, procedures, goods and services, and equipment as well as organizational and managerial procedures. This implies that when discussing transfer of technologies, the human resource development and local capacity-building aspects of technology choices, including gender-relevant aspects, should also be addressed. Environmentally sound technologies should be compatible with nationally determined socio-economic, cultural and environmental priorities.”

The concept of environmental soundness is relative and normative. The term implies that the chosen technology fulfils goals other than facilitating a given industrial, regulatory, commercial or domestic process, and provides benefits or utility more broadly than solely to productivity (UNCTAD, 1997a). It is an evolving concept: a technology that reduces use of resources or pollution today may be relatively “dirty” in a few years, as more advanced technologies become available. Maintaining today’s cleaner technologies for an inappropriate length of time on lists of favoured goods (e.g. benefiting from tax breaks or tariff preferences) could therefore delay innovation or distort investment and trade decisions towards relatively less clean processes than those that become available with innovation and technological progress (OECD, 2001b).

### ***What are the differences between EST transfers and other transfers?***

Neither the literature nor the case studies examined in the framework of this report show significant differences between the transfer of EST and of other technologies. A few differences exist, for example, in regard to the main drivers for the development and transfer of technologies, financing and location of research and development (R&D) laboratories, but they do not seem to affect trade-related aspects of transfers. The main differences are briefly explained below, and summarised in Table 1.

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<sup>2</sup> The study examined a number of internationally traded technologies, in order to establish whether (and to what extent) trade-related policies and practices actually interfered with the transfer of these technologies. The research for that study involved extensive interviewing with the major exporters and importers.

<sup>3</sup> Agenda 21, Chapter 34.



The framework for the introduction of EST is highly regulatory, ranging from legislation on waste and wastewater treatment to CFC substitution following adoption of the Montreal Protocol. EST therefore requires a broad scope and focus to assess appropriateness and success. This scope must include not only the needs (environmental and other) of the end consumer, but also designated environmental goals as dictated by various stakeholders - primarily, governments. In some cases, the requirements of private providers and end users of technology may not match the aspirations of the government of the country receiving a technology. In the case of EST this might occur because the criterion for success is broader at government level. The United Nations Environment Programme (UNEP) and the International Energy Agency (IEA) have pointed out that “few countries will choose a more expensive technology if its only benefit is avoiding the potential adverse effects of climate change. Yet such technology can provide associated benefits, such as reduced air and water pollution.” These benefits are not always immediate or demonstrable. Equally, they might have a longer lead time than would be acceptable if public benefits were not involved. (IEA/OECD, 2001).

Compared with technology transfer in general, EST transfer is more reliant on public funds than on private investment (IPCC, 2000). Therefore the general trend away from public sector to private-sector finance for channelling technology is likely to have a disproportionate impact on EST. Least developed countries (LDCs) still rely more heavily on official development assistance (ODA) for all kinds of technology transfer than other countries, and even more so in the case of EST (IEA/OECD, 2001).

Unlike other types of technology, EST often necessitates public “seed” funds as incentives for companies to initiate EST-related research and development. In addition, many EST are developed and commercialised by small-and-medium enterprises, which must often rely on support structured to develop markets, both domestically and in other countries (UNCTAD, 2000).

Further, EST is most often highly localised in its application. That is because countries’ physical environments differ widely, as do modes of human interaction with the physical environment. These modes, in turn, are enmeshed in social customs and culture. This specificity means that to be successful, EST must be adapted to suit local environments and cultures.

**Table 1. Similarities and differences between EST and other technologies**

	<b>EST</b>	<b>Other technologies</b>
Main drivers	Regulation, public policy multilateral environmental agreements	Market forces: demand, competition, production bottlenecks, etc.
Finance	Public funding is important	Largely private funding, including reinvested earnings, venture capital and sale of stocks.
Location of R&D	Mainly in universities, public R&D institutes and laboratories	Mainly enterprise-based
Mechanisms for transfer	Transfer to private sector; emerging role of public-private sector partnerships (e.g. university-enterprise co-operation)	New structures through inter-firm R&D collaboration as well as partnerships of firms with public R&D
Commercialisation	Increasingly private; many SMEs involved; need for support structures and incentives	Generally, private
Application	Often site-or location-specific applications, some EST could be applied globally (e.g. CFC substitutes)	Increasingly global
Transfer to developing countries and countries with economies in transition	Private commercialisation; ODA; sometimes with funding from multilateral sources (e.g. Multilateral Fund under the Montreal Protocol, GEF)	Almost exclusively through private commercialisation

Source: based on UNCTAD (2003).

## Main channels for technology transfer

There are three basic ways for a firm to exploit its technologies abroad, and consequently, three different ways for countries to acquire technology (OECD, 2002). These channels are closely interrelated and support each other.

- Through *trade*: international technology transfer through trade occurs when a country imports higher-quality (than it can produce itself) intermediary goods to use in its own production processes. The study by Hakura and Jaumotte (1999), referred to in OECD (2002), using data from 87 countries, concludes that trade indeed serves as a channel for international technology transfer to developing countries. It would appear however that intra-industry trade plays a more important role in technology transfer than inter-industry trade. Intra-industry trade is more pervasive among developed countries, and inter-industry trade is more prominent in trade between developed and developing countries. Hence, an immediate implication of their findings is that developing countries will enjoy relatively less technology transfer from trade than developed countries.
- Through *investment*: a firm can set up a foreign establishment to exploit the technology itself. FDI is the most important means of transferring technology to developing countries. Technology transfer through FDI generates benefits that are unavailable when using other modes of transfer. For example, an investment not only comprises the technology but also includes the entire “package”, such as management experience and entrepreneurial abilities which can be transferred by training programmes and learning by doing. Further, many technologies and other know-how used by affiliates of multinational enterprises (MNE) are not always available in the market, but only through the MNE itself. And some technologies, even if available in the market, may be more valuable or less costly when applied by the firm that developed them rather than by an outsider.
- Through *licences*: a firm may *licence* its technology to an agent abroad who uses it to upgrade its own production. Successful penetration of foreign markets can seldom be based on exports alone. Various tariff and non-tariff barriers, government policies or the general investment climate can make exporting a costly option. Also, for certain industry sectors, notably in services, trade can be a complicated means to exploit a firm’s superior technology or management capabilities overseas. In those cases, a firm may choose to licence its technology to a local firm.

### Box 1. Main channels of technology transfer through FDI

The main channels by which technology transfer through FDI occurs, either directly or indirectly through spillovers include:

*Vertical linkages*: MNEs may transfer technology to firms that supply them with intermediate goods, or to buyers of their own products.

*Horizontal linkages*: local firms in the same industry or phase of the production process may adopt technologies through imitation, or are forced to improve their own technologies due to increased competition from MNEs.

*Labour migration*: workers trained or previously employed by the MNE affiliate may transfer their knowledge to other local firms when switching employers or when setting up their own business.

*Internationalisation of R&D*: the R&D activities of MNEs, when located abroad, may contribute to creating local knowledge generation capacity arising from the partially public good characteristics associated with these activities.

Source : OECD (2002)

***Technology transfer through trade in goods and services***

Technology is comprised not only of “hardware” elements – such as machinery and equipment involved in the production process, but also “software” elements – including knowledge of science and technology, skills, know-how and related organisational and institutional arrangements, as well as the goods or services resulting from the process. When these elements are bought and sold outside the boundaries of the firm, they represent technology flows through goods and services (UNCTAD, 1997a).

Technology transfers through goods and services are linked in many ways. At a simple level, a piece of hardware is unlikely to be easily adapted without accompanying manuals or training, and equally, training in industrial processes assumes some kind of access to hardware. Four different modes for technology transfer through trade are outlined through examples in table 2 below. These examples also demonstrate the importance of linkages between goods and services.

*How can liberalisation of goods and services trade benefit transfers of EST?*

Difficulties in defining EST add to the difficulties of defining environmental goods and services. One problem, for example, is dual motivation, which is intrinsic to many kinds of cleaner technologies. Examples from the chemicals industry include the use of mixers to reduce sludge formation in storage vessels, leak detection, cleaning of heat exchange tubes and better reaction control to eliminate hot and cold spots or to speed reaction. This option can be more economical than end-of-pipe measures, and, since pollution is managed here as another kind of resource use, reducing the costs of (polluting) resources will be factored in along with the costs of other resources. In such cases it is difficult to distinguish environmentally motivated changes from those motivated by economic savings (OECD, 2001a).

**Table 2. Modes of technology transfer through trade**

Mode	Import of goods	Import of services
Transfer of techniques	Operating skills and techniques for efficiency for blast furnace hot stoves were provided in training courses for operators in China, using capital equipment imported from Japan. The process can be adapted to existing furnaces with adequate training and access to capital goods. (IPCC, 2000).	A GEF program provided funding to developing countries to purchase training in techniques from Dutch energy consultants, who provided workshops on efficient lighting (IPCC, 2000).
Transfer of designs and patterns	The Ministry of Environment and Forests in India, funded in part by German and Swiss aid, purchased capital equipment to produce ozone-friendly fridges under the "Ecofrig" project. The equipment was exempted from all customs and excise taxes (IPCC, 2000).	Under favourable financing policies, Totalgaz exported 6kg bottles of butane and stoves to Senegal, where this reduced deforestation and charcoal use. Stoves were designed for local needs in a close exchange of services between Total's foreign engineers and local providers, supporting Total's market (IPCC, 2000).
Transfer of technical information	In India tax incentives were provided for imports of wind energy capital goods, and tariffs on the import of wind turbines were lifted. Imports prompted joint-venture partnerships between foreign and local manufacturers, through a range of different business models, for the provision of technical information relating to the maintenance of imported and locally produced turbines (IEA/OECD, 2001).	The Swedish Government provided financing for technical assistance services for heat-supply companies in the Baltic region that were seeking to outsource the supply of bio-fuel energy domestically. Technical assistance included teaching companies how to issue tenders, evaluate bids, negotiate bio-fuel supply contracts and operate converted boilers (IPCC, 2000).
Sharing of research results	The European Commission-ASEAN COGEN program brings together industrial sectors of South East Asian countries and European suppliers of co-generation equipment to promote the benefits of co-generation. COGEN helped advance the Chia Meng Rice Mill co-generation project in Thailand. COGEN linked buyers and sellers of co-generation technology through a network of national teams. In the case of the Thai plant, demonstrations were carried out to show the technical reliability of the imported hardware. (IEA/OECD, 2001).	Taiheyo Cement, Japan undertook research into bamboo-fibre in reinforced cement board as a substitute for mineral and synthetic fibres with natural ones. The original research was carried out by Japanese technicians in Java, selected for its proximity to sources for bamboo, but through the purchase of technology services, Indonesian firms have "fine tuned" the technology and transferred it to bamboo forests in Colombia. Both Indonesian and Colombians have since exported the technology (IPCC, 2000).

Agenda 21 emphasised that technology transfer does not just relate to equipment or "hardware", but also to total systems and their component parts, including know-how, goods and services, equipment, and organisational and managerial procedures. The liberalisation of the global economy presents both opportunities and challenges for those seeking to encourage transfers of EST to developing countries. Greater flexibility is possible in the sourcing of knowledge and supporting finance and a much wider range of possible routes for technology are available as barriers to trade in goods and services are lowered. Liberalisation of goods and services trade can help remove barriers which inhibit EST transfer. Examples are tariffs on environmental goods, or restrictions on various modes of foreign service provision. In indirect terms, liberalisation can foster a particular competitive environment in a given economy.

Barriers to service provision are likely to create significant barriers to technology transfer, because flows of goods, services and technology are mutually reliant (Radosevic, 1999). UNCTAD (2003a) points out that “barriers to one mode translate into actual or potential barriers to other modes, but also singles out, however, potential benefits to development and technology transfer of lower barriers to GATS Mode 4 (the movement of people). The movement of natural persons supplying services under the GATS exceeds its purely static economic, trade and competitiveness benefits for developing countries. Dynamic gains for the home country are significant, because they increase investment and domestic savings, promote development of other sectors of the economy and trade, ensure transfer of technology, entrepreneurship and knowledge, and build human capacities. Under these conditions, barriers to service trade in all modes are likely to create obstacles to EST transfer.

Traditionally, the environmental services sector has not been highly export-oriented, as service providers frequently required specific knowledge of local environmental conditions (Andrew, 2003). However, due to the importance of FDI for technology transfer and the links between investment and the import of services, reform and liberalisation of services regimes is arguably among the most important tools of trade policy for promoting EST transfer.

The potential benefits of liberalisation of environmental goods and services for developing countries are the creation of new export opportunities and the promotion of imports of high-quality environmental services. Since the provision of basic environmental services requires high levels of investment and expertise, the commercial presence of foreign enterprises may contribute to increased investment and capital formation and improvements in the coverage and quality of environmental services (UNCTAD, 2003a).

### *Technology transfer through foreign direct investment and licences*

As already mentioned, the most important means of transferring technology to developing countries remains FDI. Similar to FDI, but not conferring the same level of control to the parent investor, are a range of co-operative arrangements, including joint ventures, licensing between firms, subcontracting and franchising.

#### *FDI seeking markets*

FDI drives EST transfer by seeking new markets for EST. An example of an “EST seeking a market” is the introduction of photovoltaic (PV) systems in Kenya, which began when an American engineer found a niche demand among off-the-grid consumers of electricity for whom solar PV systems were cheaper than the available alternatives. Based on this demand, an export market was built, without substantial subsidy, such that Kenya is now an internationally recognised market for PV systems (IEA/OECD, 2001). In this case, technology transfer was originally driven by investment and services trade serving a local market for technology.

An example of “FDI seeking markets for environmental goods and services” is that of seven Japanese companies which invested in Thai refrigerator production plants to produce CFC-free refrigerators for local sale. Strong domestic demand was imminent given a Thai government decision to set a target date for CFC phase-out. Three of these companies imported all the critical parts, while the other four launched a joint project with local manufacturers to assist local companies to improve reliability and to help with implementation of the CFC phase-out. With the right government signals, FDI promoted corporate leadership, which helped drive EST transfer.

Another illustration of an international investment seeking markets is that of a Japanese recycling company which invested in, and established recycling facilities in China.<sup>4</sup> As a result of the recent development of the package-recycling industry in China, the demand for waste PET bottles has increased and China has started to import waste PET bottles from Japan. Competition with Chinese buyers has become severe and made it difficult for Japanese recycling companies to collect waste PET bottles. Moreover, some Chinese local governments have also begun to establish their own collection schemes for waste PET bottles. It is also likely that China will increase its recycling of waste PET bottles in the future. Considering these circumstances, Negoro Sangyo, a Japanese recycling company that produces carpets from waste PET bottles using advanced technology and has 50% of the market share of such carpets in Japan, undertook to build an advanced carpet plant to produce carpets from waste PET bottles in China, using the latest Japanese technology. By bringing that technology to China, the company has been able to produce high quality carpets with recycled Chinese materials.

#### *FDI seeking resources*

Environmental damage tends to be highest in low-productivity operations working with obsolete technology, outdated work methods, poor human resource development and inefficient capital and energy use. MNEs can be seen as repositories of clean technologies, which can be transferred to developing economies (Sgro, 2001). Thus, MNEs with access to cutting-edge technology can drive EST transfer.

An example of this was the discovery, in 1971, of liquefied natural gas (LNG) in the Arun Natural Gas Field in rural Indonesia. Mobil Corporation developed Arun Field to process LNG for exportation to Japan and Korea as well as for use in Indonesia. In the process it created an industrial infrastructure where none existed previously (IPCC, 2000). In this case foreign investment sought a resource for local sale and export. In gaining access to the resource the company also developed a partnership to foster EST transfer.

Another example of investment seeking resources and thereby creating flows of EST and environmental goods and services is that of Taiheyo, a Japanese cement company. Taiheyo invested in research on substituting mineral and synthetic fibres in cement with natural alternatives. The research was carried out in Java, Indonesia, due primarily to its cheap and abundant supply of bamboo. Indonesian partners further adapted the technology for onward export. The initial foreign investment sought Indonesian resources; this led to EST transfer. The research effort created subsequent flows of services (Japanese experts operating with Indonesian counterparts in Java) and of goods, in the form of natural fibre cement exports to Columbia from domestic Indonesian producers. The specificity of local environmental conditions also drove EST transfer (IEA/OECD, 2001).

#### *Technology transfer through licences*

There was a period when licensing was preferred by developing-country governments because it was perceived that FDI did not require firms to divulge enough of their technology to the host economy (Blomström and Sjöholm, 1998). More recently, the view that joint ventures and licensing are more valuable in providing cutting-edge technology has been challenged both theoretically and empirically (Ramachandran, 1993; Kokko, 1996; Smarzynska, 2000).

Licensing may be an especially economical way to transfer technology for standardised, relatively simple, and mature technologies. UNCTAD data show that transactions between parent firms and their subsidiaries in royalty and license fees account for more than 80 per cent of international technology

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<sup>4</sup> Example provided by Japan.

transactions, implying that FDI and licensing often go hand in hand. FDI also entails costs, as profits are realised on the entire package of skills, not just on the technology sought by the host economy.

### ***Factors affecting EST transfer: drivers and obstacles***

This section analyses the main factors affecting EST transfers, as reflected in a range of case studies. In some circumstances these factors can have positive effects, and thus *drive* technology transfer, in other circumstances, they may constitute *obstacles* to technology transfer. Among these factors, only a few are directly relevant to trade. However these cannot be easily dissociated from other factors which are quoted in the literature and appear in the case studies as being relevant to all kinds of technology transfer, such as access to information; adequate capacity; and access to financing.

### ***Access to information***

Adequate information about the performance of technologies, processes and equipment, with specific references to the environmental and financial benefits, are the necessary first step towards technology transfer. However, often, lack of information and understanding of skills and infrastructure required for the successful operation of systems using transferred or acquired technologies result in sub-optimal performance (IPPC, 2000).

Access to information in developing countries is often poor. Lack of adequate information in developing countries has distorted the selection of appropriate EST by governments and end users, has restricted training in the use and marketing of EST, and has hampered the development of public and private partnerships to support EST transfer (UNCTAD, 1997a). Lack of information among multilateral bodies and donor parties about the needs of technology or aid recipients also creates obstacles to technology transfer (IEA/OECD, 2001). An inadequate assessment of the needs of the consumer of a technology can result in barriers to technology transfer that could have been avoided had the assessment fully captured the social and other attributes of the technology (IPCC, 2000).

Many case studies examined in the framework of this report highlight the importance of continuous information exchanges, through the whole transfer process. An example of the importance of two-way information flows is the testing and adoption of solar stoves in South Africa. Funded by German aid, project teams assessed a range of models, gauging local reactions in order to inform local production. It then supported dissemination of information surrounding the benefits of the systems among consumers. Lack of information or failure to adequately disseminate information on local needs and the technical characteristics and benefits of the stoves would have stalled the project and halted EST transfer.

Studies of Chinese environmental markets highlight the difficulties of coping with practices and requirements in the importing or host country, and stress the need to partner with local companies, or hire people with knowledge of local markets. Another recurrent problem were the difficulties for foreigners to understand and adjust to local business practices, for example in regard to tenders (CESTT, 2002). The WBCSD case studies also highlight the importance of effective communication with local partners, from the beginning and throughout the whole technology transfer process (WBCSD, 2002).

## ***Regulation and policy***

### *Environmental policies and regulation*

Many case studies examined for this report show that environmental regulation is an essential factor in the development of, and trade in, EST. Strong environmental regulation fosters the development of technologies and the creation of technology markets. It is also generally recognised that strong environmental regulation and enforcement are the main incentives for firms to acquire new technologies. Policies that extend the responsibility of producers, which are common in OECD countries and are also starting to be implemented in developing countries, are a further incentive for transfer of EST.<sup>5</sup>

At the other extreme, weak environmental regulation and enforcement is considered to be one of the main obstacles to successful technology transfer and diffusion. Low environmental standards may perpetuate existing control technologies rather than supporting innovation. This type of standard-setting can result in regulations focusing on “end-of-pipe” type pollution control technologies, and can create strong disincentives for going beyond the proven standards dictated by existing technologies (TERI, 1997). According to the IPCC, ineffective regulatory structures to support the phase-out of “dirty technologies” are a common problem for developing countries (IPCC, 2000).

A case study on alternatives to CFC use in the electronics industry shows that in countries where governments had not instituted controls on CFCs, exporters of these alternative technologies had very limited success in penetrating electronics industry markets. Indeed, many companies considered environmental regulations, or rather, the lack thereof, to be the only obstacle to exports to potential markets (OECD, 1992). Similar conclusions apply to other cases, such as the one on membrane cell technology in the chloralkali industry, where the lack of environmental controls on the level of mercury was seen as the most important obstacle to trade. The case studies on Chinese environmental markets mention the fact that fines for non-compliance with certain regulations (in this case, sulphur dioxide emissions) were very low and constituted only a fraction of the cost of investment in new technologies (for example, fines were 1-2 % of the cost of desulphurisation equipment). This constituted a clear disincentive for investments in new technologies (CESTT, 2002).

### *Government initiatives*

The role of government in providing pathways for technology transfer has changed, and is now viewed by many as helping put in place policies and measures that hasten the transfer of technologies to the private sector. According to the IPCC, the broad changes in transfer pathways have diminished the role of developed-country governments in technology transfer and cooperation. In some sectors, such as solid waste management and waste-water treatment in developing countries, technology still travels

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<sup>5</sup> Extended producer responsibility (EPR) is a policy approach in which producers accept significant responsibility — financial or physical, or both — for the treatment or disposal of products. The two distinguishing features of EPR policies are the shifting of responsibility upstream to the producer and the provision of incentives for producers to include environmental considerations in the design of their products.



predominantly along government-driven pathways. In the fossil fuel sector, improved efficiency technology is mature, and operates almost always through industry (IPCC, 2000).

Numerous case studies reflect the importance of government leadership in fostering changes to unsustainable practices and introducing new, more sustainable technologies. One example is the program by China's Inner Mongolia Autonomous Region to foster the local production and dissemination of stand-alone wind electric systems among its herding population. The regional government employed a combination of market and state planning mechanisms to create markets, adapt foreign technologies and develop a unified system of design, manufacturing and service. By the end of the 1990ies, one third of the target population was using that technology, and had avoided substantial greenhouse gas emissions that would otherwise have been produced by coal or diesel alternatives (IPCC, 2000).

Another example, reported by the WBCSD, is that of China's efforts to update its public solid waste management systems, by promoting environmentally sound and sustainable solid waste management practices. The project was intended to provide incentives for eliminating greenhouse gas emissions of methane from landfills as China develops modern solid waste disposal methods, and centred on the design and implementation of three demonstration projects to recover and utilise gas from municipal landfills (WBCSD, 2002).

Government procurement policies also have the capacity to enhance, or, on the contrary, create obstacles to, EST transfer. Governments are important purchasers of goods and services, for which, often, environmentally sound options exist. Moreover, governments, especially at regional and municipal levels, are the primary purchasers of environmental services, such as waste management and water treatment, and related technologies. Government procurement strategies that seek to promote competition and act in a transparent manner are less likely to disrupt the efficiencies of markets for EGS and related technologies (UNCTAD, 2003c). One of the benefits of public procurement policies which support purchase of "green" goods and services is that, by supporting the demand for such products, they can result in their increased diffusion throughout the economy as a whole. Further upstream, such policies can encourage innovation (OECD, 2003).

### *Multilateral Environmental Agreements*

Many Multilateral Environmental Agreements (MEAs) contain specific provisions to encourage the transfer of technologies which are necessary to comply with obligations under the Agreement or achieve its goals. Examples include the Montreal Protocol on Substances that Deplete the Ozone Layer (Article 10a), and the Convention on Biodiversity. In a range of countries, the Montreal Protocol has given impetus to technology improvements and transfer. Notable examples are India and Thailand (IEA/OECD, 2001). In both countries, multilateral commitment made it easier for governments to set tight, but still realistic, targets and provided frameworks for corporate leadership in EST transfer. Following entry into force of the Montreal Protocol, to gain access to markets in industrialised countries, Indian appliance manufacturers realised they had to produce CFC-free refrigerators. This accelerated the pace of the CFC phase-out in India, and the country developed an export market in CFC replacement manufactures, following its accession to the Montreal Protocol in 1992 (IEA/OECD, 2001).

The case study on alternatives to CFC use in the electronics industry (OECD, 1992) indicated that "due to the much higher cost of [this technology] compared with conventional cleaning using CFCs, environmental regulations governing CFC imports and consumption were considered to be the single most important factor determining the volume of trade in these technologies." Other MEAs drive technology transfer mainly by changing the relative demand for goods, services and technologies. Examples are the

UN Framework Convention on Climate Change and the Kyoto Protocol, which privilege sources of non-fossil fuel sources of energy, and have given rise to a wide range of alternative technologies.

Both IEA/OECD (2001) and IPCC (2000) contain numerous examples of technology transfer in the energy sector, aimed at contributing to combating climate change. One of them refers to a reduced-impact logging project to decrease greenhouse gas emissions in the forest of Malaysia, with financial aid from a US utility. The project aimed at demonstrating reduction in carbon emissions from logging activities. It included a variety of activities, including training in reduced-impact logging techniques; field studies for quantifying carbon storage and fluxes; development of a model to simulate changes in biomass and carbon pools following logging and a simple projection model to generate an estimate of the carbon benefit (IPCC, 2000).

### Box 2. Technology transfer in selected MEAS

The *UN Framework Convention on Climate Change (UNFCCC)* emphasizes the transfer of technology as an important element in the process of climate change mitigation. The Convention contains provisions regarding technology development, application, diffusion, and transfer, as well as financing, that are to be facilitated and promoted by the Parties to the Convention.<sup>6</sup> This commitment is echoed in similar provisions under the Kyoto Protocol.

Access to and transfer of technologies for conservation and sustainable use of biodiversity (or that make use of genetic resources) are considered essential elements for the attainment of all three objectives of the *Convention on Biological Diversity (CBD)*.<sup>7</sup> The importance of “appropriate transfer of relevant technologies” is reflected in Article 1 of the Convention and further referred to in Article 16.

Several provisions of the *UN Convention to Combat Desertification (CCD)* refer to the transfer and diffusion of appropriate technologies to developing countries. Article 12, for example, provides for international co-operation, and Article 18 calls for the “transfer, acquisition, adaptation and development of technology” as well as the facilitation of the necessary financing.

Article 10 of the *Montreal Protocol on Substances that Deplete the Ozone Layer* calls for the transfer of “the best available, environmentally safe substitutes and related technologies” to developing countries. In ODS-consuming industries, even in developing countries where eligible enterprises are receiving assistance from the Multilateral Fund established under the Protocol, the private sector, including both domestic and multinational corporations, makes substantial investments in alternative technologies on their own account for mostly economic reasons.

Source : OECD (2005)

In addition to incentives under MEAs, related initiatives have emerged that have contributed to EST transfer. For example, the Climate Technology Initiative, developed through the International Energy Agency included a variety of actions which contributed to technology transfer, including setting up national advice and technological development plans, enhancing markets for emerging technologies and promoting collaboration between States on technology research and development (IEA/OECD, 2001).

In 2002, a multi-stakeholder initiative was established to provide adequate, affordable, sustainable energy services in rural, peri-rural and urban areas in order to contribute to climate change mitigation and sustainable development, as well as poverty eradication.<sup>8</sup> The main objective of this partnership was to

<sup>6</sup> UNFCCC, Article 4.

<sup>7</sup> The three objectives of the CBD as set out in Article 1 are: “the conservation of biological diversity, the sustainable use of its components and the fair and equitable sharing of the benefits arising out of the utilization of genetic resources”.

<sup>8</sup> The partnership included the governments of one South American, 8 African, 15 European, and 2 Caribbean states; an Italian private company; 2 European NGOs; the Austrian multi-stakeholder platform

create economic, social and institutional conditions that will enable developing countries energy needs to be met while abiding with UNFCCC and other MEAs' provisions.

### *Market instruments*

It is generally recognised that adequate policy mixes involving both regulatory instruments and market based mechanisms, as well as adequate involvement of stakeholders, are key to successful environmental policies. Fiscal incentives and disincentives, and, in general, schemes that spread the cost of environmental goals through the economy play an important role in encouraging investments and imports of "clean" versus "dirty technologies". Fiscal incentives to increase the use and transfer of EST can take various forms such as the elimination or reduction of taxes on income or sales from investment, including FDI; the deferment of taxes; tax holidays; and taxation graded according to the level of environmental improvement achieved (UNCTAD, 1997a).

Switzerland submitted a Communication to the WTO Working Group on Trade and Technology Transfer which examines the Swiss experience with technology transfer to developing countries through special centres working in the field of EST transfer (WTO, 2003). According to that note, EST lead to a decrease in the use of resources such as energy, water, raw materials etc., and reduced emissions of potentially harmful substances to the environment. In countries where environmental costs are (at least partially) internalised, EST often have a positive cost-benefit ratio and their application is thus widespread. Old and "outdated" technology is therefore replaced more quickly than in other countries, where the environmental costs are not, or to a lesser extent, internalised. In the experience of the Swiss financed technology centres, it has become apparent that a gradual increase of measures aimed at internalising external environmental costs can have a two-folded positive impact: improved environment and health of citizens and increased EST transfer, and thus also benefits from spillovers to other enterprises.

Adequate resource pricing can contribute to the acquisition of better EST. The case studies on the Chinese environmental markets show that China's water supply and wastewater fees, where they existed at all, were too low even to cover operational costs, acting as a disincentive to introduce new, often more expensive technologies (CESTT, 2002).

It may sometimes be difficult, for social reasons, to raise resource prices too rapidly. In Kiev (Ukraine), transfer mechanisms led to municipally and cooperatively owned energy efficiency investments at the end-user level in public and residential buildings. The program relied heavily on "soft financing", or financing not directly for investments in efficiency, but for capacity building and facilitating institutional learning. Raising energy prices to reflect their real costs could have hastened the need for EST transfer. However, in this case, an entirely market-based approach to technology transfer was not socially or politically acceptable, since it would have involved raising electricity rates too quickly. Instead, the process of market reform needed to carry an acceptable political and social cost (IPCC, 2000). Furthermore, according to the IPCC, "although the private-sector pathway is one of the key channels for the transfer of EST, it should not be assumed that the search for economic gains on the part of individuals and firms will guarantee adoption of best-practice techniques."

Institutional capacity is vital if regulations and market instruments are to operate effectively (IEA/OECD, 2001). For tax disincentives to operate effectively requires political commitment of the enforcing authorities; availability of information for decision-makers on technological hazards; a capability to adapt the available information to regional and local conditions; and bilateral and multilateral

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'Global Forum on Sustainable Energy'; and 3 intergovernmental organisations, and was led by the European Commission.

cooperation between countries and development agencies to share information and experience as well as to coordinate specific actions and policies to avoid “pollution havens” or unilateral trade protectionist measures (UNCTAD, 1997a).

### *Voluntary approaches*

A number of corporate codes of practice encourage the transfer of technologies to host countries. Governments also increasingly encourage transfers of technology and know-how by the private sector as a way to complement government efforts and contribute to sustainable development and capacity building. The OECD Guidelines for Multinational Enterprises for example encourage business practices that permit the transfer and rapid diffusion of technologies and know-how (see box 3 below). Other initiatives aimed at enhancing corporate responsibility are the UN Compact and the ICC Business Charter for Sustainable Development. The latter’s “Principles for Environmental Management” encourage enterprises to “contribute to the transfer of environmentally sound technology and management methods throughout the industrial and public sectors.” Similarly, Principle 9 of the UN Global Compact provides that “Businesses should encourage the development and diffusion of environmentally friendly technologies”.

#### **Box 3. Technology transfer in the OECD Guidelines for MNEs**

The OECD Guidelines for Multinational Enterprises, which adhering countries are committed to promote, stipulate that “enterprises should:

- endeavour to ensure that their activities are compatible with the science and technology (S&T) policies and plans of the countries in which they operate and, as appropriate, contribute to the development of local and national innovative capacity;
- adopt, where practicable in the course of their business activities, practices that permit the transfer and rapid diffusion of technologies and know-how, with due regard to the protection of intellectual property rights;
- when granting licenses for the use of intellectual property rights or when otherwise transferring technology, do so on reasonable terms and conditions and in a manner that contributes to the long term development prospects of the host country .”

*Source* : OECD (2000)

One example of enhanced corporate social responsibility contributing to EST transfer is that on integrated crop management capacity building in Brazil and Guatemala, reported by the WBCSD. One of the main driving forces behind the development of the project, which included extensive training to local staff in new techniques, was the supplier’s corporate strategy and its commitment to “Responsible Care” (a voluntary code of conduct developed by the chemicals industry) principles and approaches (WBCSD, 2002).

Partnerships between governments and business (public-private partnerships) are also opening new avenues for technology transfer. For example, the US Environment Protection Agency’s “Green Lights” project in Poland relies on a voluntary approach to encourage public and private institutions to enter into partnerships. Corporate and government partners agree to invest in 90% of profitable lighting efficiency upgrades within five years. Partners appoint implementation managers and submit annual progress reports. “Green Lights” also recruits utilities and lighting companies to become certified allies. “Green Lights” has

over 1600 partners (85% corporate, 15% government) and 594 allies (41% manufacturers, 25% distributors, 21% lighting management companies, and 14% utilities). The agreements have helped to stimulate demand for efficient lighting and for other energy-efficiency products and related services (IEA/OECD, 2001).

### *R&D and industry policies*

Governments of countries that are recipients of technology transfer have an important role in providing positive and productive industry policies to drive EST transfer. Encouraging appropriate technologies, supporting their adoption, and harnessing competition in their supply can drive EST in the private sector.

Thailand's decision in the early 1990s to replace T12 with T8 tubular fluorescent lamps was motivated by the need to reduce electricity consumption at a time when adding new electricity generating capacity would have been costly. Having identified improving energy efficiency as the least-cost option, the Thai cabinet in November 1991 gave the Electric Generating Authority of Thailand (EGAT, a state-owned generation and transmission utility that provides power for the electricity needs of Thailand's 60 million inhabitants) the legal mandate and authority to pursue a National DSM (Demand Side Management) Master Plan. DSM activities seek to meet energy needs by influencing customer demand rather than by building new supply. EGAT was keen to avoid subsidy programs and instead sought to rely on voluntary agreements, market mechanisms, and intensive advertising and public education campaigns. EGAT concluded that the best course of action was to convince all five local manufacturers (Asia Lamp, Daichi, Philips, Saffi, and Toshiba) and the one importer (Osram) to switch their production from T12 to T8 lamps. In September 1993 a Memorandum of Understanding (MoU) was signed between the Thai Prime Minister, the Chairman of EGAT, and the presidents of each of the five manufacturers, in which the latter committed to retool their production from T12 to T8s within two years. In return, EGAT promised to support the manufacturers through a USD 8 million public awareness campaign (IAEEL, 2000).

In addition to identifying long-term environmental priorities and enabling markets, publicly funded R&D and the training of scientists and engineers has contributed to the effective functioning of national innovation systems. Some experts view cooperative and coordinated research efforts between public centres for research and private sector vital to promoting positive outcomes in EST since "many public environmental sound technologies 'remain on the shelves' and are not brought into the market as rapidly as may be expected" (UNCTAD, 1998; IPCC, 2000).

### *Privatisation and decentralisation*

Privatisation can be effective in promoting market-led EST transfer. For example, El Salvador's electricity law reform in 1996 led to increased opportunities for profitable private-sector driven EST transfer, opening the door to privatised electricity production, transmission and distribution, where previously these functions had been the exclusive domain of the state-owned enterprise. Among other things this created profitable opportunities for co-generation from biomass. The proceeds from privatisation were used to provide new incentives to energy projects (IEA/OECD, 2001).

Another example of market reform driving EST transfer is the case of Brazil. The central government's attempts to deliver reduced-cost or free energy to remote rural areas failed due to insufficient resources. The government then pursued a strategy of decentralisation, where the relevant government body provided market co-ordination to facilitate private investment. Funds saved were redirected towards projects in the poorest communities to strengthen institutional capacities. Under these regulatory conditions

private operators found profitable opportunities for non-fossil fuel energy provision and EST transfer (IEA/OECD, 2001).

### *Trade-related policies and practices*

Trade policy can influence the transfer of EST directly in various areas. A number of provisions in the WTO agreements mention the need for a transfer of technology to take place between developed and developing countries (e.g., Art 66 of the TRIPS Agreements). However, it is not clear how such transfer takes place in practice and if specific measures might be taken within the WTO to encourage such technology flows. In the Doha Declaration, Ministers agreed to examine the relationship between trade and transfer of technology and any possible recommendations on steps that might be taken within the mandate of the WTO to increase flows of technology to developing countries. These discussions are taking place in the Working Group on Trade and Technology Transfer.<sup>9</sup> The remainder of this section briefly discusses the role, for technology transfer, of tariffs, trade-related investment measures and subsidies.

#### *Tariffs*

Tariffs raise the cost of environmental goods imports and the costs of related products, including those linked to environmental services. Conversely, lower tariffs can influence the transfer and use of EST by lowering their price relative to other technologies in the importing country. The importance of lowering tariffs on environmental goods and services has been recognised in the Doha Declaration, where Ministers agreed to negotiations on the reductions or elimination of tariff and non-tariff barriers to environmental goods and services.

The impact of tariffs and other cost factors on technology transfers seems to vary across markets, and will largely depend upon the tariff levels applied.<sup>10</sup> Several case studies on the Chinese environmental market indicated that high tariffs were a major problem for importers of EST (CESTT, 2002).

Some case studies show the positive impact of tariff reduction on technology transfer. One example is the case of Kenya. In 2000 the Kenyan Minister for Finance committed to reducing duties and value-added taxes on solar modules and panels to zero. This contributed to the ease with which related technology was imported and the profitability of operations, where cost margins between less environmentally benign alternatives were small (Duke, 2002). In 2001 Kenyan manufacturers made more than 90% of the batteries used in local solar home systems, 30-50% of the lamps and around 10% of the charge regulators (Hankins, 2002). A range of products that are traditionally used in conjunction with solar home systems, such as batteries, charge regulators, inverters and efficient appliances, were still charged duty in excess of 35%, as a hangover from the days of import substitution (Hankins, 2002). The import duties on battery powered lights of 12 to 24 volts are charged at 25%, which was also the rate applicable to

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<sup>9</sup> The WTO Working Group on Trade and Technology Transfer has discussed various papers dealing with issues of relevance for this report. "Trade and technology transfer" (WT/WGTTT/W/1) for example analyses the relationship between trade and technology diffusion, and other forms of technology transfer. "A taxonomy on country experiences on international technology transfers" (WT/WGTTT/W/3) provides an overview of policy tools and approaches to favour technology transfer, and includes case studies of successful technology transfers to developing countries. Switzerland recently submitted a Communication on "Creating incentives for the transfer of Environmentally Sound Technologies" (WT/WGTTT/W/7).

<sup>10</sup> The OECD (2001a) describes average tariffs of 10-12% (with cases of 3%) on environmental goods and services in some countries (the Quad countries), and of 18% in others (emerging economies) with peaks up to 100- 150% in some of them (e.g., in India).

lights which are mains-powered. Several leading solar home system (SHS) companies in Kenya successfully petitioned the Ministry to lower tariffs on both PV panels on related goods. Kenya has since developed a recognised export capacity in various inputs for solar home systems (IPCC, 2000).

#### *Trade-related investment measures*

The private sector is likely to be the major engine of technological innovation within an economy and the major conduit through which technology is transferred. Policies which foster competition and the reduction of barriers to market entry are likely to create conditions for the development and transfer of EST. Examples of such barriers include multiple procedures for registration of foreign companies, or national content requirements. To spur private investment in clean technologies, developing countries need to establish a favourable enabling environment. Examples of such measures include facilitating registration of foreign companies in host countries.

Investment liberalisation has been and remains an engine for economic growth and for integrating developing economies into the world economy (OECD, 2001b). For these benefits to be realised, appropriate social, economic and trade policies are also needed. While there is no multilateral agreement on investment in place, the WTO Agreement on Trade Related Investment Measures (TRIMs) deals with the impact of regulatory requirements made on investment and relating to trade flows. A range of bilateral and regional trade agreements and investment agreements cover border measures influencing the trade effects of investment rules.

A key benefit of trade policy reform such as that initiated by TRIMs and investment chapters in regional trade agreements is that they seek to lessen discrimination against the activities of foreign investors, notably, by restricting policies that tie foreign investment to quotas on local inputs or to a certain level of foreign export. The TRIMs Agreement recognises that certain investment measures can cause trade restrictive and distorting effects (UNCTAD, 2003b). The Illustrative List of Inconsistent Measures in the Annex to the TRIMs Agreement includes measures which require particular levels of local purchases or which restrict the volume or value of imports that an enterprise can purchase or use to an amount related to the level of products it exports.

Generally speaking, adherence to the principles of TRIMs seems likely to enhance the performance of firms where they are operating as vehicles for globally competitive low-cost EST (Sgro, 2001; IPCC, 2000; Zarrilli, 2003). TRIMs and similar agreements promote non-discrimination, lowering transaction costs on MNEs' integrated import and export processes and promoting efficiency in trans-national production. Since MNEs remain a vital vehicle for EST transfers through trade, investment policies and measures in recipient countries that discourage unnecessary discrimination between foreign investors are likely to support EST transfers.

The investment chapters in regional agreements, such as NAFTA, aim to defend the rights of the foreign investor, increasing the predictability of investment, and thereby potentially encouraging higher quality technology to be transferred through intra-firm imports of goods and services (Caves, 1986; Mueller and Schnitzer, 2003).

Some case studies reflect that certain investment-related measures constituted problems for technology transfers. For example, in the case studies dealing with markets in China, among the major problems were licensing requirements, *i.e.*, difficulties for obtaining a licence to operate in the country (CESTT, 2002).

### *Subsidies*

Subsidies used to encourage the diffusion of environmental goods have proven helpful in promoting EST transfer (IPCC, 2000; IEA/OECD, 2001). Any such subsidies have to be in conformity with the country's international obligations, including trade disciplines. According to IPCC (2000) and IEA/OECD (2001), the most effective subsidies are those that have allowed for competition among firms and those that support product development (market support, information and training), rather than production. Trade policy that increases competition by reducing discriminatory subsidies will enhance the competitive environment for foreign investors seeking to import goods, leading to lowest cost solutions to technology needs and transfers of higher-quality EST (UNCTAD, 2003b; IPCC, 2000).

The literature suggests that subsidies that promote EST can be either an enabling mechanism or a potential barrier to EST transfer. Some authors consider that, as a barrier they have "spoiled a market for a new technology" through perpetuating dependency, "resulted in an inferior product by stifling competition", or otherwise "blocked market forces from operating properly" (IPCC, 2000; Barnes *et al.*, 1994; Kammen, 1995a,b). Government support for a particular sector or industry that distorts the value of its output can blunt the incentives producers have to lessen the environmental impact of that industry. This can make producers less likely to react to changing environmental conditions, and less receptive to EST.

The IPCC study reports numerous examples where subsidies have risked fostering long-term economic dependency on subsidy or other support mechanisms. It also noted that subsidies that have created most of these problems are those that provide direct cash payments, or were on-going, or were not targeted to correct a specific market imperfection. Where fiscal incentives are provided to promote a given EST, experience suggests this should be done in a transparent way, promoting competition between private-sector operators (IEA/OECD, 2001; UNCTAD, 2003b).

### *Intellectual property rights*

A large range of EST are in the public domain, but many others are covered by some kind of intellectual property right (IPR). IPRs may play an important role in ensuring economic returns to investors, including research and development resources that have been devoted to developing and improving a technology, and enabling its transfer and diffusion.<sup>11</sup> Generally speaking, IPR regimes that are too weak to protect initial ownership over technology can discourage transfer of EST, and thus constitute a barrier. Equally, IPR regimes that provide too extensive a monopoly on a given technology can limit the diffusion of that technology. It has also been argued that, if technologies are imported, and protected too strongly, the importer will not be able to lay its own technological groundwork (Magic, 2003).<sup>12</sup>

Regimes for IPR tend to vary widely, especially between developed and developing countries, due to differing interests, cultures and administrative capacities. Industrialised countries (which are the main exporters of technologies) tend to see IPR as a primary means for promoting technology development by offering inventors protection to reap the benefits from their invention. Developing countries are more concerned to access existing technologies at affordable costs, and to make them more widely available. Consequently, developing countries tend to have far weaker IPR laws than industrialised countries (IPCC, 2000; UNCTAD/ICTSD, 2004).

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<sup>12</sup> According to Magic (2003), 80-85% of patents in developing countries are held by persons foreign to that country.



The 1994 Agreement on Trade Related Aspects of Intellectual Property (TRIPS) is leading to increased homogeneity of laws among Parties in accordance with minimum standards, while at the same time ensuring that incentives are put in place to ensure technology transfers to least developed countries (Box 4).

#### **Box 4. Technology transfers and TRIPS**

According to Article 7 of the TRIPs Agreement, “the protection and enforcement of intellectual property rights should contribute to the promotion of technological innovation and to the transfer and dissemination of technology, to the mutual advantage of producers and users of technological knowledge and in a manner conducive to social and economic welfare, and to a balance of rights and obligations.”

Under Article 66.2, “developed country Members shall provide incentives to enterprises and institutions in their territories for the purposes of promoting and encouraging technology transfer to least-developed country Members in order to enable them to create a sound and viable technological base.”<sup>13</sup>

The actual effect of IPR regimes on EST transfers is difficult to measure, and there is a lack of empirical data to support the literature. In none of the case studies done by OECD in 1992 did IPRs appear to constitute an obstacle to technology transfer. Some of the case studies examined in that report observed that there are many environmental technologies available that are not protected by patents, so intellectual property regimes are not relevant to much of the volume of clean technology transfer. They also indicated that even when clean technologies were under patent, these patents were not a major concern either to importers or exporters. In general, exporters were willing to accept the risk of patent infringements, the reasoning being that technological development were moving so quickly that by the time a competitor can effectively copy a particular process, the technology is likely to have been overtaken by new technologies. Importers of patented technologies did not generally find royalty fees to be a major obstacle, and were more concerned about other costs, such as that of capital investments in new plants and machinery. Other case studies, such as those on environmental markets in China (CESTT, 2002) mention IPR infringements as a problem, though they are not characterised as a major obstacle. One example is that of a German company introducing solid waste management equipment and technology, where counterfeit products manufactured by competitors were a problem.

A recent study analyses the manner in which multinational firms facilitate technology transfer from industrialised countries to “countries just removed from the world’s technology frontier”, and the role played by the latter’s IPR policies. It concludes that “stronger IPRs encourage firms to prefer overseas production due to the expanded protection of their ownership advantage. Different firms choose different modes of entry due to their relative sensitivity to protection. Firms with natural barriers to imitation tend to choose licensing, and vulnerable firms choose FDI, but stronger IPRs may cause substitution between these modes. Not only is there an increase in FDI and licensing with stronger IPRs, but also a change in the composition of technology transfer.” (Nicholson, 2003)

<sup>13</sup> In the Doha Declaration, Ministers reaffirmed “that the provisions of Article 66.2 of the TRIPS Agreements are mandatory” and agreed that the TRIPS Council should put in place a mechanism for ensuring the monitoring and full implementation of that obligation. A decision adopted by the TRIPS Council in February 2003 lays down practical ways of implementing Article 66.2 of the TRIPS Agreement and provides for developed Member countries to submit reports on actions taken or envisaged to provide incentive to enterprises and institutions in their territories for the promotion of technology transfer to least-developed countries.

Another recent, more empirical, study examines how technology transfer among US MNEs has changed in response to IPR reforms undertaken by various countries (Branstatter *et al.*, 2004).<sup>14</sup> It uses affiliate-level data on US MNEs and aggregate patent data to test whether legal reforms that strengthen IPR regimes result in increases in technology transfers to reforming countries. The results provide strong evidence that US multinationals respond to such changes in IPR regimes abroad by increasing technology transfers. The results of the study are however not sufficient to demonstrate that IPR reforms are welfare-enhancing for the reforming countries. For example, it does not consider the impact of reforms on locally owned firms that may be displaced after reforms, nor does it examine the effects of the reforms on the pace of innovation in non-reforming countries.

Much research and development of new EST is done within the realm of public institutions. However, according to UNCTAD (2000), only a small proportion of EST resulting from publicly funded R&D are patented, commercialised or transferred. Among the reasons are costly and lengthy procedures for obtaining patent rights, the lack of knowledge about business aspects of technology development, and the absence of an incentive structure conducive to commercialisation. Consequently, relatively few of the technologies generated in public R&D institutions reach the development and transfer stages.<sup>15</sup>

### *Capacity*

Lack of capacity has been cited as one of the main obstacles to the successful transfer and absorption of EST. This includes, *inter alia*, lack of capacity to enact and enforce regulations, lack of information about local needs and adequate available technologies, lack of skills to use and diffuse the technologies, and lack of financial capacity to acquire technologies. Capacity needs in this context can be seen in a broad sense, including capacity to adopt and enforce adequate environmental legislation and intellectual property protection, to put in place investment incentives, etc. In a narrower sense, it includes capacity by governments and industry to understand the need for, and foster the introduction of new, more environmental friendly technologies and production processes.

Capacity is also required for producers to switch from known or traditional technologies to new, less polluting ones. The OECD (1992) cites the case of the leather tanning industry. Many tanners strongly resisted to abandon established technologies that produced a quality of leather that consumers had come to expect, and were unwilling to switch to other processes that produced a different result, be it merely optical, from what they were accustomed to. Moreover, many tanneries in developing countries are small to medium scale family businesses; tanners in these countries often have little or no formal education and use traditional methods which they have learned from their elders. Thus it was difficult to convince tanners to move toward more environmentally-friendly processes, even where no extra cost was involved.

Capacity is also a determinant for the absorption and diffusion of technologies. Often, environmental technologies (*e.g.*, waste and water treatment technologies) are acquired by municipalities, and, in many cases, officials in charge of purchases have little knowledge or expertise in environmental technologies. Thus it happens that municipalities only consider the price without taking into account the value added of more efficient technologies (CEST, 2002).

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<sup>14</sup> The study analyses the effects on US MNEs of IPR reforms undertaken in 12 countries over the 1982-99 period.

<sup>15</sup> Chapter 34, paragraph 34.18(a) of Agenda 21 states that "Governments and international organisations should promote the formulation of policies and programmes for the effective transfer of environmentally sound technologies that are publicly owned or in the public domain."

Lack of skilled personnel has hampered the uptake or upkeep of EST in developing countries. The IPCC (2000) reports on a World Bank/GEF project to fund alternative energy in India. After-sales service was vital in helping to maintain PV panels and their related hardware. The lack of skilled personnel limited the capacity to maintain the machines. The result was confusion among brands and very low expectations of the technology from consumers. Similarly, one of the problems mentioned in the case studies on Chinese environmental markets was the lack of knowledge of the technologies by local purchasers (CESTT, 2002).

When technology transfer is accompanied by capacity building efforts, the result is generally satisfactory, and numerous case studies show the importance of adequate training and technical assistance to enhance local capacity to absorb new technologies. One example is that of electrification in shantytowns in Casablanca, Morocco, where the technology supplier also provided the necessary training to local electricians to keep the new system up, and put the appropriate equipment at their disposal (WBCSD, 2002). Another example is that of the installation of municipal solar infrastructure in the Philippines, where social preparation and capacity building activities were vital for the success of the project. Training was provided at all levels, including local employees (WBCSD, 2002).

#### *Development assistance and technology co-operation*

Several countries have put in place initiatives under national development programmes to facilitate the transfer of EST to developing countries. For example, Japan's initiative for mitigating global warming (the "Green Initiative") aims at promoting and accelerating the introduction and dissemination of technologies for energy-saving and non-fossil fuel energy technologies in developing countries. Canada has signed a number of Memoranda of Understanding on Environment Cooperation with other countries which have contributed to facilitating specific projects, some of which involve EST transfer. One of these projects, called "Watershed Management 2000" involves a broad range of support measures to improve water management and treatment in the State of São Paulo, Brazil (UNCTAD, 2000).

The Technology Co-operation Agreement Pilot Project (TCAPP) is a US-Philippines bilateral initiative fostering the implementation of non-fossil fuel energy sources. From 1997 to 2000 the TCAPP has identified technologies, suggested policy reforms, assisted in organising and disseminating information on renewable energy sources and provided technical assistance for project development. While funded by the US government, through the Department of Energy, the project operates on the premise that "technology transfer must be driven by host-country needs", and "harnesses the power of the private sector" (IEA/OECD, 2001). Thus the link between assistance funds, local demand for technology and private sector involvement lies at the cornerstone of the project.

The German aid arm, Gesellschaft für Technische Zusammenarbeit (GTZ) has provided research assistance in Africa to promote solar stoves as an alternative to traditional fuels in South Africa. GTZ reported to the German Development Co-operation Ministry on whether various stove models were appropriate for widespread adoption. This approach to aid is targeted to particular needs: that of assessing the potential market for a given technology, and what modifications might be required to adapt the technology to local conditions. Assistance funds drove EST transfer through market development (IEA/OECD, 2001).

Some regional and bilateral trade agreements and co-operation arrangements also provide for measures to enhance technology transfer between partners. One example is APEC, which emphasises the importance of co-operation in science and technology, including technology transfer, in order to achieve

the aim of contributing to sustainable development.<sup>16</sup> However, few such agreements (including environmental side agreements) refer specifically to facilitating the transfer of EST between partners.

### *Financing*

Lack of financial resources to acquire technologies is frequently reported as a primary barrier to technology transfer, including that of EST. In addition, high financial risks may also be a deterrent for potential investors. For example, typical barriers to financing renewable-energy and energy efficiency projects are that investors lack experience in the relevant areas and so are overly cautious; domestic capital markets in developing countries are weak; small and medium-sized businesses often have poor credit ratings and risk profiles; energy-efficient equipment often has little value as collateral; and long-term loans are rarely granted in this area (IEA/OECD, 2001).

Sometimes projects are overlooked because the risk prospect of a new technology will be carried disproportionately by a small number of investors (UNCTAD, 1997a). An example is technology for utilising local biomass fuels in the Baltic States, which was transferred from Swedish firms to local Baltic heating enterprises. While the projects were considered “highly viable from an economic and financial perspective”, they were too costly for direct investment by the small number of suitably placed private firms in the recipient economies. Instead, financing relied on the Swedish government, through the Swedish National Board for Industrial and Technical Development (IPCC, 2000).

In a number of technology transfer cases, specific financing mechanisms were developed to ensure absorption of the technology. Examples include micro-financing programmes to facilitate access of the poor to the new technologies or services. For a project allowing for micro-hydro energy dissemination in Peru, a special mechanism (a combination of credit, subsidised promotion and technical assistance) was developed with support of the Inter-American Development Bank, to facilitate access to funds to the rural population (IPCC, 2000). Specific financial mechanisms have also been set up under MEAs to promote the transfer of technologies that contribute to implementing the MEAs’ objectives. Examples include the Global Environment Facility (GEF) which facilitates investments under the three Rio Conventions, and the Multilateral Fund established under the Montreal Protocol (OECD, 2004b).

Through their support to financially risky projects, export credits agencies (ECAs) — within the limits of disciplines and arrangements that govern their activities — also contribute to technology transfers that might otherwise not have taken place. Some agencies support the export of environmentally sound goods and technologies, thereby facilitating transfers and diffusion of such technologies (Box 5). A case study on clean-coal technology shows the importance of ECAs in supporting a financially risky project. The latter benefited from innovative finance mechanisms, involving private banks and ECAs, the manufacturers being backed by the ECAs from their countries (the UK ECGD and the US Ex-Im Bank). The ECAs’ contributions were a vital catalyst for the sourcing of funds for the utility to develop its power stations. This case study also reflects the need for manufacturers to be proactive in arranging financing (IPCC, 2000).

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<sup>16</sup> 1994 APEC Leaders Declaration (Bogor Declaration) [www.apec.org](http://www.apec.org)

### Box 5. Export Credit Agencies and EST transfer

One of the main objectives of ECAs' environmental policies is to ensure that projects benefiting from finance or support are in line with certain environmental standards. Some ECAs also specifically mention the objective of promoting the export of national environmental solutions or technologies, and some have developed specific initiatives in support of this objective. For example:

- *Australia's EFIC* declares its interest in supporting operations that promote energy and resource efficiency, renewable resources, cleaner production and waste minimization, and encourages exporters involved in these technologies to approach the agency regarding financial facilities.
- Under its Environmental Exports Program, the *US Ex-Im Bank* provides enhanced levels of support for a broad range of renewable energy and other environmentally beneficial exports. Exports qualifying for enhanced support under this program include products or services for foreign environmental or renewable energy projects or facilities, or the export of products and services specifically used to aid in the prevention, abatement, control, or mitigation of air, water and ground contamination or pollution, or which provide protection in the handling of toxic substances and wastes.
- *Canada's EDC* has put in place "EnviroExport", an initiative to support Canadian exporters of environmental technologies and solutions.
- The objectives of *Japan's JBIC* include: to support projects that reduce and absorb CO<sub>2</sub> to address global warming; projects promoting the broader application of clean technologies, raising awareness and capabilities to address global warming and acid rains, as well as building institutional capacities.

Source: OECD (2004) and [www.jbic.go.jp](http://www.jbic.go.jp).

Consumers are not always well placed to take on the financial commitments required for adoption of costly new technology, particularly if the process the technology facilitates falls, or appears to fall, outside their immediate needs. One example is the attempt to extend credit to rural customers for PV panels in India. The solar heating systems represented core purchases for consumers, being for many the cheapest source of energy for low voltage applications such as lighting and television. Yet financial institutions perceived rural consumers as unwilling to repay loans and therefore, would not extend credit (Duke *et al.*, 2002; Martinot, 1998).

While innovative financing arrangements can reduce these barriers, the time involved in devising a workable financial arrangement can itself pose a barrier to EST transfer (IEA/OECD, 2001). For example, the Efficient Lighting Project in Poland relied on short-term subsidies to leverage private investment in compact fluorescent lamps (CFLs). The subsidies were devised to incorporate a competitive process and thereby steer away from dependency and inefficiency; yet devising appropriate financial solutions required significant time, which represented a further cost (IEA/OECD, 2001).

Several case studies also mention that rigid procedures and lengthy bureaucratic requirements often hampered smooth technology transfer processes. Examples include cases in China and India (WBCSD, 2002, CESTT, 2002). In particular, lengthy and complex procedures to dispense funds to assist the transfer of EST may constitute obstacles to such transfers. In the case of chlorofluorocarbons (CFC) phase-out in Mexican electronic industries, the Mexican government showed leadership and cooperation with business. However, funds from the Multilateral Fund of the Montreal Protocol were delayed by government procedures, thus slowing down the actual transfer of technologies (IPCC, 2000).

## Concluding remarks

### *General remarks*

Many studies dealing with technology transfer in general, or EST transfer in particular, provide conclusions, lessons, key recommendations or suggestions on the conditions for successful transfers. The following section summarises the conditions which contributed to successful transfers of EST in the case studies examined in the framework of this report.<sup>17</sup>

There seem to be few areas in which EST transfers differ from technology transfer in general. Those factors that seem to be more specific to transfers of EST, and, more specifically, transfers through trade, include: adequate environmental regulation, enforcement, and market instruments; the removal or reduction of trade barriers, such as tariffs on environmental goods and services; intellectual property regimes and the potential of publicly owned technologies; sufficient capacity in governments and enterprises to acquire EST; and appropriate financing mechanisms.

### *Overview of conditions for successful transfers of EST through trade*

#### *Government regulation and market based instruments*

- Government commitment to implement sustainable development approaches, strengthening of environmental regulations and policies and adequate enforcement are major drivers for EST development and transfer.
- In addition to command-and control measures, market-based instruments have contributed to driving EST transfer. Adequate incentives and disincentives also play an important role in encouraging investments in, and imports of “clean” versus “dirty” technologies.
- The private sector is the major engine of technological innovation and the major conduit through which technology is transferred. Policies which foster competition and the reduction of barriers to market entry are likely to contribute to the development and transfer of EST. Certain voluntary agreements and private-public partnerships also contribute to promote EST transfer.

#### *Trade-related policies and practices*

- Lower tariffs and the removal of trade barriers on environmental goods and services will result in lower prices for EST, and will make them more accessible to governments and the private sector in developing countries.

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Generally, the case studies described examples of technology transfers that were successful, thus providing generally a positive picture of such transfers. This should not hide the fact that, in reality, there are also many cases in which technology transfer was unsuccessful, and which remain unreported.

- The most effective subsidies are those that, in line with international trade disciplines, have allowed for competition among firms and support product development (market support, information and training), rather than production.

#### *Intellectual property rights*

- Little empirical evidence exists on the actual effects of IPR regimes on EST transfer. Strong IPR regimes seem to provide incentives to companies (mainly, from developed countries) to transfer technologies (*e.g.*, through their affiliates). Further analysis would be necessary to assess the actual benefits of strong IPR regimes for developing countries which import technologies.
- A large number of EST are in the public domain or publicly-owned. Ways of easing and fostering their transfer to developing countries might merit further exploration.

#### *Capacity*

- In many cases, EST are purchased by municipalities or local governments, generally following a tender procedure. Capacity by officials to understand the value added of certain EST is essential.
- Often, municipalities and local governments have very limited financial capacity to purchase new technologies. In some cases, more adequate pricing of services (waste treatment) or resources (water provision), appropriate to local circumstances, would increase the resources available to purchase new technologies related to such services.
- Government procurement strategies that seek to promote competition and act in a transparent fashion, and those favouring purchases of environmentally preferable goods and services, are likely to support successful transfers of EST.
- Local enterprises and populations are important stakeholders in EST transfer. Adequate training as well as local partnerships can contribute to the absorption and maintenance of new technologies.

#### *Financing*

- Lack of financial resources to acquire technologies is frequently reported as a primary barrier to technology transfer. Lengthy procedures to access funding may hamper the usefulness of individual financial mechanisms. Innovative financing mechanisms, including those devised under MEAs, have contributed to EST transfer to developing countries. Dissemination of information on such mechanisms, and of related success stories, could be a useful means to broaden the scope of financing to a larger number of actors.
- High financial risks may be a deterrent for potential investors and exporters of EST; especially in the case of small and medium sized enterprises. Support to export of EST, *e.g.*, through export credit agencies, in compliance with international trade disciplines, can contribute to drive EST transfer that investors would otherwise consider too risky.

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