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Financing and Partnerships for Technology Transfer

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EXECUTIVE SUMMARY

Financing is an important dimension of environmentally sound technology transfer. This chapter looks at the practical issues involved in conducting technology transfers, and explores a wide range of mechanisms and approaches. Initiatives need to be carefully tailored to the relevant circumstances and objectives. Many environmentally sound technologies (ESTs) are essentially new – often requiring change and innovation in the relevant institutions to support their transfer, such as new partnerships, new financing mechanisms, new information distribution, and new models for participation.

Public finance has a crucial role in supporting the transfer of ESTs, especially in the absence of pricing that incorporates environmental costs. Public finance has different roles than private finance, which can vary by investment type and sector. For example, it is more important for long-term and infrastructure investments. Public finance remains central in the coastal zone adaptation and transport sectors, and still plays a large role in the energy sector despite growing private finance in some countries. There has been increasing interest in opening public infrastructure development to the private sector, for example, by privatising state-owned companies, opening markets to competition, and opening projects to private finance.

Official Development Assistance (ODA) is still significant for the economies of the poorest developing countries. There is increasing recognition that ODA can best be focused on mobilising and multiplying additional financial resources. ODA can also assist the improvement of policy frameworks and take on long-term commitments to capacity building. Donor coordination by the host country is key to avoiding distortions such as those induced by tied aid, which can be detrimental to the technology transfer process, preventing the establishment of the institutions to support technology choice, financing, operation and management, etc. More generally, trade support (*e.g.*, export credits) rarely takes account of environmental factors and may in many respects be biased against environmentally sound technologies.

Because of the ongoing shift in many countries from the public to the private sector as a principal source of finance, maximising the support for technology transfer may require a new degree of financial innovation and an increased emphasis on new or different forms of finance such as microcredit, leasing and venture capital. While the private sector has started a number of environmental initiatives, there is scope for governments to enhance these mechanisms through partnerships.

There is a need for adequate resources to enable adequate project preparation in the agreement stage of all pathways, yet this is precisely the area where funding can be most difficult to obtain, particularly for private-sector-driven and community-driven pathways. Project preparation needs to consider issues of financing and participation. There is wide scope for governments, both industrialised and developing, as well as multilateral organisations, to provide support directly for the project preparation process in private-sector-driven and community-driven pathways.

Public-private partnerships are becoming increasingly important, because the relationship between government and private finance has changed considerably in recent years in many countries. These partnerships can involve a mixture of governments at national and local levels, private firms (companies), private financial institutions, and non-governmental organisations. Examples include voluntary agreements, technology partnerships, information dissemination to the financial sector and support for the development of innovative financial instruments. There have been a number of examples in these areas, many of them funded by the multilateral development banks and the Global Environment Facility (GEF).

Technology intermediaries are an important form of financing and/or partnership that can overcome barriers associated with information, management, technology, and financing. Information clearinghouses are simple forms of technology intermediaries, but policies can create an environment that encourages more sophisticated forms of technology intermediaries, such as technology-specific national-level institutions, energy-service companies, and electric power utilities.

There is scope for governments to more formally organise, develop and report on the practical initiatives they undertake in support of environmentally sound technology transfer. A formal programme could monitor activities, disseminate best practices, and develop new ideas and initiatives. These initiatives could encompass a variety of action-oriented interventions that support technology transfer, typically based on addressing specific problems, and incorporating both private- and public-sector involvement.

5.1 Introduction

Finance is a critical aspect of technology transfer. This chapter reviews various funding sources and financial mechanisms for conducting EST transfers, and the types of partnerships and stakeholder relationships that can support technology transfers. The chapter looks at the practical issues involved and explores a range of mechanisms and approaches. As discussed in Chapter 4, greater emphasis is being placed on more participatory models of technology transfer and creation of "social infrastructure." This chapter continues this discussion with a review of different forms of public-private partnerships.

Introduction of a new technology into a country usually requires investment, as does the diffusion of existing technologies within a country. Technology adaptation may also require substantial investments in design and/or production. Financing is also often required (and particularly difficult to obtain) in the early (developmental) phases of a technology transfer project or business. Without financing, very little technology investment or transfer takes place. The provision of financing depends upon those who have financial resources—whether governments or the private sector—being convinced that projects and the businesses that run them will justify the financial support or investment. And investment in ESTs and businesses will depend upon governments and private investors being convinced that these will justify—by whichever criteria they apply—the expenditure. This is the financial reality that underpins all technology investment and transfer processes. However, financing perspectives may differ enormously not only according to the project, technology and business, but according to the investor. Thus governments may offer a range of financing possibilities that differ radically from the private sector—and each contains enormous diversity itself.

Table 5.1 summarises the policy tools available related to financing and partnerships, and the barriers these are designed to overcome. The chapter begins by considering the role and scope of participatory techniques to help promote stakeholder dialogues and partnership. The chapter then considers the investment decisions made by private firms that bear on climate-change mitigation and technology transfer for private-sector-driven pathways. Public-sector finance and investment, which is of key significance for many forms of transfer, is considered in terms of direct government finance, official development assistance, and multilateral development bank lending. The section on private-sector finance and investment, which is becoming increasingly important in both the national and international diffusion of technology, discusses a broad range of financial mechanisms and modalities for finance within the private sector. Because the relationship between the public and private sectors has already changed markedly in recent years in many countries, public-private partnerships are discussed. Public-private partnerships can combine the positive attributes of both sectors and provide increasingly important opportunities to promote technology transfer. Finally, technology intermediaries are discussed as important mechanisms to overcome barriers associated with information, management, technology, and financing.

5.2 Public-Sector Finance and Investment

Public sector finance inevitably has a substantial role in investing in environmentally sound technologies and otherwise supporting the transfer of ESTs (see also section 2.2 in Chapter 2 on the public sector contribution in international financial flows)[1]. At a fundamental level, much of this involvement arises because the public sector has direct responsibility for managing public and common goods, and investing in their protection and conservation. The role of public sector finance becomes particularly important in supporting the development and dissemination of ESTs in the absence of efficient pricing mechanisms or other policies to incorporate environmental costs, when the private sector finance will be unable to operate efficiently.

The public sector typically directly invests in a range of infrastructure, although this is changing. There has been increasing interest in opening public infrastructure development to the private sector, for example, by privatising state owned companies, opening markets to competition, and opening projects to private finance.
The public sector can also provide various incentives (tax benefits, grants, subsidies, etc.) to private firms to encourage investment in ESTs – these can cover R&D grants, project subsidies, support for information dissemination and support for trade activities (note that several of these are covered primarily in Chapter 4).
The public sector is a major purchaser of goods and services, and can use its purchasing power to buy ESTs.

Public finance has different roles from private finance, being more important with respect to long-term and infrastructure investment, and assumes different roles in different sectors. For example, it remains central in the coastal-zone adaptation and transport sectors, and still plays a large role in energy alongside rapidly growing private finance.

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1. A large number of case studies in the Case Studies Section, Chapter 16, address the use of subsidies to promote market development. These include: Wind in Inner Mongolia (case 3), Butane gas stove by TOTAL (case 7), renewables in Ladakh (case 14). Innovative private sector initiatives include: Mobil (case 13), Green Lights (case 2), PV in Kenya (case 5), micro-hydro in Peru (case 25), GEF in India (case 22). Public-private partnerships are illustrated by cases 4, 17, 22 and 23.

Table 5.1. Policy Tools for Financing and Participation (Source: Mansley et al., 1997a, b)

POLICY TOOL	BARRIERS ADDRESSED	RELEVANCE
PUBLIC-SECTOR FINANCE AND INVESTMENT (5.2)		
• Provide direct finance • Provide official development assistance • Provide multilateral development bank finance	• Lack of confidence in "unproven" technology • Lack of access to capital • User acceptability • Costs of developing new public infrastructure • Lack of policy harmonisation • Uncertain future energy prices	Government-driven and community-driven pathways All sectors All stages
PRIVATE-SECTOR FINANCE AND INVESTMENT (5.3)		
• Support, through a variety of policy tools, private-sector financing mechanisms such as microcredit, leasing, venture capital, project finance, "green" finance, and a range of other private-sector financing initiatives. • Reduce perceived risks through consistent policies and transparent regulatory frameworks (see Ch. 4)	• Lack of access to capital • High transaction costs • High front-end capital costs • High user discount rates • Inadequate financial strength of smaller firms • Lack of information • Lack of confidence in "unproven" technology	Private-sector-driven pathways All sectors Agreement and implementation stages
PRIVATE-FIRM INVESTMENTS (5.4)		
• Create incentives for firms to make environmentally sound investments, such as energy taxes, investment tax credits, and emissions fees (see Ch. 4) • Engage firms in public-private partnerships, as discussed in 5.6, particularly to overcome managerial misincentives	• Managerial misincentives • Competing purchase decision criteria • Sunk investments in existing equipment and infrastructure • Energy-supply-side financing bias • Lowest-cost equipment favoured	Private-sector-driven pathways Buildings, transport, industry, and energy sectors All stages
PUBLIC-PRIVATE PARTNERSHIPS (5.5)		
• Enter into voluntary agreements with the private-sector • Develop technical partnership programmes • Conduct informational initiatives • Provide tax incentives, guarantees, and trade finance • Promote new financial initiatives	Barriers are similar to those for public-sector and private-sector financing and investment, plus the following: • Uncertain markets for technologies • Import duties • Utility acceptance of renewable energy technologies • Permit risk • Environmental externalities • Shortage of trained personnel	All pathways All sectors All stages
TECHNOLOGY INTERMEDIARIES (5.6)		
• Create information networks, advisory centres, specialist libraries, databases, liaison services • Create and support technology intermediaries like energy service companies and national-level institutions	• High transactions costs • Lack of available information about technology costs and benefits among potential purchasers and partners • Missing connections between potential partners and credible information about partners • Disaggregated opportunities that do not provide sufficient benefits for individual firms to capture on their own • Lack of capacity to contract and conduct technology transfers	Private-sector driven pathways Buildings, industry, and energy sectors Primarily assessment and agreement stages

5.2.1. Government Finance in Climate-Change-Related Projects

Governments raise finance from tax revenues and through borrowing from domestic and international financial markets or from multilateral organisations, and use the funds for government spending, including on projects that are perceived, or assumed, to be justified in terms of the public interest. Traditionally, governments have been the principal suppliers of finance for infrastructure projects, which are seen as being in the public interest. This encompasses many sectors of relevance to climate change such as energy, transport, agriculture, water and waste, and coastal defences.

Such finance can be provided as part of the capital expenditure programmes of state or local governments, through the investment activities of state owned industries, or through the lending of government-owned financial institutions, such as national development banks. While there has been a trend in recent years to increase the involvement of the private sector in such activities, public sector finance remains a very important source of finance in many areas, both in the developed and developing world.

While the allocation of government finance is subject to a number of influences, such as political pressure and central spending limits, the principal method used for many public sector projects by governments and government-controlled companies is through the internal rates of return. Because such businesses are backed by government and/or by a monopoly customer base (as with many electricity systems), the risk is perceived to be very low, and low rates of return are required. Financial rates of return in the range 3-8%/yr, set by governments according to macroeconomic and other factors, have been typical.

To expand the scope of this approach, sometime governments have sought to expand the definition of benefits beyond financial returns, to include other factors such as environmental benefits based on estimates of quantified 'external costs.' This results in sophisticated and extensive cost-benefit evaluation of approaches against a range of criteria (Anderson, 1979). Such an approach has provided the dominant criteria for public sector financing decisions in many countries over the past few decades, both nationally and - to some extent - in the area of foreign aid. It is also possible to incorporate non-financial factors into the decision process by means of multi-criteria analysis, which takes different non-monetary considerations into account and makes them comparable using a system of non-monetary weights. The external costs may also be "internalised" by measures to make Coasian bargaining possible[2] or by targeted policy measures in line with the Polluter Pays Principle. It should be noted that such cost-benefit analysis is largely the preserve of the public sector – the commercial private sector cannot include non-financial considerations into its analysis, unless measures are taken to monetise them.

Such approaches to quantitative evaluation are also applied in developing countries, and often indicate that government funding of programmes with positive climate change impacts are worthwhile in their own right. This has been seen particularly in the area of energy efficiency, and developing countries are increasingly turning to energy efficiency investment as a means to provide energy services rapidly with limited capital resources. They are doing this by enabling more work to be done and more services to be provided with less energy input, reduced capital expenditure, and minimal environmental impact. Economic planners in some developing countries seek to employ demand side management (DSM) as a cornerstone of sustainable economic expansion. The government of Thailand, for example, has committed US$60 million per year to an Energy Conservation Fund. In addition, the Electricity Generating Authority of Thailand has adopted a five-year, US$189 million DSM programme focused on commercial and industrial energy savings. In Mexico, the national electric utility has begun a move toward DSM with a programme to procure and sell two million compact fluorescent lamps (CFLs) for residential applications in two cities. The Mexican government is also committed to promoting energy efficiency in its federal buildings, and in municipal services such as street lighting and water pumping. Similar initiatives are emerging in the Philippines, Indonesia, Poland, the Caribbean, and China, among others.

With continuing pressures to reduce taxation and government expenditure, governments are increasingly seeking to justify expenditure on public infrastructure and to consider alternatives. Thus, in many cases there has been increasing interest in opening public infrastructure development to the private sector, for example, by privatising state-owned companies, opening markets to competition, and opening projects to private finance. This increasing role of the private sector in areas such as electricity supply has tended to increase the required rate of return. While this might at first glance appear to increase the cost of the services to be provided by the project, in many cases this is expected to be more than offset by the gains in efficiency. However, this can create problems for environmentally sound technologies if, as is often the case, they involve increased capital costs (in return for reduced operating costs). Such problems can be exacerbated by the fact that the private sector will not be able to take account of external costs/benefits in the same way as public entities. These factors are not insurmountable, and there are structural options to help direct private finance both at the macro level (*e.g.*, environmental charges) and micro level (*e.g.*, the public-private partnerships in section 5.6) to help overcome them. However, governments should be aware of the potential climate change drawbacks in shifting from public to private sector finance.

One clear example of the consequences of this shift is the impact it has on DSM programmes above. As the energy market is deregulated and privatised it becomes increasingly difficult to support formal DSM programmes. As such attention has shifted to alternative mechanisms for encouraging energy efficiency, both through macroeconomic measures and through specific activities such as energy service companies or ESCOs (see section 5.7.3)

Since the beginning of the 1990s, several countries in Central and Eastern Europe (CEE) and the Newly Independent States (NIS) have explored the creation of public environmental funds with the specific purpose of investing in environmental infrastructure, technology and conservation. These funds are financed by earmarked revenues from charges and fines for pollution and use of natural resources or environmentally harmful products. The significant advantages of these funds are that the resources are dedicated for environmental purposes and not such to competition with other demand, and that they are off-budgetary. Although in NIS (countries) these funds remain insignificant and somehow a flawed source of financing environmental investments, they have been able to mobilise significant resources and play an essential role in maintaining high levels of environmental investments in the economy of some CEE countries (in particular Poland and the Czech Republic). Such funds could potentially be developed in other economies. (See OECD 1995a, OECD 1995b, OECD 1999a, Peszko 1995; Peszko and Zylicz 1998; Mullins *et al*., 1997).

5.2.2 Official Development Assistance

It is increasingly recognised that ODA should not be seen as a leading source for investment in environmentally sound and cleaner technologies, but rather be used to address the fundamental determinants of development, which include a sound policy environment, strong investment in human capital, well-functioning institutions and governance systems and environmental sustainability (Killick, 1997; OECD, 1998a). This realisation has arisen partly from the policy view among donors that aid should not go to sectors where the private sector can take the lead role, and also from the mixed experience with development aid programmes. The dominance of certain interests in donor governments led most industrialised countries to promote economic and geo-political goals – *e.g.*, contracts for their domestic firms, support for friendly political regimes – that often ran contrary to the fundamental development objectives. This has resulted in development aid and, in particular, to tied bilateral aid having a very mixed record. Problems range from the controversies over major projects such as big hydro-electricity projects, to the disappointments and failures of some programmes to support the transfer of smaller-scale renewable energy. ODA is still

[2] If actors will be able to solve the problem among themselves through appropriate distribution of property rights, symmetric information and low negotiation transaction costs (see Coase, 1960). [If adopted insert ref.: Coase R.H., 1960, The problem of social cost, Journal of Law and Economics, pp.355-378.

significant for the poorest developing countries, where it accounts for up to 20% of gross domestic product (GDP), with external private flows accounting for 3-4% on average (OECD, 1998b; see also section 2.2.2 in Chapter 2 on ODA flows).

The extent to which aid is tied to being donor-country supplied reveals the persistence of the tendency for development to be subordinated to other goals. Accurate estimates of the extent to which aid is tied are difficult to come by because of the multitude of ways it can be hidden in mixed credit financing. The Organization for Economic Cooperation and Development (OECD) estimates that in 1996 tied aid accounted for around US$22 billion of a total of US$52 billion of official development assistance. Another estimate is that only half of the top 20 donor countries tie less than half their aid (Jain, 1996).

Tied aid started in part because of industry pressure in donor countries. In the 1970s and 1980s, the effects of an overly simplistic approach to development through industrialisation, and the harmful effect of self-serving economic and political motives in the donor nations became noticeable. Increased unemployment, white elephant projects, rural-urban migration, foreign debts and growing technological dependency brought into question the appropriateness of the technology being transferred to developing countries (Chambers, 1997):

Early beliefs of the 1950s and 1960s in linear and convergent development through stages of growth, in central planning, in unlimited growth, in industrialisation as the key to development, in the feasibility of a continuous improvement in levels of living for all these have now been exposed as misconceived and, with the easy wisdom of hindsight, naive. Hundreds of millions of people are now worse off than twenty years ago.

In the 1990s, the apparent absence of sustained economic and social improvement in many recipient countries, the end of the Cold War as a motive for providing aid to friendly nations, and budgetary constraints in donor countries have led to increased questioning of the effectiveness of overseas development assistance and to a sharp decline in aid flows (Graham and O'Hanlon, 1997). Funding might have declined even further in some countries were it not for industry in donor countries arguing for subsidies for exports, to protect jobs and to match subsidies provided by other donor nations to their firms (Morrissey, 1992), although in other countries there is more general public support for aid, partly based on its effectiveness. Thus, while aid has always been tied to some extent, the proportion of tied aid may have lately increased in importance[3].

Tied aid is less likely to promote economic growth in recipient countries than untied aid. Empirical studies suggest that tied aid increases costs for the acquiring country anywhere from 10 to 50% (Morrissey, 1992). In principle tied aid is better than no aid, and could be a positive sum transaction; in practice it often ends up that neither side benefits. The importation of more expensive, capital intensive, and inappropriate technologies creates a dependency for maintenance and spare parts. In general, the technology being imported may be a low national priority for the recipient country.

The consequences of tied aid go beyond the distortion of technology choice. It inhibits the development of domestic capacity in selecting technology – technology choice becomes a matter of finding the biggest subsidy rather than the most appropriate technology. It can crowd out good technologies and viable business models. It also acts to prevent private financial institutions from becoming involved in supporting technology transfer and developing appropriate expertise, notably when tied aid finance is provided on greatly subsidised terms in order to [win/secure/procure exports. For example, there are few cases where aid finance has been useful in helping to mobilise private capital into technology transfer, or to support financial innovation and new forms of financing for technology transfer - most such work is being done by the multilateral development banks. The challenges of tied aid have been recognised by the donor community, and Development Assistance Committee (DAC) donors have made important efforts to limit tied aid on the grounds that it limits the effectiveness of aid. Specifically, the "OECD 1992 tied aid discipline" prohibits subsidised finance (*e.g.*, to support manufacturing or power investment) to developing countries except the least developed countries or LDCs (OECD, 1998c). Nonetheless, there remains substantial scope for the abuse of tied aid. Transparency has been advocated as a way of reducing donor's use of tied aid, recipients' use of aid for short-term political and economic gains, and temptations to divert aid to private pockets (Lin See-Yan, 1997).

Increasingly, there is recognition that aid can be more effective and useful to development if it is focused less on core financing of specific projects and more on areas such as capacity-building, in providing incentives for direct investment (public or private) or in supporting the public private partnerships discussed later in this chapter (OECD, 1998a):

> Support for the dissemination of technological know-how must concentrate on developing the necessary human, scientific, technological, organisational, institutional and resource capabilities to underpin the long-term application of new technologies.

Specifically, this can include supporting development of the right policy mix, direct support for investment in appropriate technologies, or support for project preparation and development. That is to say that such support should be provided in the abstract – in many cases it will be more effective if linked to specific projects or programmes. Also, it is recognised that adapting assistance to local needs requires establishing working relationships among the various external and domestic actors involved and that coordination under the leadership of the host country is key (OECD, 1998a)

5.2.3 Trade Finance and Export Credit Agencies

The largest source of public sector support for cross-border finance is trade finance in its various forms, where a government agency provides a guarantee on loans to support exports (see also section 2.2.7 in Chapter 2 on international ECA flows). Export credit is a massive area – in 1996 export credit agencies (ECAs) supported exports totalling US$432.2 billion (Berne Union Yearbook, 1998). While much of this was short-term cover, approximately US$100 billion was for medium and long-term transactions (over one year). Such guarantees normally cover political and sovereign risks only and not commercial risks, and will usually require that the business is either a state entity or is backed by a local bank guarantee. Trade finance is also particularly relevant in that it normally operates in conjunction with the private financial sector, and, for example, has increasingly played a critical role in supporting project finance. Many deals would not be possible without the support of ECAs.

A key aspect of trade finance however is that it does not focus particularly on clean technology, and indeed the ECAs appear to be heavily involved in supporting activities which contribute to climate change. One study found that the two U.S. export credit/investment insurance agencies (ECAs), the Overseas Private Investment Corporation (OPIC) and the Export-Import Bank of the United States (Ex-Im), underwrote US$23.2 billion in financing for oil, gas and coal projects around the world between 1992 and 1998. These projects will, over their lifetimes, release 29.3 billion tonnes of CO_2 (Institute for Policy Studies *et al.*, 1999). The experience of the US ECAs is unlikely to be atypical and around 60% of ECA activity may be related to carbon or energy intensive exports or investments.

Given this, it is not surprising to find that most ECAs have no environmental or climate change policies. This is because the mandate of ECAs is not developmental or environmental, but to support the trading activities of the host nations.

Furthermore, they are traditionally secretive in their operations and policy, failing to disclose their activities openly and act accountably. There are some exceptions: the US Ex-Im and OPIC mentioned above have some modest environmental requirements. Even these have been under pressure, as they have led to trade tensions, notably over the Three Gorges Dam Project (in China), which Ex-Im refused to back, whereas the German Hermesbuergschaften and other ECAs were prepared to provide support. This has lead to the Ex-Im Bank coming under pressure to relax its standards. In the absence of harmonisation among ECAs, any ECA seeking to develop environmental standards will be penalised. (Cornerhouse, 1999)

The fact that no standardised environmental requirements exist among ECAs is in many cases at odds with the commitments many countries have made in multilateral agreements such as the Climate Change Convention. It reflects the fact that ECAs generally report to the trade ministry, rather than the environment or development ministries. It would clearly appear desirable to develop some harmonised environmental standards, probably based on World Bank standards, with a particular emphasis on avoiding technology dumping and (supporting) undesirable projects, and possibly considering giving special support for transfer of ESTs. Rather than "a race to the bottom" there should be procedures for upwards harmonisation. Furthermore, in keeping with the discussions on participation in Chapter 4, it would appear important that such mechanisms are developed in an open and accountable manner, with participation from all interested parties.

Increasingly there is international recognition of the need for environmental standards within ECAs, and it has been placed on the international policy agenda. The final communiqué of the G8 summit in Koln stated "We will work within the OECD towards common environmental guidelines for export finance agencies. We aim to complete this work by the 2001 G8 Summit". The OECD Export Credit Group has been attempting to share information and coordinate between ECAs for some time now, but relatively little progress has been made, with reluctance from some ECAs to take action, although with the emergence of increased political pressure it may be that the process will gain new impetus.

With environmental policies, Export Credit Agencies will be better placed to focus on issues particularly relevant to the transfer of ESTs. This will including moving away from the focus on exports (the most limited form of technology transfer in that there is no capacity building or value added in the host country) as well as the emphasis on large deals. It may also involve looking at the potential for specific activities in climate change related areas (for example, ECAs may have a role to play in the operation of the Clean Development Mechanism).

To date there have been few examples of activities which have sought to focus particularly on the problems of environmental technology transfer. One interesting exception, which illustrates

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[3] In order to increase the effectiveness of aid, both increased recipient participation (including NGO) and reduced donor control are required. Today, aid is increasingly seen as a resource to help ensure the sustainable and efficient use of domestic resources in recipient countries. One approach to increase the effectiveness of aid has been the call to link, or tie, aid to performance. To the extent this is perceived as another conditionality, and leads to a reduction in country ownership, it could be counter-productive. Untying of aid has advantages for both recipients and donors. In 1992, OECD Member countries agreed that tied aid should be extended only to projects that are not commercially viable and that are unable to attract commercial financing. To the extent that this commitment is respected, it could prove beneficial to several climate-friendly renewable energy technologies, which face difficulty in attracting financing even when they are least-cost options for certain applications.

the potential, is the creation of the private-sector Global Environmental Fund (not to be confused with the Global Environment Facility) in the United States, which invests in environmental projects and businesses worldwide. Its formation was greatly facilitated by the provision of an investment guarantee from the OPIC.

5.2.4. Financing by Multilateral Development Banks

The Multilateral Development Banks (MDB) have seen technology transfer as part of their mission to encourage development. More recently they started to focus on the challenges of the environment and the specific problems involved in transferring environmental technology. In response many have started to develop a range of initiatives and activities.

In particular, development banks have become aware of the role they can play in helping to mobilise private capital to help meet the needs of sustainable development and the environment, and of the potential to use financial innovation to encourage environmental projects and initiatives. While much of the earlier work they did was sporadic, the private sector arms of the MDBs are now seeking to identify ways they can work with international private capital to help address the environmental and developmental needs and are discussed in section 5.5.

- The World Bank itself is limited by its charter to only working with governments and quasi government organisations, although it is increasingly developing mechanisms to deal with private and quasi-private sector entities. Its affiliate, the International Finance Corporation (IFC), is most directly involved in private sector investment. However, the World Bank has developed a number of initiatives with the potential to support environmental technology transfer (Asad, 1997) . These include financing a number of environmental lending programmes at domestic financial institutions, which will then lend to industry. An important new World Bank initiative is the proposed US$60-$150 million Prototype Carbon Fund. This vehicle will provide additional finance for CO_2 mitigating projects in return for carbon offsets, *i.e.* the right to transfer the credit for the CO_2 saved to the investor. It is expected to have a substantial private sector financing and project execution. The World Bank has also prepared a major environmental strategy for the energy sector called Fuel for Thought.

- The Global Environmental Facility is a financial mechanism that was established prior to the 1992 Earth Summit (see Box 5.2) to provide grant and concessional finance to recipient countries for projects and activities that aim to protect the global environment. There are three official implementing agents, the UNDP, UNEP and the World Bank. The World Bank also acts as trustee of the GEF Trust Fund. The focus of the GEF is on providing incremental funding for projects that would not be viable on the basis of domestic considerations alone. The GEF has supported a growing, but proportionately small number of private sector investment operations. As part of its private sector portfolio, the GEF has made US$110 million in commitments to the IFC for climate change mitigation initiatives. A requirement for funding by the GEF is the demonstration of incremental global environmental benefits. This can be a time consuming and expensive process that increases transaction costs, although these problems are more marked with the Biodiversity Convention than support provided under the FCCC. The Buenos Aires Conference (CoP4) also officially expanded the scope of the GEF, for example, to include adaptation.

- The European Bank for Reconstruction and Development (EBRD), as the newest MDB, is the only one to have sustainable development incorporated in its charter. It is also much more active in working with the private sector than the other regional MDBs. Thus it is not surprising that it has shown a fair amount of leadership in helping to encourage technology transfer. It has built up a large and successful portfolio of loans in areas such as private energy service companies and municipal environmental infrastructure in developing countries. In addition, it has also worked with intermediary banks to educate them on environmental issues and the potential of clean technology.

- Other MDBs, such as the regional development banks (ADB, IDB, AfDB) all play an important role in regional investment, and most have given some attention to issues of sustainable development, in varied ways. The European Investment Bank, while differing in that it is an institution of the European Union (and thus has a limited membership), is also a huge investor with an increasing focus on lending outside the EU, particularly to the Asia-Pacific-Caribbean countries under the Lome Convention, and also to Central and Eastern Europe and the countries of the Mediterranean basin. Its investment programmes, however, have not generally been coordinated with the EU's goals on sustainable development and climate change.

- Various international agencies also harness considerable expenditure. Most notably, the UN Development Programme makes substantial grants in the area of institutional capacity-building. It has also directly supported the development of various financial mechanisms to encourage environmental technology transfer, such as supporting the feasibility work for an environmental ven ture capital fund.

BOX 5.1 ECAS: THE TOOLS OF THEIR TRADE (SOURCE: MAURER AND BHANDARI, 2000)

ECAs are bilateral organisations such as investment promotion agencies or Export Import banks that offer a variety of financing options for foreign export and investment. Most advanced industrialised countries in the OECD have ECAs that are dedicated to promoting their economic and business interests overseas. Most of their incentives are directed toward companies trying to enter or compete in emerging market economies of developing countries and economies in transition (newly independent states). ECAs use a variety of financial instruments to give their private sector clients a leg up on foreign competitors. The following are the most common instruments used by ECAs:

Export credits or loans: loans to buyers or suppliers of export goods usually of a short term nature (maturities of less than a year or two) including letters of credit and banker's acceptances. These are provided on favourable terms that are not as easily available from private commercial banks.

Import credits or loans: essentially the same as export credits, but they are provided to overseas purchasers of domestic goods and services.

Project financing: direct or indirect loans for overseas projects with the significant participation of a domestic company, including joint-ventures. These are provided on favourable terms, such as extended maturities, that are not as readily provided by private commercial banks for politically risky markets.

Guarantees: agreement by a sovereign entity (usually a government) to cover or insure a domestic investor against any losses suffered on an investments or export that results from civil unrest, expropriation of property, or nationalisation (political risk), the inability to convert local currency into hard currency (currency transfer risk), from a breach of contract by the host country government (partial risk guarantee), and back a loan provided by a commercial bank against a borrowers default (loan guarantee).

Insurance: this is very similar to guarantees, the difference being that the coverage against political, currency transfer or loan defaults are purchased as an insurance premium.

Equity: these are direct investments into a project or an equity fund that in turn invests directly in development, infrastructure or other projects in the recipient country. Essentially, this equity buys down credit risk and permits private funds to raise additional financing more easily.

The instruments most commonly used by ECAs are export and import credits (also known as trade financing), project financing and various forms of guarantees and insurance. The use of equity funds is a fairly recent phenomenon, but it is growing more common as various types of financing instruments are increasingly packaged together (equity, bonds, loans, guarantees) to assemble sufficient capital to get a project off the ground.

5.3 Private-Sector Finance and Investment

Private sector finance is increasingly important in both the national and international diffusion of technology, and the relationship between public and private is particularly important in the context of technology transfer. It will have a major role in private-sector-driven pathways and often a role in community-driven pathways. This section thus discusses the criteria used by private sector finance and the forms it can take, and then identifies some of the financing mechanisms most relevant to environmentally sound technology transfer, and then looks at the some of the important initiatives taking place in private finance.

While such initiatives can be successful, they clearly will not work if the macroeconomic and environmental framework is not adequately supporting ESTs so that they are financially viable. Even if this is the case, they may not be sufficient to cover other concerns of the financial markets such as the significance of climate change to their business or the risks of getting involved in this area. Governments can be a source of risks themselves in the way they develop policy and consistent, consensual policy development can help reduce risks.

It is also important to distinguish between investment and financial products from private sector financial institutions, which is the real focus of this section, and investment by private businesses as part of their business development, which will be discussed in section 5.4 on private-firm perspectives. Most foreign direct investment is by its nature in this latter category.

5.3.1 Private-Sector Finance: Criteria and Forms

Private financial institutions invest in businesses - or specific projects - which can generate a financial return. However, they have no particular interest in any individual business and can typically choose from a very wide range of investments available to them. In selecting investments most financiers will focus on the two criteria of risk and return - higher perceived risk results in higher expected return, with the level being primarily set by the market. Different financiers will have different preferences for risk and return. An impact of the emphasis on risk, and compensation for that risk through increased return, is that the private sector will find it most difficult to finance high risk, longer term projects. Many environmentally sound technologies are essentially of this nature with low operating costs and high up front expenditure.

In trying to alter the behaviour of the financial markets, governments can choose regulation or persuasion. Regulation is unpopular with financial institutions, particularly internationally. Persuasion is difficult to initiate, but can ultimately be more successful, offering major benefits for relatively small outlays and gives rise to opportunities for private-public partnerships (discussed in section 5.6). In seeking to persuade the

way the financial markets allocate capital, governments can focus on four key aspects: the perception of risk; the calculation of expected return; the structuring of the financial package; and the transaction costs associated with that investment. However, to be relevant these aspects have to be looked at in the context of an individual financing problem or type of finance.

Understanding the role of private finance in technology transfer necessitates some understanding of the detail of different forms of finance in technology transfer. There is a very wide range of types of finance which are potentially relevant in financing technology transfer. Their relevance depends on the specific opportunity under consideration. Key factors are the scale of the investment and whether the investment is a venture (a business intending to grow and develop) or a project (a stand-alone specific entity – *e.g.*, a power plant). Scale can be roughly divided into large (roughly at least US$20 million), medium (over $500,000), small ($10,000 to $500,000), or micro (say less than $10,000, but mostly from $10 to $100), although the size is to some extent subjective and, for example, will depend on the level of economic development.

BOX 5.2: TECHNOLOGY TRANSFER AND MARKET DEVELOPMENT PROMOTED BY THE GLOBAL ENVIRONMENT FACILITY

Since its inception in 1991, the Global Environment Facility (GEF) has promoted technology transfer of energy efficiency and renewable energy technologies through a series of projects in developing countries. Following a three-year pilot phase, the GEF in 1996 adopted an operational strategy and three long-term operational programmes for promoting energy efficiency and renewable energy technologies by reducing barriers, implementation costs, and long-term technology costs. A significant aim of these programmes is to catalyse sustainable markets and enable the private sector to transfer technologies.

From 1991 to mid-1999 the GEF approved grants totalling US$706 million for 72 energy efficiency and renewable energy projects in 45 countries. The total cost of these projects exceeds US$5 billion, because the GEF has leveraged financing through loans and other resources from governments, other donor agencies, the private sector, and the three GEF project-implementing agencies (UN Development Programme, UN Environment Programme and World Bank Group). An additional US$180 million in grants for enabling activities and short-term response measures have been approved for climate change.

GEF projects are testing and demonstrating a variety of financing and institutional models for promoting technology diffusion. For example, fourteen projects diffuse photovoltaic (PV) technologies in rural areas through a variety of mechanisms: financial intermediaries (India and Sri Lanka), local photovoltaic dealers/entrepreneurs (Peru, China, Zimbabwe and Indonesia), and rural energy-service concessions (Argentina). Several other projects assist public and private project developers to install grid-based wind, biomass and geothermal technologies (China, India, Philippines, Sri Lanka, Indonesia, Mauritania, Mauritius). For energy-efficiency technologies, projects promote technology diffusion through energy-service companies (China), utility-based demand-side management (Thailand, Mexico and Jamaica), private-sector sales of efficient lighting products (Poland), technical assistance and capacity building (China), and regulatory frameworks for municipal heating markets in formerly planned economies (Bulgaria, Romania, Russia). In addition, projects provide direct assistance to manufacturers for developing and marketing more efficient refrigerators and industrial boilers through foreign technology transfer (China).

The achieved energy savings and renewable-energy capacity installed through GEF-supported projects are small but not insignificant relative to world markets. For example, wind-power capacity directly installed or planned for approved projects is 350 MW, relative to an installed base of 1,200 MW in developing countries in 1997. The GEF has approved close to 500 MW of geothermal projects, which compares with over 1,100 MW installed worldwide from 1991 to 1996. There are an estimated 250 to 500 thousand solar home systems now installed in developing countries and approved GEF projects would add up to one million additional systems to this total in the next several years. Replication or "indirect" effects are also key aspects of GEF project designs; through demonstrations, new institutional models, policy changes, stakeholder dialogues, and other project activities, GEF projects have provided an important stimulus for technology transfer beyond these direct project impacts.

Capacity-building is a central feature of most GEF projects and is resulting in indirect impacts on host countries' abilities to master, absorb and diffuse technologies. Projects build the human resources and institutional capacities that are widely recognised as important conditions for technology adoption and diffusion. For example, the China Energy Conservation project is building capacities of private-sector energy service companies, as well as those of public agencies to disseminate information, experience and best practices. In West Africa, a GEF project is helping develop regulatory frameworks, standards, tariff structures, and technical capacity for more efficient buildings.

Several GEF projects are designed to directly mobilise private-sector finance. For example, in the IFC/GEF Poland Efficient Lighting project (Case Study 2, Chapter 16), a US$6 retail price reduction for energy-efficient lamps was possible with only a US$2 grant because of manufacturer contributions, and 1.6 million lamps were installed. Through the International Finance Corporation (IFC), four GEF projects—the Renewable Energy/Energy Efficiency Fund, the Photovoltaics Market Transformation Initiative, the Solar Development Corporation, and the Hungary Energy Efficiency Co-financing programme are designed to leverage US$490 million in private-sector financing for technology transfer with US$105 million in GEF grants. *(Sources: GEF 1996, 1997, 1998; Martinot and McDoom 1999)*

Table 5.2 Applicability of types of finance

TYPE OF FINANCE	APPROPRIATE SCALE				APPROPRIATE TYPE		
DEBT	**LARGE**	**MEDIUM**	**SMALL**	**MICRO**	**VENTURE**	**PROJECT**	**COST**
Personal Loans	-	-	++	++	+		medium
Bank Overdraft	-	+	++	?	?		medium
Secured Loans	++	++	+	-	+	++	low
Leasing	+	++	++	+	+	++	low
Export Finance	++	+	-	-	+	++	low
Securitised Debt	++	+	-	-	+	+	low
EQUITY							
Personal	-	+	++	++	+		N/a
Private Investors		+	++	+	+	?	High?
Venture Capital	+	++	+		++		V High
Strategic Investors	+	++	+		+	++	High
Institutional	++	+			+	++	High

KEY: ++ MOST RELEVANT DEVELOPING COUNTRIES + QUITE RELEVANT ? OCCASIONAL RELEVANCE - NOT RELEVANT DITTO

It is also important to note that in many cases there may be two stages of financing required: *e.g.*, the financing to establish the business of manufacturing/distributing the technology, and the financing for the end-users of the technology to enable them to purchase the technology. For example, financing the establishment of a PV module factory in the developing world has different challenges from providing finance to households to enable them to purchase the solar home systems produced by the plant. Table 5.2 summarises the applicability of different forms of finance to different scales and types of business.

5.3.2 *Initiatives within the Private Financial Sector*

While on one level the private financial sector has no special reason to consider environmental issues, many are beginning to realise, like much of the rest of business, that environment is a strategic issue for them, and a particular focus has been climate change. It is with adaptation to the impacts of climate change that progress has been most rapid as financial institutions recognise that climate change could directly affect their business. Insurance companies are increasingly aware that climate change could increase their losses on property and general insurance (*e.g.* from increased sea level rises and storm damage). Banks could also see the undermining of the security behind much of their lending. As a result, some insurance companies have become increasingly active, and have been working with others to develop and transfer technology in this area. Measures taken have included: adjusting premiums to reflect risks (where they are permitted to do so), thus sending a clearer signal about the dangers of climate change to owners and developers; working with local authorities on preventative measures such as enforcing building codes and zoning; and developing disaster recovery measures such as improved telephone support.

In the other areas of climate change the mainstream financial industry has had a less direct impact, and to date most financial institutions have made only a modest commitment to supporting the development and use of mitigation technologies, and particularly to overcoming some of the barriers identified in section 5.1 as preventing greater investment. However, progress has been made in some areas – for example, bankers no longer regard wind energy technologies as being a particularly high risk.

Certain financial institutions have been prepared to innovate and show leadership in finance related to the environment. For example, some banks have also been active in working with smaller businesses to improve their environmental impact, often with a focus on energy efficiency, through providing advice and information. In doing this they hope to improve the credit standing of their clients, as well as secure general environmental benefits. Some banks have also instituted lending programmes with more favourable terms than in ordinary lending for businesses seeking to reduce their environmental impact.

Other initiatives within the private financial sector include:

Green financial institutions. While most mainstream financial institutions have paid only modest attention to the environment, a number of smaller organisations or groups within organisation have made it a major feature of their activities. These "green financiers" are usually driven by, firstly, the growing number of investors with concerns about the environment and a desire to see their money invested to take account of these concerns and, secondly, a high level of personal commitment by the professionals involved. These green financial organisation are much more prepared to work to overcome some of the problems identified earlier, either independently or in conjunction with the public sector. Many of these "green" financiers are involved in some of the activities above. They include:

- a number of Ecological or Social Banks (typically very small, although growing) that focus on providing fairly low cost lending for environmental and other worthy projects, and have strong links to the micro-credit movement (see Box 5.3);
- environmental equity funds which invest in listed "green" companies (many billions of dollars are now invested in such funds, but they are limited in the extent to which they can provide money to new ventures);
- a few environmental venture funds and specialist corporate financiers which provide support to new environmental businesses.

While these green financiers are still small as a proportion of the overall financial markets, they are providing a very useful pathfinder role in developing new concepts and ideas. There

BOX 5.3: ENVIRONMENTAL PROTECTION BANK IN POLAND

An example of a successful green financial institution is the Polish Environmental Protection Bank. Established at the beginning of the 1990s, it has received substantial equity investments from the Polish National Fund for Environmental Protection. Share capital has also been raised several times from strategic investors and from the private sector. The bank was listed on the Warsaw stock exchange in 1997 and became the world's first publicly traded bank specialising in environmental protection financing. In 1997, the bank granted over 27,000 individual credits and loans worth PLZ 1,431 million (363 million Euros). The bank lends primarily to businesses (54 %), municipalities and other public-sector entities (26 %) and individuals. Specific environmental investments make up two thirds of the bank's portfolio. The bank held a one-per cent share of the banking market in Poland (in terms of total assets of all commercial banks), and it has built up a good reputation for quality of services as well as for financial performance.

appears to be substantial merit in the public sector finding ways to support them and work with them to encourage their work.

Collective initiatives and organisations. In recent years a number of initiatives and organisations have been created to bring together industry participants to look at environmental issues as a collective basis. The most notable have been the UNEP initiatives, where banks and insurance companies have signed a statement on the environment, and subsequently the signatories have formed organisations to develop further activities. Other organisations have developed, mostly at a national level, to further the cause of environmental investment, such as the Social Investment Forum (USA), UK Social Investment Forum, VfU (Verein fur Umweltmanagement in Banken und Versicherung) in Germany/Switzerland and the Social Venture Network (USA). These organisations provide forums for networking, information gathering and sharing experiences. They also have been involved in lobbying for change and encouraging investment and green finance.

5.3.3 Potential Financial Solutions

Slow diffusion together with the consideration of cost and availability of finance suggest that there is potential for innovation and focus to help support and accelerate the transfer of environmentally sound technology. In particular, certain types of finance appear to offer particular potential for helping to finance the transfer of technology, although they may require adaptation to the specific issue; it is worth considering these in more detail. (Mansely *et al*., 1997a and b).The public-private partnerships discussed in section 5.6 can play a role in developing and implementing these solutions.

Project finance. Project finance is the packaging of investment into specific, stand-alone projects. Notably there is only limited recourse to other parties (*e.g.*, the promoters and financiers) if the project runs into difficulties, so the project has to stand on its own merits. Of particular relevance to climate change are energy projects, which are frequently financed this way. Project finance uses a range of finance instruments and typically consists of a mixture of debt (normally secured loans) and equity (strategic investors and institutions). Project finance aims to reduce risks and thus financing costs through a series of robust contracts, notably to charge for the services provided (*e.g.*, power). Negotiating these contracts can be difficult and time consuming. Often there can be some flexibility over ownership of the facility - such as build-operate-transfer (BOT) structures. One key issue for climate change technologies is the need to achieve a certain scale. To justify the transaction costs involved, project finance normally requires sums of US$20 million and above. This can restrict its applicability in many areas such as renewable energy and energy efficiency where only few projects in certain sectors reach this size. Project finance is particularly relevant to government-driven pathways, and to the transport, energy, solid waste and coastal zone adaptation sectors.

Leasing. Leasing is a highly flexible form of finance used throughout business to finance everything from photocopiers to aircraft. In 1994 over US$350 billion of new equipment, machinery and vehicles were financed through leasing, and some US$44 billion in developing economies. It is often packaged as a form of sales financing - *i.e.*, it helps customers of a company buy that company's equipment. Despite higher spreads than conventional lending, leasing offers several advantages such as simplified security arrangements, convenience and speed, flexibility, low transaction costs and frequently tax advantages. The principle constraint on the development of leasing has been access to local currency medium-term lending. MDBs, notably the IFC, have been active in promoting leasing businesses and have found it to be a successful form of investment (Carter, 1996). Leasing offers potential to be a major source of finance for the transfer of EST, particularly to the business community (private-sector-driven pathways). Leasing has been used to buy various types of environmental technology from monitoring equipment to wind turbines, although it has not been possible to identify any leasing company focusing specifically on environmental technology. There is scope to encourage leasing companies to support the transfer of EST through selective tax incentives, information sharing and bringing together environmental entrepreneurs and leasing companies. Leasing is particularly relevant to the private-sector-driven pathways, although it can be used by governments, and especially the industrial sector, although it can be used in several other sectors.

An example of an established and successful leasing company that focuses specifically on environmental technology is Towarzystwo Inwestycyjno-Leasingowe Ekoleasing S.A. (joint stock company Investment and Leasing Society Ekoleasing) in Poland. It was established in 1993. Currently the share capital is almost US$1 million. Over 40% of the total value of PLZ 33 million (about US$9 million) of contracts concluded in 1998 was leasing of specifically environmental technologies.

Private equity from strategic investors. Strategic investors, often in the form of multinational corporations, have the potential to be major investors in technology transfer. As large organisations they have ready access to finance. As well as using capital internally they can also act as external investors, investing in projects or businesses. They look for a financial return but also usually expect other business benefits, such as a role as supplier to a project or investing in a joint venture as a way to gain access to new markets. They frequently bring additional skills and expertise as well as finance. They are major suppliers of equity to many energy projects already, and with many major companies becoming increasingly interested in climate change (such as Enron, BP and Shell) are increasingly investing in renewable and clean energy internationally. This type of investor is also the most interested in the flexibility mechanisms of the Kyoto Protocol, as indicated by their participation in the various precursor instruments such as joint implementation and the Carbon Investment Fund, probably because they can see benefits beyond the strictly financial ones.

Portfolio investment. For listed companies in developing countries, issuing new stock is an option for raising capital that can be attractive. Doing so enables risk capital to be raised, without involving loss of control, for example to overseas partners, and enables investment in several needed areas, which may include energy efficiency or environmental technologies, without changes to management or business structure. However, the vast majority of portfolio investors will place little direct importance on the investment in environmental technologies, and will instead consider more general aspects of the firm and management's track record when deciding to purchase the new shares. Furthermore, the ability to raise such capital cannot be guaranteed, and depends on market conditions and on the company's performance at the time.

Venture capital. Venture capital is particularly relevant to the development and transfer of new technologies. Venture capitalists are prepared to back risky investments in return for high returns and will invest in small companies, such as those who have developed new technology and/or have difficulties raising capital from most other investors. Venture capitalists have a relatively long-term focus, aiming to hold companies for several years before selling them, and have a more active approach than most other types of investors, in terms of participating in management of the company. This means they can play an active role in supporting technology transfer if it forms part of the business development plans of their investee companies. Venture capital is largest in the USA but has grown recently in the rest of the world, including in developing countries where multilateral institutions have provided substantial support. Venture capitalists have tended to focus on high-return sectors such as computer software and biotechnology, and to date only a relatively small amount of finance has gone into environmental business, and only a few funds focus on environmental ventures. Indeed, the environmental sector has had a very mixed track record in delivering returns to investors. However, there is growing interest in venture capital funds with an environmental focus and a number are expected to be launched in coming years. Venture capital is predominantly relevant to private-sector-driven pathways, and especially important in the industrial sector, with some relevance in the transport and energy sectors. It does require a relatively sophisticated financial infrastructure.

Micro-credit. Micro-credit is the provision of small amounts of finance to individuals. While the basic concept is the same as traditional banking, the attitude to risk is radically different, because micro-credit institutions are prepared to lend to those ignored by conventional financial institutions – those on low incomes or with no assets. A particular emphasis is on enabling access. It is often provided by non-conventional financial intermediaries such as cooperatives, farmers' associations and distributors. Micro-credit has been successful in many areas now and is receiving increasing attention from Multilateral Financial Institutions as a way of encouraging development (Ledgerwood, 1999). Many believe there is substantial scope for adapting and focusing micro-credit to finance the uptake of ESTs at the household level. However, others have argued that micro-credit is generally not suitable for environmental technologies. because the credit is usually short-term (less than 1 year), comes with high interest rates, is limited to small amounts (US$100, whereas a solar home system might cost US$600) and is not granted for capital investments (van Berkel and Bouma, 1999).

5.4 Private-Firm Investment Decisions and Foreign Direct Investment

While section 5.3 has looked at external private sector investment, in many areas the most significant investment decisions are those made within firms. Within a single country, such investment decisions have an important role to play in the diffusion of technology. Across borders such investment forms Foreign Direct Investment (FDI), increasingly seen as one of the largest and most important financial flows (see section 2.2.2 in Chapter 2).

Particularly in the buildings, industrial, transport, and energy sectors, investment decisions made by private firms can significantly affect greenhouse gas (GHG) emissions in firms' processes and products, and in firms' conduct of environmentally sound technology transfer along private-sector-driven pathways. These decisions are often at variance with simple economic models that assume universal optimisation, because of barriers that can exist within firms to technology transfer. Private-sector investment comes in many varieties (see section 5.3), but whatever form the financing mechanism takes, obstacles originating in the organisational structures and decision-making procedures of firms may limit adoption of the most environmentally sound technologies. Internal barriers within a firm are those that slow down the adoption of technologies that would be in the firm's own interest given prevailing market prices, external macroeconomic conditions, and regulatory requirements. Both local and multinational firms

are subject to internal barriers, but the ways in which technology transfer is impeded by the barriers may differ across classes of firms, depending on the nature of the barriers.

5.4.1 *Multinational Corporations and Foreign Direct Investment*

Concern has been expressed that multinational corporations' (MNCs) direct foreign direct investment gravitates toward countries with lower environmental standards or lax enforcement (pollution havens), as MNCs seek to avoid the high cost of environmental compliance in their original bases of operation. There is debate about differences between local and foreign firms with limited empirical evidence available (Jun and Brewer, 1997). However, according to some sources, there is growing evidence that foreign-owned or joint ventures tend to be cleaner ("halos") than local firms for the following reasons: they use the usually higher standards of the developed countries embedded in the overseas subsidiary; they export to environmentally sensitive markets, and the parent firms do not want their image to be tarnished by irresponsible overseas operations (as has happened) (Panayotou, 1997).

Multinational corporations (MNCs) have significantly expanded their environmental management capacity. In general the environmental effects on the host economy depend also on the policies of the host government as well as their practises. Domestic regulatory policies can increase the contribution of private capital flows to sustainable development (Jun and Brewer, 1997). Environmental sustainability, including mitigating and adapting to climate change, can then be seen not as a barrier to growth, but as a boundary condition that could stimulate the emergence of a sustainable industrial economy, a process in which technology transfer is likely to play a major role. Host governments can require enforcement of environmental regulations, transparency in reporting and pre-screening of projects before commencement. Home governments could potentially screen projects for their environmental effects before granting them political risk guarantees (see the discussion on ECAs, section 5.2.3). MNCs themselves have in some cases assumed responsibilities to minimise the detrimental consequences of FDI projects and guidelines have been developed by both private-sector and public sector organisations, such as the Business Charter for Sustainable Development developed by the ICC (Jun and Brewer, 1997). Presently under discussion is a revision of the OECD Guidelines for Multinational Enterprises. Capacity building is required in developing countries to strengthen regulatory reform and monitoring.

Western multinational corporations are sometimes at the leading edge of lean production techniques and new ways of working with the community. Transfer of these approaches through foreign direct investment by MNCs can be a critical pathway for developing countries to acquire these essential building blocks for sustainable industrialisation. Today's dominant industrial paradigm – lean production – tends towards minimising raw material needs (by reducing waste and unwanted stock, Womack *et al*., 1990). It is associated with participation and individual responsibility of workers throughout the chain of production, and is, therefore, potentially a building block for an integrated system of industrial production within an environmentally sustainable economy (Wallace, 1996). At the same time, possible elements of a future sustainable industrial economy can be seen in developed economies. Some essential elements have already been suggested, including: new relationships with workers and the community (Hawken, 1993; Silverstein, 1993); decentralised production of a wide variety of goods (leading to greatly reduced pollution, lower costs with a transfer of wealth from large corporations to local communities; Hawken, 1993); and the integration of production, consumption and waste streams into a single "ecological" system (Socolow, 1994). In the real world, limited application of industrial ecology principles is being demonstrated in the Kalundborg, Denmark, eco-industrial site (Hawken, 1993).

However, barriers and obstacles do exist with modern multinational corporations to the transfer of technology and the reduction of GHG emissions. It is in the nature of such large organisations that they must be divided into semi-autonomous divisions, and that central coordination can only imperfectly control the actions of the far-flung branches. Even if the central headquarters of a MNC were to decide on a particular course of technology transfer or diffusion, it would require effort and management attention to make that decision happen. Control from the centre can be exercised only imperfectly, so it would be unusual if all branches performed up to the same standard in every dimension. Thus, there should be no reason to presume that all segments of a globally dispersed MNC have optimised their technological choices. Rather, there will always be opportunities for profitable transfers of knowledge and technique.[4] A great deal of foreign direct investment takes the form of expansion of operations by MNCs, so internal or trans-divisional decisions regarding technology choices, in addition to decisions about the location and direction of capital flows, are important in determining the pace of transfer of ESTs

Decisions within firms may not be made according to rational decision-making models, and a more open process can help the private sector decision-maker. Traditional economic theory would tend to predict that the choice of a technology would be chosen on the bases of cost minimisation and perfect information. Even where such adherence to theory would be expected to be most prevalent, such as in the choice of manufacturing methods, empirical studies have shown this to be inadequate to explain technology choice decisions actually made by managers. Observers have noted that firms in the same country use quite different technologies to manufacture ostensibly identical products. Flouting theory, labour-intensive and capital-intensive plants survive side by side (Stobaugh and Wells, 1984). Factors that do influence choice include the ratio of manufacturing costs to total costs, the price elasticity of demand, competition faced by the firm, flexibility in changing output, quality of the product, whether it was being produced for the domestic market or export, etc. Moreover, lack of information is an important determinant of choice (Stobaugh and Wells, 1984), and is often accompanied by a lack of initiative in searching for information other than that provided by existing suppliers of technology (Chantramonklasri, 1990).

It is also well known that the present configuration of technology choices depends to a significant degree on past choices (Arthur, 1994). This sort of "path dependence" of technological progress may result from economies of scale that cause technologies with larger market shares to exhibit lower costs than newer, potentially superior, technologies. Alternatively, path dependence can arise in the normal course of a firm's evolution, because it can be easier in the short run to make marginal changes in existing methods than to switch to an entirely new way of doing things. In the case of energy technologies, the past choices were made without taking account of the climate externality. Thus, existing technologies enjoy advantages over newer, lower-emission technologies, in terms of having learned by doing, having learned by using, having already realised scale economies, having established information channels and user confidence, and having established inter-related technologies. These factors can perpetuate continued "lock-in" of the fossil fuel technologies that have grown around the historic availability of cheap fossil fuels and historic neglect of the greenhouse gas externality. Policy intervention may be required to replace locked-in technological choices that are no longer globally optimal.

Probably the most general reason large firms fail to take advantage of opportunities to adopt profitable new technologies that would reduce GHG emissions is that doing so is not a strategic priority. Investment in energy technologies usually is not seen as central to the firm's growth and survival, so this type of decision receives a lower level of attention from top management than other concerns. The mechanisms and controls that serve to maintain accountability and control principal/agent problems across different layers in the organisation's hierarchy in relation to its mainstream activity can themselves become barriers to action in relation to energy efficiency. These considerations suggest that an effective way for a corporation to achieve emissions reductions would be an organisational change that would make a clearly identifiable person or group within the firm responsible for the monitoring and abatement of greenhouse gas emissions. Such an internal organisational unit could be charged with identifying and implementing profitable energy-saving investments (with the managers of the group rewarded accordingly), and could be self-financing to the degree that such opportunities exist. Other regulatory or policy regimes, such as carbon taxes, cap-and-trade systems, or proportional abatement obligations (PAOs) could play an important role in focusing the attention of management and making GHG emissions reductions a measurable objective for the firm.

[4] Even if a MNC could be optimised at a given moment in time, the rapid rate of change of the market, regulatory, and environmental factors with which it must contend would guarantee the emergence of profit opportunities.

5.4.2 *Incentives and Barriers to Energy-Saving Investments*

At one level, it may see sensible for a private firm to invest in GHG reductions only if there is an obvious financial benefit. But for many firms, greenhouse gas reductions can result from corporate decisions that are taken in response to direct economic incentives—like reduced costs, increased profits, and increased market share. For example, the World Business Council for Sustainable Development is promoting the view that corporate efforts for eco-efficiency are a sign of management competence, and hence will increase shareholder value (*e.g.*, ease raising of equity) as well as credit-worthiness (*e.g.*, ease raising of debt financing) (Schmidheiny and Zorraquin, 1996). A "green" corporate image can become a corporate asset, and some preliminary research in the United States has shown that better environmental management systems and environmental performance tend to reduce firms' risk profile (controlling for other factors), with the expectation of a positive impact on the stock price of the greener firms because of their reduced risk (Feldman *et al*., 1997). The value of a company's equity ultimately is determined by the present value of the entire expected future stream of earnings (suitably discounted), so long-run concerns including environmental performance should have an effect on the market evaluation of a firm's net worth.

Internal barriers are often overlooked, partly because economic models typically make the simplifying assumption that all market agents are fully maximising their objectives. Yet several strands of recent research have shown that private sector firms do not take full advantage of all the cost-effective investments in energy efficiency and other cleaner energy technologies that are available. This evidence comes from "bottom-up" studies (Interlaboratory Working Group, 1997; Energy Innovations 1997; National Laboratory Directors 1997; IPCC, 1996, Table 9.8 and the studies cited therein), statistical tests of the maximisation hypothesis (DeCanio and Watkins, 1998a; DeCanio, 1998), and theoretical and empirical studies (Koomey, 1990; Ayers, 1993; Lovins and Lovins, 1991; Jaffe and Stavins, 1993; Koomey *et al*., 1996; DeCanio and Watkins 1998b; Porter and van der Linde, 1995a, 1995b).

A number of specific intra-firm barriers to the adoption and diffusion of profitable energy saving and other cleaner energy technologies have been identified. In addition to the long-recognised tension between the goals of shareholders and management, managers at different levels within a firm may have conflicting incentives. It is often the case that data that could be used for energy auditing and control either is not available or is scattered through the organisation in such a way as to make cost-saving investments in energy efficiency more difficult. Capital budgeting procedures that are put in place to control principal/agent problems within the organisation may have the unintended side effect of screening out profitable energy-saving investments. Managers can be inappropriately risk averse because of the way their performance is evaluated, and their incentives to pursue energy efficiency blunted by

frequent turnover or switching of positions within the company. Managers rarely have incentives to make the long-run decisions that will benefit their successors at the expense of their own performance in the short run (DeCanio, 1993, 1994).

Furthermore, many firms in NIS countries (mainly Russia and Ukraine) operate under perverse microeconomic conditions that encourage them to under-report or hide revenues, expenses, and profits. Barter transactions, which make up a substantial percentage of economic activity in these countries, along with corruption in many forms, complicate matters further. Under these conditions, judging the financial condition of enterprises become problematic, and adds risk and uncertainty to energy efficiency and other types of otherwise profitable investments. In general, issues of corporate governance in non-monetary, distorted economies of some large NIS countries can represent significant barriers to environmentally sound technology transfer (OECD, 1997; EBRD, 1998; Commander and Mumssen, 1998).

Firms are not unitary entities having a mind and will of their own. Instead, they are made up of a multitude of individuals, each of whom has their own individual interests and objectives. The decisions of firms are thus the result of collective action, and it has long been understood that collective action may not yield optimal outcomes, even if all the individuals taking part in the decision-making process are perfectly rational (Olson, 1965). This problem can manifest itself in the operation of for-profit firms just as it does in voting models of group choice. In both cases, the (possibly divergent) interests of individuals have to be 'aggregated' into organisational decisions.[5] The task of management is to bring about as much correspondence as possible between the interests of the individuals making up the organisation and its formal goals, and this task is neither straightforward nor simple. The modern theory of the firm is based on an exploration of the multitude of ways in which agency problems, asymmetric information, and incentive incompatibility can create a gulf between the formal objectives of the firm (maximisation of profits or of stock value) and the behaviour of its employees. It should come as no surprise that perfect maximisation is rarely achieved, and in particular that it is not realised in the realm of energy efficiency.

[5] Of course, the assumption of individual rationality has itself been questioned (Zey, 1992; Etzioni, 1987). For studies dealing specifically with energy technology choices, see Stern and Gardner (1981), Dennis *et al.* (1990), Stern (1992), Geller (1992), and Crabb (1992). Arrow (1951) gives the classical rigorous treatment of the problem of reconciling individual and social choice. The general problem of governance and of the efficiency of collective action pertains not only to voting rules for public decisions and the operation of capital-controlled firms, but also to cooperatives and worker-managed firms.

BOX 5.4A: SMALL- AND MEDIUM-SIZE ENTERPRISES IN CHINA

Small and medium size enterprises (SMEs) in China consist of community enterprises (mainly owned by townships and villages), multiple cooperative enterprises, joint ventures, and individual and private enterprises. SMEs produce a significant share of China's GDP in a number of industrial sectors. In 1995, there were about 22 million SMEs in China employing 129 million people. SMEs in China face a number of constraints to engaging in technology transfer, such as for producing more energy-efficient products or investing in more-energy-efficient processes, including:

Information. SMEs lack contact with technology manufacturers and customers so information about technology availability and customer demands is lacking. The evolution of industrial SMEs from non-sector-specific commune-based enterprises made SME rely on low-grade technologies and gave them little access to formal information and training channels. SMEs learn largely by visiting and copying other firms in the same sector. This constraint on information acquisition is especially true of what might be called organisational technologies such as project analysis, financial methods, or studies of market developments and factor price forecasts. SMEs have limited interchange with government ministries that might be in a position to advise them on technology choices.

Rural customer demand. Rural customers show little appreciation for product quality (such as energy-efficiency). Competition is based solely on price and regulatory initiatives to promote product quality do not exist. In cases where some product quality standards do exist (i.e., minimum heat efficiency of bricks), they are usually not enforced. Even when customers do appreciate quality, they are often not able to pay for higher up-front capital expenditures because of severe capital constraints. And there are usually few marketing activities or product labelling initiatives to better inform customers, and encourage them to distinguish between higher quality products and lower quality products.

Financing. SMEs do not possess the financial means to invest in more advanced technologies. On the other end, technology manufacturers are not in the position and other intermediaries do not exist to provide financial mechanisms encouraging technology supply push. Financial institutions are reluctant to lend for such investments to SMEs.

Market competition: SMEs face little competitive pressure in their rural markets. All local producers operate under the control of the SMEs and local markets are highly segregated. SMEs are integrated into a spatial network of enterprises supplying largely to local markets and not in a product oriented network. For this reason, inter-local distribution networks are weak or not existing, and opportunities to exploit existing economics of scale in production are limited. Product pricing is somewhat arbitrary and an SME is not driven out of the market when its profitability is too low. So far, SMEs have no experience with market/competition based regulation.

BOX 5.4B: SMALL- AND MEDIUM-SIZE ENTERPRISES IN THAILAND

SMEs are the real backbone of the Thai economy. A major barrier in transferring environmentally sound technologies to SMEs is insufficient financial resources. However, the difficulty in improving technology transfer capacity is not merely a financial problem. To prop up Thailand's industrial strength in the long run, Thailand has to modernise SME management and international marketing, and enhance industrial science and technology capability and labour skills.This means that:

(1) Government policies for restructuring Thai industries, including SMEs, need to be spelled out more clearly. Even though SME assistance programmes have been launched recently, resource allocation and priorities are not well managed and cannot efficiently meet the needs of SMEs.

(2) SMEs' pool of skilled personnel and ability to attract skilled R&D staff are still comparatively weak and must be strengthened. Academia-industry linkages that target SMEs would be one potential remedy.

(3) The application of voluntary environmental management in SMEs is urgently needed. Good examples are the implementation of ISO 14000 standards for medium-scale industries and the promotion of cleaner production to enhance competitiveness and environmental sustainability. It is necessary that the adoption of the environmentally sound technology transfer be on a "willingness to accept" basis.

(Source: Chantanakome, 1999)

5.4.3 Small- and Medium-Size Enterprises

Many of the incentives to embody best practice (in both capital equipment and in the products produced) that exist in multinational corporations also exist in small- and medium-size enterprises (SMEs). Indeed, SMEs can be highly innovative and competitive. But organisational difficulties and the lack of scale economies can diminish the ability of SMEs to make the best economic and environmental decisions (Lin See-Yan, 1997). Even if an SME in a developing country understands (or receives a policy signal) that it would be a good choice to invest in environmentally sound technology, it may still fail to do so simply because of a lack of information, skilled personnel or financial resources (see Box 5.4a for the example of SMEs in China and Box 5.4b for Thailand).

SMEs may also face additional barriers to technology adoption because of language differences or a lack of scientific and technical training on the part of their personnel. Even though much of the current stock of technical knowledge is available in the open scientific and engineering literature, this literature is not easily accessible in all parts of the world.

This last possibility illustrates that SMEs may be handicapped by the lack of infrastructure. The emission-reducing benefits of cogeneration in manufacturing cannot be obtained if there is no hook-up to the electrical grid, or if the scope and stability of the grid is limited so that there is no steady demand for cogenerated power. Absence of adequate infrastructure may place an additional constraint on technology choice that leads to less energy-efficient methods being chosen, as when, for example, production techniques have to be designed to work around the likelihood of power outages or brownouts.

5.5 Public-Private Partnerships

Public-private partnerships are increasingly seen as an effective way in which the public sector can achieve public policy objectives by working with the private sector. For the public sector such partnerships have the potential of harnessing the efficiency of the private sector, as well as overcoming budget restrictions and leveraging limited public funds. For the private sector, they aim to help overcome some of the internal and external barriers which prevent appropriate technology transfer taking place, and to create interesting business opportunities. Central to the concept is the recognition of corporate self-interest, and the opportunity to harness this self-interest to achieve goals such as greenhouse gas reduction.

Public private partnerships can take many forms and involve different entities. From the public sector, they can involve central government departments, agencies, multinational organisations or local government. On the private side, they can involve technology suppliers, technology user or private financiers.

5.5.1 Build Operate Transfer Projects

The Build-Operate-Transfer (BOT) structure for projects has gained considerable popularity as a form of private - public partnership that enables private participation in the development of public infrastructure. The essence of the BOT structure is that the private sector takes responsibility for the detailed design, construction, commissioning and operation of a particular project. In return it receives a payment for providing the services once operational, either from the public sector or from users, in the form of a long-term contract. After an agreed period (typically of between 10 and 30 years) the project is transferred back to the public sector. Finance for BOT projects is usually provided through project finance, discussed earlier. Equity investors usually include strategic investors such as the private construction or equipment companies, and public sector partners may also take an equity holding.

BOT and related arrangements(*e.g.* BOOT, Build Own Operate Transfer and BOO, Build Own Operate) have been very successful in opening up public infrastructure to the private sector finance, and they have a number of advantages. They bring pri-

vate sector disciplines to the project development and design process, and the public sector is far less exposed to risks of cost overruns or below expected performance. By enabling focus on a particular facility they can be more readily financed and do not impose a burden on public funds, and have thus probably helped encourage financial flows. The costs of financing are relatively low, with the bulk of the capital cost being financed by bank lending at modest margins. (UNIDO, 1996; World Bank, 1994; World Bank Group, 1994)

However, there is increasing recognition of some of the limitations of BOTs. The costs are increased by high project arrangement fees, and with private sector finance being more costly than public finance, the overall costs of the output can be higher than, *e.g.*, a well managed project by a public sector utility. The long term contract typically provided to the project by the public sector is inflexible and can become a burden to the public spending if for example demand falls or prices change, particularly if certain risks have been passed through to the public sector (*e.g.*, fuel costs). Finally, BOT projects can lead to a project based focus (*e.g.*, what is the cheapest power project at present), to the detriment of broader considerations (*e.g.*, what other power options, such as energy efficiency, are best). Thus, in certain areas attention is moving away from BOTs to other mechanisms (such as merchant power plants which sell power in a deregulated market).

From the perspective of ESTs, BOT projects usually encourage the use of modern equipment and there is an incentive to be efficient, with climate benefits. However, it is worth noting that the BOT mechanism is heavily used in sectors with major climate impacts (power, transport, oil & gas). Thus, the success of the mechanism itself could be seen to be contributing to increasing greenhouse gas production. More significantly, there is some indication that the BOT mechanism favours climate unfriendly technologies (*e.g.*, coal power generation) over alternatives (such as wind power), because of the need for proven technology, the preference for established project paradigms, the large scale of BOTs and the failure of governments to internalise environmental costs.

5.5.2 *Voluntary Agreements*

Traditional legislation creates a legal sanction for desired activities by the private sector and imposes penalties for non-compliance. Alternatively, regulations may specify contractual obligations between parties, including targets, time schedules, monitoring and evaluation efforts, etc. More recently, self-regulation, or so-called voluntary agreements have gained prominence. Under voluntary agreements, industry and government get together and come to some form of understanding and commitments on certain targets and achievements, and agree to undertake their own monitoring and reporting.

One example of a voluntary programme is the Top Management Commitment Programme (TMCP) in the UK. This programme, implemented by the Energy Efficiency Office (EEO), is targeted at the top management of companies in the UK. The programme attempts to elicit a formal commitment from the Chief Executive Officer (CEOs) of a company, requiring them to state their commitment to energy efficiency and display the same all over the company. The commitment was signed by the CEO and the Minister in charge, and it requires the company to formalise their commitment to energy efficiency. The company would undertake to report on energy consumption and efficiency, set up working groups and/or councils, suggestion schemes, etc. This programme has already been joined by over 1,000 companies, including IBM, Shell, Ford, BA, etc. Follow-up surveys carried out by the EEO indicated that the success on energy conservation efforts was significantly higher in the companies that signed on than in the companies that were not part of the TMCP.

The U.S. EPA's Green Lights Programme is another example of a voluntary agreement (see Case Study 2). Companies participating in the programme agree to invest in energy-efficient lighting retrofits in exchange for technical expertise and public relations benefits from the programme. China has started its own Green Lights programme. Numerous successful corporate voluntary programmes for ozone-depleting-substance phaseouts have also occurred (see Case Study 17).

In developing countries, one example of an especially successful voluntary programme was part of the Thailand Promotion of Electricity Efficiency Project by the Thai national electric utility (EGAT), partially financed by the Global Environment Facility (Martinot and Borg, 1999). EGAT wanted to rely on voluntary agreements and market mechanisms, and elicited a voluntary agreement with all five Thai manufacturers and the sole importer of T-12 fluorescent tubes. Under the voluntary agreement, the manufacturers and importer of T-12 lamps agreed that they would switch to producing and importing more-efficient T-8 lamps instead of the less-efficient T-12 lamps. In return, EGAT engaged in an extensive public education and information campaign to educate consumers about the switch and make the switch acceptable to the market. By 1995, all lamp manufacturers and importers had complied with the agreement, and virtually all T-12 lamps were eliminated from the Thai market. Success was aided by a zero net cost to manufacturers (reduced T-8 production costs paid for the production conversion), T-8 retail prices similar to those for the T-12 lamps, and luminaire compatibility. Success was also attributed to cultural factors ; the utility stated that the public considered such voluntary agreements more desirable and fairer than price incentives like rebates or subsidies.

There is much scope for voluntary agreements and other types of voluntary pollution prevention programmes, particularly for reduction of GHG emissions (Aloisi de Larderel, 1997). Berry (1995) suggests that industry and government should together take steps to refine knowledge of technologies and to educate users and manufacturers. Bringing the cost of non-standard technologies such as photovoltaics (PV) systems down implies reaping economies of scale in manufacturing the PV systems. To bring the transaction barrier down, Berry further suggests more

knowledgeable buyers, sellers, and suppliers, risk taking on the part of investors in large manufacturing plants, efforts at cooperation by major users of PV systems, and opportunities for risk sharing.

However, as identified in a recent report (OECD, 1999b), there can be problems with voluntary agreements, and the overall experience has been more mixed. In particular, an essential prerequisite for voluntary agreements is an underlying ability and willingness by policymakers to develop and enforce environmental regulations, so that the threat of alternative measures is credible. In countries where such conditions do not exist, the use of voluntary agreements could be at best ineffective and potentially very damaging for environmental objectives.

New examples of unilateral corporate commitments are also emerging, involving senior executives of the company voluntarily making a clear commitment to addressing environmental issues. An example of leadership has been the recent clear announcement of BP Amoco to reduce CO_2 emissions by 20%, combined with the establishment of an internal trading system to achieve that end.

5.5.3 *Technology Partnership Programmes*

Technology transfer aimed at fostering mitigation and adaptation responses to climate change will be most effective where it engages all key stakeholders in designing and implementing technology transfer actions. These key stakeholders include in-country and international private businesses and investors, government agencies, and bilateral and multilateral donor organisations. While private businesses play the key role in implementing most technology transfer activities, national governments and international donor agencies can help remove market barriers and set conditions to ensure effective private sector participation in technology transfer. Technology transfer activities will be most effective where businesses, governments, and donor organisations collaborate in designing and implementing these activities to make the most productive use of their respective resources and authorities.

Since climate change is not explicitly considered in most development plans, climate change considerations are not fully integrated into the development plans that shape markets for new technologies. In many cases, consideration of climate change issues will only require marginal adjustment to development plans, but this process of adjustment and review is critical in ensuring that development programmes contribute to climate change goals. Therefore, it is important for climate change technology transfer activities to respond to developing country determination of what type of technology transfer will best contribute to their development needs while also addressing climate change. Once these technology transfer priorities are well understood, developing countries can work with the private sector and the international donor community to facilitate technology transfer activities to respond to these priorities.

Technology partnerships can also be exclusively at a firm (company) level. The United Nations (1996) has suggested that "firms in many developing countries—the least developed ones in particular—often do not have the funds, trained human resources or infrastructure to pursue a technology-based innovation process

BOX 5.5 TECHNOLOGY COOPERATION AGREEMENT PILOT PROJECT (TCAPP)

In 1997, the U.S. Government launched the Technology Cooperation Agreement Pilot Project (TCAPP) to provide a model for a collaborative approach to foster technology cooperation for climate change mitigation technologies. Under TCAPP, the Governments of Brazil, China, Kazakhstan, Mexico, and the Philippines are currently working with the private sector and bilateral and international donor organisations to attract private investment in clean energy technologies in their countries. Many other donor initiatives have also adopted similar collaborative approaches between country officials, businesses, and donors in fostering private investment. However, TCAPP is one of the few initiatives that has engaged climate change officials in this collaborative process to lead to actions that address both development needs and climate change goals.

TCAPP has two basic phases of activities. In the first phase, the participating countries have developed technology cooperation frameworks that define their climate change technology cooperation priorities and the actions necessary to attract private investment in these priorities. These actions include efforts aimed at capturing immediate investment opportunities (e.g., issuance of investment solicitations, investment financing, business matchmaking and capacity building, etc.) and longer-term efforts to remove market barriers. In the second phase, TCAPP assists the country teams in securing the private sector, in-country, and donor participation and support necessary to successfully implement these actions. This second phase of activities includes two major types of activities:

1 Attracting direct private investment in immediate market opportunities. This includes helping the countries develop and issue investment solicitations for large-scale opportunities and business matchmaking and financing activities. TCAPP has established an international business network to help guide the design and implementation of these activities.

2 Securing support for actions to address market barriers. These actions range from business capacity building to policy reform. This includes development of domestic implementation plans for these actions and securing necessary donor support to assist with implementation of these plans. TCAPP assists the countries in preparing implementation plans and donor proposals and in matching country needs with donor programmes.

(Sources: NREL, 1998, UNFCCC, 1999)

on their own. In such cases a level of cooperation is needed that is qualitatively different from that associated with traditional technology transfer. Technology partnership (TP) is one opportunity for participation by developing countries' firms in the emerging forms of technological alliances and cooperation."

The essential characteristics of technology partnerships between enterprises from industrial and developing countries are typically the following: (a) they are long-term arrangements; (b) they are mutually beneficial; (c) they contain an explicit commitment to cooperation; (d) they have as one of their central goals the learning process of both partners; (e) they occur within a technology system and within specific economic relations; (f) they enhance the level and depth of both partners' technological capabilities (UN, 1996).

One recent example of a technology partnership programme is the Technology Cooperation Agreement Pilot Project by the U.S. government (see Box 5.5). Another example is the Technology Partnership Initiative, run in the United Kingdom by the Joint Environmental Markets Unit of the DTI and DETR. Joint demonstration projects of many kinds represent another form of technology partnership; one example is the project in Brazil by a consortium of twelve companies, including private and public Brazilian enterprises and multinational firms, to develop a biomass gasifier/gas turbine power plant designed to use wood chips as fuel. The consortium was created by the joint entrepreurship of foundations, industry associations, and government entities (Norberg-Bohm and Hart, 1995). And the multilateral "Climate Technology Initiative" has established a programme called "Technology Cooperation Implementation Plans" (TCIP) to carry out a number of partnerships (UNFCCC, 1999).

5.5.4 Informational Initiatives in Private Finance

The public sector can aim to encourage private finance to be more active in the development, dissemination and transfer of environmentally sound technology through a variety of activities which aim to remove some of the obstacles identified above, without spending large sums of public expenditure. A wide range of initiatives is possible here such as:

- Providing particular support to environmental businesses on accessing finance to help them in their dialogues with financiers. The USA, U.K. and Canada have all had initiatives in this area.

- Raising awareness within the financial sector on climate change, through seminars and working groups. Some countries have actively tried to get the financial sector involved in discussions on the appropriate response to climate change.
- Supporting the activity of some of the industry organisation identified above, and involving them in government consultations.
- Looking at industry training and regulation to ensure that there is a level of environmental management. Most active in this area have been the multilateral development banks such as the EBRD, who have required banks to develop environmental procedures as part of their financial markets' development programmes. While such activities will tend to emphasise avoiding the worse rather than actively encouraging the use of the best technology. it can still encourage a change in attitude among financial institutions.

- The lower risks are perceived to be, the cheaper finance will be. The public sector can help reduce risk perceptions by supporting information dissemination, *e.g.* of successful case studies.

5.5.5 Fiscal Measures: Tax Incentives and Guarantees

Governments can take a number of fiscal actions to encourage the uptake of environmental technology. While these can be highly effective, it should be noted that in many cases these may be second best alternatives to more consistent measures to internalise environmental costs or remove subsidies, which may not be politically acceptable (essentially offsetting one subsidy with another). In other cases they may be useful to initiate a market, but should not become permanent features.

Investor tax incentives. Governments can seek to encourage investment by supplying tax incentives for investors in certain types of companies or investments. One example is in the U.K. where private investors buying venture capital funds and new shares in unlisted businesses (not necessarily environmental) can partially offset the investment against income thus reducing tax liabilities. This has helped to encourage investors to put capital out into new technologies, although it has proved difficult to ensure that investors back the kind of risky investment the schemes are aimed at (rather than creatively packed less risky alternatives). An alternative approach has been taken in the Netherlands where the Government has given a tax-free status to returns on investments in approved environmental funds. These have succeeded in attracting substantial amounts of capital and in reducing the cost of finance for appropriate environmental projects. Perhaps most importantly they have helped encourage financial institutions to find and help develop new "green projects". However, they do not provide risk capital, and there have been problems of definition. While such projects normally support domestic businesses and ventures, the Dutch government recently extended its investor tax incentives to the selected projects in developing countries, with the potential to support technology transfer. In theory, the sort of tax support given to domestic venture capital could also be extended to selective venture capital opportunities in developing countries which might be an effective way of encouraging appropriate technology transfer.

Capital expenditure tax incentives. An effective way to encourage the uptake of new technology is by providing accelerated capital depreciation on certain equipment – in extreme cases all in the first year, or alternatively on a faster schedule than normally used. This has been used in a number of markets to help accelerate the uptake of renewable energy (California, India) and is currently being used in the Netherlands to encourage businesses to install certain types of environmental technology. One advantage of accelerated capital allowances is that they can usually be combined with leasing to provide an accessible and flexible sort of financing.

Loan guarantee schemes. In order to help support new business development, a number of governments have introduced loan guarantee schemes to support domestic small business development. They consist of the central government guaranteeing loans made by domestic banks to the small business sector to encourage the development of that sector. In most cases only a partial guarantee is provided so the participating private sector banks have an incentive to lend prudently. Other organisations have introduced schemes more specifically targeted at lending for environmental projects (*e.g.*, the European Investment Bank). Such loan guarantees do depend on the existence of a strong, independent financial system.

5.5.6 Partnering and Sponsorship for New Financial Initiatives

Another area in which the public sector can encourage the financial sector to become involved in the transfer of environmentally sound technology is through partnering and sponsoring new financial initiatives. This can reduce the costs and risks for private financial institutions in developing new products and instruments, and can help them give such initiatives a higher priority.

Support for such initiatives could come from a number of areas within the public sector: domestic industry or environment departments, bilateral assistance agencies, bilateral development banks, multilateral development agencies, and multilateral development banks. While some other examples do exist, it is the multilateral development banks that have been by far the most prominent in this sort of activity.

In particular, the World Bank's IFC, through its environmental projects unit, is now aiming to find ways to develop and support innovative mechanisms which help address environmental challenges and also encourage private financial sector participation, thereby using limited concessional finance efficiently. While in many cases it is proving more challenging and time consuming than originally expected to pull together and develop such initiatives, the IFC has started to accumulate a portfolio of activities (Asad, 1997). These include:

Finance for SME environment business. IFC's Environmental Projects Unit delivers a GEF-funded Small and Medium Enterprises (SME) programme which is designed to channel concessional funds through intermediaries to SMEs for renewable energy, eco-tourism, energy efficiency, sustainable forestry and agriculture. The SME activity needs to address the objectives of GEF programmes involving climate change and conservation of biodiversity. Intermediaries have included private companies, NGOs, financial institutions and a venture capital fund. These intermediaries can benefit from low interest rate loans and incentives, along with limited amounts of technical assistance to assume the business risk and invest in SME enterprises. The use of intermediaries by the GEF/IFC SME Programme helps overcome the obstacles of scale and of transaction costs identified above when dealing with the SME sector. The EBRD has developed similar programmes to encourage finance through intermediaries.

Emerging sector and market funds. The IFC is helping to create Sector and Market Investment Funds to assist professional and institutional investors to look at biodiversity, renewable energy and energy efficiency. Of greatest relevance is a major fund, co-financed with the Global Environment Facility (see Box 5.2), which will invest in renewable energy and energy efficiency projects, namely the proposed Renewable Energy and Energy Efficiency Fund for Emerging Markets (REEF). In addition, the IFC is also encouraging the development of environmental funds for a particular region or country, such as the proposed MENA Environmental Fund – while such funds invest in a variety of environmental projects, energy and climate-change-related investments are a significant proportion of the total. With these funds, the IFC contributes some of the capital but the aim is to attract funds from outside, particularly from mainstream financial investors. Here the IFC, as a supporter of the fund, can play a valuable role in reassuring investors about new markets. In addition, the IFC can help reduce the costs and risks of developing such funds.

Transforming inefficient or non-existent environmental markets. IFC's Market Transforming Initiatives recognise that while new environmental markets may offer potential, there are significant barriers to their development which other market players cannot address on their own. Examples relevant to climate change technologies include the Photovoltaic Market Transformation Initiative (PVMTI), and the Poland Efficient Lighting Project (PELP, see Case Study 2). The Initiatives aim to minimise the risks of developing them by providing concessional funds for innovative solutions to market development, with the objective of taking the markets to the point where fully commercial operations are viable, or to accelerate the penetration of commercial technology. Although concessional, the funds are intended to operate in many ways like private sector funds, and projects will be judged on the basis of current and future ability to leverage additional private sector finance, trigger market growth potential and promote longer term sustainability and replicability. The World Bank is also actively developing new market transformation approaches

These initiatives are to be welcomed. However, it should be noted that the close cooperation between the public and private sectors that these initiatives are based on can often entail tension

in areas such as cost-sharing, timescales and objectives. For example, REEF has taken several years longer to develop than originally anticipated. There is a need to learn from experience, for increased education of the private sectors and possibility some more flexibility and pragmatism from the sponsors of such initiatives to encourage private sector participation.

5.5.7 The Case of the Montreal Protocol

The possibilities for partnerships and financing for climate change mitigation can be better understood through an examination of the historical experience in phasing out ozone-depleting substances (ODSs) under the Montreal Protocol on Substances that Deplete the Ozone Layer (see also section 3.3.3 in Chapter 3). Evaluations of the economics of the phaseout process that have been made since the Protocol was signed in 1987 have concluded that the speed of the phaseout has been faster, and the cost lower, than had been anticipated when the Protocol was negotiated (Hammitt, 1997; Cook, 1996; Economic Options Committee, 1991, 1994, 1998). This happy surprise is attributable largely to the unusual and unexpected channels for technology transfer that emerged once the Protocol was in place.

The signing of the Montreal Protocol meant that significant cutbacks in ozone-depleting substances had become a strategic business necessity. Industrial leaders' recognition of this fact may in part have been simply an acknowledgement of the legal reality of the Protocol, but there is ample reason to believe that their support of the Protocol was based on an understanding of the science as well. Given the existence of this sort of consensus, undertaking the kind of organisational changes needed to eliminate ODSs followed. Participation in the ozone protection effort became a basis for career advancement and a source of personal pride for individuals within companies. Firms found that by redesigning processes to reduce their need for ODSs, they could realise previously unforeseen productivity gains, as when it was discovered that printed circuit boards could be manufactured without having to clean off soldering residues with a CFC solvent (Iman and Lichtenberg, 1993; Wexler, 1996a).

A variety of cooperative arrangements evolved under the umbrella of the Montreal Protocol that facilitated technology transfer. Soon after the Protocol was signed, a number of large corporations with major electronics interests formed ICOLP, the Industry Cooperative for Ozone Layer Protection, to share information, discoveries, and procedures for eliminating ODSs in their manufacturing processes. A similar consortium was founded in Japan, the JICOP (Japan Industrial Conference for Ozone Layer Protection). Company-to-company deals, multifaceted agreements involving both companies and governments, and both formal and informal information exchanges characterised the process. Examples include the trilateral agreement between Thailand, Japan MITI, and the U.S. EPA (see Case Study 23) and the cooperation between the Government of Mexico, Camara Nacional de la Industria de la Transformacion, the Canadian telecommunication company Nortel (Northern Telecom), the International Cooperative for Ozone Layer Protection, and the U.S. EPA. (Economic Options Committee 1994; also see Case Study 17)).

Governments played a supportive role in the formation of information-exchange networks. In the United States, for example, a vital clearinghouse role was filled by the U.S. Environmental Protection Agency's Stratospheric Ozone Protection Division. The U.S. EPA, along with the industry-based Alliance for Responsible Atmospheric Policy (formerly the Alliance for Responsible CFC Policy), Environment Canada, and the United Nations Environment Programme, co-sponsored an annual meeting in which industry practitioners presented papers detailing the progress they had made in eliminating ODSs in their own operations. The culture of this well-attended meeting was akin to a scientific symposium or a scholarly conference, with an emphasis on free exchange of ideas. Part of the conference space was devoted to a trade fair, in which the most recent advances in technology to replace ODSs were on display. By 1998 the conference had evolved into the "Earth Technologies Forum" covering climate protection technologies as well as ODS elimination.

The Multilateral Fund, set up under the Montreal Protocol to assist developing countries in defraying the "incremental costs" of compliance with the Montreal Protocol, also played an important role. The Fund has financed projects ranging from the development of individual country ODS-elimination programmes to the building of large-scale industrial facilities that use alternate technologies. In some respects, the Fund may be seen as a precursor and proving ground for the functioning and organisation of the Global Environmental Facility (see Box 5.2 on the GEF). It has been the objective of this Multilateral Fund to provide development assistance that is "additional" to other aid funds. Through establishment of the Multilateral Fund, the Parties to the Montreal Protocol have addressed the equity concerns that for a time retarded full participation in the ozone protection process by all the key countries (neither China nor India signed the Montreal Protocol until the Multilateral Fund was established at the London meeting of the Parties in 1990).

Government policies were able to exert a positive influence on technology development in other ways. A major stumbling block to the elimination of ODSs in electronics manufacture was removed when the U.S. Department of Defense changed its requirement that CFC-113 be used to clean soldered electronic assemblies to a performance standard (Wexler, 1996b). Governments have helped to develop standards for recycling CFCs, and have supported the establishment of Halon "banks" to get full use from the stock of ODSs that have already been produced (Economic Options Committee, 1994). The United States imposed both an excise tax on 'new' ODSs and a 'floor tax' on inventories beginning in 1990. The effect of such taxes is to make new chemicals and technologies more attractive, and to encourage reclamation and recycling (Economic Options Committee, 1994). The Ninth Meeting of the Parties in Montreal, 1997, decided to require Parties to the Protocol to establish licensing systems to control the import and export of new, used, recycled and reclaimed substances, in order to reduce and eventually eliminate illegal trade in controlled ODSs (Economic Options Committee, 1998).

5.6 Technology Intermediaries

The World Bank and many other agencies have recognised that technology intermediation is needed to reduce barriers to technology transfer associated with information, management, technology, and financing (World Bank, 1993; Martinot *et al*., 1997; Heaton *et al*., 1994). Research on technology innovation also highlights the role of intermediaries in the innovation process (Dodgson and Bessant, 1996, p.54; see also section 4.3 on National Systems of Innovation and Technology Infrastructure). Examples of technology intermediaries include specialised government agencies, energy-service companies, non-governmental organisations, university liaison departments, regional technology centres, research and technology organisations, electric power utilities, and cross-national networks. Non-governmental organisations in particular are playing a greater role in technology intermediation; for example, there are many cases where technology intermediation by NGOs played a key role in the success of particular technology transfer efforts for renewable energy (Kozloff and Shobowale, 1994). The functions of technology intermediaries can include:

- articulation of specific technology needs and selection of appropriate options
- education, information dissemination, and communication
- identification of skill and human resource needs
- selection, training, and development of personnel
- investment feasibility, appraisal and business plan development
- development of business and innovation strategies
- locating key sources of new knowledge
- building linkages with the external sources of information
- creating and/or operating new dealer and service networks
- project management and organisational developmentreferrals
- training and consulting
- energy audits
- matching potential supplier and recipient firms
- feasibility, evaluation, and packaging of projects for public or private financing
- translating, compiling, vetting, and endorsing information

In general, there are seven key questions for policies that promote technology intermediaries:

1. What are the needs of users?
2. Who are the suppliers of technology?
3. What are the needs of technology suppliers?
4. What is an appropriate role for intermediaries?
5. What kinds of agency can help bridge the gap between suppliers and users as an intermediary?
6. What are the mechanisms whereby such intervention can take place?
7. What can public policy do to enable or assist the process of intermediation?

5.6.1 The Value of Technology Intermediaries

The need for intermediation to overcome transaction barriers is often discussed in the context of technology development, both internationally and in purely domestic contexts. The World Resources Institute (Heaton *et al*., 1994) has proposed sector-specific intermediation as an important policy goal for greater international technology transfer, development and cooperation:

> In intermediation, third parties create linkages, transmit knowledge, and expedite other transactions for the principals. The greater the barriers that separate parties who could create relationships of mutual benefit, the greater the need for intermediation. In technology development, the value of intermediation is well recognised. (p.20)

Evidence to-date with institutions that perform some intermediary functions shows that sector-specific intermediaries have advantages over broad, general-purpose intermediaries, because the technologies and applications involved are simply too diverse. A consequence is that intermediaries for energy efficiency and renewable energy should to some extent be specialised. In this view, many or most or the actors are already in existence and working, but communication and new, and more specific, problem-solving capacities are required.

Others have called technology intermediaries bridging institutions. Dodgson and Bessant (1996) highlight the importance of the intermediaries that operate between users and suppliers of technology and which help to create the links within networks and systems. They say that "bridging institutions...encourage interaction within the system, assisting with undertaking search, evaluation and dissemination tasks. They ensure that technological know-how is broadly dispersed within the system and can provide a compensating mechanism for weaknesses or 'holes' in the system" (p. 26). Innovation agents are another name for intermediaries(Dodgson and Bessant, 1996, p.186).

The high value of technology intermediation is illustrated by many of the case studies presented throughout this report. In the Baltic States, the Swedish government aid agency NUTEK promoted conversion of heating boilers to biomass by bringing boiler operators and manufacturers of conversion equipment together, by providing financing for the conversions, and by providing assistance to boiler operators in financial and technical analysis, competitive procurement, and contracting (see Case Study 18). In Mexico, the national electric utility played an intermediary role by marketing and selling efficient lighting through its offices, and by reducing the retail price through bulk procurement (see 5.2.1). In East Africa, the promotion and dissemination of improved efficiency cookstoves

was facilitated by small-scale informal-sector entrepreneurs providing sales and service (see Case Study 1).

In countries with economies in transition (CEITs), technology intermediaries are important ways to overcome the lack of business, financing and marketing skills among firms whose managers never learned these skills in the centrally planned economy (because these skills were not needed). In particular, energy service companies, financial intermediaries and information centres have been playing important technology intermediation roles for climate-friendly technologies in many CEITs (discussed in more detail in the sections below). In CEITs, because of generally well developed technical skills among enterprises, intermediaries can focus on business, information, and financing services (Evans and Legro, 1997; Martinot *et al*., 1997; Martinot, 1998; Marousek *et al*., 1998).

In many rural photovoltaic programmes, a local or foreign intermediary provides critical marketing activities, education, financing or leasing mechanisms, sales and service infrastructure that helps to create a market. In the Dominican Republic, an innovative leasing programme by SOLUZ has successfully transferred PV technology. In Kenya, a network of dealers, along with education and training programmes have resulted in 80,000 solar home systems in use (see Case Study 5). In Bangladesh, the Grameen bank has successfully provided micro-credit for solar photovoltaic home systems (see Box 5.3). The World Bank and GEF have recently incorporated innovative intermediary mechanisms into solar PV home system projects in China, Indonesia, and Argentina, reflecting the World Bank's increased focus on rural energy for development (World Bank, 1997).

Technology intermediaries also can play an important role in strengthening the enabling environments for technology transfer discussed in Chapter 4. In particular, they can help to establish codes and standards locally or nationally, they can help facilitate programmes that create sustainable markets for environmentally sound technologies, and they can influence regulatory conditions and macroeconomic policies.

5.6.2 *Information Clearinghouses and Technology Transfer Agencies*

In order for technology transfer transactions to take place, parties must know about each other and understand the costs and benefits of different technology transfer pathways. Often projects, particularly to introduce the new energy technologies, are conceived without proper understanding of the needs and priorities of the targeted users (Mapako, 1997). Consumers or purchasers must be aware that technologies exist, must know their performance characteristics, reliability, capital costs, operating costs, and economic benefits, and must know how to maintain and service technologies or know of firms who can. While in most of the developed countries there are a multitude of information sources, the same is not the situation in the developing countries. Interviews with more than a hundred negotiators and policy-makers in developing countries can be summed up in the words of one interviewee: "we do not know what is available and what we really need" (Gupta, 1997, p.89).

Information clearinghouses and technology transfer agencies are specific forms of technology intermediaries that have been proposed by UN and other public agencies. These agencies point out that numerous public and private environmental information systems already exist. Improving these existing systems and linking them through clearinghouses can be a first step towards establishing an international network of technological information. A number of international information networks and databases that specifically address climate-mitigation technologies already exist (UN, 1997).

Although governments commonly set up information centres, in some countries, national or sector specific industry associations have also set up information centres. The information centres are of two types: information of a highly technical nature, required by larger energy consumers, and general information as would be required by households and small commercial establishments. Traditionally, schools and colleges, science centres, and museums have also been common vehicles for providing general information.

But beyond the simple supply of information, more sophisticated technology transfer agencies can actively promote knowledge transfer through a number of activities:

- conducting workshops, seminars, and conferences
- assisting technology producers in marketing their technology and understanding markets
- providing training and assistance in preparing business plans
- matching potential joint venture partners
- securing intellectual property rights and assisting in creating licensing agreements
- educating financiers about specific technologies and channelling investment proposals

Notwithstanding the UN initiatives in this direction, many countries in the developing world and CEITs have initiated systems to provide information on different technologies. In a recent climate technology and technology-information-needs survey among developing countries under the auspices of the Subsidiary Body of Scientific and Technology Advice, 60% of the respondents pinpointed to national technology information centres as an important vehicle for dissemination of climate relevant technologies and practices. In over 75% of these respondents' home countries at least two such technology information centres exist (van Berkel & Arkesteijn, 1998). Successful energy-efficiency centres in several economies in transition (China, Russia, Bulgaria, Romania, and the Czech Republic) are good examples of technology intermediaries that have been established with international assistance (Chandler *et al*., 1996). As another example, Box 5.6 describes national-level technology intermediaries in India for energy efficiency and renewable energy technologies.

BOX 5.6 NATIONAL TECHNOLOGY INTERMEDIARIES IN INDIA

National-level government agencies acting as intermediaries can also be important in creating incentives and facilitating a market for cleaner technologies. The Energy Management Centre (EMC), an autonomous agency, under the Ministry of Power, Government of India, is an example of a technology intermediary for energy efficiency. EMC has been carrying out a number of initiatives to promote energy conservation and efficiency in India. To begin with, EMC set up and trained 25 agencies (public, private, NGOs), to provide specialised energy auditing and management to consumers in India. Each of these agencies are carrying out an average of 10-12 energy audits annually, and the feedback from the industry is that there is an urgent need for many more such professional agencies to be able to serve the consumers in the country. EMC also carried out a number of studies in the area of technologies for energy efficiency, issues relating to standards and labelling, as well as implementing a nation-wide energy conservation awareness project. EMC annually organises, through industry associations, about 20-25 training programmes and workshops for wider dissemination of information on energy conservation in the country. To date, it is reported that over 5,000 professionals have been provided training in different aspects of energy efficiency. Regular feedback carried out indicated that the participants have actually implemented energy efficiency projects in their organisations. EMC was the executing agency for international cooperation projects with Germany, the European Union, and the Department of Energy (USA), among others.

The initiatives of the Indian Government implemented through the EMC have resulted in a significant rise in the exposure and awareness on energy conservation technologies. It is reported that there are proposals to introduce standards for appliance and energy consuming devices and these would be mandatory. Penalties for non-compliance would be enforced once the law is passed by the Indian parliament. Under a collaborative programme with the EU, EMC has set up an Information Service on Energy Efficiency (ISEE), jointly with a national industry association. The database established is expected to contain information on technologies, guide books, manuals, best practice programmes, a list of manufacturers, etc. and is expected to fill the gap in information for energy consumers.

The Technology Information, Forecasting and Assessment Council (TIFAC) in India was established as an autonomous organisation of the Indian Department of Science and Technology, and has been particularly successful in making the public-private sector linkages, providing information on patent issues, and supporting start-up ventures. Each of these activities provides important examples for other similar, knowledge-based technology transfer policy offices.

The Ministry of Non-conventional Energy Sources (MNES) in the nodal ministry responsible for providing the overall thrust and direction for increased adoption and installation of renewable energy devices in the country. MNES implements the programmes through the state governments and through state energy nodal agencies. MNES has separate programmes for biogas, solar thermal, solar PV, biomass gasifier, and for new technologies.

Most developing countries have a large proportion of small and medium-scale industrial concerns whose outputs constitute a significant portion of the GDP of these countries. The technology information needs of these enterprises may not be the same as that of big MNCs operating in these countries. Nevertheless the technology information centres springing up in developing countries do or can not serve MNCs. While the private sector has often been disdainful of such information programmes, many representatives of developing countries report that they find vendor information biased and confusing and need help to evaluate competing vendor claims. Such technology information centres can provide such help. The small and medium scale industries are generally short in management and technological capabilities, and can make effective use of information clearinghouses on ESTs. Having said that one should also realise that the small-scale industries or the so-called informal sector are far removed from such initiatives, thus it is desirable that agencies use intermediaries to reach them with this information.

BOX 5.7 REGULATING ELECTRIC POWER UTILITIES TO BE TECHNOLOGY INTERMEDIARIES

The key role played by electric utilities as technology intermediaries in promoting energy efficiency has been well established in scientific literature. Historically, utilities in the US began offering energy efficiency or demand side management (DSM) programmes to consumers after regulators made this a policy goal. The utilities were compensated by the utility commissions for any loss of revenue that may have occurred in this process, after accounting for other savings due to reduced fuel costs, etc. Investment on DSM is reported to exceed US $2 billion, and this is expected to account for about 14% of the new investment in the power sector in the US in 1994. Utilities in Germany, Denmark, Canada and other countries followed. Now DSM programmes are being taken up in Thailand, the Philippines, Mexico, Jamaica, Brazil and other developing countries as well (see Case Studies 10 and 23 on DSM in Chapter 16). These programmes are in their early phase, and they account for a small portion of the activities on energy efficiency in these countries. Utilities are essentially playing the role of information provider to start with; then they assist consumers to achieve energy efficiency at the consumers' premises. Several utilities have set up independent companies, 100% owned by the utility, which are outside the control of the regulator, since energy efficiency business was essentially unregulated.

Regulating electric power utilities to perform so-called Demand-Side Management (DSM) is a form of technology intermediation that became well established in the United States in the 1980s (see Box 5.7). Utilities in Germany, Denmark, Canada and other developing countries have followed. Now DSM programmes are being taken up in Thailand, the Philippines, Mexico, Jamaica, Brazil and other developing countries as well (see also Case Studies 10 and 23 in Chapter 16).

5.6.3 Energy Service Companies

Energy service companies (ESCOs) are a specific form of technology intermediary that has gained widespread acceptance in developed and developing countries and countries in transition. Due to the previously discussed barriers to conventional financing, innovative financing schemes are needed. A financing scheme is a particular institutional arrangement that determines who pays what to whom and who bears the risks of the transaction(s). An energy service company "ESCO" addresses the financial capability, and other institutional market issues. An ESCO is a company that offers energy services to customers with performance guarantees. Typical performance contracting arrangements provide customers with feasible means of improving their competitiveness by reducing energy consumption costs. Additionally, companies' cash flows are enhanced, which add value to their financial worth.

Historically, ESCOs evolved in three broad categories as follows:

- Technology based (technology suppliers).
- Financial and legally based, with sub-contracting for the technical aspects of projects
- Technically based such as engineering consultancy firms

Two common ESCO approaches in the United States are guaranteed savings and shared savings approaches. In the guaranteed savings structure, the end-user finances the project's initial investment costs from a third financier and, in turn, the ESCO guarantees that the energy savings will at least cover the debt services. Then the ESCO receives a share of the net savings after debt services and the operations and maintenance costs. However, if the savings fall short of the customer's financial obligations as stated in the performance contract the ESCO assumes the shortfall. In this respect, the ESCO assumes all the risks associated with the project's performance and the third party financier assumes the end-user's credit risk. In the second approach, the shared savings structure, the ESCO finances the project's initial investment costs, usually by borrowing from a third party financier. In turn, the ESCO is compensated by a higher share of the project savings. Given the current market situation in most of the developing countries, ESCOs are most likely to evolve in one of the following forms:

- Local engineering consultancy firms expanding their portfolio of services to include energy efficiency as one of their activities.
- Local engineering consultancy firms entering into joint ventures with foreign technical partners.
- Local equipment suppliers expanding their services to include energy efficiency services.
- Financial and legal firms creating specific companies for this purpose.

ESCOs have been successful in many developed countries, in particular the United States, United Kingdom, France, Germany, Australia and Brazil. However, the risks and the absence of clear success in developing countries are still issues. While there have been one or two successes in the former communist countries with specific injection of bilateral grant funds, the ESCO concept is still emerging. Nevertheless, energy service companies are operating or being formed in several developing countries and countries in transition, including Brazil, Mexico, China, Thailand, India, Russia, Hungary, and the Czech Republic (see Case Studies, Ch. 16). With assistance from USAID, two or three ESCOs are now operating in India, with efforts underway to increase the number of operations as well as to sensitise the consumers to take advantage of the services provided by the ESCOs. A pilot project by the World Bank and the Global Environment Facility is pioneering parastatal ESCOs in China by developing standard contractual models, providing financing and technical assistance to a group of pilot government-owned ESCOs (which may be privatised over time), and disseminating information about energy efficiency measures to industry (World Bank, 1998).

Energy service business associations have been recently formed in Egypt and Brazil. They represent groups of private companies offering energy efficiency products and services. Their members share the common goal of providing solutions that reduce energy costs, improve productivity, and enhance operating conditions of energy users. The associations will address current market barriers facing the energy service business community, and will provide a forum for energy efficiency development. Members of the associations include companies providing turn-key services as energy service companies (ESCOs), equipment vendors and service suppliers, support vendors such as legal firms and consultants, and other interested organisations.

5.7 Conclusions

ODA is still significant for the poorest developing countries. There is increasing recognition that ODA can best be focused on mobilising and multiplying additional financial resources, assist the improvement of policy frameworks and be based on long-term commitments to capacity-development. However, the advantages of public-sector finance may be offset by assistance in the form of tied aid, which can be detrimental to the longer-term prospects for indigenous technology development by preventing the establishment of the institutions to support technology choice, financing, and operation and management. Tied aid is more useful at targeting areas such as capacity building and project preparation.

There are several channels for international public finance. Bilateral development aid is the largest, with very mixed records relating to technology transfer and sustainable development that, furthermore, varies widely between countries. The MDBs are another major route, and in many cases these now have more developed environmental criteria and sources. Agencies such as UNDP may also strongly influence technology transfer through their programmes. On the other hand, trade support, such as export credits, rarely takes account of environmental factors and may in many respects be biased against environmentally sound technologies.

The choice between different international financing routes is determined by many factors. One major issue regarding the effective transfer of ESTs through public finance is the fact that foreign aid expenditure tends to be institutionally divorced from other powerful agencies that also have a huge influence on technology choice and investment patterns, such as trade ministries. It is not uncommon to find governments pursuing seemingly contradictory international financial policies, and one of the strongest recommendations in this area is for greater institutional coherence within donor governments.

An important trend is the shift away from the public sector to the private sector as the principal source of finance. Transfers of ESTs are influenced by this trend, partly because the private sector requires relatively high rates of return and does not monetise externalities. Although the private sector has begun to recognise the importance of climate change, governments can enhance private involvement through various types of initiatives and partnerships. Private support for climate-friendly technology transfer may also require financial innovations and emphasis on different forms of finance such as micro-credit, leasing and venture capital.

There is a wide variety of types of traditional private sector debt and equity finance available depending on the scale and type of the project. The most flexible way to finance debt is secured loan and leasing. The transfer of ESTs to developing countries will also involve increased use of innovation to structure existing financial products to new markets and to develop new ones as appropriate. Just as support for scientific and technical innovation is seen as an appropriate use of public funds, so is support for financial innovation. A number of worthwhile initiatives have been undertaken to date (such as micro-credit, project finance, green finance and also the use of strategic investors), and there is scope to replicate and extend these as well as develop new concepts.

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. A number of obstacles that are internal to firms can retard the diffusion of pollution-reducing innovations even when such innovations would be profitable. These obstacles are not instances of "market failure" in the traditional sense, because they originate within firms rather than arising from the strategic interactions between firms or from the existence of externalities or public goods. These barriers can also retard the transfer of environmentally beneficial technologies between firms. Policy measures, public-private partnerships, and internal organisational improvements can help overcome these barriers and promote the interests of all stakeholders.

Public-private partnerships are increasingly seen as an effective way in which the public sector can achieve public policy objectives by working with the private sector. For the public sector they have the potential of harnessing the efficiency of the private sector, as well as overcoming budget restrictions and leveraging limited public funds. For the private sector, they aim to help overcome some of the internal and external barriers which prevent appropriate technology transfer from taking place, and to create interesting business opportunities. There have been a number of examples in this area, many of them funded by the multilateral development banks, and the support of the GEF has been useful in many cases – its flexibility and adaptability has been a major strength.

In order to overcome information barriers, technology information centres have been widely advocated, but existing experience and literature does not provide enough certainty about exactly what is required for key stakeholders at critical stages. The value of other forms of technology intermediaries is better established, such as national-level technology transfer agencies, electric utilities, and energy service companies. ESCOs in particular have gained widespread acceptance to stimulate innovative financing schemes; they address the financial, capability, and other institutional market issues. An ESCO is a firm that offers energy services to customers with performance guarantees. Typical performance contracting arrangements provide customers with feasible means of improving their competitiveness by reducing energy consumption costs. Governments and other public-sector entities can develop technology intermediaries through direct support and other interventions.

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Section II

Technology Transfer: A Sectoral Analysis

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