



Managing Technological Change

An explanatory summary of the IPCC Working Group III Special Report
Methodological and Technological Issues in Technology Transfer



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Foreword

This document introduces and explains the ideas and issues covered by the Special Report from the Intergovernmental Panel on Climate Change (IPCC) entitled *Methodological and Technological Issues in Technology Transfer*.

Technology transfer has taken on an increased prominence given the recent agreement amongst governments about implementing certain provisions of the United Nations Framework Convention on Climate Change. At their July 2001 meeting in Bonn, Germany, Parties to the Convention agreed to establish a Climate Change Fund that will in part support technology transfer, and to create an Expert Group on Technology Transfer that will represent the interests of developing, developed, and small island countries. Technology transfer is clearly a topic that will remain on the global agenda.

Written by 185 experts from around the world, the Special Report provides a state-of-the-art overview of how to achieve and enhance technology transfer. It provides accurate, unbiased, policy-relevant information on technology transfer that is of use to industry, policy makers, environmental organizations and researchers interested in global change, technology, engineering, economics and development.

UNEP played an active role in the preparation of the Special Report. It will continue to support action to combat climate change, and to help facilitate the technological changes that are needed to reduce and mitigate greenhouse gas emissions. The IPCC has confirmed that many cost-effective solutions are available today. However, governments will need to adopt more supportive policies if this potential is to be realized.

This 'popular' version of the Special Report on technological change has been written to help raise understanding of this complex issue. Such awareness is a critical first step in designing the necessary policies to tackle the threat of global climate change.

'Climate change is real and will get worse unless steps are taken to reduce the world's greenhouse gas emissions. This report moves us from a focus on the problem to a focus on the solution.'

Klaus Töpfer,
Executive Director, UNEP

'There are many technological options to reduce near-term greenhouse gas emissions and opportunities for lowering costs, but barriers to the deployment of climate friendly technologies need to be overcome.'

Robert T. Watson,
Chair, IPCC

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Introduction

Methodological and Technological Issues in Technology Transfer is published in a context in which there is increasing evidence that most of the global warming of the last 50 years is attributable to human activities, and in which raised sea levels and more potentially dangerous extreme weather events are considered very likely in many areas of the world. Climate change is a uniquely complex global problem that may have grave consequences for all nations and for present and future generations. The ways in which we respond to change will thus have broad implications for future global development patterns.

A starting point for the Special Report is that the wider use of innovative technologies to adapt to climate change and to prevent it can form an important part of an effective response to the phenomenon. The Report emphasizes that, although technology transfer occurs every day in many walks of life, there is a need for a much stronger effort that links with the aims of sustainable development.

The Report clearly indicates that there is no pre-set answer to enhancing technology transfer and shows that, while creating correct market conditions will be sufficient in some cases, in others there is a need for enlightened public policies that go further to provide the necessary conditions. Governments can act both to improve markets and to create the broad 'enabling environment' in which technology transfer flourishes.

There is no single agenda for successful technology transfer and the world situation is constantly changing. Technology transfer as presented in the Special Report is a complex, multi-faceted and intertwined process, and neither the Report nor this Summary attempts to encompass all of its complexities. The analysis of transfer that emerges from the Report is, of necessity, a simplification, but one which the authors hope will provide insights into how the enhanced transfer of environmentally-sound technologies can contribute to the growth of vibrant and sustainable economies.

Part I: Basic concepts

The development and transfer of environmentally-sound technologies between countries and within them is an important part of the global response to climate change, both to slow the process and to enable people and societies to adapt to changes that do occur.

Transfer, if it is to be successful, will require more than just the moving of high-tech equipment from the developed to the developing world. Other elements, such as knowledge, management skills and technical capabilities will also need to be transferred, making technology transfer a broad and complex process. The basic concepts behind this broad view of technology transfer are presented in this first section.

The link between technology and climate change

One expert has summed up the link between technology and the environment as follows:

'... the state of the environment in the 21st century will be determined by the technologies we choose today.'

'To a large extent, the state of the environment today is the result of the technological choices of yesterday. Similarly, the state of the environment in the 21st century will be determined by the technologies we choose today¹.'

This statement is particularly relevant to climate change, the inference being that the introduction of large numbers of new technologies since the beginning of the industrial revolution has contributed significantly to the climate change the world is experiencing today. A further inference, and a frequently expressed view in worldwide deliberations on climate change, is that *'if the introduction of new technologies created the problem, other new technologies will help in solving it.'*

Background to technology transfer

Many of the technologies that could help to address the problem of climate change already exist. The problem is how to make them readily available where they are needed most. Although technology transfer is a common feature of many sectors of human activity these days, the idea of actively encouraging it is a fairly recent one. Transfer has only really been seen in practice in the second half of the 20th century, prior to which technological advance was viewed (and of course, to some extent is still viewed) as synonymous with power, both military and economic, and was closely guarded.

¹ Trindade, 1991.

There is no doubt that technology transfer has been much encouraged by the development of multinational corporations seeking to expand their markets, and has been facilitated by developments in communications and changes in legislation on intellectual property rights. However, there are other important forces of change, including actions by multilateral organizations such as the United Nations, and by governmental and non-governmental organizations (NGOs). Such organizations are concerned with promoting development that is more sustainable and equitable than in the past, and have identified technology transfer, especially from industrialized to developing countries, as an important element in this process. Where climate change is concerned, the importance of, and need for, technology transfer is given formal expression in the UNFCCC. The Convention states that its Parties, especially developed countries, should:

'take all practicable steps to promote, facilitate and finance, as appropriate, the transfer of or access to, environmentally-sound technologies and know-how to other Parties, particularly developing country Parties ... [and] ... support the development and enhancement of endogenous capacities and technologies of developing country Parties.'

This is the situation which the Special Report analyses: one in which technology transfer is a consequence both of commercial transactions and of proactive actions to create a favourable environment for it based on sustainable development and equity concerns.

The meaning of technology transfer

On the face of it, technology transfer may appear a relatively simple process. Assuming the classical 'economic' view of technology – as 'objects' that can be moved around – transfer can be as simple as the sale or purchase of industrial equipment. However, inherent to this view of technology transfer – as a 'one-shot' relocation of a fully-blown technology from one economic and cultural context to another – is that it creates and maintains dependency on the part of the recipient. If transfer is to lead to a more satisfactory outcome, and one which is more in line with the ends of sustainable and equitable development, a much wider approach is required. This wider view is provided by the Special Report which presents technology transfer as a process that is more complex, but also far richer.

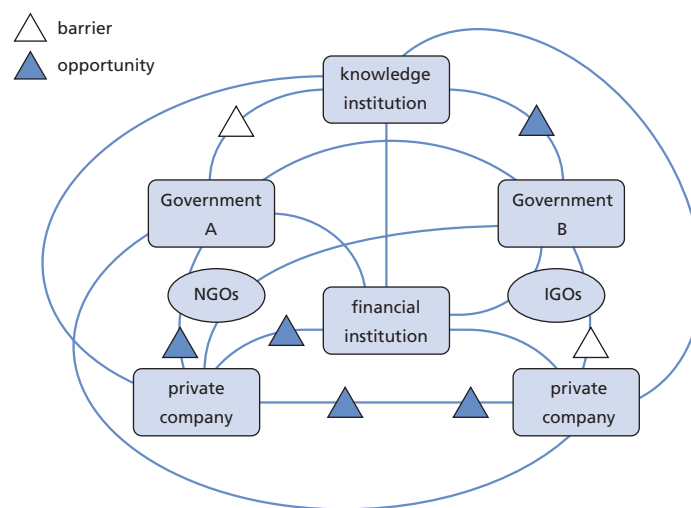
Basically, the Report views technology as knowledge, and transfer as a learning process. Knowledge arises from the process of innovation, building up with progress from the conceptual design phase to actual provision of new products and services. Transfer is the complex process of learning, leading to the point at which a recipient fully understands the new technology, is able to use it, replicate it, and is possibly in a position to re-sell it. In fact, many experts now feel that it is only at this point that transfer of the technology can be said to be achieved.

... the Special Report views technology as knowledge, and transfer as a learning process.

Technology transfer is a broad process which includes both the 'hardware' of technology ... and the relevant human capacities and skills, organizational development and information networks.

Technology transfer seen in this light is a broad process which includes both the 'hardware' of technology (the final products or services) and the relevant human capacities and skills, organizational development and information networks (referred to as the 'software' aspects). In this context, both 'hardware' and 'software' move via flows of knowledge, money (investment) and goods among a variety of people and agencies including governments, private sector entities, financial institutions, NGOs, research and teaching institutions, businesses, etc. Figure 1 shows this process diagrammatically.

Figure 1. The technology transfer/innovation system



There is no single agenda for successful transfer that is appropriate to all situations.

A vital element of this wider view of technology transfer is choice. There is no single agenda for successful transfer that is appropriate to all situations. Technologies are at different stages of development, local conditions vary widely from place to place, and the situation is dynamic. If transfer of inadequate, unsustainable, or unsafe technologies is to be avoided, it is essential that recipients should be able to select technologies that are appropriate to their actual needs and capacities, and it is the 'soft' technologies, i.e. the human capacities and relevant institutions and networks, that allow recipients to assess, select, adapt and make optimum use of technology. Achieving successful technology transfer in this broad context is the central problem addressed by the IPCC's Special Report.

'Mitigation' or 'adaptation' — an important distinction

When discussing technology transfer in relation to climate change, it is important to distinguish between technologies for 'mitigation' and those for 'adaptation'.

Put simply, mitigation technologies are those that focus on slowing climate change. Three sectors are key in determining levels of greenhouse gas emissions (GHG) emissions affecting climate change: energy (including transportation,

industry and buildings), agriculture and forestry. Common examples of mitigation technologies include: energy efficient boilers and power generation equipment; wind, solar and other renewable energy technologies; zero emission vehicles; and high-efficiency buildings.

Adaptation technologies are those which reduce vulnerability to the effects of climate change. To date, adaptation has not been a focus of IPCC reports. However, there is now a view that some climate change is unavoidable and is a genuine threat, and this has led to adaptation being considered as a part of a sensible response strategy, along with mitigation.

Adaptation technologies include everything from agricultural practices to coastal zone management. Many of them not only reduce vulnerability to anticipated impacts of climate change but also to existing risks associated with climate variability. In this sense, adaptation can produce immediate benefits as well as increase capacity to cope with future climate change.

The Special Report contains an extensive 'Sectoral Analysis' section which includes details of both mitigation and adaptation technologies appropriate for different sectors.

'Environmentally-sound technologies' and sustainable development

The Special Report refers to 'environmentally-sound technologies' (ESTs) throughout, and these are also mentioned in the UNFCCC. This is an important concept in terms of the type of development to which technology transfer may contribute.

Box 1: Ceramic stoves—saving energy and improving health in Kenya

The Kenya Ceramic *Jiko* (KCJ) is a charcoal burning stove which can reduce fuel consumption by 20–50 per cent in relation to the conventional types of stove or traditional fires used for cooking in Kenya. In addition to the important economic benefits to users, KCJs can also reduce exposure of families to pollution. According to the World Health Organization, there are more than 2 million premature deaths per year in the world due to indoor pollution caused by household solid fuels.

The KCJ, a portable, metal clad charcoal stove with a ceramic liner, is the result of several years of research and design work. It was originally produced by a single manufacturer in Kenya. Since 1982 the Kenya Energy and Environment Organization (KENO) has organized promotion and outreach efforts to encourage use of the stove. NGOs and national development agencies have also played important roles in its development and dissemination. There are now 200 manufacturers producing more than 13,000 stoves per month; 700,000 KCJs are in use in Kenya, and a network of informal stove manufacturers is promoting manufacture and sales across sub-Saharan Africa.

(From Case Study 1, *Methodological and Technological Issues in Technology Transfer*)

ESTs that can help to combat climate change are often also the very technologies that can help to reverse the present unsustainable pattern of development.

ESTs are defined as technologies that *'protect the environment, are less polluting, use all resources in a more sustainable manner, recycle more of their waste products, handle residual wastes in a more acceptable manner than the technologies for which they are substitutes, and are compatible with nationally determined socio-economic, cultural and environmental priorities.'*

ESTs that can help to combat climate change are often also the very technologies that can help to reverse the present unsustainable pattern of development or alleviate persistent problems (see Box 1). Development based on transfer of ESTs offers many opportunities for developing countries to avoid the past unsustainable practices of the developed nations and to go directly to a more sustainable form of development.

In the context of the UNFCCC, it is assumed that technologies transferred will be applied in an environmentally sound manner and will support the overall aim of sustainable development. This assumption is also accepted in the Special Report and in the discussion of technology transfer in this summary.

Part II: The transfer process

If the UNFCCC's aim – 'to stabilize greenhouse gases in the atmosphere at levels which are not dangerous for the climate' – is to be achieved, both mitigation and adaptation ESTs must be disseminated widely, and this must occur quickly enough and must continue over a sufficient period of time to allow GHG concentrations to stabilize.

The Special Report suggests that current efforts and established processes of technology transfer will not be sufficient to meet this challenge. Barriers too often hinder the movement of developed technologies via commercial channels and completely block movement of less developed 'close to market' technologies. There is a need to make markets work by 'opening the channels' by which technologies could diffuse. For less developed technologies not yet ready to 'diffuse' of their own accord, sound public policies should stimulate demand and create conditions that encourage transfer. The Special Report examines barriers and points the way to policy options that can facilitate and encourage technology transfer.

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Trends and barriers

Measuring technology transfer is difficult given the diverse and interconnected ways in which transfers occur. It is nevertheless possible to draw some general conclusions about global trends in technology flows from data on international trade, development assistance, foreign direct investment and portfolio investment, foreign lending and related topics.

The 1990s saw a broad change in the types and magnitude of the international financial flows that drive technology transfer – a change which altered the relative capacities and roles of various stakeholders. Official Development Assistance (ODA) experienced a downward trend during 1993–97, both in absolute terms and as a percentage of funding for projects, with significant impact on technology flows to developing countries. Concurrently, there was a dramatic increase in opportunities for obtaining private sector financing for technology acquisition.

Levels of foreign direct investment (FDI), commercial lending and equity investment all increased dramatically during the 1990s, to the point where ODA became less than a quarter of the total foreign finance available to developing countries by the middle of the decade. During this period, many developing countries introduced policy changes making them more attractive to private investors. This was often achieved with the assistance of bilateral and multilateral donors.

However, the increase in the importance of private sector investment in developing countries masks three points.

- Private sector investment in developing countries has been very selective with a handful of countries, notably in East and South-East Asia and Latin America, receiving most attention.
- This investment tends to favour certain sectors.
- Private investment, especially foreign portfolio equity investment and commercial lending, is often fickle. Private investment can dry up if investors find more attractive – or less risky – opportunities elsewhere.

Table 1, from the Special Report, shows the importance of the different types of financing to various transfer routes.

Table 1: The international financing of technology transfer						
technology transfer pathway	relative importance of type of financial flow to technology transfer pathway					
	<i>official development assistance</i>	<i>loans</i>	<i>commercial sales</i>	<i>foreign direct investment</i>	<i>foreign portfolio equity investment</i>	<i>NGO and other flows</i>
government	•••	••	•	•	•	•
private sector	–	•••	•••	•••	••	–
community	••	–	–	–	•	•••

Key: ••• primary component of pathway •• secondary component of pathway • minor component of pathway

Geographically, most technology transfer takes place within the countries that generate the technologies, which means within or between industrialized countries. However, the transfer of technologies from developed to developing countries is an important theme of the UNFCCC and this ‘north-south’ transfer is the focus of the Special Report. In the future, far more south-south and even south-north transfer is also expected (see Box 2).

Barriers to the spread of proven ESTs exist in almost all sectors, in developed and developing countries, and in countries with economies in transition. There is no preset pattern of barriers that will be encountered in all transfers of technology and their identification, analysis and prioritization must be suited to the situation if they are to be overcome. Commonly encountered barriers identified in the Special Report include:

- lack of information;
- insufficient human capabilities;

Box 2: Dissemination of biogas digester technology: China—an example of south-south technology transfer

Dissemination of biogas digester technology, backed by the Asia-Pacific Region Biogas Research and Training Centre (BRTC), is an example of successful south-south technology transfer.

Global methane emissions from livestock manure have been estimated at 20–30 million tonnes per year. The biogas digester is a proven EST that reduces such emissions and maximizes production and recovery of methane which can be used to meet energy requirements.

The BRTC, established in China in 1981, has been responsible for training technical engineers in countries from the Africa and Asia-Pacific region. To date, 21 training workshops have been held with more than 270 participants from over 70 countries, and more than 70 digesters have been constructed in 22 developing countries. This project is a clear indicator that transfer between developing countries can work extremely well.

(From Case Study 19, *Methodological and Technological Issues in Technology Transfer*)

- political and economic barriers such as lack of capital, high transaction costs, lack of full cost pricing;
- trade and policy barriers;
- lack of understanding of local needs;
- business limitations such as the aversion to risk felt by some financial institutions; and
- inadequate environmental codes and standards.

Box 3 gives an example of how some specific barriers were overcome in a given situation.

An enabling environment

The barriers outlined above illustrate a key point: that there is a definite role for government policy where technology transfer is concerned. Constraints such as insufficient human capability, trade and policy barriers or business's aversion to non-commercial risks are not barriers that are likely to be eroded quickly, if at all, in the normal course of business. Governments can act here, both by providing favourable conditions for transfer and by participating in it directly. Many governments now see their main role in technology transfer as facilitating the role of the private sector by removing barriers. However they can go further, to create what the Special Report refers to as an 'enabling environment'.

Box 3: Demand side management in Ukraine

This case study highlights a transfer mechanism that encouraged investment in improved energy efficiency in heating systems in publicly and privately owned buildings in the city of Kiev, Ukraine. The key barrier here was not the technology itself, but the lack of a policy framework to allow the transfer mechanism to operate.

In Kiev, heating and warm water are supplied to buildings via inefficient district heating systems that have high transmission and distribution losses and thus poor delivery to end users. The energy is provided from natural gas, mostly imported from the Russian Federation, paid for by public, commercial and private building owners.

Projects in which the US Department of Energy (DoE) and the Swiss Agency for Cooperation and Development (SDC) were bilateral partners—acting in cooperation with the local Agency for Rational Energy Use and Ecology (ARENA-ECO)—have demonstrated the feasibility of investment in demand-side management at four schools and in two cooperatively owned apartment buildings in Kiev.

However, an entirely market-based technology transfer would have been neither socially nor politically acceptable in this economy in transition, and some 'softer' financing was required. Investment in the cooperatively owned buildings was pre-financed jointly by the SDC and by local authorities, with the cooperatives agreeing to repayment based on 75 per cent of the estimated reduction in their energy bills. Investments in public buildings are financed from the municipal budget and from a World Bank loan, return on the investment being in the form of reduced expenditure for heat supply.

In this case, the bilateral donors played an important role in enhancing the policy dialogue with local stakeholders, in capacity building and in facilitating institutional learning. By spreading information and raising awareness about the potential for energy saving in buildings, the projects increased acceptability of the transfer model among end users and policy makers. They also helped to develop energy service infrastructure, create employment and business opportunities, and encourage investment of public and private money in energy efficiency, making the effort replicable and sustainable.

(From Case Study 10, Methodological and Technological Issues in Technology Transfer)

For governments, creating a multifaceted enabling environment means addressing a wide variety of issues including: creating sound macroeconomic conditions; encouraging involvement of social organizations and national institutions for technology innovation; building of human and institutional capacities for selecting and managing technologies; underpinning sustainable markets for environmentally sound technologies; supporting national legal institutions that reduce risk and protect intellectual property rights; developing codes and standards; encouraging research and technology; and developing the

means to address equity issues and respect existing property rights. Major aspects of such an enabling environment are described briefly below. They are, of course, dealt with in greater depth in the Special Report.

Stakeholders and pathways

Technology transfer is the result of day-to-day decisions made within enterprises and elsewhere. Investment and trade decisions made by firms, acquisition of knowledge and skills by individuals through formal education or in their work, purchase of patent rights and licenses, assimilation of research results, or the migration of skilled labour are all forms of technology transfer. Taking this broad view of technology transfer implies that a very wide range of stakeholders will be involved, and that they must act and interact to open an equally wide number of channels or 'pathways' by which technology will transit. Some key stakeholders are:

- developers;
- owners;
- suppliers;
- buyers;
- recipients and users of technology (e.g. private firms, state enterprises and individual consumers);
- financiers and donors;
- governments;
- international institutions; and
- non-governmental organizations (NGOs) and community groups.

The exact pathway that any technology will follow in transfer will vary depending on the stakeholders involved, the sector, country circumstances, and type of technology. Common pathways identified in the Report include:

- government assistance programmes;
- direct purchases;
- licensing;
- foreign direct investment;
- joint ventures;
- cooperative research arrangements and co-production agreements;
- education; and
- direct government investment.

The Special Report makes it clear that technology transfer often involves many stakeholders interacting along any of a number of pathways (see Box 4). Successful transfer relies on the possibility of interaction among different stakeholders, often with very different agendas. For example, as illustrated by Table 2, the motivation of a multinational corporation seeking to expand its share of international markets is very likely to be different from that of an NGO

The Special Report makes it clear that technology transfer often involves many stakeholders interacting along any of a number of pathways. Successful transfer relies on the possibility of interaction among different stakeholders, often with very different agendas.

concerned with the appropriateness of technologies transferred in a local context and with social and cultural impacts. In spite of their very different roles and motivations, such stakeholders must be able to cooperate and form both formal and informal partnerships encouraging transfer. Here again there is an important role for governments: enlightened policies can facilitate such partnerships and foster communication.

Box 4: Inner Mongolian household wind electric systems—providing energy and integrating manufacturing

China's Inner Mongolian Autonomous region (IMAR) has achieved widespread local production and dissemination of standalone wind generating systems among the rural herding population living on the Inner Mongolian steppe. These ethnic Mongolian livestock herders earn around US\$120 per year and the low population density (less than three people per km²) and high costs have led to only about 5 per cent of the herding population being served by the regional electricity grid or standalone diesel generators.

However, the region has abundant wind resources and, in 1980, the regional government established a New Energy Leading Group (NELG) to oversee development of use of this resource. A key guideline for the project was: 'local management with the state providing support.' NELG-sponsored task forces brought together a wide variety of stakeholders including the agricultural, finance and planning ministries, universities, research institutes, factories, local governments and herders all of whom participated in the project.

The region now has a diverse manufacturing system with six factories producing 20 different models of generator with power ratings from 50W to 7.5 kW and 11 factories making batteries, inverters and charge controllers. Water-pumping windmills and renewable-energy products such as electric fences and DC lights are also produced. Sales of wind power systems are supported by a government subsidy of US\$25 per 100W of capacity.

Technology was based on local adaptation of foreign products. For example, the design of the Shangdu Livestock Machinery Factory's 100W and 300W generators for the region resulted from collaboration with SVIAB of Sweden. The Shangdu plant now produces generators for SVIAB in return for the technology license.

The IMAR wind programme has greatly improved the quality of life in the region providing lighting, conveniences and access to information from the outside world for the low-income inhabitants of this remote region. The programme exemplifies successful government leadership in rural energy using realistic programme guidelines, adequate preparatory research and multiple stakeholder participation in goal setting.

(From Case Study 3, Methodological and Technological Issues in Technology Transfer)

Table 2: Principal stakeholders and their decisions or policies in technology transfer

stakeholders	motivations	decisions or policies that influence technology transfer
Governments <ul style="list-style-type: none"> ● national/federal ● regional/provincial ● local/municipal 	Development goals Environmental goals Competitive advantage Energy security	Tax policies (including investment tax policy) Import/export policies Innovation policies Education and capacity-building policies Regulations and institutional development Direct credit provision
Private-sector business <ul style="list-style-type: none"> ● transnational ● national ● local/microenterprise (including producers, users, distributors and financiers of technology) 	Profits Market share Return on investment	Technology R&D/commercialization decisions Marketing decisions Capital investment decisions Skills/capabilities development policies Structure for acquiring outside information Decision to transfer technology Choice of technology transfer pathway Lending/credit policies (producers, financiers) Technology selection (distributors users)
Donors <ul style="list-style-type: none"> ● multilateral banks ● GEF ● bilateral aid agencies 	Development goals Environmental goals Return on investment	Project selection and design criteria Investment decisions Technical assistance design and delivery Procurement requirements Conditional reform requirements
International Institutions <ul style="list-style-type: none"> ● WTO ● UNCSD ● OECD 	Development goals Environmental goals Policy formulation International dialogue	Policy and technology focus Selection of participants in fora Choice of modes of information dissemination
Research/extension <ul style="list-style-type: none"> ● research centres/labs ● universities ● extension services 	Basic knowledge Applied research Teaching Knowledge transfer Perceived credibility	Research agenda Technology R&D/commercialization decisions Decision to transfer technology Choice of pathway to transfer technology
Media/public groups <ul style="list-style-type: none"> ● TV, radio, newspaper ● schools ● community groups ● NGOs 	Information distribution Education Collective decision Collective welfare	Acceptance of advertising Promotion of selected technologies Educational curricula Lobbying for technology-related policies
Individual consumers <ul style="list-style-type: none"> ● urban/core ● rural/periphery 	Welfare Utility Expense minimization	Purchase decisions Decision to learn more about a technology Selection of learning/information channels Ratings of information credibility by source

When innovative technologies arrive, social structures and personal values are forced to evolve and new social challenges arise. Successful integration of technologies into any cultural context requires a capacity on the part of people and organizations to adapt to new circumstances and to acquire new skills.

Capacity building

There is no single path to a sustainable future in which emissions of greenhouse gases are stabilized at acceptable levels. Each country that is a recipient of technology will have to choose its own way. But whatever the chosen path, social, economic and institutional change will almost certainly be necessary. When innovative technologies arrive, social structures and personal values are forced to evolve and new social challenges arise. Successful integration of technologies into any cultural context therefore requires a capacity on the part of people and organizations to adapt to new circumstances and to acquire new skills. If this is to be achieved, capacities need to be built at all stages of technology transfer, with a focus on human, organizational and information-assessment skills. Some aspects of capacity building identified in the Special Report are described below.

Human capacity

It is important to bear in mind that capacity building must be adapted to local circumstances, to specific local barriers, and to the culture and interests of local stakeholders. In the past, donor agencies have often assumed that such capacity can be built using the management and organizational models of donor countries. This assumption has frequently proved to be incorrect and the history of technology transfer reveals many instances where lack of technical, business and regulatory skills has resulted in failure. Experience of technology transfer suggests ways of developing capacity for the assessment, selection and implementation of technology. These include:

- formal training of employees;
- technological monitoring, by keeping abreast of technical literature, forming links between enterprises, professional and trade organizations, and research institutions; and
- learning through operational experience, such as twinning arrangements between firms.

Organizational capacity

Involvement of community institutions is an essential part of successful sustainable development and of technology transfer. The activities of local government agencies, consumer groups, industry associations and NGOs can help to ensure that ESTs being adopted within a particular country/region are consistent with sustainable development goals.

In addition to these community institutions other organizations – such as private networks or information assessment services, management consultants, financial firms, lawyers and accountants – are also active in increasing transfer flows.

These insights underline the importance for governments of strengthening the networks through which such organizations can contribute to technology transfer.

Information assessment and monitoring capacity

Access to relevant information and the ability to assess it are essential to technology transfer. However, while building of infrastructure to generate access to new knowledge and information is generally recognized as being of overall public benefit, it rarely has direct economic value for individual firms. Firms are not therefore motivated to create such infrastructures themselves. This points to an important role for governments in creating and encouraging the necessary information and monitoring capacities.

Mechanisms for technology transfer

Research into technology transfer in recent years has highlighted the advantages of integrating the actions of people and organizations involved in the transfer process into mechanisms that increase effectiveness. Integrated actions by stakeholders such as specialized government agencies, energy service companies, NGOs, university liaison departments, regional technology centres, research and technology organizations, electric power utilities and cross national networks can reduce barriers, ensure that technological know-how is disseminated broadly, and compensate for weaknesses in existing dissemination systems. In some ways technology transfer is like a chain: it breaks when the weakest link fails. Strengthening that chain by integrating the actions that form its links can greatly contribute to efficiency of transfer.

Technology transfer is like a chain: it breaks when the weakest link fails.

National Systems of Innovation

Technology transfers are influenced greatly by what are known as National Systems of Innovation (NSI). NSIs are institutional and organizational structures set up to integrate actions that support technological development and innovation. They create synergistic mechanisms for transfer of ESTs, integrating elements such as capacity building, access to information and an enabling environment. NSI activities may include:

- targeted capacity building, information access and training for public and private stakeholders, as well as support for project preparation;
- strengthening of scientific and technical educational institutions in the context of technology needs;
- collection and assessment of specific technical, commercial, financial and legal information;
- identification of technical, financial, legal policy and other barriers to wide deployment of ESTs and development of solutions to such barriers;
- technology assessment, promotion of prototypes, demonstration projects and extension services through links between manufacturers, producers and end users;
- innovative financial mechanisms such as public/private sector partnerships and specialized credit facilities;
- local and regional partnerships between different stakeholders for the transfer, evaluation, and adaptation of ESTs to local conditions;
- market intermediary organizations such as Energy Service Companies.

Official Development Assistance (ODA)

In spite of the increased importance of the private sector in providing financial support for technology transfer (see *Trends and barriers*, page 9), Official Development Assistance (ODA) is still important, especially for the poorest countries. There is increasing recognition that ODA can be best used to help lay the foundations of development. This implies directing it towards, among other things, creation of a sound environment for formulation of policy, investment in human capacities, ensuring institutions and systems of governance that function well, and encouraging environmental sustainability, rather than using it as a source of direct investment in ESTs.

Global Environment Facility (GEF)

The Global Environment Facility (GEF), the funding mechanism of the UNFCCC, is a key multilateral institution for transfer of ESTs. The GEF aims to promote energy efficiency and renewable energy technologies by reducing barriers, implementation costs, and long-term technology costs. A significant aim of GEF programmes is to catalyse sustainable markets and to assist the private sector in transferring technologies.

Capacity building is a central feature of most GEF programmes meaning that, in addition to their direct effects, its programmes enhance host countries' abilities to understand, absorb and diffuse technologies. GEF projects have been the subject of considerable attention from policy makers and industry in technology transfer host countries and from the international community. Through policy changes, stakeholder dialogues, and project design activities and studies, GEF projects have provided an important stimulus for technology transfer going beyond the direct impacts of projects.

Multilateral Development Banks

In the past, Multilateral Development Banks (MDB) have tended to view technology transfer as part of their general mission to encourage development. More recently they have started to focus on environmental issues and the specific role of technology transfer in addressing them. Many MDBs are now developing a range of initiatives and activities that focus on promoting climate-friendly technologies. In particular, they have become aware of the role they can play in helping to mobilize private capital to meet the needs of sustainable development and of the potential of using financial innovation to encourage environmental projects and initiatives.

About the UNEP Division of Technology, Industry and Economics

The mission of the UNEP Division of Technology, Industry and Economics (UNEP DTIE) is to help decision makers in government, local authorities, and industry develop and adopt policies and practices that:

- are cleaner and safer;
- make efficient use of natural resources;
- ensure adequate management of chemicals;
- incorporate environmental costs;
- reduce pollution and risks for humans and the environment.

The UNEP DTIE, with its head office in Paris, is composed of one centre and four units:

- **The International Environmental Technology Centre (Osaka)**, which promotes the adoption and use of environmentally sound technologies with a focus on the environmental management of cities and freshwater basins, in developing countries and countries in transition.
- **Production and Consumption (Paris)**, which fosters the development of cleaner and safer production and consumption patterns that lead to increased efficiency in the use of natural resources and reductions in pollution.
- **Chemicals (Geneva)**, which promotes sustainable development by catalysing global actions and building national capacities for the sound management of chemicals and the improvement of chemical safety worldwide, with a priority on Persistent Organic Pollutants (POPs) and Prior Informed Consent (PIC, jointly with FAO).
- **Energy and OzonAction (Paris)**, which supports the phase out of ozone depleting substances in developing countries and countries with economies in transition, and promotes good management practices and use of energy, with a focus on atmospheric impacts. The UNEP/RISØ Collaborating Centre on Energy and Environment supports the work of the Unit.
- **Economics and Trade (Geneva)**, which promotes the use and application of assessment and incentive tools for environmental policy, and helps improve the understanding of linkages between trade and environment and the role of financial institutions in promoting sustainable development.

UNEP DTIE activities focus on raising awareness, improving the transfer of information, building capacity, fostering technology cooperation, partnerships and transfer, improving understanding of environmental impacts of trade issues, promoting integration of environmental considerations into economic policies, and catalysing global chemical safety.

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