7

Residential, Commercial, and Institutional Buildings Sector

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EXECUTIVE SUMMARY

The residential, commercial, and institutional buildings sector accounted for about one-third of the global energy used in 1990 and roughly one-third of the associated CO_2 emissions. The sector's share of energy consumption is higher in developed countries than in developing and transition countries. Energy is used to heat and cool buildings, and to provide lighting, as well as services ranging from cooking to computers. The emissions from the building sector includes those from the direct use of fossil fuels in buildings, and emissions from the fuels used to furnish electricity and heat to buildings. About two-thirds of these emissions were from residences; the other one-third from commercial and institutional buildings (IPCC, 1996a). The achievable reductions below baseline projections are estimated at 10-15% in 2010, 15-20% in 2020, and 20-50% in 2050, relative to the IS92 scenarios.

To achieve these reductions requires technology transfer programmes that work rapidly and effectively to diffuse the best environmentally sound technologies (ESTs). The buildings sector is more atomistic and decentralised than the industrial, energy, and transportation sectors, making it more difficult to transfer technology and transform markets. The most successful government-driven pathways include (mandatory) energy and environmental standards for new buildings and equipment; information, education and labelling programmes; and government-supported research, development, and demonstration (RD&D) programmes. Governments also have a key role in creating a market environment for successful private sector-driven technology transfer through decisions on financing, taxes, regulations, and customs and duties. Governments, particularly local governments, can encourage successful community programmes by proactively identifying community-level needs, and by encouraging and responding to community initiatives.

In the near term, the most successful technology transfer programmes will not be driven by their environmentally sound benefits alone, but because they also meet other human needs and desires. Examples include new energy-efficient buildings that are more comfortable and provide more services, yet have lower energy costs and lower greenhouse gas (GHG) emissions. The most successful technology programmes focus on new products and techniques that have multiple benefits.

7.1 Introduction[1]

Those responsible for the transfer of ESTs to residential, commercial and institutional buildings face two challenges. First, they must find ways to advance the best technologies from a great range of new technologies available to the buildings sector. And second, they must advance them rapidly to meet international climate change goals. Buildings are long lasting and community development patterns have even longer lives. The incremental costs of the best technologies is slight at time of construction, compared with the cost of replacing energy-wasteful buildings and equipment. The technologies themselves are varied and powerful. The IPCC Technical Report I found an existing technical potential to meet the sector's global energy needs through 2050 with no increase in energy use from the 1990 level (IPCC, 1996b).

Yet, the transfer of these technologies poses special problems. Buildings vary greatly in their size, shape, function, equipment, climate, and ownership--all of which affects the mix of technologies needed to improve their performance. In some countries, the energy used in housing is "free" or subsidised to the occupants. When they do not have to pay the full cost of the energy they use, they have less incentive to use it wisely. Where a large portion of the occupants would have great difficulty paying the full costs immediately, there is strong political pressure to continue the subsidies. Governments and energy suppliers find it simpler and more predictable to invest in increasing energy supplies than in reducing the energy demands of millions of building owners and operators.

The nature of the buildings sector is changing. Urbanisation is having a great impact on development choices, particularly in developing countries, causing a rapid expansion of the housing and commercial building sectors. Due to an unmet demand for adequate housing in many countries, this trend is expected to continue, especially in some developing countries. Driven by these changes, a growing share of the GHG emissions in many countries is coming from the buildings sector. The related government decisions on environmentally sound land use planning and energy, water, and wastewater infrastructure will have long-term effects on population density and ecology systems.

The challenge is to identify and implement technologies that meet these changes and also lower GHG emissions. Fortunately, the same investments can achieve multiple goals. Investments in energy efficient buildings also lower future energy costs; produce more comfortable and healthy indoor environments; create more productive work places; achieve other environmental improvements; and acquire more durable, long-term investments. Successful technology transfer strategies link climate change goals with measures that produce these companion benefits. See Figure 7.1.

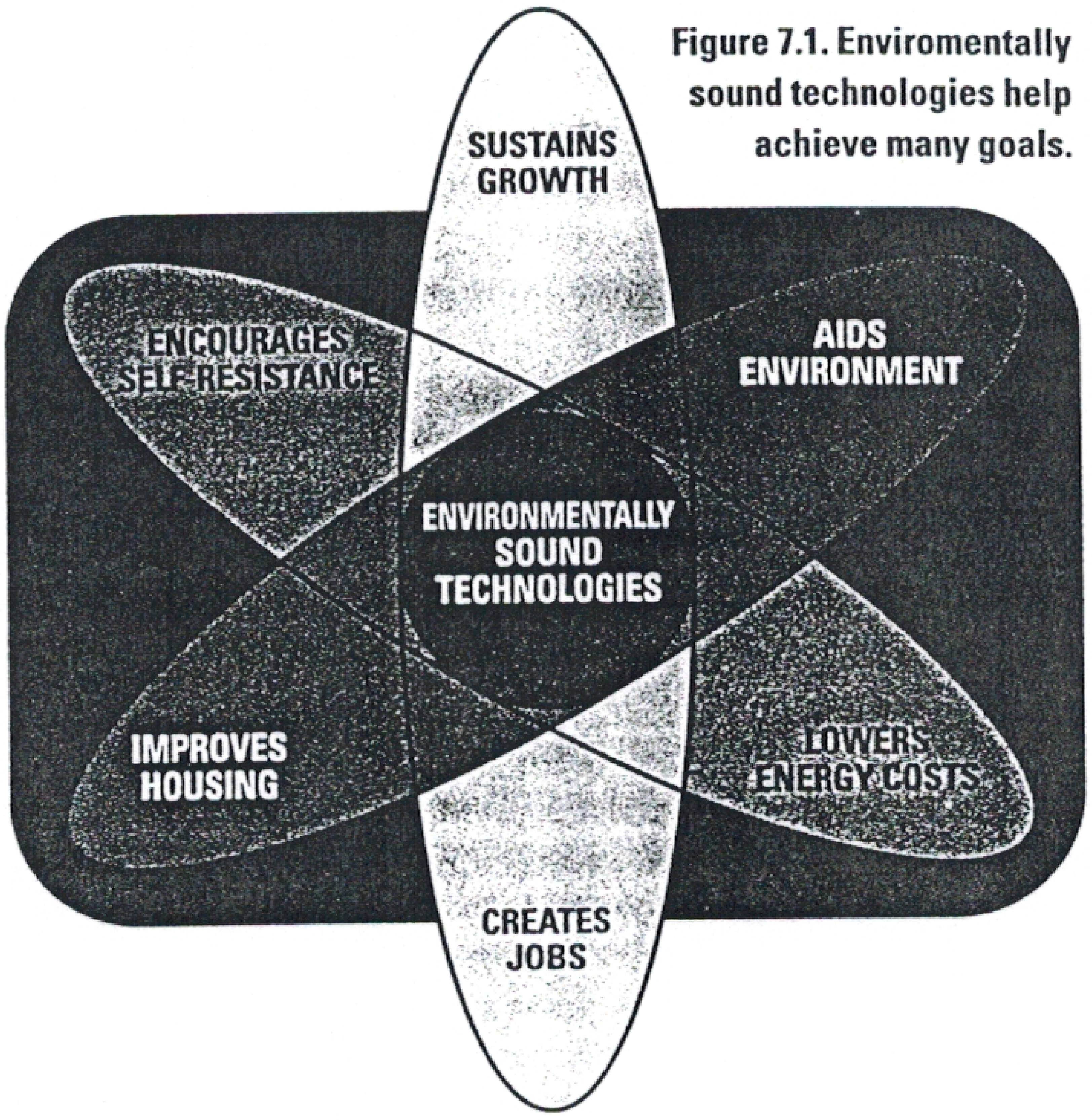


Figure 7.1. Enviromentally sound technologies help achieve many goals.

For each country, the desired mix of new technologies will be different, depending upon its unique climate, building stock, energy sources, stage of development, and social, economic, and political priorities. These values will be reflected in its assessment of its technology transfer priorities, which is the first stage in the technology transfer process. Following this assessment, the next stages will be obtaining agreement on the technology transfer programme and then its implementation, evaluation and adjustment, and replication. (See also Figure 1.2, Chapter 1.)

This chapter will provide a brief description of ESTs to illustrate their nature and potential. The current technology transfer processes are described, including their limitations, focusing on the barriers to change, the different pathways for overcoming these barriers, and the roles of the different stakeholders. Governments play a prominent role in the buildings sector through their programmes and through decisions that affect private-sector stakeholders and community groups. The bulk of the chapter describes experiences with different technology transfer programmes, both national and international, analysing what has worked, what has not, and the lessons to be learned.

The primary focus of this chapter is buildings. The boundary between the buildings sector and the energy supply sector is the building envelope, where electricity, thermal energy and other energy resources are delivered to buildings. Renewable systems that deliver energy directly to buildings, such as photovoltaic

[1] Relevant cases from the Cases Studies Section, Chapter 16, for Chapter 7 are: Cookstoves (case 1), Green Lights (case 2), Inner Mongolia Wind (case 3), PV in Kenya (case 5), Butane in Senegal (case 7), Ladakh renewables (case 14), CFC-free refrigerators in Thailand (case 23).

rrays, are considered part of the buildings sector. When an ndustrial process dominates a building's energy consumption, it ies part of the industrial sector.

Vhile the primary emphasis is on increased efficiency, fuel witching also can lead to lower GHG emissions. This is partic- ılarly important in the buildings sector, where the choice among uels, including renewable sources, is wider than in other end-use ectors. In developing countries, the energy used in the residen- ial sector includes a significant share of "non-commercial" or tra- litional energy sources, such as fuel wood, charcoal, and other iomass, particularly for cooking (Ang, 1986). The changing atterns in energy sources and the possible mix of future sources vill influence a country's selection of its preferred buildings ector technologies.

'his chapter also covers some of the subjects in the chapters on Iuman Settlements in earlier IPCC reports (IPCC, 1996a). Be of their influence on building energy use, the chapter ncludes brief references to land use planning and water use top- cs. Significant energy savings result from water conservation pro- ects, because of the large amount of energy used to heat, treat, nd pump water. The embedded energy and the ability to recycle ne construction materials used in buildings also are important and rovide an important link to sustainable systems. While most of ne attention is given to GHG mitigation, this chapter includes ome adaptation measures, *i.e.* water management, sewage sys- and building codes and standards.

.2 Climate Mitigation and Adaptation Technologies

n extensive body of literature describes building and municipal echnologies that improve energy efficiency, apply renewable nergy resources, reduce GHG emissions, and adapt to potential limate change. For much of our history, energy was viewed as o abundant and inexpensive that insufficient scientific and tech- ic ntion was given to how to use it wisely. During the last 5 years, this has changed. Scientists have focused on energy and ound fertile ground in virtually every area of energy use. The iversity of the building sector has made it a favourite field for echnology innovation. Since, however, this Report focuses on ow to transfer the technologies to new users, only a summary escription is provided of this rich field.

.2.1 *Residential Buildings*

ı the residential sector, GHG mitigation technologies can be ivided into three groupings: building envelope strategies, build- ıg equipment strategies and renewable energy strategies. uilding envelope strategies address the size, shape, orienta- c d thermal integrity of the residential unit. Examples of mit- gation technologies include increased wall and roof insulation, dvanced window technologies, roof coatings, and reduced or ontrolled infiltration. Building equipment strategies improve the pace heating and cooling, lighting, cooking, refrigerators, water heating, clothes washing and drying, air conditioning and other household appliances used in homes. Examples include such advanced technologies as condensing furnaces, compact fluorescent lamps and advanced refrigerator compressors. The renewable energy strategies include passive solar building designs and active solar water and space heating systems, ground-source heat pumps, daylighting strategies, and photovoltaic systems. In the residential subsector, the choice of technologies will vary greatly due to climate, between single-family residences and multi-family apartment buildings, and between urban and rural (traditional) communities.

7.2.2 *Commercial and Institutional Buildings*

This sub-section includes different building types, such as offices, retail stores, schools, hospitals, hotels, warehouses, theatres, and places of worship. However, within each building type, such as office buildings, the buildings are often similar in both developed and developing countries, inviting similar energy-saving strategies. Electricity is the dominant energy source, providing 70% of the resource energy demand in the industrialised countries (EIA, 1994). However, energy sources vary greatly among countries, e.g. coal is the dominant heating source for commercial and institutional buildings in China, while other sources are dominant in other countries.

As with residences, the mitigation technologies for commercial buildings can be divided into three categories. Building envelope strategies vary, depending upon the size and type of building and the climate. Wall and roof insulation is important in many building types. Modern commercial office buildings have higher internal heat loads from equipment and people, decreasing the importance of insulation and raising the importance of window and glazing systems. Building equipment strategies emphasise heating and cooling, efficient lighting, energy management control systems, and office equipment efficiency. Renewable technology strategies include photovoltaics, active and passive systems and daylighting. Too often overlooked, renewable strategies are most effective when integrated into the building orientation, shape, and design, and can be important in constraining the growth of energy consumption in urban settings. In the near future, the growing use of Internet-based information systems may change the shape of the workplace with dispersed and at-home work stations. The restructuring of the electric power industry is placing more attention on time-of-day pricing and encouraging the incorporation of load-shedding by agreement and energy storage systems within commercial buildings.

7.2.3 *Adaptation Technologies.*

Many of the technologies that mitigate GHG emissions also help adapt to the potential effects of climate change. For example, the ability of local governments to provide effective land use planning is essential to address many environmental problems. With such authority, local governments can cluster higher density residential and commercial land use to improve the system efficiency of combined heat and power systems. A city's streets and building lots can be laid out to optimise the potential use of solar energy. By limiting developments on flood plains or potential mud slide zones, a city can adapt to both current and anticipated future flooding. The minimisation of paved surfaces and the use of trees can reduce flooding, moderate the urban heat-island effect and reduce the energy required for air conditioning. Water using equipment, such as clothes washers, can be developed and marketed that are both energy efficient and use less water. Building codes and standards reduce energy consumption and also reduce the damage to buildings from destructive weather anomalies. A systems, or whole-building approach, can achieve both mitigation and adaptation objectives through the optimal integration of land use, building design, equipment and material choices and recycling strategies.

A fuller description of these technologies can be found in the IPCC's Second Assessment Report, Working Group II (IPCC, 1996a) and IPCC's Technical Paper I, *Technologies, Policies and Measures for Mitigating Climate Change* (IPCC, 1996b). Other sources are included in the references (Interlaboratory Working Group, 1997; CADDET, 1997; Worrell, 1996). Adaptation strategies vary between developed and developing countries. While the published literature deals primarily with new technologies, indigenous technologies using thermal mass, convective air movement and night radiation use no energy, and could be more widely used in both developing and developed countries.

7.3 Current and Future Technology Transfer Systems

The barriers to the rapid transfer of these ESTs include the lack of information about new technologies, their higher initial cost, the presence of subsidies for electricity and fuels, the absence of delivery and maintenance services, a diversity of building and equipment codes, different performance testing methods, public procurement practices, restrictions in building materials and limited recycling (See Chapter 6). This report analyses the role of different stakeholders in the technology transfer process, the primary pathways they use, and the stages in this process. The key stakeholders include the developers, owners, and suppliers of technologies, buyers of technologies such as private firms, state enterprises, and individual consumers, financiers and donors, governments, international institutions, non-governmental organisations (NGOs) and community groups. These roles of these stakeholders are intertwined in each stage of the major strategies that are used to accelerate the transfer of ESTs in the building sector. Developed countries have a very important role to play in technology transfer, since most advanced technologies in the buildings sector are developed within those countries.

Governments play an important leadership role in the transfer of "climate friendly" technologies, which reduce GHG emissions from the buildings sector. The major pathways include information and education programmes, the use of cost-based energy prices, energy and environmental labels, building energy codes, appliance and equipment efficiency standards, leading by example in government buildings and purchases, and government support for RD&D. Governments also play the leading role in the transfer of "climate safe" technologies, which reduce vulnerability to climate changes, through land use planning and infrastructure developments.

The primary role of the private-sector stakeholders is to meet the consumer demand for the shelter and services provided by the buildings sector. While consumer surveys show support for environmental goals, this support may not be expressed in their purchasing decisions (Federal Environment Agency, Germany, 1998). Education programmes that draw this connection are gaining popularity and are starting to influence private-sector decisions. Governmental policies affect the marketplace through subsidy and taxation programmes, the regulation of energy tariffs, import and export controls and laws covering intellectual property rights.

The role of community groups is of great importance for the buildings sector, but is less well characterised in the technology transfer literature than the other pathways. Decisions about land-use, building materials and intensity, energy and water services are made within communities. These decisions are driven by immediate priorities, yet they have long-term environmental impacts. The rapid urbanisation in many developing countries underscores the importance of finding ways to use sustainable development pathways in cities.

It is important to recognise that traditional technologies have an important role in providing building energy services. Natural ventilation provides comfortable building environments in both hot humid and hot dry climates, including India and the Middle East. Traditional methods of heating are used in Korea (floor heating) and Japan (under-table heating). These traditional approaches may be enhanced through modern scientific re-investigation, measurement technologies, and computer simulations. The resulting guidelines for building design based on local conditions and using local craftsmen could minimise the cost and environmental impact of providing energy services. The combination of traditional and new technologies in buildings offers promising results, which only recently are beginning to draw some attention.

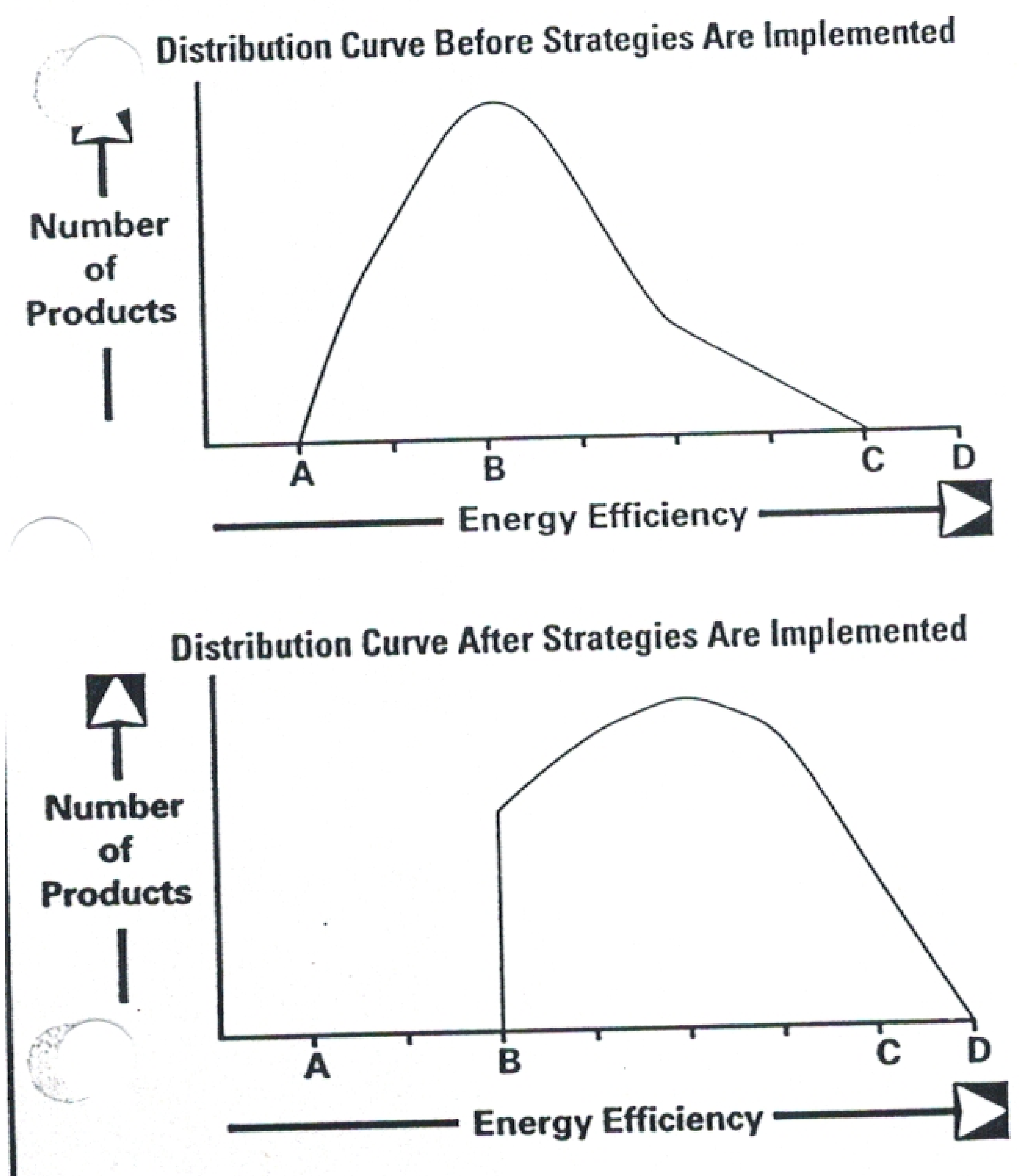
The flexibility mechanisms in the Kyoto Protocol could give these stakeholders powerful new tools to advance the dissemination of ESTs. The Clean Development Mechanism is a potential tool for the transfer of ESTs to the growing building sectors of non-Annex I countries. Joint Implementation projects are particularly attractive for reducing the GHG emissions of the buildings sectors of countries with economies in transition (CEITs). By monetising GHG emissions, emissions trading would add value and flexibility to environmentally sound investments.

7.4 Technology Transfer Strategies

The strategies for accelerating the transfer of ESTs are illustrated in Figure 7.2. The top curve shows the distribution curve of the efficiency of products acquired by consumers prior to the start of ology transfer programme. The curve could be applied to ıy product that uses energy or produces GHG emissions, such ; furnaces, cookstoves, or housing. The slope on the right side : the curve shows the slow penetration of more efficient tech- ɔlogies.

he bottom curve in Figure 7.2 shows the combined effect of a ıccessful technology transfer programme. Building codes and ppliance standards eliminate the sale of energy-wasteful prod- cts on the left side of the curve. RD&D introduces advanced ːchnologies on the right side of the curve. Market transforma- ion strategies encourage consumers to select more ESTs. Vorking together, they can produce major changes.

Figure 7.2. Impact of Technology Transfer Strategies.



The impacts of Technology Transfer strategies are shown in the distribution curves above. Mandatory Standards eliminate the availability of energy wasteful products (A-B). Market Transformation programs encourage the purchase of energy efficient products (B-C). Research, Development and Demonstrations introduce new energy-saving technologies (C-D).

International interests are playing an increasingly important role both in government-driven and private sector-driven technology nsfer. The recognition of a common global interest in reduc- ıng GHG emissions has become a powerful additional motive for international programmes. The growing role of multinational corporations has led to an increasing global market for new goods and services. For each of the national technology transfer pathways, described above, there are parallel international path- ways.

7.5 Role of Governments in Technology Transfer[2]

7.5.1 *Information and Education Programmes*

Within Countries

The most pervasive barrier to increased energy efficiency and environmentally sound practices is simply the lack of information about the impact of our decisions and how they can be improved. Many families do not realise what they can do to end (or reduce) energy waste in their own homes. Building owners and operators do not know how operation and maintenance and retrofit decisions can reduce their energy costs. Entrepreneurs do not recognise the potential market for new energy-saving products and services. Because of the large number and diversity of the decision-makers in the buildings sector, this barrier requires special education and information programmes and the establishment of a permanent consulting infrastructure. Governments can play an influential role through Best Practices guides, school curricula and public education campaigns.

There are many audiences for these programmes. Homeowner guides provide practical, money-saving tips. Adult training programmes teach building engineers how to manage and operate the new energy systems of commercial buildings. Business and finance classes show how to develop bankable projects. Innovative school curricula combine lessons on energy sources and environmental issues with how to read meters and calculate utility bills.

At a deeper level (of involvement), these programmes encounter behavioural barriers, such as the limited ability of individuals to deal with life cycle cost minimisation due to the complexity of this concept, lack of data, and the low priority given to energy use, which remains a relatively small fraction of the total costs of owning and operating buildings in many countries. Another behavioural barrier is a short time horizon—consumers often demand two or three year paybacks (i.e., high implicit discount rates) even though there is a societal interest in accepting longer paybacks on efficient and renewable energy measures. To a greater or lesser degree in all countries, poverty is a barrier. Impoverished consumers often are forced to buy the cheapest product available, even if this means higher future energy, environmental and social costs in the long term.

When confronting these barriers, does the provision of free technical information really influence human behaviour? A recent study by the Resources for the Future seeks to answer this question as it applies to a private firm by modelling the many factors that go into a company's decisions on whether to invest in energy-efficient lighting. The study found that information programmes make a significant contribution to the transfer of efficient lighting in commercial buildings, although these programmes are less important than the basic price signals (Morgenstern, 1996).

[2] See also chapter 4 on the role of governments in creating enabling environments for technology transfer.

Among Countries
International programmes offer a relatively low cost and highly important mechanism for exchanging information on ESTs. For example, the Centre for the Analysis and Dissemination of Demonstrated Energy Technologies (CADDET) of the International Energy Agency (IEA) provides a large and growing computer database of more than 1,600 energy efficiency and renewable energy demonstration projects (CADDET, 1998). CADDET also provides valuable analyses of technology applications. Designed to complement national programmes, CADDET is now seeking to provide information to persons in developing countries.

Although the transfer of information from developed to developing countries is important, a higher priority also needs to be given to the transfer of information about the energy-using patterns and opportunities in developing countries to developed countries, and the exchange of information among developing countries and countries with economies in transition.

7.5.2 Energy Pricing

Within Countries
For the market to stimulate investments in energy efficiency, energy prices must reflect the full cost of providing energy to end users. While this is true for all end-use sectors, it is particularly relevant in the buildings sector, because of the political interest in keeping energy prices low to homeowners in countries with administered price systems. Where energy prices are subsidised, homeowners and commercial building owners and managers receive muted signals on the benefits of investing in efficiency, undercutting the potential market for energy-efficient products. In countries with administered price systems, the industrial sector often subsidises the housing sector. These cross-sector subsidizes can make industries less competitive. If the housing subsidies were paid by governments, taxes would need to be increased or funds diverted from other public services, such as education or health care.

A World Bank study of the effect of energy price increases in six countries--Columbia, Ghana, Indonesia, Malaysia, Turkey and Zimbabwe--found that eliminating subsidies does not cause disproportionate hardship for the poor, lower economic growth, create inflation or reduce industrial competitiveness, but does improve public revenues (Hope, 1995). The consumption of commercial fuel increases greatly with income, according to the study, so energy subsidies largely benefit non-poor, urban households. A study of subsidised household energy prices in transition economies also concluded that they benefited the rich more than the poor (Freund, 1995). One approach is a staged removal of energy subsidies, which creates a market for investments in energy-saving products and services.

The landlord-tenant relationship can create problems unique to the buildings sector when the landlord pays the energy costs, but has little control over the energy-using practices of the tenant. For tenants, if energy services are free, there is no incentive to use energy wisely. Technical problems may also make it difficult to make homeowners and tenants responsible for the energy they use. In many high-rise multifamily buildings, heat is delivered to apartments through vertical pipes, making it difficult and costly to try to measure the energy used by each individual apartment unit. In new buildings, this problem can be addressed by building codes that require that heating systems be designed to serve individual, metered apartment units.

Even in market economies, energy prices rarely include the full societal costs of related environmental externalities. These costs are reflected in adverse health impacts and environmental degradation. If the market mechanism is to exercise its full potential for achieving environmental goals, the price of energy needs to incorporate these environmental externalities.

Among Countries
The lessons learned from in-country technology transfer programmes also need to be recognised in international programmes. This is particularly important for countries moving toward market economies. During this transition, it is often useful to ask: Who is paying the energy costs?. Someone is. It may be municipalities through subsidies, industries through cross-sector subsidises, or energy supply industries through unrecovered costs. Whoever is paying these costs will have an interest in reforms. It is also useful to track the flow of energy from source to end use, to identify the changes in ownership, to metre the quantity of energy in each transaction, to measure the performance of each owner, and to move toward a system of rewards and penalties that improves the overall efficiency of the energy delivery system.

Multilateral and bilateral assistance programmes can encourage the movement to full-cost energy pricing by ensuring that any projects that are supported incorporate progress toward market reforms. The Russian Enterprise Housing Divestiture Project of the World Bank exemplifies this approach. The Bank is providing loans of US$300 million for basic energy efficiency measures in a total of 3,500 residential apartment buildings in six Russian cities. The participating cities are undertaking policy reforms designed to reduce housing maintenance and utility costs. The World Bank is also initiating a similar project in Lithuania.

7.5.3 Energy and Environmental Labels

Within Countries
To create more informed consumers, a number of product labelling programs have been initiated. At least 11 countries and the European Union have initiated mandatory or voluntary programmes that have products labelled with descriptions of their energy performance (Casey-McCabe, 1995). The United States requires labels on furnaces, water heaters, refrigerators, central and room air conditioners, clothes washers, dishwashers and lamp ballasts (USDOE, 1996). The European Union has initiated a programme under the SAVE (Specific Actions for Vigorous Energy Efficiency) Programme that requires labels for refriger-

ators and freezers, washing machines and clothes dryers, and is being phased in for other appliances.

Worldwide, more than 30 products are covered by one or more labelling programme, including the major energy-using appliances, such as refrigerators, furnaces, clothes washers and dryers, and ovens. Labelling programmes may be mandatory or voluntary and comparison or endorsement in type. Comparison labels describe the performance of a product with others in the same class. Endorsement labels identify a product that meets a high efficiency standard. Most programmes use comparison labels, are mandatory, and are operated by government agencies. Only the United States, Canada, and the European Union also have programmes with endorsement labels, which may be operated by government agencies or NGOs.

Stakeholder cooperation is illustrated by the window labelling programme of the National Fenestration Rating Council (NFRC), a coalition of window manufacturers, governments, utilities, and consumer groups. The labels, which identify the energy performance of windows, doors and skylights, help consumers select high performance products in an area of rapid technology change. Manufacturers pay a fee to have their products tested in NFRC-accredited laboratories. Since 1993, the NFRC has certified and labelled 12,000 products made by more than 160 manufacturers. NFRC is working with the International Organization for Standardization (ISO) on an internationally recognised testing and labelling programme.

The record of labelling programmes is mixed. The initial U.S. Energy Guide labels were largely ineffective, because they were difficult to understand, yet went unchanged for 10 years. The initiation of harmonised energy labels in Europe was slow—17 years between the initiation and implementation of common levels for refrigerator-freezers. On the other hand, two years after the initiation of the Energy Star computer programme, 50 per cent of the computers and 80 per cent of the printers were meeting its standard. The average power requirements for personal computers fell from 75-80 watts to 35-45 watts (Duffy, 1996).

The policy objectives of the programmes make a significant difference in its results, according to a comparison between the U.S. and Thai household appliance labelling programmes. The objective of the 20-year-old U.S. programme is to provide customers with information to assist them with their purchasing decisions. By contrast, the objective of the three-year-old Thai programme is to persuade customers to buy more efficient appliances that save money and protect the environment, an objective that is backed by a massive, nation-wide advertising campaign. Energy efficiency was reported among the top three purchase priorities by 28 per cent of the Thai customers, compared with only 11 per cent of the U.S. customers (du Pont, 1998).

Among Countries
Since many appliances and other energy using equipment are produced and sold worldwide, it would be beneficial to have a uniform international labelling system, rather than separate national systems. The initial move in this direction might be through regional programmes, such as those being implemented by the European Union. Multinational efforts are already underway through the ISO to harmonise the test procedures that underlie national labelling and standard programs (CADDET, 1997).

An international approach faces formidable obstacles, including the standardisation of testing protocols, the treatment of different product designs, and non-tariff barriers. Even so, some international approaches are moving forward. The Green Lights and Energy Star computer programmes, initiated by the U.S. Environmental Protection Agency, have been transferred successfully to other countries (Case Study 2, Chapter 16).

7.5.4 *Mandatory Standards*

Within Countries
For many years, governments have been responsible for setting standards for new buildings to protect the health and safety of their occupants. After the 1973 oil embargo created a growing public awareness of the cost and security risks of wasting energy and rising energy imports, many countries expanded these regulatory programmes to ensure that new and renovated buildings were designed to avoid squandering energy. Without standards, architects and builders are under pressure to minimise investments in efficiency to hold down the initial cost of the buildings, even when the additional investments would be repaid rapidly through lower energy costs. These standards now have the additional advantage of reducing GHG emissions from the burning of fossil fuels.

Building energy codes have become widespread. A survey of 57 countries found 31 of them with codes for both residential and non-residential buildings, nine countries with codes for non-residential buildings only, four countries with codes for residential buildings only, and 13 countries without any building codes (Janda and Busch, 1994). Many countries modelled their building codes on those in other countries. The most often cited codes were those of the American Society of Heating, Refrigeration and Air-Conditioning Engineers (ASHRAE); 11 countries used the ASHRAE standards.

The rate of compliance with energy codes varies widely among countries (Duffy, 1996). While most codes are adopted nationally, local agencies often are responsible for their enforcement. Buildings differ in size, function, and location. An effective enforcement system requires trained local inspectors, who periodically visit the construction sites of complex buildings. Studies in the United States report rates of non-compliance of 50 per cent or more. By contrast, in Singapore compliance with the Energy Code is reported to be very high (Alliance to Save Energy, 1997). After building standards laws are approved, it is necessary to have strong implementation, training, and enforcement programmes to realise their potential benefits.

Some governments have also moved lately to mandate appliance and equipment energy efficiency standards. A recent international survey found that at least nine countries have energy efficiency standards for household appliances (Duffy, 1996). The United States and Canada cover the most appliances, followed by Switzerland and China. The programmes cover 18 different household appliances, the most common being refrigerators, air conditioners, clothes washers and clothes dryers. The standards are mandatory in all nine countries, except Japan and Switzerland. Japan's standards are voluntary, but largely met. Switzerland's standards are target values; however, the Swiss legislation indicates that if the target values are not met the government intends to mandate standards.

The survey found that at least six countries have standards for commercial and industrial equipment. The United States and Canadian programmes cover the most types of commercial equipment, including fluorescent lamps and ballasts, incandescent lamps, electric motors, and commercial air conditioning/heat pumps, furnaces/boilers, water heaters and water chillers. Japan and Korea cover lamps. China covers electric motors and furnaces/boilers. Malaysia covers electric motors. In the United States and Canada, the standards cover an estimated 70 per cent of the energy used in commercial buildings.

Among Countries

The same factors that led to national energy standards are creating pressure for international standards, i.e. the public interest in increased efficiency and decreased emissions of pollutants, the market failure when low initial cost dominates the selection of products with long lifetimes, and the benefits of harmonised standards throughout the growing international market. The standards programmes in developed countries cannot be simply extended to other countries. The standards need to be modified to reflect the energy uses and preferences of a country. New infrastructure investments may be needed, including new laboratory testing and certification facilities. Domestic industries may need support to upgrade their products to meet the international standards. However, the potential benefits are large. A harmonised international approach to standards would widen the market for energy-saving products, lower the cost of such products, increase their market penetration, and encourage manufacturers to produce only the more efficient units (CADDET, 1997).

Box 7.1 — Appliance Success Story

Appliance standards were first initiated in the United States in California in 1974, a year after the 1973 oil embargo. During the 1970s, California extended standards to cover 15 products. Other States also initiated their own standard programmes. Meanwhile, little was happening at the national level. A 1978 law created a U.S. appliance standards programme, but opposition delayed its implementation. The impasse was broken in 1986 with the passage of the National Appliance Energy Conservation Act, which established minimum U.S. efficiency requirements for 12 types of residential appliances. The Act was approved due to a remarkable--and instructive--collaboration between energy and environmental NGOs and appliance manufacturers. NGOs had long championed standards. Manufacturers came to recognise that uniform national standards were preferable to the growing number of different State standards.

This political process contains lessons for other national and international standard initiatives. The command and control strategy was used, but its impact was moderated to recognise industry's interests. In setting standards, the U.S. Department of Energy is required by law to consider their economic consequences, including any adverse impacts on manufacturers. The standards cannot be changed more frequently than every five years and manufacturers are given at least three years to meet any new standard levels. While this schedule makes the standards more acceptable to industry, it also delays the resulting energy savings and reduced GHG emissions.

The U.S. standards programme continued to be politically controversial, but was expanded by the 1992 Energy Policy Act. The results are significant. The average refrigerator sold in 1994 used about 653 kWh per year, down from about 1725 kWh per year in 1972. In 2001, the next iterations of the standards will lower this average to 475 kWh per year. The standards already adopted are expected to save 1.3 EJ[6] of primary energy in 2000, rising to 3.4 EJ in 2015 (Geller, 1997). An analysis shows that for every US$1 increase in the price of products due to the standards, consumers save an average of $3.20 during the life of the product (Goldstein, 1996).

[6] 1 EJ (Exa Joule) = 10^{18} joules

7.5.5 Leading by Example

Within Countries

The government is the largest single consumer of energy in most countries. Governments can reduce their own energy costs through the operation of their buildings, through the design features of new buildings, and through the efficiency of the energy-using products they buy. Through environmentally sound decisions, governments can also provide an example to those who own, rent, and operate privately-owned residential, commercial and institutional buildings. Government policies are also important in myriad additional ways. For example, governments can use their purchasing power to create a market for energy-efficient products. Government leaders can stimulate the demand for "Green" products through public recognition for voluntary industry efforts to market ESTs.

Few governments are taking advantage of the opportunity to show leadership in their management of their own energy consumption, according to a recent survey of 25 countries in Europe, North America, Latin America and Asia (Borg *et al.*, 1997). The survey questionnaire was distributed to knowledgeable government people in 25 countries. The most active programmes were reported in Canada, the Netherlands, Switzerland and the United States. The common government ogrammes included setting energy-saving targets, tracking s toward the targets, recognising successes, requiring the rchasing of efficient equipment, providing information and iining, as well as financing schemes, and conducting energy dits and demonstration projects. Additional countries have lopted Climate Change programmes in their building secrs, including Australia, the United Kingdom, Japan, New ealand, France and Germany (OECD, 1999)

nong Countries

eading by example has an appealing potential for transferring ie country's success to another in the climate change field, here countries are striving for a common, international goal. The iildings sector offers highly visible opportunities to demonstrate is leadership, for example, by integrating climate friendly polies into government operations, housing and education proammes. Annex I countries have a special responsibility to lead y e le in order to stimulate adoption by developing counies and CEITs.

potentially powerful form of international cooperation is resent among the countries of a region that share common esources, climates, languages, traditions and aspirations. or example, renewable energy resources such as solar raditon, hydropower, wind, biomass, and geothermal resources re distributed regionally without regard to political boundr The demand for heating and cooling and the available o uction materials are common to multi-country regions. Vithin these regions, the technology opportunities are simlar. The successful deployment of a new technology can pread rapidly. The enhanced regional demand for climate riendly technologies can attract development and investnents that otherwise would be slow to respond to efforts of single country.

.5. Research, Development and Demonstration

Vithin Countries

Government and private sector research programmes play a critcal role by developing and demonstrating advanced technologies hat meet human needs more effectively, at lower costs and with ewer adverse environmental impacts. The technologies that are naking a difference now are the results of past research. While his Report focuses on existing and near-term technologies, it is mportant to recognise the role that today's RD&D programmes will have in developing the ESTs for the technology transfer programmes of the future.

For example, the U.S. Department of Energy played a key RD&D role in the introduction--among other new products--of low- ivity windows, electronic ballasts, and high efficiency supermarket refrigeration systems. These three technologies, alone, have provided U.S. manufacturers with US$3.5 billion in cumulative sales and are delivering 250 Tbtu (264×10^{15} J) /yr of primary energy savings worth US$1.5 billion a year (Alliance to Save Energy, 1997).

Although not often recognised, a high degree of scientific skill is also required to develop improved products in developing countries, such as the Jiko cookstove in Kenya (See Case Study 1, Chapter 16). In sub-Saharan Africa, where household cooking accounts for more than 60 per cent of total energy use in some countries, this is a high priority. Inefficient combustion of traditional fuels has also resulted in high concentrations of pollutants and acute respiratory infections. For 20 years, international aid organisations have tried to develop improved cookstoves, but have encountered a complex tangle of combustion, convection, conduction, cost, and acceptance problems. The Jiko cookstove is a collaboration between scientists, local craftspeople, and potential users. Today, hundreds of local craftspeople manufacture some 20,000 stoves a month and more than 1 million are in use throughout Kenya. Each stove cost roughly US$2 , uses 1,300 pounds less fuel per month, and saves urban households as much as US$65 a year (one-fifth of the average annual income) (Kammen and Dove, 1997). Another example is in Senegal where the butane cookstove was re-engineered to meet local conditions (See Case Study 7, Chapter 16).

The demonstration component of RD&D can be important in countries with little experience in the application of technologies used elsewhere. This is the situation in Russia and other transition countries with limited experience in modern space heating technologies. Space and hot water heating dominate the energy use of the building sector in Russia, accounting for two-thirds to three-fourths of total residential energy consumption. Most of the space heating is provided to multifamily buildings supplied by district heating systems. The buildings suffer from high energy losses due to heating intensities--the energy required for indoor comfort adjusted to different climate conditions--that are one to two times higher than in Western countries (Martinot, 1997). In typical apartment units, if households paid the actual cost of the space heat and hot water they receive, this would represent 40% of their monthly wages. National and municipal governments face the challenge of addressing this problem, which requires a combination of technical, financial, institutional and social measures. The challenges include forming homeowners associations, developing consumption-based metering, creating utility regulations that encourage energy efficiency investments, providing long-term financing, and increasing the number and capabilities of local design and construction firms.

Among Countries

Research activities among countries fall into two categories. The first area is multilateral and bilateral RD&D programmes that can give countries access to research advances at a lower cost than through separate national programmes and enlarges the pool of researchers, which can lead to more creative approaches and more significant results. An example is the collaborative energy RD&D programme of the International Energy Agency.

A second area is adaptive RD&D, which examines how the advances in one country might be adapted to the needs of another. For example, the RD&D in a developed country might lead to the commercial introduction of a highly efficient 20-cubic-foot refrigerator. In other countries, there may be little interest in such a refrigerator. However, the technologies embedded in the refrigerator—the advanced insulation, seals, compressor, and controls—may be adapted to different refrigerator models for a wide variety of different international markets.

7.6 Role of the Private Sector in Technology Transfer[3]

In the buildings sector, the roles of governments and the roles of private sector stakeholders often overlap; they merge in patterns that vary from country to country. The private sector is defined here as including two quite different types of organisations: 1) businesses and industries that are motivated primarily to improve their profit-making positions and long-term economic viability, and 2) NGOs, including charitable and church organisations, that are motivated by environmental, humanitarian, and religious missions, or organisations which are advocates of certain interest groups.

7.6.1 *Business and Industry*

Within Countries

While government decisions create an enabling environment for environmentally sound investments, the bulk of investment funds are coming increasingly from the private sector (See Chapter 2). The developing countries are expected to be the largest markets for energy efficiency products in the 21st Century, driven by a growth in population, economic activity, and energy demand that far outstrips that of industrialised countries. For example, the developing countries' current rate of growth in annual energy demand is more than double that of the OECD countries, 3.7 per cent versus 1.7 per cent (IIEC, 1996). To respond to this trend in ways that minimise economic, environmental, and social costs will create an attractive opportunity for new, environmentally sound products and services. While these changes are often characterised as opportunities for international exports, they also invite the growth of domestic production and joint ventures. To grasp these opportunities, participating governments could remove any artificial trade, regulatory, taxation, or commercial barriers that hinder the diffusion of advanced technologies (World Energy Council, 1998).

Among Countries

The largest market for ESTs in the 21st Century will be in the developing countries and CEITs. This will offer an opportunity for the domestic industries of these countries. It also will also be an export opportunity for international industries. A 1995 study by Hagler Bailly Consulting, Inc. estimates the annual international market for energy efficiency will rise from about US$40 billion currently to US$125 billion in 2015 (Hagler Bailly, 1995). A recent assessment of the export market identified building technologies among the major items, including building environment controls; heating, ventilation and air conditioning equipment; lighting; household appliances; and building materials (IIEC, 1996). International strategies can capitalise on this demand by identifying the international corporations that are targeting this market and by encouraging them in the rapid deployment of the best ESTs.

7.6.2 *Financing Programmes*

Within Countries

The buildings sector faces inherent problems when it seeks to attract environmentally sound investments. The size of the investment in any one building application is relatively small. As a result, the acquisition cost for a building project is a relatively high share of the total project cost when compared with other investment opportunities. In addition, the number of parties involved in a project is large and diverse, including the architects and engineers, who design the project; the technicians, who install the measures; and the owners and occupants, who operate and maintain the new systems. As a result, there is an increased risk that the project will not achieve its expected benefits. To address these complications, financing programmes need to be developed that lower administrative costs and reduce risks.

The risks are perceived as being particularly high in countries with limited experience in energy efficient investments. In such settings, there is little experience in preparing, reviewing, approving, financing, implementing, evaluating, and replicating climate friendly projects. Because of these barriers, a market transformation strategy needs to consider approaches that will attract environmentally sound investments. Direct approaches have included tax credits for energy efficiency or renewable energy investments and partial subsidies of the project costs. Special funds have been created to cover all or part of the cost of such investments. Energy-saving performance contracts have been used, where the investment costs are paid back from the energy savings. A new business venture has emerged, the energy service companies (ESCOs), which deliver energy performance contracts and a broad range of contract energy services (see also section 5.6.3 on ESCOs). Lending institutions can encourage efficiency in new buildings by allowing the additional administrative costs to be included in the normal financing agreement.

Among Countries

The lack of investment by developed countries in developing countries and in CEITs is often cited as the greatest obstacle to the deployment of mitigation and adaptation technologies. In addition, developed countries, when they undertake investments in developing countries, do not always bring in the latest technologies in which they have invested in their own home countries. This financial support by developed countries is crucial for increasing the transfer of advanced technologies to developing countries. Host countries can make such investments more attractive by taking appropriate, supportive public policy decisions. These include the elimination of trade barriers, the avoidance of

[3] See also Chapter 5 on the role of private sector finance, investment and public-private partnerships in the technology transfer process.]

punitive taxation, the lifting of import and export restrictions, and the adoption of fair and expedient procedures for resolving disputes.

After reviewing data from 52 countries, a World Bank Policy Paper has recommended major reforms in financing programmes in the building sector (World Bank, 1994). The reforms would shift government policy from producing small-scale public housing toward managing the housing sector as a whole. On the demand side, it suggests ways to develop property rights, increase mortgage finance, and target housing subsidies. On the supply side, it shows how to regulate land and housing development and organise the building industry for maximum productivity. The framework for initiating the reforms brings together public agencies, NGOs, community groups, and the private sector. Different strategies are recommended for low-income countries, highly indebted middle-income countries, other middle-income countries, and CEITs.

The creation of special funds to finance energy-saving and climate-friendly investments has also been done successfully in a number of countries. An international example is the use of German Coal Aid to create the Hungarian Environment and Energy Service Co. (EESCO). The fund has made more than 200 revolving loans totaling more than 7 billion HUF (28 million USD[4] and been producing savings of more than 110 thousand tonnes of oil per year. A significant portion of these savings is being returned to replenish the fund.

7.6.3 *Utility Programmes*

Within Countries

Under some conditions, utilities—the electricity, natural gas, and thermal energy supply organisations—can play significant roles in market transformation. Public utilities are given special powers, such as limited monopolies in their service territories, and the right to use eminent domain to obtain easements for their distribution networks. In turn, they are subject to varying forms of regulation, including the approval of the tariff rates that they charge to different classes of customers. The role of utilities places them in a unique position to deliver energy efficiency and renewable energy programmes to their customers. They are a source of technical expertise in the supply and use of energy; are in regular contact with their customers; and are in a strategic position to aggregate customer demand to introduce new technologies.

Despite these advantages, utilities historically have had a disincentive to encourage energy efficiency. In the past—and continuing in many jurisdictions—the profits earned by utilities have been based on the volume of their energy sales. In this regulatory climate, if a utility encourages efficiency successfully, its sales and earnings decline. To correct this disincentive, a number of national and state governments are adopting utility reforms. Regulatory programmes are being changed to require utilities to carry out energy efficiency programmes and to allow them to earn a profit on these services—the traditional demand-side management (DSM) model. Where utility restructuring is taking place, utilities are under competitive pressure to reduce costs, which has reduced their investments in DSM programmes. To preserve these programmes, some restructuring legislation is experimenting with mandatory "line" charges–surcharges on each kWh of electricity carried on a transmission line–to create special funds for DSM services, including energy efficiency and renewable energy investments and subsidies for low-income customers.

Among Countries

The features that made utility DSM programmes successful--the technical expertise of utilities and their customer contacts--have lead to the transfer of utility programmes among countries. In Brazil, a comprehensive national electricity conservation programme, PROCEL, conducts R&D, energy audits, equipment testing and rating, and educational campaigns (Geller, 1997). In Thailand, a DSM programme has been initiated through cooperation between the utility and manufacturers. In China, DSM is integrated into a Sustainable Future programme. The rapidly increasing cross-boundary investments in utilities is increasing the potential of this form of technology transfer.

7.6.4 *Non-Governmental Organisations*

Within Countries

During the last quarter century, the growing attention given to energy efficiency and renewable energy and environmental issues has seen the creation and growth of NGOs, which are playing an increasingly influential role in all forms of technology transfer. NGOs provide an organisational focus for public concerns about energy and environmental issues; influence public policies at the local, state and national levels; represent their members' priorities in interaction with governments, businesses and industry; and sometimes are able to initiate programmes more rapidly and at lower costs than the traditional government programme.

Among Countries

The influence of NGOs within developed countries has been transferred by international NGOs and government programmes to developing and transitioning countries. With this support, energy conservation centres have been created in many countries, including Russia, China, Poland, the Czech Republic, Hungary, Bulgaria, Ukraine, India, Indonesia, Pakistan, South Korea and Thailand. The centres perform numerous functions, including public education, energy audits, professional training, development of model legislation, demonstration projects, and innovative financing schemes (IIEC, 1996).

7.7 Role of Community Groups in Technology Transfer[5]

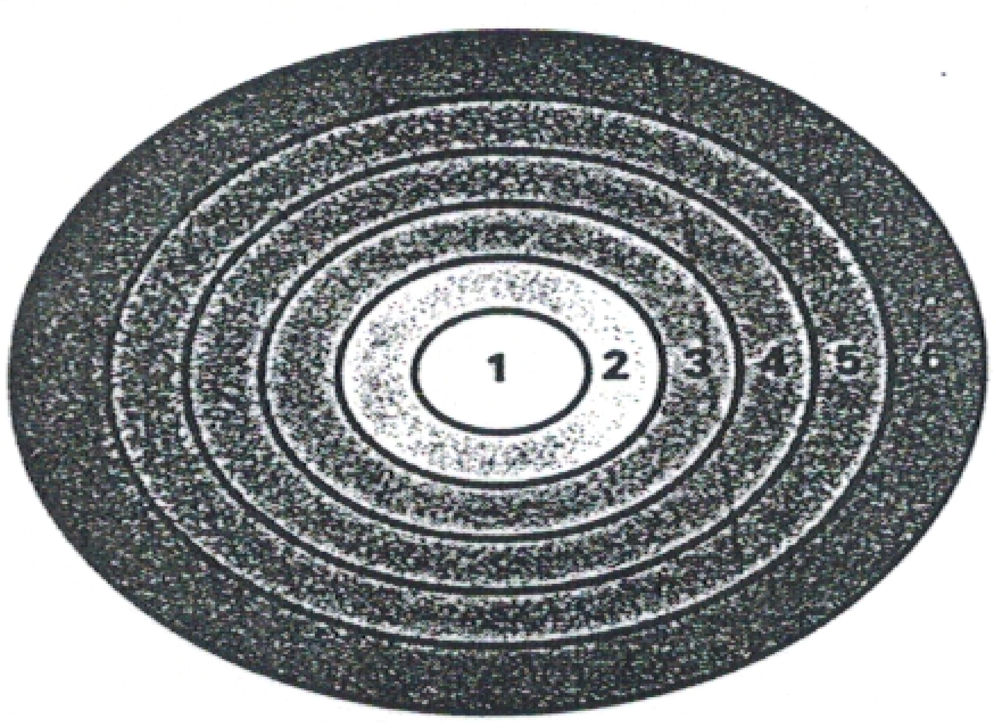
[4] This (rounded-off) figure is based on the exchange rate from November 1999.

[5] See also section on the role of participatory approaches and community groups in the technology transfer process.

Within Countries

Technology transfer strategies are recognising alternatives to the old paradigm that envisioned all change as being mandated by top-down directives. The pervasive influence of community programmes has been recognised; these programmes often involve a vibrant mix of stakeholders, representing international, national, regional, city and community organisations (See Figure 7.3). With increasing frequency, programme responsibilities are being delegated by national governments to regional and local governments and community organisations. In Russia, for example, the 89 regional governments are moving toward a federal structure with a more flexible fiscal system that is more responsive to the country's changing needs (Wallich, 1994). In Columbia, municipalities are developing the capacity needed to take control of responsibilities formerly belonging to the national government (World Bank, 1995). The city of Curitba has earned the nickname, "Ecology Capital of Brazil", through its innovative public transportation system, garbage recycling programme, and large number of trees, parks and green spaces (Dobbs, 1995; Fiszbein, 1999).

Figure 7.3. Transfer of Enviromentally Sound Technologies Depends on Action on Many Levels



Within this context, there is an increased recognition of the role of communities where citizens' organisations, such as villages, neighbourhoods, and grassroots organisations, are the initiators in defining the need for new technologies through a high degree of collective decision-making (See Chapter 1). The development of the Jiko cookstove, mentioned above, is an example of a community-driven pathway (Case Study 1, Chapter 16). Many other examples are reported in a growing Best Practices Database maintained by the Together Foundation, an NGO, and the United Nations Centre for Human Settlements (UNCHS)-Habitat (Together Foundation, 1999).

Some of these examples:

- In Benavides, a small Argentine village north of Buenos Aires, a non-profit civic association created a 173-home neighbourhood at 40 per cent of the cost of private real estate developers;
- In El-Tadamon Village in upper Egypt, the inhabitants of two villages destroyed by floods–one Moslem and one Christian–were relocated into a new village on higher ground. The new inhabitants worked together to build 102 houses, using a new "healthy house" design, and a textile and handcraft;
- In Rajasthan, India, the Academy for a Better World, by the Brahman Kumaris, constructed a new village for 800 people on barren land. The complex is using renewable energy and recycling its water to reforest the adjoining land.

An analysis by the Inter-American Development Bank of the role that community organisations have played in alleviating poverty throughout Latin American suggests that governments could recognise the potential of such organisations (Navarro, 1994). The objective of most community-driven initiatives has been to alleviate poverty, which often includes improved housing. However, community leaders have also shown a sensitivity to environmental issues (Tietenberg and Wheeler, 1998). The community-driven pathway appears open to playing a larger role in the diffusion of ESTs.

Among Countries

Government-to-government programmes can empower community-driven technology transfer in two ways. The first is by simply informing communities about what other communities have done and how they did it. NGOs, such as the Together Foundation, can provide this information exchange, as it does through its Best Practices Database. Through their support for the Together Foundation, the UNCHS-Habitat and the European Union make this information exchange possible (Together Foundation, 1999). Other international NGOs also are recognising the potential of the community-driven pathway, such as the International Institute for Energy Conservation, Alliance to Save Energy, Natural Resources Defense Council, Environmental Defense Fund, and Habitat for Humanity.

The second way to empower these community-based initiatives is to recognise their potential role in the design of international programmes. The multinational development banks and multilateral assistance agencies are starting to do this in many of their analyses (Bamberger and Aziz, 1993; World Bank, 1994, 1995; Fiszbein, 1999; Navarro, 1994). The challenge now is to work with developing and transitioning countries to incorporate these insights into their lending and technology assistance programmes.

7.8 Lessons Learned

- The lessons learned from the experiences gained in the transfer of ESTs in the buildings sector include:
- Buildings vary greatly in their function, size, shape, climate, ownership, lifetimes, equipment, construction material, culture, quality and cost. The mixture of characteristics also varies among countries and regions. Technology transfer strategies need to respect these differences.
- National governments have a central responsibility for promoting successful programmes directly through government-driven programmes, and indirectly through the creation of national environments that attract private-sector-driven programmes and encourage community-driven programmes.

- National governments could begin by identifying the technologies that are most important in achieving its social, environmental, economic, and energy goals for their buildings sector.
- The most effective way to advance these technologies is through an integrated programme that includes information and education programmes, full-cost energy pricing, energy and environmental labels, building and equipment standards, leading by example, and support for RD&D.
- The largest source of funding for ESTs will be from the private sector. To attract these funds, a country needs to remove any artificial trade, regulatory, taxation, or commercial barriers that discourage investments.
- Community organisations have an essential role to play as part of a national strategy. Direct citizen participation in identifying priorities, barriers, and pathways is especially important in the design and implementation of housing reform programmes.
- International linkage and regional alliances are necessary to identify the technology needs of the buildings sector, to stimulate the development of these technologies, and to facilitate their transfer.

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