Technology Transfer:

The Seven "C"s for the Successful Transfer and Uptake of Environmentally Sound Technologies

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Summary for Policy and Decision Makers

Background

This report is motivated by the recognition that the uptake of technologies that support sustainable development has been disappointingly slow, despite many major international and other initiatives to support sustainable development through increased and more effective transfers of technology. The information presented here complements a parallel initiative by UNEP's International Environmental Technology Centre, namely the studies and other activities culminating in publication of the report "Environmentally Sound Technologies and Sustainable Development" (IETC, 2003). That report emphasises specific and practical methodologies and tools for promoting the adoption and use of environmentally sound technologies (ESTs).

Scope and Approach

In essence the present report attempts to answer two simple but fundamental questions:

- Why has technology transfer in support of sustainable development failed to fulfil expectations and meet the clearly evident and pressing needs?
- What must be done to ensure that the success of renewed international sustainable development initiatives, and those being undertaken at community and national levels, are not frustrated by continued shortcomings in technology transfer?

Emphasis is on technology transfer to, between and within developing countries and countries with economies in transition, covering the broad range from community-based technology initiatives to those undertaken in support of comprehensive national, regional and international policies.

It is self evident that there is no ubiquitous approach to enhancing technology transfer - the suite of measures for addressing barriers, and facilitating successful technology transfer, is typically community specific. So how can a global report contribute understanding, and make a difference at the operational level? The approach taken is to advocate higher-level actions which help ensure that local decisions are made and implemented by stakeholders who are well informed and who operate within an enabling environment that enhances the possibility of their technology investment outcomes being simultaneously environmentally sound, socially acceptable and economically viable.

Technology Transfer in Support of Sustainable Development

Technology transfer must be recognised as a broad and complex process if it is to avoid creating and maintaining the dependency of the recipient, and if it is to contribute to sustained and equitable development. The end result for the recipient must be the ability to use, replicate, improve and, possibly, re-sell the technology. Transfer of technology is more than just the moving of high-tech equipment from the developed to the developing world, or within the developing world. Moreover, it encompasses far than equipment and other so-called "hard" technologies, for it also includes total systems and their component parts, including know-how, goods and services, equipment, and organizational and managerial procedures. Thus technology

transfer is the suite of processes encompassing all dimensions of the origins, flows and uptake of know-how, experience and equipment amongst, across and within countries, stakeholder organizations and institutions.

If the transfer of inadequate, unsustainable, or unsafe technologies is to be avoided, technology recipients should be able to identify and select technologies that are appropriate to their actual needs, circumstances and capacities. Therefore, a key element of this wider view of technology transfer is choice. There is no single strategy for successful transfer that is appropriate to all situations. *Desirably* a technology recipient will choose a technology which at least meets the definition of being "environmentally sound". ESTs are technologies that have the potential for significantly improved environmental performance, relative to other technologies. ESTs protect the environment, are less polluting, use resources in a sustainable manner, recycle more of their wastes and products, and handle all residual wastes in a more environmentally acceptable way than the technologies for which they are substitutes. *Preferably* a technology recipient will go even further, and select a "sustainable technology" – i.e. a technology that is not only environmentally sound but also economically viable and socially acceptable. Such technologies contribute to the three pillars of sustainable development.

The Seven "C"s for the Transfer and Uptake of Environmentally Sound Technologies

Context

Technology transfer does not take place in a vacuum. The performance of a given technology is dependent on a wide range of factors, making identification of an environmentally sound or otherwise appropriate technology somewhat problematic. For example, a technology that is assessed to be environmentally sound in a given locale, culture, economic setting or stage in its life cycle may not be in another. Its performance may be influenced markedly by the availability of supporting infrastructure and by access to the expertise necessary for its management, maintenance and monitoring. Moreover, a technology that qualifies as being environmentally sound at one point of time, may not do so at another – the performance criteria against which it is assessed may change as a consequence of new information or changing values or attitudes; a technical breakthrough may give rise to more desirable alternatives. It is therefore vital that recipients and users of a technology are able to choose an option that meets their specific needs and capacities, while also being environmentally sound in its operating locale and over its operational life cycle. It is, of course, highly desirable that the technology is also found to be economically viable and socially acceptable, and hence sustainable.

Challenges

There are many barriers to successful technology transfer. All along the transfer path, from the supply side of technology transfer (the innovators and developers) to the demand side (the recipients and users), impediments occur at every node and, due to restrictions on the movement of information and materials, for every linkage in the technology transfer chain. While some generalizations are possible, the specific nature and severity of the challenges depend on the prevailing circumstances, varying with the type of technology, its specific application and the characteristics of the technology providers and recipients. Examples of challenges include shortfalls in technology creation and innovation, underperformance in technology sourcing, sub-

optimal enabling environments, and insufficient and unverified information. Small and medium enterprises are disproportionately impacted by these challenges.

Choice

A key aim of barrier removal, that is of facilitating technology transfer, is ensuring that technology recipients and users are able to make informed choices by being able to identify and procure the most appropriate (in environmental and preferably also in economic and social terms) technology for a given application in a given locale. Several requirements must be met, including:

- needs well defined, documented and understood;
- several technology alternatives, all of which are well and reliably characterized in terms of environmental and economic performance and potential social impact;
- rational and functional methods (decision support tools) that facilitate choice of an optimal technology; and
- capability to make the chosen technology fully operational, so that it fulfils its potential, and meets the identified needs, without detrimental side effects, including during decommissioning.

Certainty

A lack of certainty, and the consequential high levels of risk, both real and perceived, are recognized as major impediments to the successful establishment and ongoing operation of functional markets for ESTs. The common perception that many ESTs are "emerging", and hence "unproven", means there is little confidence in their economic, commercial or technical viability. Removing barriers to technology transfer often translates into increased certainty, and decreased risks, for the key stakeholders such as the developers, suppliers, financiers, insurers, recipients and regulators. One example is ensuring access to sufficient, verified information. Risk assessment and management capabilities for financial institutions are also of special importance.

Policy instruments can also be used to enhance certainty, in two principal ways:

- through consistency in policy goals and measures over time, and with long lead periods for substantive changes in policy directions and the measure that implement them; and
- use of policy instruments to reduce regulatory, investment and other uncertainties in the market.

Macroeconomic conditions that favour technology transfer include those which will deliver low inflation, stable and realistic exchange and interest rates, pricing that reflects the true (marginal and fully internalised) costs of material, energy, labour and other inputs, deregulation, free movement of capital, operation of competitive markets, open trade policies and transparent foreign investment policies.

Communication

The technology transfer chain is often long, in terms of both distance and time. Effective communication is thus another essential ingredient in the recipe for successful technology transfer. Efficient and effective two-way communication and cooperation between key stakeholders will do much to remove barriers. Information management systems, knowledge management tools and formal and informal networks, both centralized and dispersed, can all make important contributions. Technology transfer often involves a dissonant mix of informal actors (e.g. innovators) working in formal and highly regulated settings. Effective communication is a requisite to harmonizing the contributions to the processes of technology transfer being made by diverse players.

Capacity

Enhancing the transfer of technologies that support sustainable development is largely about creating favourable circumstances for technology transfer – ensuring all stakeholders have the ability (potential and realised) to fulfil their roles and meet their responsibilities, expeditiously. Generally speaking, government is the principal player in creating an enabling environment for technology transfer, but financial and insurance institutions and international organizations can also be influential.

Circumstances which are supportive of technology transfer include:

- open and competitive market;
- comprehensive and credible specifications on the technology performance;
- financiers who are at least technology neutral;
- the most cost competitive technology also has the most favourable environmental and social performance specifications; and
- policy risks are addressed.

All key players and stakeholders must have the necessary knowledge and skills to perform the roles and tasks expected of them. High levels of awareness, motivation and empowerment within the public and private sectors and in civil society will help ensure that people, communities and wider societies are able to adapt continuously to new circumstances and challenges that drive and arise from technology transfer.

Effective and efficient national and regional systems of innovation, research and development should be in place, to facilitate such procedures as adaptation of traditional technologies for use in current settings. The enabling environment also benefits from policy implementation that fosters an appropriate mix of government and private sector investment in ESTs and address such issues as lack of access to appropriate sources of capital, high or uncertain inflation or interest rates, subsidised or average-cost (rather than marginal-cost) prices for material and energy inputs, high import duties, uncertain stability of tax and tariff policies; investment risk (real and perceived), loss of rights to intellectual property and to productive resources and risk of expropriation.

Commitment

If there is to be an improvement on the last decade or so, where technology transfer failed to deliver the anticipated and much needed advances in development and sustainability, we must make a commitment to overcoming the challenges, providing technology users with the choice they deserve and desire, increase certainty, thereby reducing risks, enhancing communication between technology transfer stakeholders and building and strengthening the enabling environment and thus the capacity for technology transfer.

Key actions that will foster technology transfer include:

- needs assessments, including identification of shortcomings in the enabling environment, with relevant organizations and agencies helping to address these;
- evaluation and strengthening of policies that influence the enabling environment;
- greater communication and interaction between key parts of government
- intra- and inter-governmental coordination, cooperation and assistance;
- protection of intellectual property rights and legal contracts;
- political support for programmes and institutions that foster technology transfer;
- seed investment programmes to stimulate private sector investment;
- capacity enhancement for major stakeholders;
- delineation of the roles of the private and public sectors in both developed and developing countries;
- economic incentives targeting industries that have the potential to make critical and major contributions to technology transfer; and
- ensuring that technology transfer initiatives are compatible with national sustainable development agendas;
- increase communication among technology transfer bodies across various multi-lateral environmental agreements (MEAs) with a view to leveraging limited financial and human resources on issues of common interest, integrating and strengthening regional and country level activities through information sharing and joint activities and providing a platform for multilateral approaches and consistency in technology transfer.

As part of its catalytic and facilitation role in creating and implementing strategies for transformation and change, UNEP and its partners are working together to develop and implement a strategic framework for promoting the adoption and use of ESTs. UNEP is well-positioned to provide an effective platform for meaningful interaction and dialogue in support of the harmonisation of assessment approaches and methodologies related to ESTs. To demonstrate the benefits of ESTs, UNEP has established an EST Initiative with a number of partner organisations. A key objective is the transparent and credible acquisition and reporting of environmental performance information related to technologies.

Preface

To be successful, transfer of technology requires more than just the moving of high-tech equipment from the developed to the developing world, or within the developing world. Other requirements include enhanced knowledge, management skills and technical and maintenance capabilities of those receiving the technology. Integrating human skills, organisational development and information networks is also essential for effective technology transfer. Thus technology transfer is a broad and complex process if it is to avoid creating and maintaining the dependency of the recipient, and if it is to contribute to sustainable and equitable development. The end result for the recipient must be the ability to use, replicate, improve and, possibly, re-sell the technology. A key element of this wider view of technology transfer is choice. There is no single strategy for successful transfer that is appropriate to all situations. If the transfer of inadequate, unsustainable, or unsafe technologies is to be avoided, technology recipients should be able to identify and select technologies that are appropriate to their actual needs, circumstances and capacities.

Six main steps in technology transfer have been identified:

- establishment of cooperative and collaborative partnerships between key stake-holders, with the common purpose of enhancing technology transfer;
- implementation of technology needs assessments;
- participation in the processes of technology creation, development and adaptation;
- design and implementation of technology transfer plans and specific actions;
- evaluation and refinement of the actions and plans; and
- dissemination of technology information.

Moreover, transferring environmentally sound technologies (ESTs) successfully depends on the potential recipient:

- recognising and taking advantage of their benefits;
- obtaining information, and having the knowledge and tools to make an assessment and decide on the most appropriate technology option
- understanding the technologies, especially their operation, responsible use and the systems and infrastructure on which they depend; and
- knowing how to implement and manage technological change successfully.

Encouraging the adoption and use of environmentally sound and, desirably, fully sustainable technologies thus requires both voluntary approaches and a regulatory framework that nurtures innovation and economic, social and environmental accountability. Enacting policies that lower

costs and stimulate a demand for sustainable technologies is necessary in order to achieve the environmental and other benefits that might not otherwise be realised. Furthermore, there needs to be greater clarification of existing environmental rules and regulations, as well as better coordination and harmonisation with international standards.

UNEP's International Environmental Technology Centre (IETC) has a comprehensive and leading involvement in promoting the development, transfer, uptake and use of ESTs. This involves data gathering and information management in relation to ESTs, as well as the development of decision support tools to assess life cycle performance and the environmental benefits of ESTs. It also facilitates technology transfer and supports capacity building initiatives to assist in the development, demonstration and dissemination of ESTs.

This IETC report is motivated by the recognition that the uptake of ESTs has been disappointingly slow, despite many major international and other initiatives to support sustainable development through increased and more effective transfers of technology. The reasons for the current situation are identified, and ways in which the situation might be remedied are elaborated.

What do the following have in common?

- improving the water quality of the Kuang River, which flows through the city of Lamphun in northern Thailand, by treating domestic wastewater using a contact aeration process;
- a residential training facility which is energy self-sufficient as a result of harnessing both traditional and modern means of tapping renewable sources of energy, and of energy conservation, to offer modern amenities such as lighting, air conditioning, cooking, and laundry at substantially reduced costs;
- use of computer software to create long term future scenarios of the Langat Basin, Malaysia, by making policy choices and exploring the environmental, social, and economic consequences of the decisions, including the complexities and tradeoffs of sustainability;
- implementation of a regional knowledge management system for ESTs;
- implementing the advice of international consultants to construct coastal defence structures in order to arrest the erosion of the coastline adjacent to a major urban area, and deterioration in the quality of the sandy beaches, the result being a series of problems such as erosion of neighbouring areas, water quality problems and disruption of the ecological balance in the areas with coastal structures; and
- the uptake and application of environmental management systems (EMS) by local government authorities in China.

They are examples of technology transfer. In some cases uptake was successful; in other cases noted above it resulted in failure. The examples serve to highlight the diversity and complexities of technology transfer. But there is one common view of technology transfer – successful transfer of appropriate technologies is essential to facilitating national and community development and enhancing sustainability, especially in developing countries and countries with economies in transition.

The above examples show the potential for technology transfer to contribute to sustainable development. This potential, and the need for resolute and coordinated actions to realize it, have been recognized at the highest levels internationally. For example, the Rio Declaration on Environment and Development, a key output of the UN Conference on Environment and Development (UNCED) (Rio de Janeiro, 1992), includes the following:

> *States should cooperate … by enhancing the development, adaptation, diffusion and transfer of technologies, including new and innovative technologies* (UN, 1992).

To operationalise this principle, an entire chapter of Agenda 21 was devoted to the transfer of technology, and to the related topics of cooperation and capacity building. The chapter formalized a definition of ESTs as technologies which:

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

We are now at the threshold to the third generation of environmental technologies – having moved from "end of pipe" technologies to pollution prevention technologies that reduce the environmental "footprint" of processes, products and services in ways that increase overall efficiency and reduce risks to humans and to the environment. Such technologies emphasise pollution prevention through reduced consumption of raw materials and energy and no or reduced waste generation. The third generation of environmental technologies will lead to that term becoming redundant, to be replaced by "sustainable technologies", where environmental performance considerations will be fully integrated with economic, social and other operational issues and the system as a whole is sustainable. Truly sustainable production and consumption technologies will require the development and use of planning, design and management practices that facilitate innovative approaches to the reuse, remanufacturing and recycling of the limited amounts of "waste" that cannot be avoided, despite the emphasis on minimising the consumption of raw materials and energy.

Agenda 21 also emphasized that technology transfer does not just relate to equipment and other so-called "hard" technologies, but also to total systems and their component parts, including know-how, goods and services, equipment, and organizational and managerial procedures (Figure 1). Thus technology transfer is the suite of processes encompassing all dimensions of the origins, flows and uptake of know-how, experience and equipment amongst, across and within countries, stakeholder organizations and institutions (Figures 2 and 3).

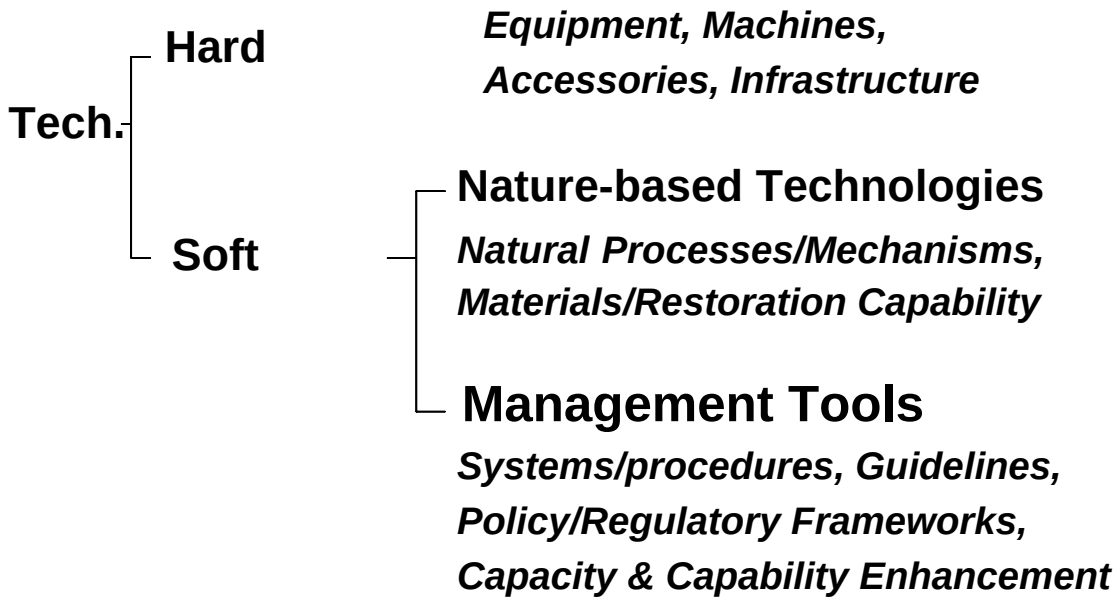


Figure 1. Technology typology.

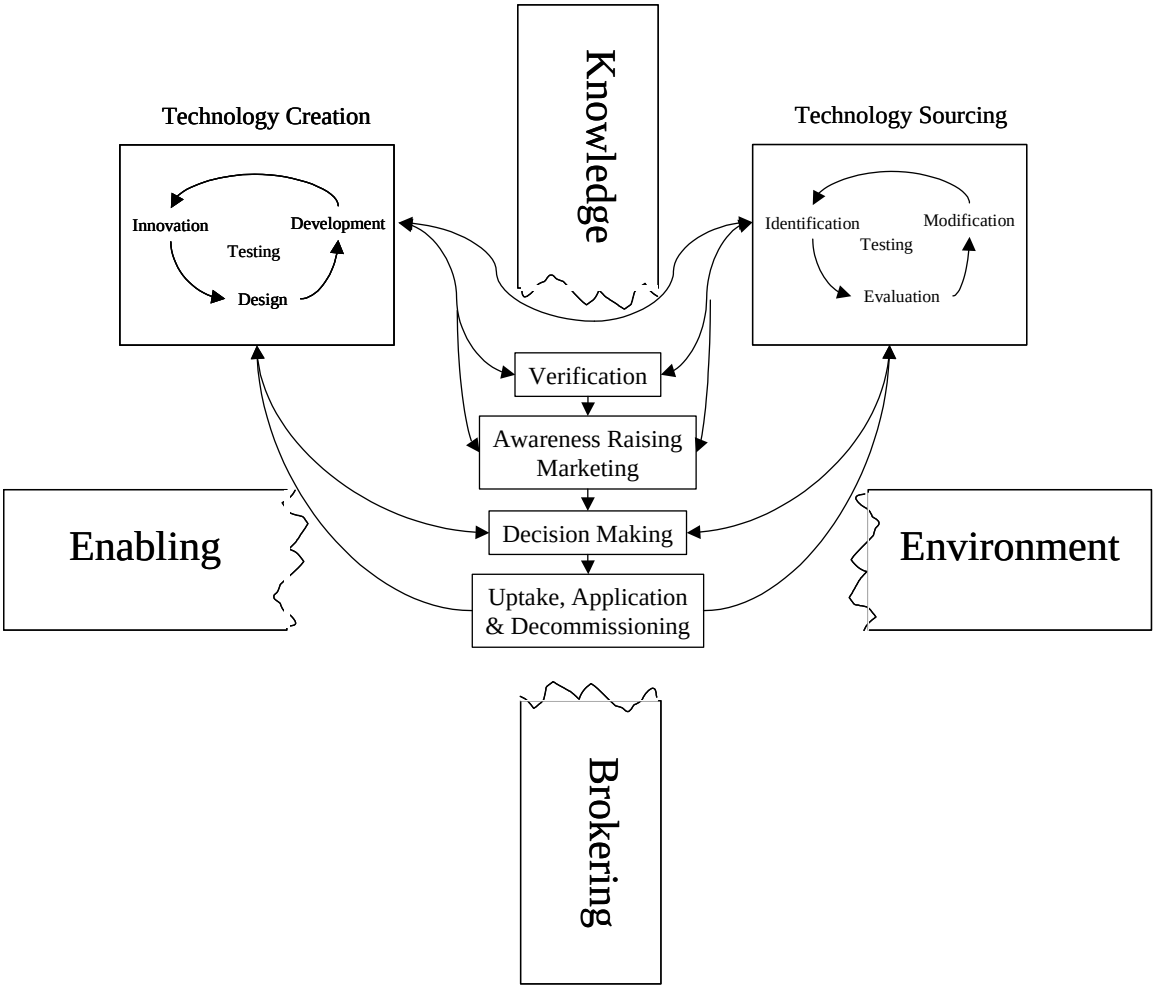


Figure 2. The technology transfer process.

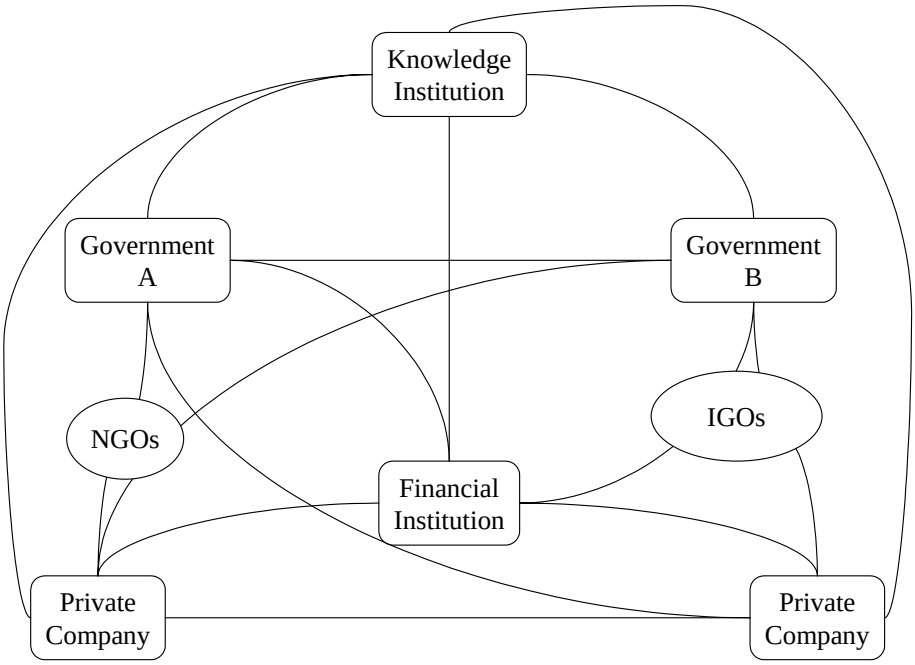


Figure 3. Some of the key players in the transfer of technologies, illustrating the diversity of pathways (after UNEP, 2001).

But ten years later, at the World Summit on Sustainable Development (WSSD) (Johannesburg, 2002), a global stock take showed that for most communities and countries the anticipated improvements in levels of development and sustainability have proven elusive, with the lack of widespread and effective technology transfer being identified as one of the root causes. Since the 1992 UNCED, such revelations and the subsequent soul searching have resulted in renewed calls for comprehensive but targeted programmes of technology transfer. Two key examples are the Millennium Development Goals and the Plan of Implementation agreed to at the WSSD.

Two simple but fundamental questions arise from this brief historic review:

- Why has technology transfer failed to fulfill expectations and meet the clearly evident and pressing needs?
- What must be done to ensure that the success of renewed international sustainable development initiatives, and those being undertaken at community and national levels, are not frustrated by continued shortcomings in technology transfer?

This report will identify and characterize the barriers to successful and effective technology transfer, and provide a roadmap for removing the major impediments to successful technology transfer. Emphasis will be on technology transfer to, between and within developing countries and countries with economies in transition, covering the broad range from community-based technology initiatives to those undertaken as a result of comprehensive national and regional policies. But it is self evident that there is no ubiquitous approach to enhancing technology transfer - the suite of measures for addressing barriers, and facilitating successful technology transfer, is typically community specific.

So how can a global report contribute understanding and make a difference at the operational level? The approach taken will be to advocate higher-level actions which help ensure that local decisions are made and implemented by stakeholders who are well informed and who can operate in a setting that enhances the possibility of their technology investment outcomes being simultaneously environmentally sound, socially acceptable and economically viable. A key to facilitating technology transfer is to provide mechanisms by which the critical stakeholders can communicate their needs, and promote and deliver their products and services.

Who are the stakeholders in technology transfer? The multiple dimensions of technology transfer (Figures 2 and 3) mean there are many potential stakeholders, including innovators, developers, owners, suppliers, buyers, recipients, users, consumers, financiers, donors, governments (including policy makers and regulators), insurers, international institutions, and non-governmental and community-based organizations. The stakeholders involved in any specific transaction will depend on the type and status of the technology and the associated nature of the transfer pathway.

The next section, *Challenges*, characterizes the barriers associated with technology transfer – barriers are the impediments to technology transfer that arise at each stage of the process, or at each node in the transfer pathway.

This is followed by discussion of a key attribute of technology transfer, namely *Choice*. One aim of barrier removal, or facilitating technology transfer, is to provide the recipient and user with choice. The performance of a given technology is dependent on a wide range of factors, making identification of an environmentally sound or otherwise appropriate technology somewhat problematic. For example, a technology that is assessed to be environmentally sound in a given locale, culture, economic setting or stage in its life cycle may not be in another. Its performance may be influenced markedly by the availability of supporting infrastructure and by access to the expertise necessary for its management, maintenance and monitoring. Moreover, a technology that qualifies as being environmentally sound at one point of time, may not do so at another – the performance criteria against which it is assessed may change as a consequence of new information or changing values or attitudes; a technical breakthrough may give rise to more desirable alternatives. It is therefore vital that recipients and users of a technology are able to choose an option that meets their specific needs and capacities, while also being environmentally sound in its operating locale and over its operational life cycle. It is, of course, highly desirable that the technology is also found to be economically viable and socially acceptable, and hence truly sustainable.

The next section of the report highlights the need for, and benefits of, *Certainty*. A lack of certainty, and the consequential high levels of risk, both real and perceived, are recognized as major impediments to the successful establishment and ongoing operation of functional markets for ESTs. The common perception that many ESTs are “emerging”, and hence “unproven”, means there is little confidence in their economic, commercial or technical viability. Removing barriers to technology transfer often translates into increased certainty, and decreased risks, for the key stakeholders such as the developers, suppliers, financiers, insurers, recipients and regulators. One example is ensuring access to sufficient, verified information. Risk assessment and management capabilities for financial institutions are also of special importance.

The technology transfer chain is often long, in terms of both distance and time. *Communication* is thus another essential ingredient in the recipe for successful technology transfer. Efficient and effective two-way communication and cooperation between key stakeholders will do much to remove barriers. Information management systems, knowledge management tools and formal and informal networks, both centralized and dispersed, can all make important contributions. Technology transfer often involves a dissonant mix of informal actors (e.g. innovators) working in formal and highly regulated settings. Effective communication is a requisite to harmonizing their contributions to the processes of technology transfer.

In sum, barrier removal is largely about creating favourable circumstances for technology transfer – ensuring all stakeholders have the *Capacity* to fulfil their roles and meet their responsibilities, expeditiously. Generally speaking, government is the principal player in creating an enabling environment for technology transfer, but financial and insurance institutions and international organizations can also be influential.

Finally, if there is to be an improvement on the last decade or so, where technology transfer failed to deliver the anticipated and much needed advances in development and sustainability, we must make a *Commitment* to overcoming the challenges, providing technology users with the choice they deserve and desire, increase certainty, thereby reducing risks, enhancing communication between technology transfer stakeholders and building and strengthening the enabling environment and thus the capacity for technology transfer.

Challenges are more commonly referred to as "barriers" – we prefer the former term, as it has fewer longer-term negative connotations. The discussion of challenges will commence with the supply side of technology transfer (the innovators and developers) and move to the demand side (the recipients and users). Of course, as shown in Figure 2, technology transfer processes are neither linear nor so simple. Commonly, challenges occur at every node and, due to restrictions on the movement of information and materials, for every linkage. Moreover, the nature and severity of the challenges will be dependent on the prevailing circumstances, varying with the type of technology, its specific application and the characteristics of the technology providers and recipients. But some generalizations are possible.

Shortfalls in Technology Creation

Many of the needs for technologies that arise from implementation of development plans, and from the wish for enhanced sustainability, can be met only through innovation – the design, development and proving of new technologies. New challenges, such as the management of toxic chemicals or the disposal of intractable wastes, often require new solutions rather than a modification of old procedures.

Technology creation can be hindered by both supply and demand factors, as well as by the low quality and effectiveness of the emerging technologies and shortcomings in the enabling environment, as shown by the following examples:

- a small company, recognised as a technology "incubator", cannot afford to invest in a market survey which would demonstrate the potential demand for a new flocculation agent that might well improve the efficiency and environmental performance of conventional wastewater treatment plants;
- a large company has developed an oxygenated fuel for use in motor vehicles – it produces significantly less carbon monoxide, hydrocarbons and sulphur and measurably less carbon dioxide, but the company is unable to identify an independent agency that will verify these environmental performance claims and also confirm that risks to human health and safety are well within acceptable limits;
- a local authority in a developing country has been offered technical assistance to prepare and implement a comprehensive traffic management system in order to address a growing congestion problem, but under current policies and legislation it does not have the mandate to carry out the required infrastructure, regulatory and other changes;
- a multi-national biotechnology company has identified, in a developing country, a plant which is indigenous to that country and has been used traditionally as a natural cure for inflammation of the digestive organs – but with major changes pending in international

property right agreements and national legislation, the company is unwilling to undertake the necessary financial investment; and

- a government research agency has developed a new, highly efficient process for recovering lead from used automobile batteries, but it is not cost effective given current international prices of lead.

Challenges that need to be addressed if technology creation is not to impede the transfer process include lack of the following: information relevant to strategic planning and market development; science, engineering and technical knowledge, especially in the private sector; institutions with the mandate and resources to equip people with the requisite knowledge and skills; research, development and testing facilities; technology development and adaptation centres; and joint industry-government planning and collaboration.

Creation of useful and usable technologies is a major factor in ensuring there is the opportunity to make informed and confident choices in technology investment projects. Ways of overcoming constraints on technology creation will therefore be one focus of the discussions on *Choice* and *Certainty*.

Underperformance in Technology Sourcing

Technology sourcing covers those situations where the technology already exists, be it traditional or modern. Transfer of such technologies might start with identifying their existence, evaluating their general suitability and making modifications, as needed. The technologies can then be made available for use in specific applications and locations, where another tier of requirements must be met if the technologies are to prove appropriate for that use.

Technology sourcing can be frustrated in similar ways to technology creation, as the following examples illustrate:

- a small community faces major health problems due to contamination of ground water by septic tanks, but there are no mechanisms by which it can identify suitable solutions, other than to rely on the unsubstantiated claims of companies wishing to sell imported systems;
- the government of a country with an economy in transition wishes to improve its solid waste management practices by developing sanitary landfills and specialized facilities for intractable wastes, but officials do not have the technical expertise to evaluate the various options and make recommendations to government;
- a community based organisation in a developing country is advocating the return to using the seed of the *Moringa oleifera* as a flocculent aid for water purification, but the public is reluctant to spend time cultivating the trees and thereby provide a reliable source of supply;
- a businesswoman has identified a technology which she believes will address the growing local demand for water conservation devices as a result of a user pay system being introduced, but to her dismay she finds that the products attract a very high level of import duty due to an anomaly in the customs regulations;
- a non governmental organisation in another developing country is keen to establish waste shops operated by local youth who purchase recyclable and reusable materials, for on-selling – but the organisation cannot identify examples of the shops operating successfully in a similar socio-economic and cultural setting, and hence cannot gain the support of all

stakeholders, including those companies which argue that they will lose business as the waste shops will be competitors.

If technology sourcing is not to impede the transfer process, challenges often need to be addressed, including those related to: ready access to independently verified information on suitable technology options; use of traditional technologies being seen as retrogressive; inability to address the concerns of stakeholders who consider they will be worse off if the technology is introduced; and financial and other disincentives to acquire and use ESTs.

Overcoming such challenges will also be discussed under *Choice* and *Certainty*.

Sub-optimal Enabling Environments

Figure 2 shows that the enabling environment is a key component of the technology transfer process. The enabling environment encompasses many aspects of the context within which the transfer takes place. Shortcomings in the enabling environment reduces the likelihood that the transfer will be conducted in a successful and timely manner.

Stakeholders must have the necessary knowledge and skills to perform the roles and tasks expected of them. High levels of awareness, motivation and empowerment within the public and private sectors and in civil society will help ensure that people, communities and societies are able to adapt continuously to new circumstances and challenges, including developing and modernizing in less wasteful ways than is the current development paradigm, but without losing the sound social and cultural values and practices that underpin their traditional ways of life.

Effective and efficient national and regional systems of innovation, research and development should be in place, to facilitate such procedures as adaptation of traditional technologies for use in current settings. Such systems will also contribute to the design, testing and widespread uptake of new technologies suited to local conditions. Networking of organizations and institutions which share a common interest in technology development, diffusion and application will also foster successful transfers of technology.

Networking is just one of many reasons why a functional information management system will facilitate technology transfer. Such a system will also enable needs and practical constraints to be communicated to those involved in designing, developing and providing technologies, including creating a favourable environment for technology transfer. Performance and other data on possible technology options can also be made known to parties contemplating a technology investment, facilitating the communication and appropriate use of guidelines, codes of practice, standards, verification information and certification procedures. Information management systems will help ensure that key players are aware of both successes and failures in selecting, procuring and applying a technology, allowing systems to be improved. Timely access to quality information is also required if technology investment risks are to be minimized, in part through reductions in both information gaps and uncertainties.

The enabling environment benefits from policy implementation that fosters an appropriate mix of government and private sector investment in ESTs. This can be achieved by implementing policies that address such issues as shortcomings in the financial sector such as lack of access to appropriate sources of capital, high or uncertain inflation or interest rates, subsidised or average-

cost (rather than marginal-cost) prices for material and energy inputs, high import duties, uncertain stability of tax and tariff policies; investment risk (real and perceived), loss of rights to intellectual property and to productive resources and risk of expropriation.

Appropriate use of regulations, economic incentives and other measures will also facilitate the uptake and operation of ESTs at community to national level, and discourage the continued use of environmentally unsound technologies. Moreover, a competitive and open market will encourage ongoing, replicable technology transfers. Financial, insurance and related systems that facilitate investment in ESTs at various levels - community through regional – are also desirable. All institutions must be able foster and facilitate the transfer and effective operation of ESTs in a transparent, accountable and technically competent manner.

Finally, technology transfer will also be assisted by the ability to access, use, and benefit from decision support and related methodologies and tools, including those that will help ensure technology investments have equitable, beneficial outcomes that are environmentally sound, socially acceptable and economically viable.

The section on *Capacity* focuses on ways to overcome these challenges and improving the enabling environment for technology transfer.

Insufficient and Unverified Information

In addition to the movement of the technology itself, the transfer process involves a two way flow of information. For example, technology creation cannot be totally serendipitous – it must reflect, at least in part, the needs and circumstances of the target beneficiaries of the creative effort. Similarly, it is essential that those involved in supplying, procuring, financing and insuring technologies be aware of the potential technologies, including their procurement and operational requirements and performance profiles.

ESTs are often considered “emerging”, and hence “unproven” – there is little confidence in their economic, commercial or technical viability. Such views often relate to a lack of data, information, knowledge and awareness, meaning there is no credible record of performance. Consumer acceptance is thus low and investors, especially those in the private sector, are adverse to financing ventures that appear to carry high risks.

Moreover, available information on the performance and other key attributes of the technology is typically prepared by the technology developer or owner, or their agents, often with little or no accountability for its veracity. The existence of sufficient, reliable information is essential for judging the likely commercial success and other outcomes of a proposed technology investment. A realistic expectation is that the information being used in decision making is a reasonable representation of reality, with providers of information accountable for reporting in an accurate and meaningful way. Thus the reporting of information must be sufficiently frequent, complete and reliable if stakeholders are to assess, on a timely basis, the extent to which their expectations of performance are being satisfied.

This requirement has major implications for the manner in which performance information is collected, analysed, and communicated. However, uniform reporting measures remain elusive, and the variety of approaches to reporting performance information often makes it difficult, if not

impossible, to compare technologies and judge their likely commercial viability and environmental and social impacts. This impedes, if not precludes, informed choice. The situation is exacerbated if the information which is available cannot, or should not, be relied upon. An even greater challenge exists for developing countries, given the complexity of factors that influence and determine investment decisions and the environmental, social and commercial successes of a technology intervention.

The sections on *Certainty*, *Communication* and *Capacity* discuss ways to enhance the adequacy and reliability of the information used to underpin the technology transfer process.

Challenges for Small and Medium Enterprises

Impediments to engaging in technology transfer are especially acute for one group of key players in technology transfer in developing countries – the small and medium enterprises. These operators suffer disproportionately from such constraints as:

- lack of technical and other information on technology needs, options, costs and benefits and of market opportunities;
- shortage of trained personnel;
- lack of ready access to capital, and hence inadequate financial strength;
- relatively high transaction costs;
- minimal presence in any markets for ESTs; and
- low participation in industry associations and networks of organizations and institutions involved in generating, diffusing and utilizing technologies.

A key component of technology transfer is informed choice – the ability of the technology user (country, community, enterprise….) to be able to identify and procure the most appropriate (environmentally, economically, socially) technology for a given application in a given locale. Several requirements must be met, including:

- needs well defined, documented and understood;
- several technology alternatives, all of which are well and reliably characterized in terms of environmental and economic performance and potential social impact;
- rational and functional methods (decision support tools) that facilitate choice of an optimal technology; and
- capability to make the chosen technology fully operational, so that it fulfils its potential, and meets the identified needs, without detrimental side effects, including during decommissioning.

Technology Needs Assessment

Technology needs are often poorly characterised and understood, even by the potential users. This failing impedes the effectiveness of others in the technology transfer chain, including innovators, designers, developers, suppliers, financiers, insurers and regulators.

Technology needs assessment is a coordinated set of country-, sector-, enterprise- or community-driven activities leading to the identification of technology needs, evaluation of specific technology options using generally accepted criteria, development of both specific and more integrated technology strategies and to facilitation of the identification, development, selection, transfer, acquisition and uptake of sustainable technologies. The assessment involves all relevant stakeholders in a consultative process to identify the opportunities for, and challenges to, the successful uptake of sustainable technologies and the measures to address these opportunities and barriers through specific and more integrated actions.

The tangible outcomes of such an assessment are typically a portfolio of technology transfer projects and capacity-building activities to facilitate and accelerate the development, adoption and diffusion of sustainable technologies in particular sectors, enterprises, locations and communities. The key activities are shown in Figure 4 and illustrated, using a case study, in Box 1.

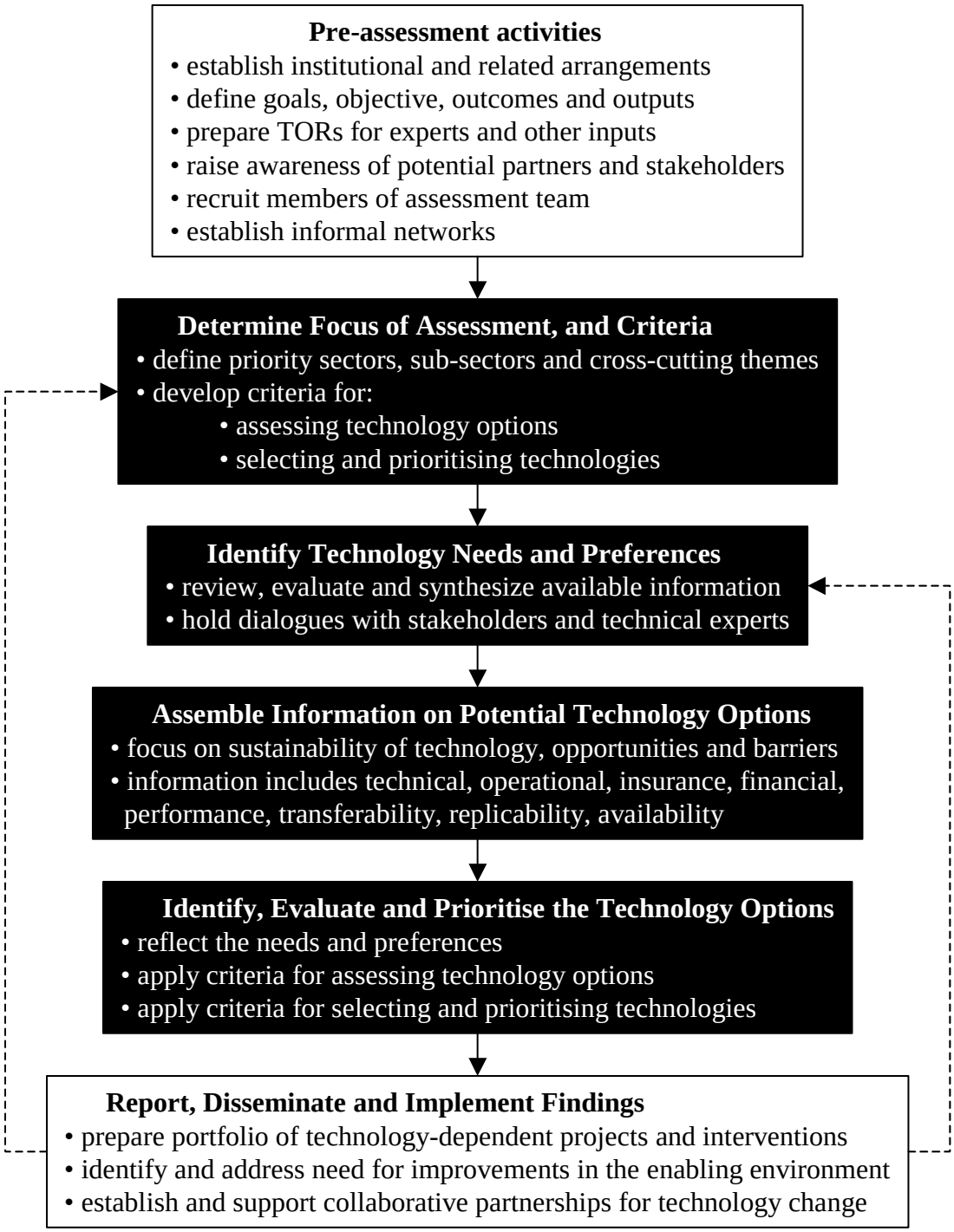


Figure 4. Key activities in a technology needs assessment (Hay, 2003).

Box 1

Technology Needs Assessment for a Small Island Developing State
Source: Hay, 2003

The technology needs assessment process indicated in Figure 4 was followed.

Criteria used to identify acceptable technologies included:

- Improve operational efficiency/effectiveness;
- Have social and economic benefits that exceed the social and economic costs;
- Reduce vulnerabilities and enhance resilience of social, economic and environmental systems;
- Be environmentally sound and compatible with the local culture, society and environment;
- Assist people to develop and modernize in less wasteful ways than is the current development paradigm, but without losing the sound social and cultural values and practices that underpin their traditional ways of life;
- Facilitate compliance with international agreements such as the UN Framework Convention on Climate Change and the Convention on Biodiversity;
- Complement existing technologies and services; and
- Be consistent with current capacities for operations and maintenance.

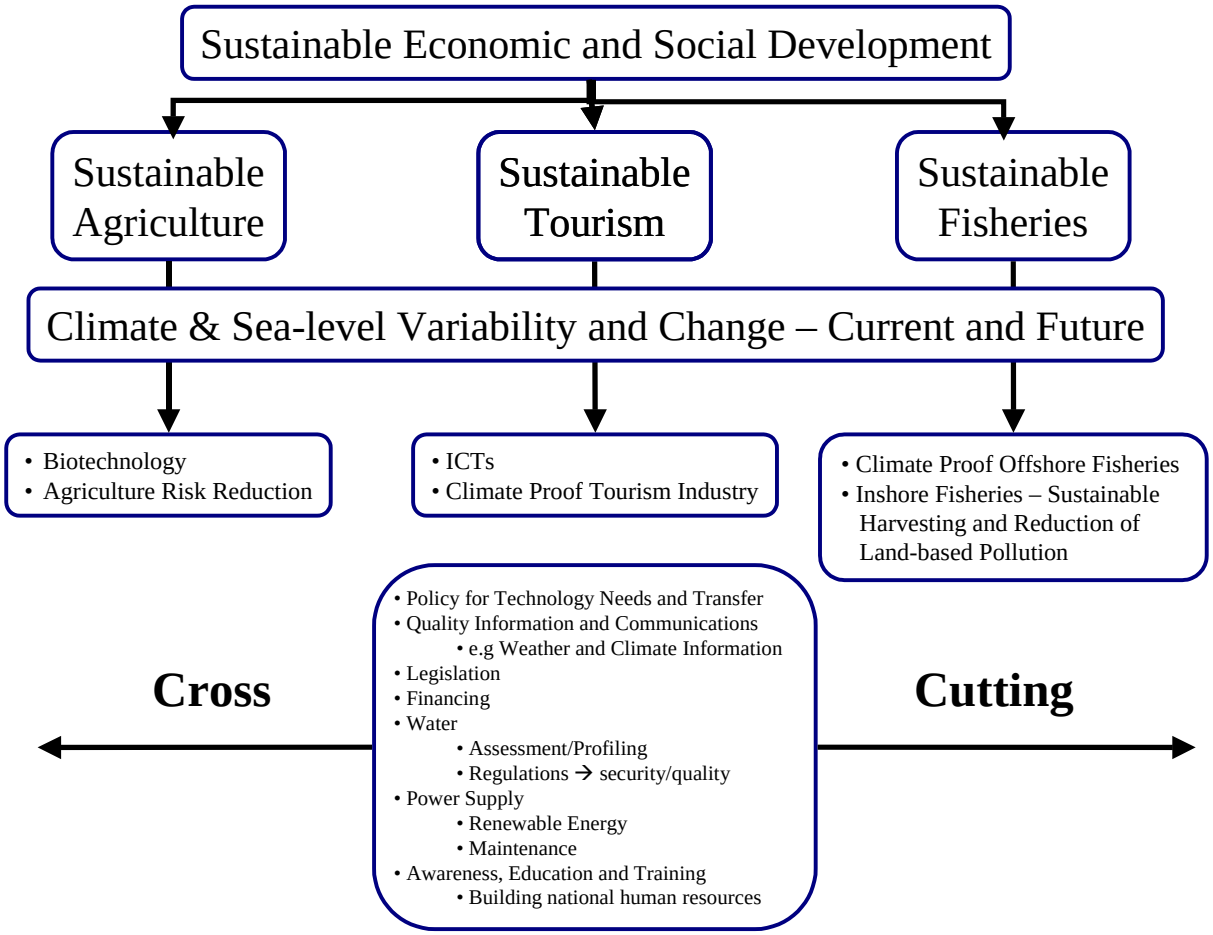
In addition, technology acquisition must involve:

- Consultations with all stakeholders;
- Recognition of the important roles of traditional knowledge and skills, including endogenous technologies;
- Decisions based on comprehensive and credible performance information;
- Either a tendering process to ensure cost effectiveness;
- Or full costing of technology projects funded by donors.

Box 1

(continued)

The outcomes of the technology needs assessment are summarised in the following diagram.



Existence of Viable Technology Alternatives

Viable technology options or alternatives are often few in number, meaning there is frequently little or zero effective choice. As previously noted, this problem can be solved, in part, by ensuring that key players in technology creation and sourcing are well informed of the needs of recipients and users.

Another key to resolving this problem is to strengthen the technology creation and sourcing processes themselves, by increasing investment in research and development and strengthening relevant institutions (see also *Capacity*). Even if a competitive and open market is operating, incentives may be required to bring technologies to a stage where they can be replicated and diffused using only market forces.

Rational and Functional Methods and Tools that Facilitate Informed Choice

Decision support tools to facilitate informed choice must take into account the specifics and complexities of the needs, operating environment and related circumstances of employing a given technology in a specific locale or under any other set of explicit conditions.

Technology assessment is a procedure that facilitates an understanding of the likely impacts of the use of new or modified technologies by an industry, municipality, country or society. Initially it was an analytical method for supporting technological development, and an instrument for assisting decision-making on scientific and technological issues. Subsequently it has also evolved into a tool for aiding the development and implementation of technology policy and for encouraging the development of environmentally and socially desirable and acceptable technologies. Technology assessment has therefore become a vehicle for providing information to all stakeholders involved in technology development. Currently it is possible to identify eight functions for technology assessment (Box 2).

Box 2

Eight Functions of Technology Assessment

- identifying and developing socially desirable and useful technology development options;
- supporting stakeholders in the formulation of their strategies for technological development;
- assessing in the earliest possible stage of technological development, the possible problematic and unwanted consequences (i.e., "early warning");
- supporting decision-making by clarifying and evaluating problems and issues;
- strengthening policy-making through an enlargement of the knowledge base related to scientific and technological developments, and making it easier to exert a positive influence on these developments;
- contributing to long term policy by providing information about possible development alternatives;
- promoting responsible science; and
- promoting the public acceptance of technology related developments.

While many different forms of technology assessment exist, and are in use, as an institutionalised practice technology assessment is unequally developed in different countries. Some countries have established formal technology assessment organizations within government or industry. Other countries have loosely organized networks for technology assessment activities. The extent to which technology assessment is used to support decision making processes also varies.

Environmental technology assessment is a specific form of technology assessment. It focuses on the effects of a technology on the environment, human health, ecological systems and natural resources (Figure 5). The tool has been developed for the specific purpose of helping to ensure quality decisions are made in the selection of the most appropriate EST for a particular

application in a specific locale. It is complemented by a suite of decision support tools. Figure 6 provides some examples. Table 1 summarises the characteristics of four of the commonly used decision support tools. While these decision support tools have wider application, they can be of considerable use in the specific role of facilitating the identification and effective uptake of ESTs.

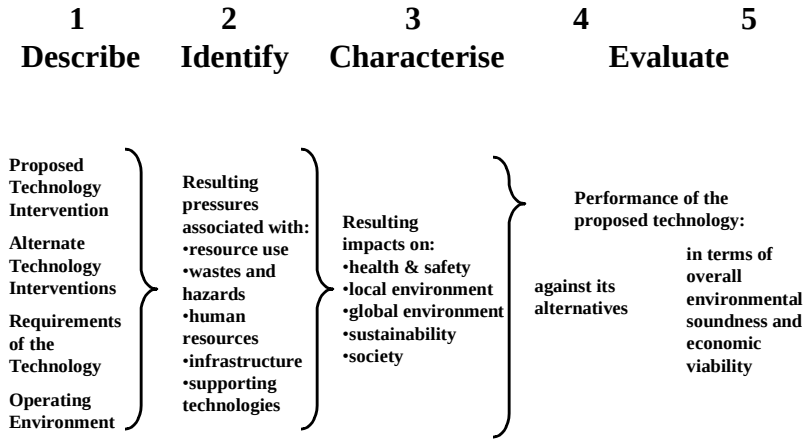


Figure 5. In an environmental technology assessment the proposed technology intervention is assessed using five steps, based on the DICE procedure of describe, identify, characterize and evaluate.

Figure 6 indicates that these decision support tools are used at specific stages of the project cycle. At the scoping stage of a technology investment, when many technology options and development alternatives are being considered; tools are required to assist with early engagement of the diverse stakeholders, facilitating early consultation and meaningful dialogue. This helps identify issues of concern to the stakeholders and hence where more detailed assessments should focus.

At the project development and approval stage the tools help achieve more specificity and certainty regarding the proposed technology investment, the potential environmental issues and, hence, the aspects on which the assessment should focus. Without such a focus, the number of options being evaluated can escalate rapidly, along with the requirements for information, technical expertise and time. For these reasons the four tools shown in Figure 6 come into their own at the project development and approval phase. One or more of these assessments may well be required as part of the regulatory or approval process for a new or significantly expanded project.

Table 1

Characteristics of Four Commonly Used Decision Support Tools

	Environmental Technology Assessment (EnTA)	Environmental Impact Assessment (EIA)	Environmental Risk Assessment (EnRA)	Life Cycle Assessment (LCA)
Purpose	Assesses implications of a technology and guides choices of technology	Identifies and predicts the environmental impacts of a project, policy or similar initiative; provides basis for decision on acceptability of the likely impacts	Risks to the environment and public health are estimated and compared in order to determine the environmental consequences of the initiative under consideration	Evaluates the environmental burdens associated with a product, process or activity, explicitly over the entire life cycle
Scope	Implications for human health, safety and wellbeing, and for natural resources and ecosystems; costs of the technology intervention and the monetary benefits	Impacts on natural resources, ecosystems human health, safety and wellbeing	Assessment of risks to the environment and human health	Implications for human health, safety and wellbeing, and for natural resources and ecosystems
Initiator	Proponent of technology; investor; stakeholders who may be impacted	Applicant for regulatory approval	Proponent of project or other initiative; investor; stakeholders who may be impacted	Proponent of project or other initiative; investor; stakeholders who may be impacted
Approach	A systematic, comprehensive and qualitative comparison of the pressures on the environment and the resulting impacts	Requirements often prescribed by regulatory authority, including identification of impacts, mitigation and monitoring measures and consultation	Hazard identification, dose-response and exposure assessments, risk characterisation	Life cycle inventory of energy and material requirements and wastes produced; impact analysis and improvement analysis
Timing	Scoping tool at the idea stage, before the development of a formal/full proposal	Prior to decision whether or not the initiative should proceed	At any time, as determined by the initiator	At any time, as determined by the initiator
Regulatory Status	None – often used to screen options before more detailed assessment	Often required under environmental protection legislation, especially for larger projects or for proposed projects in environmentally sensitive areas	None – may be used to give support to conclusions of assessments required by law	None – typically used by producers or consumers to assess the environmental merit of the product, process or activity.

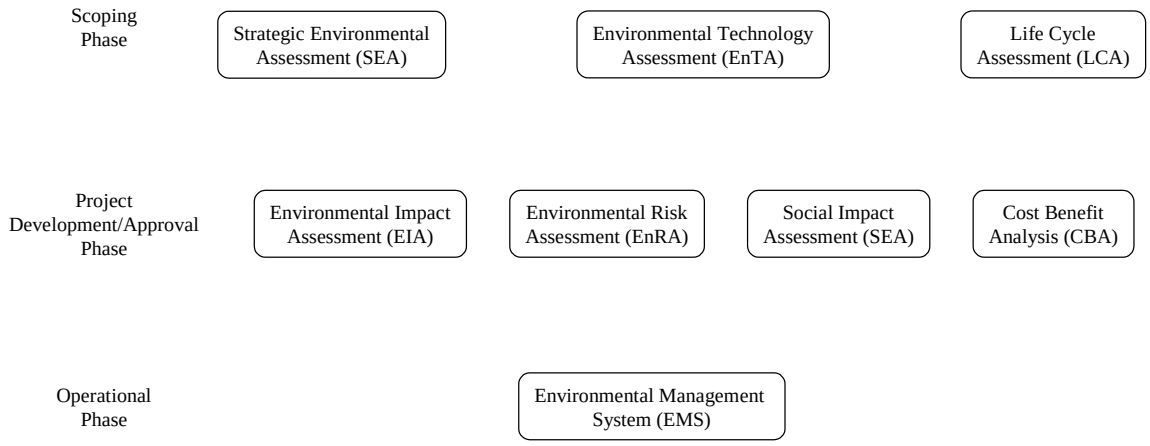


Figure 6. Decision support tools for environmentally focused technology assessment, presented according to the stage of the project cycle where their use is most appropriate.

Finally, an environmental management system brings considerable benefits at the operational phase. It can help identify the extent to which the performance of the technology is consistent with expectations and requirements, and the need for any remedial action to improve environmental outcomes.

Operational Circumstances

The intended use of, and operating environment for, a technology may also restrict choice if these are highly unusual. Assessments made using relevant decision support tools may reveal the need for customized technology solutions. But a more desirable outcome would be for awareness raising and other efforts to result in needs being redefined so that more widely available technologies will provide the required results and for capacity building activities to reduce the distinctiveness of the operating environment. Such measures are elaborated in *Capacity*.

A lack of certainty, and the consequential high levels of risk, both real and perceived, are recognized as major impediments to the successful establishment and ongoing operation of a functional market for ESTs. For example, the uncertainty that prevails in markets for ESTs has detrimental repercussions all along the transfer chain, from innovators to users.

The level of risk reduction that occurs in the real world is directly related to the level of performance and effectiveness of the technologies that are purchased or used. Superior performance can manifest itself as reduced operating risk, lower costs and competitive advantage.

There are many actions that can be taken to increase the level of certainty, and hence reduce risks to technology developers, providers, investors and users. Some are elaborated below.

Development and Use of Technology Performance Protocols, Criteria and Benchmarks

To foster the use of ESTs there is an urgent need for the following credible, comparable and objective information for each candidate technology: technical performance, life cycle cost, health and safety data, risk, process residuals, regulatory feasibility, future use, natural resource damage and stakeholder concerns. Access to relevant, high quality performance information is critical to improving the quality of decision making regarding the selection of ESTs.

Ideally the detailed measurements and assessments required to provide this information will be made in accordance with internationally recognized methodologies or accepted protocols, thereby helping to ensure comparability between information collected by different assessors and/or between commercial variants of the same generic technology. The protocol will involve science-based assessments and should produce statistically valid data sets, with quality control and assurance and application of chain of custody rules. Laboratory testing should be complemented by field trials. If the detailed measurements of performance are made in accordance with standard methods or accepted protocols this will help ensure comparability between information collected by different assessors and/or between commercial variants of the same generic technology.

Such performance assessments are capable of generating large amounts of data. A significant challenge is to identify the key criteria that characterise and distinguish the performance of the technology undergoing assessment. Criteria will be of optimal use to decision makers and other practitioners if they portray reality and facilitate unequivocal confirmation that a given technology is environmentally sound. However, as yet there is no widely accepted set of

technology performance criteria and indicators for evaluating and identifying ESTs. This is recognised as a major impediment to increasing their acceptance and uptake. To address this need the UNEP Expert Group on Environmentally Sound Technologies has drafted a preliminary set of generic environmental criteria and guidelines that can be used in assessing and evaluating ESTs (Table 2). A more comprehensive list is provided in IETC (2003).

Independent Quality Assurance of Performance Information

Performance assessments provide standardized information against which individual performance claims can be judged. But in themselves the procedures do not directly address the concerns and expectations of the end-users with respect to the quality and credibility of the reported information. Where information exists, it may not be credible. This gives rise to the need for additional quality assurance, through verification, whereby independent third parties determine whether the information provided satisfies specific criteria concerning the veracity of the way it is acquired and communicated.

Verification is the process of determining that a given technology will produce the results described in a performance claim. This is done through independent, third party application of guidelines or pre-determined criteria and is substantiated by investigation, statistical analysis and other means,. Verification is not an isolated process - it is part of a larger system that includes monitoring, auditing, certification and accreditation. Verification guidelines outline the procedures and information requirements needed to verify a performance claim.

A verification system should have:

- *Credibility* - The process should involve credible organizations working in conjunction with internationally recognized bodies that accredit competent organizations to verify and certify;
- *Transparency* - The process should be open and transparent with information shared amongst interested parties;
- *Compatibility* - Verification guidelines should to be relevant to national and international applications; and
- *Continuous Improvement* - The verification system should be designed to accommodate continuous improvement, taking into account new, emerging information and knowledge.

Independent assessments of the veracity of performance claims should follow accepted guidelines and use established criteria. The advantages of third party assessment and review of technology performance data include enhanced certainty, transparency and increased market place acceptance, as well as associated benefits for the proponents of the technology investment, the technology developers, consumers, regulators, insurers and financial investors. Verifying conformity of performance claims against accepted criteria and standards provides stakeholders with an opportunity to assess the real and relative benefits of ESTs, including cleaner production processes and practices. Benchmarking can also be used to improve the usefulness of the evaluation information.

Assessing and verifying conformity to performance standards is usually carried out at the national level, providing an opportunity to reflect at least country-level priorities and bottom

Table 2
Generic Environmental Criteria and Guidelines for Assessing ESTs

Criteria	Guidelines
Sustainable resource development and utilisation	• Plans for the sustainable resource development and use have been developed • Expenditures on sustainable resource development and utilisation have been taken into account • Expenditures on sustainable resource augmentation (i.e., reforestation) have been taken into account
Protection of freshwater quality and supply	• Annual withdrawals of ground and surface water and water consumption have been determined • Opportunities for water conservation and efficiency improvements have been determined • Potential sources of water pollution have been determined • Plans and facilities for water and wastewater treatment and hydrological monitoring are in place • Expenditures on water and wastewater treatment have been taken into account
Protection of adjacent water bodies and shoreline/coastal resources	• Potential releases of nitrogen, phosphorus and other contaminants to adjacent water bodies have been determined • Plans for the protection of water bodies and shoreline/coastal resources are in place • Expenditures on protecting water bodies and shoreline/coastal resources have been taken into account
Protection of terrestrial resources	• Population growth and distribution, and land use changes have been taken into account, including compatibility of various facilities and systems • Plans for integrated planning and management of terrestrial resources are in place, including consideration of geomorphology and ecohydrology • Decentralised local-level natural resource management is in place • Potential for soil contamination and erosion has been taken into account
Conservation and biological diversity	• Plans for the protection of biological diversity and preservation of endangered species are in place • Expenditures on the protection and preservation of endangered species and sensitive habitats have been taken into account
Protection of the atmosphere	• Ambient concentrations of pollutants in urban areas have been determined • Potential releases of air emissions have been determined • Plans and equipment for the management of air emissions (i.e., criteria air contaminants, toxics and GHGs) are in place • Expenditures on air pollution abatement have been taken into account
Environmentally sound management of solid wastes and sewage	• Potential generation of solid waste, industrial waste and sewage has been determined • Opportunities for waste minimisation and material efficiency improvement have been determined • Plans and facilities for waste management and sewage treatment are in place • Waste recycling and reuse plans and facilities are in place • Expenditures on waste management and sewage treatment have been taken into account
Environmentally sound management of toxic chemicals and hazardous wastes	• Potential generation of toxic chemicals and hazardous wastes has been determined • Opportunities for toxic chemical and hazardous waste minimisation have been determined • Plans and facilities for the management of toxic chemicals and hazardous wastes are in place • Expenditures on toxic chemicals management and hazardous waste treatment have been taken into account

lines. In addition, such national agencies providing performance assessment services can benefit from strengthened linkages with international organisations that can provide technical assistance in support their activities. Such linkages are also important in ensuring that country-specific performance assessment protocols, criteria and benchmarks are internationally recognised.

Standards, Certification, Accreditation and Related Organizations and Institutions

Standards typically encompass protocols, criteria and/or benchmarks that are given formal/official recognition. These, along with certification, help assure the quality of performance information. Certification and verification are often confused, but there is a significant difference between the two. Verification involves the assessment and validation of performance claims by an independent third party. Certification usually goes one step further, by attesting that the technology, process or product meets specific standards or performance criteria that were in force at the time of the performance audit or the verification testing.

Certification is thus the procedure by which a third party agency independently evaluates conformity or compliance with specific requirements set out in particular standards. Certification can help governments and companies achieve performance goals by significantly improving the quality of information monitoring, reporting and verification. Certification can also serve as an effective policy instrument by supplementing traditional regulatory controls and fiscal incentives. It adds value because it is based on the results of tests, inspections and audits carried out by a competent third party.

Accreditation is an additional instrument for quality assurance. Typically competency of the third party can be assured by an authoritative body giving formal recognition that an entity is competent to carry out certain tasks. For example, and in a related context, the International Standards Organization (ISO) and its ISO 14000 programme provide a measure of control over the activities of accredited environmental management system registrars. Under this programme accreditation bodies approve registrars as competent to carry out ISO14000 registration of environmental management systems. Accreditation auditors evaluate a prospective registrar's written policies and procedures, including the credentials of its auditors. An audit team then performs a rigorous on-site examination of the registrar's internal operations and witnesses the registrar conducting a complete client audit.

To date there is no internationally recognised programme that certifies the competency of entities providing independent verification of the environmental performance of technologies. This is another impediment to the identification and uptake of ESTs. National bodies, such as the environmental technology verification programmes established by the Philippine's Department of Science and Technology and the Environmental Management Corporation, a public corporation under Korea's Ministry of Environment, are in part filling the gap at a national level in those countries. As noted previously, a parallel impediment is the current absence of specific standards or performance criteria that a technology, process or product must meet in order to be judged environmentally sound.

Ensuring Effective Use of Analytical, Assessment and Other Decision Support Tools

Previous sections have identified several decision support tools that can help enhance certainty. Additional tools will be highlighted here.

As shown in Figure 7, performance assessment provides a framework for technology evaluation at a generic level. Sustained use of performance assessment will result in a suite of technologies that are designated environmentally sound. This requires development of the capacity for technology performance assessment, nationally and internationally.

Performance assessment delivers credible, comparable, standardized and targeted information against which individual performance claims can be judged. Only through further development and widespread application of this tool will there be increased certainty in decision making regarding the selection of ESTs.

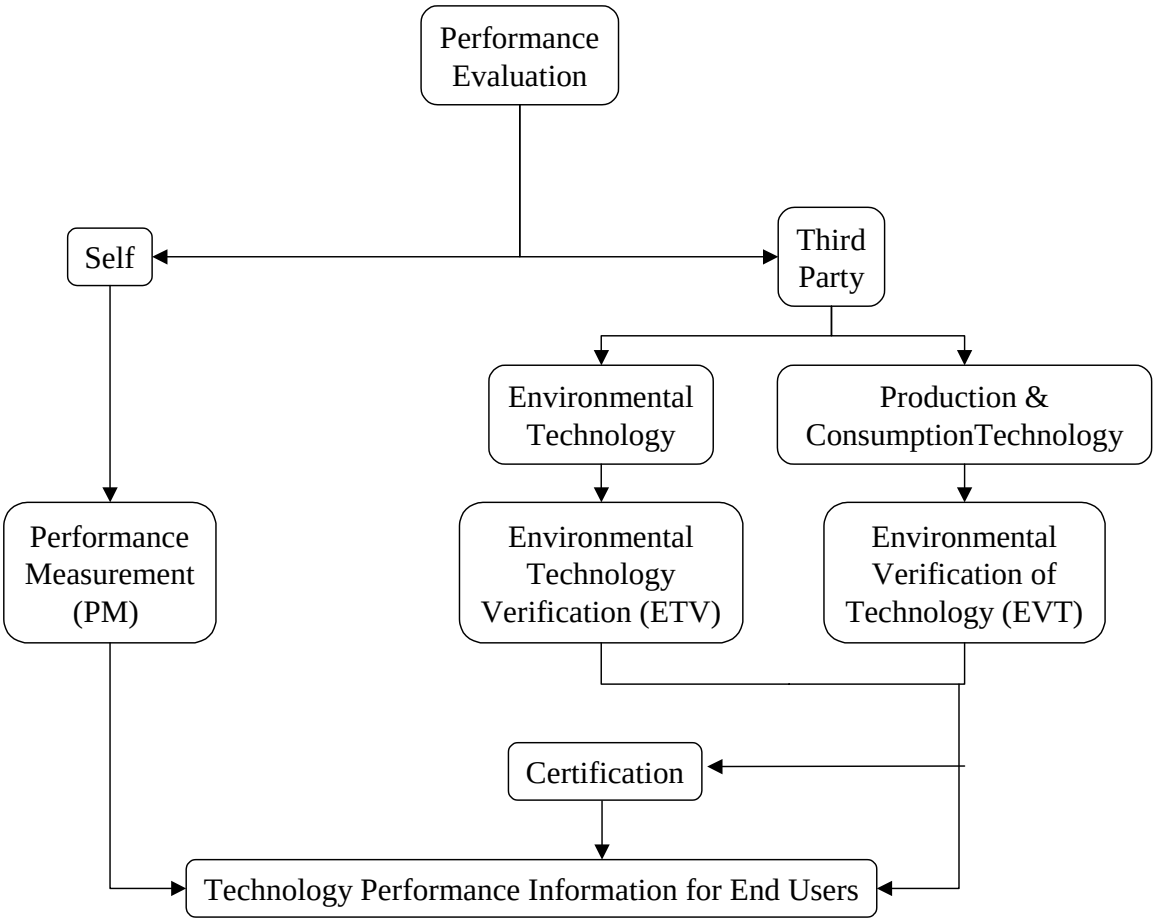


Figure 7. The Environmentally Sound Performance Assessment (EST-PA) process.

Risk assessment and risk minimisation are today an integral part of almost everyone's working lives and the application of modern risk assessment and management methods to technology development and investment is a natural extension, given the typically major consequences of technology failure and the risk adverse nature of financial institutions.

Technology risk assessment leads to the development of policies and procedures for the management, monitoring and control of risk exposures, helping financial and other professionals to make the right choices among competing technologies, solutions and providers. Technology risk assessment and management provide a framework to identify, analyse, prioritise and manage technology risks. It helps leverage competitive advantage by being able to embrace opportunities with greater certainty. Desirably, assessment and management procedures should be implemented early in the project life-cycle, such as during business case development. It is important to recognise the potential impact of technology risk from early in the life-cycle, for this enables a proactive rather than reactive approach to risk management.

Technology risk assessment and management encompass five closely related activities:

1. Identification of the hazards associated with the development, sourcing, supply, uptake, operation and decommissioning of a technology;
2. Determination of the risks *(i.e., the consequences and likelihoods)* of those hazards;
3. Reduction of the risks to acceptable levels through appropriate design and management measures;
4. Thorough documentation of activities 1 through 3; and
5. Continuing re-evaluation *(reiteration of steps 1 through 4)* in order to improve on the design or management outcomes.

Steps 1 and 2 relate to risk assessment and are often valuable in their own right because identification of likelihoods is helpful in the explicit treatment of uncertainties during decision making. The term "hazards" is defined broadly. It refers not only to traditionally defined safety, environmental and human health hazards, such as explosions or spills of toxic material, but also to more abstract hazards, such loss of public acceptance or failure of the investment to produce the anticipated returns, that might interfere with the successful uptake and operation of a technology. For example, a technology investor would state the investment goals, requirements and assumptions and then identify the hazards associated with the investment. Fiet (1995) identifies six indicators of market risk:

- technical obsolescence – when specialised technologies become obsolete they have lower value when used for purposes other than those for which they were previously purchased;
- many competitors – competition increases inter-firm rivalry, lowers the level of prices that can be charged for a technology, forces down profits and increases an investor's risk of market losses;
- many potential, new competitors – the prospect of additional technology providers, and hence the need for more competitive pricing, will increase the risk of market losses;
- many substitute technologies – existence of substitutes increases competitive rivalry; lowering the price of one substitute will typically lower the demand for the other; substitutes also increase the power of buyers to set prices; access to substitutes thus increases the risk of competitive losses;

- weak customer demand for a technology – this causes sellers to offer concessions, increasing the risk of market losses;
- market attractiveness – the more attractive a market will have a lower level of competitive rivalry within it, meaning profitability for firms will be higher and risks of market losses will be lower.

For the investor, risk management facilitates rational and economically sound decisions and actions designed to optimize the trade off between the overall risks and the financial return – higher perceived risk results in higher expected return. One consequence of an emphasis on risk, and the need to compensate for that risk through increased return, is the reluctance of private sector investors to finance longer term projects that have high levels of risk. Many investment projects involving ESTs are essentially of this nature, with high capital costs but lower operating expenditures. Currently, sustainability-related risks are not adequately addressed by the lending sector, as the direct risk assessment method generally used does not take into consideration such things as the environmental clean-up costs of contamination, or the issue of labour or human rights standards of suppliers (UNEP, 2002).

Only when risks have been identified appropriately can they then be transferred, accepted or mitigated using appropriate strategies. Investors have essentially four options when responding to adverse or favourable risks (Benaroch, 2001):

- defer investment – allowing additional time to assess the risk further;
- partial investment – staging investment in a sequential development effort that might include a pilot phase and prototypes in order to assess how competitors, customers, regulatory bodies and project partners react to the investment initiative; early implementation of the riskiest parts of the venture will also allow timely recognition as to whether the full investment project will be successful;
- full investment – with actions taken to reduce the financial consequences of potential hazards (e.g. leasing rather than purchasing outright), or reduce the likelihood of their occurrence (e.g. outsourcing some activities to more experienced operators); and
- dis-investment/re-investment – preparing contingency plans in case hazards associated with unmanageable risks do occur; thus there is the option to abandon the investment if competition, market and organizational hazards materialize, or to decrease the level of investment (dis-invest), or increase it (re-invest), in response to changes in market conditions.

Labelling

Certainty, especially for consumers, can be enhanced by the labelling of technologies. Users (such as retail consumers) are more comfortable purchasing products and services for which a given level of performance is assured, especially if this includes labelling that shows environmental burdens, ethical injustices and economic returns are within limits they judge to be acceptable.

Suppliers have, in turn, responded to this market opportunity by labelling and advertising particular products, packaging and services as having certain attributes, introducing new products, services and packaging and, in some cases, even redesigning existing products, packaging and services. Both governments and the private sector have acknowledged that this

trend offers an opportunity to not only decrease the social and environmental impacts of consumption patterns, but also to increase consumer education and sustain interest in addressing sustainable development issues.

In addition to self-declared product and service claims, an increasingly common approach is the use of third party assessment and certification programmes, whereby an independent group evaluates products and services according to their performance. Such programmes provide a market-based incentive for producers to develop new or modified products, processes and services that are more competitive regarding performance. In an increasingly global marketplace, manufacturers may also be expected to meet the criteria of internationally recognised certification programmes in order to compete effectively.

Three fundamental elements are common to all types of third party labelling programmes. First, the evaluations are conducted by groups independent from manufacturers and marketers, and are thus considered "third party". Second, labelling programmes can be positive, neutral or negative; that is, they can promote the positive attributes of products, they can require disclosure of information that is inherently neither good nor bad, or they can require negative warnings about the hazards of certain products. Third, participation in these programmes can be voluntary or mandatory.

Table 3 lists five types of environmental labelling programmes. Seal or stamp of approval programmes identify products or services as having improved performance relative to similar products or services with the same function. Single attribute certification programmes typically indicate that an independent third party has validated a particular claim made by the provider. Report cards offer consumers neutral information about a product, service and/or provider's performance in multiple impact categories (e.g. energy consumption, water pollution, product testing methods). In this way, consumers can assess for themselves what they think are the most important characteristics.

Table 3

Categories of Labelling Programmes

Programme	**Voluntary**	**Mandatory**
Seal of Approval	X	
Single Attribute Certification	X	
Report Card	X	
Information Disclosure		X
Hazard Warning		X

Examples of mandatory labelling programmes are information disclosure and hazard warning. Information disclosure specifications, like report cards, are usually neutral, disclosing facts about a product or service that would not otherwise be disclosed by the manufacturer. Unlike report cards, they are often required by law. Hazard/warning labels are negative warnings concerning

the adverse attributes of a product or service (e.g. health advisory labels found on cigarette packaging).

Establishing and Strengthening Information Systems, Partnerships and Networks

Certainty can also be increased by improving the flow of credible information between technology developers, providers and users (Figure 8). Successful technology transfer requires interaction among various stakeholders, many of whom will have different and sometimes conflicting intentions. Free and full flow of targeted and verified information is critical to resolving these differences and allowing greater harmonization of effort. Of all the factors involved in determining the success of technology transfer, the critical element is not public or private sector involvement but the forging of an effective linkage between the generator and the user. The public sector is effective in generating and applying technology when it is also the customer. But industry is more effective when the technology is intended for use in the wider socioeconomic system, including production, distribution, consumption and disposal.

Information to support technology transfer should be demand driven and results oriented, supporting key activities in the transfer process such as selecting a specific technology and making an investment decision.

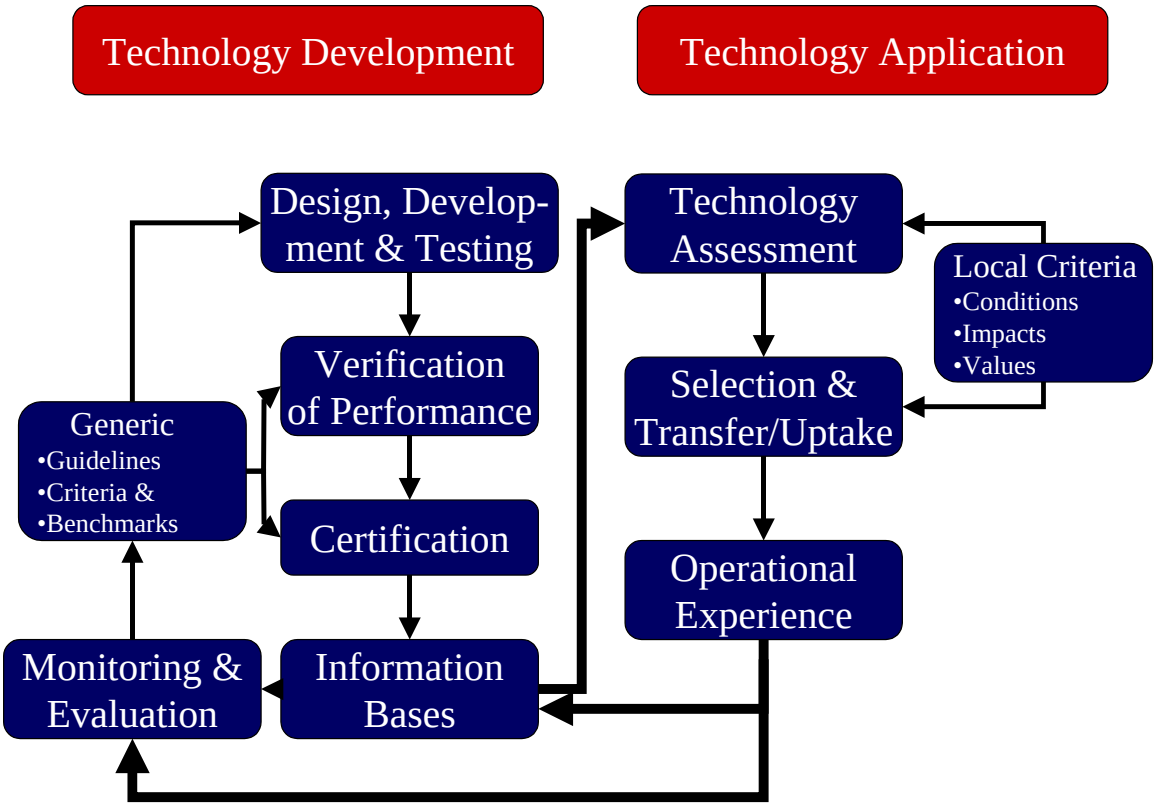


Figure 8. The technology development and application processes. Key information linkages are shown by the heavier black lines.

In previous sections it has been highlighted that limited generation of, and access to, verified performance data is currently a major barrier to the transfer and uptake of ESTs. To help address this vital need, UNEP's IETC has developed the EST Information System (ESTIS) (see Box 3). This is an example of the important role to be played by governmental organizations in technology transfer, since the comprehensive systems and infrastructure to verify and manage performance information are generally viewed as contributing to the public good. Their development and operation are also beyond the capacity of individual firms, which might prefer to reflect any direct economic benefits by making financial contributions on a user pays or some comparable basis.

Box 3

Environmentally Sound Technologies Information System (ESTIS)

ESTIS is a multi-language, Information System (IS) management tool to assist the transfer of Environmentally Sound Technologies (EST). ESTIS encompasses three integrated components (ESTISbuilder, ESTIScommunity, ESTISglobal), providing a decentralized IT network for improved access and local control in EST related information transfer. The ESTIS concept has been driven by an international group of people dedicated to EST transfer for sustainability.

ESTIS Builder allows users to construct their own customised Web site, in English and/or the national language, in order to manage and disseminate their EST information on the Internet.

ESTIS Community is populated by technology information from individual ESTIS sites. It allows users of ESTIS Builder to form an Internet community to share EST information automatically.

ESTIS Global is an Internet portal that provides users with a single mechanism to search for selected and approved EST information from ESTIS sites.

More information is available at: http://www.estis.net

As also indicated in Figure 8, monitoring plays an important role in providing information that can improve the success of technology transfer. Operational experience with technologies designated as environmentally sound provides bottom line verification of this description. Monitoring, and the effective movement of the resulting information from technology users to developers, assessors and suppliers, provides an important feedback loop that will be the main mechanism for continuing improvement all along the technology transfer chain.

Information flows can be enhanced through the establishment of partnerships involving key players who bring complementary capacities and who can share advantages and gain mutual benefits. One increasingly important example of such relationships is public-private partnerships. These are being seen increasingly as an effective means to leverage public funds,

thereby overcoming budget restrictions, while also harnessing the efficiency of the private sector and allowing it to operate more effectively through changes in public policy that create more business opportunities.

The partnerships can take on diverse forms and involve a range of players. Private sector participants can include technology developers, assessors, suppliers, users and investors, while those from the public sector might be central government departments, agencies, intergovernmental organizations and local government.

Networks can usefully bring together players who play similar roles in the technology transfer process, and wish to share experiences and information through the exchange of best practices, lessons learned and case studies as well as protocols, criteria, benchmarks and performance data on specific technologies. An example is the Asia-Pacific Regional Environmentally Sound Technology Network (APREN) (see Box 4).

Box 4

Asia-Pacific Regional Environmentally Sound Technology Network

In recent years, policy-makers have recognised the urgent need to improve the acquisition, formatting and dissemination of information on the development, promotion and transfer of ESTs, both within and among Asia-Pacific countries. In response to this need UNEPS's International Environmental Technology Centre (IETC) and Regional Office for Asia-Pacific (ROAP), and the Asian Institute of Technology (AIT), convened a regional workshop in Bangkok, Thailand, for local governments.

Consistent with discussions and recommendations made at the 1st and 2nd UNEP IETC - Global Environment Centre Foundation (GEC) International Seminars on ESTIS (see Box 3), held in Jakarta (1998) and Bangkok (2001), participants recommended the formation of the Asia-Pacific Regional Environmentally Sound Technology Information Systems Network (APREN).

The Bangkok workshop, held in March, also offered participants the opportunity to understand and comment on ESTIS. Ways to operationalise ESTIS at the country level were discussed, and participants were given a hands-on session on how to use ESTIS, with an introduction and discussion of the new system.

Other networks serve to link stakeholders from different parts of the technology transfer chain as well as those who service the technology transfer process, including advisory centres, specialist libraries, database managers, liaison services and technology intermediaries such as energy and waste service companies and national-level institutions engaged in research, development and assessment.

Ensuring Macroeconomic Policy Frameworks Minimize Uncertainties

Policy instruments can be used to enhance certainty, in two principal ways:

- through consistency in policy goals and measures over time, and with long lead periods for substantive changes in policy directions and the measures that implement them; and
- use of policy instruments to reduce regulatory, investment and other uncertainties in the market.

These considerations are part of providing an enabling environment and will be discussed further under *Capacity*.

Enforcing Regulations, Taxes, Codes, Standards and other Relevant Measures

Uncertainty, and the associated risks, can be reduced if there is effective and consistent enforcement of regulatory, economic and other measures which boost business confidence, favour the transfer and uptake of ESTs and discourage the use of technologies which are detrimental to the environment and society and which are not viable commercially.

Strengthening Legal Systems to Increase Security of Property Rights and Reduce Uncertainties in Enforcing Contracts

Two key factors contributing to uncertainties in markets for technologies are inadequate provisions for establishing, transferring and enforcing property rights and for enforcing contracts. Both serve to inhibit the replication of technologies and hence the ability of key players to obtain a reasonable return on their investment, be it intellectual, financial or practical.

National frameworks for intellectual property protection may need strengthening as well as harmonizing with international agreements, codes and standards. As part of such reforms, governments should enhance provisions for either the transfer or license of patents of publicly funded technologies to the private sector, including granting access to foreign investors. Governments are major funders of technology research and development, a role that is particularly important to the development and diffusion of ESTs given that they often lack short term commercial viability. Governments often underpin private sector investments in developing such technologies.

Special attention needs to be given to intellectual property protection in and by developing countries, including protecting the rights of indigenous companies and communities regarding traditional technologies.

In a similar manner, administrative processes, legal institutions and regimes and judicial procedures may need strengthening and made more transparent, with greater participation in regulatory policy-making and independent review procedures.

Simplifying and Enhancing Transparency of Public Procurement and Project Approval Procedures

Just as governments are key players in technology research and development, so too are they important users of technologies. Indeed, they have the opportunity to show leadership in the selection, use and demonstration of ESTs. Importantly, the private sector is a growing supplier of technologies to governments, with local government being an increasing source of demand.

Complex and closed public procurement procedures add to uncertainties, and hence to market risks, thereby discouraging investment in technology development and implementation. Simplifying and increasing the transparency and accountability of public procurement procedures will reduce uncertainties and risk, encouraging greater generation, flows and uptake of ESTs.

Similar arguments apply to project approval procedures. Project plans and documents normally define the opportunities for technological innovation and set the performance standards of the technologies to be used. If project plans are not open for external review and approved by competent and accountable parties, there is often less incentive and opportunity for innovation and adoption of best practices, including the use of better performing technologies.

Many of the topics that might be covered under communication have been addressed elsewhere as part of discussions related to information access and sharing – see especially *Challenges, Choice and Certainty*.

However, one important theme that has not been given the attention it merits is risk communication. Previous sections have highlighted the influential role of risk in determining the willingness of potential key players, such as investors, to commit resources to technology development, transfer and uptake. Risk is influential in two ways:

- there is often a major difference between the perceived and real risk; and
- perceived risk is typically a major factor in decision making.

To facilitate technology transfer there needs to be an improved alignment between perceived and real risk, with decision makers having access to credible and usable estimates of the risks to which might be exposed. This is very much the challenge for risk communication, which has been defined as "an interactive process of exchange of information and opinion among individuals and groups, and institutions. It involves multiple messages about the nature of risk and other messages (not strictly about risk) that express concerns, opinions, or reactions to risk messages or to legal and institutional arrangements for the management of risk".

Thus the three main elements of risk communication are:

- informing (changing knowledge), to make sure that all recipients of the information are able and capable of understanding its meaning and significance;
- persuading (changing attitude/behaviour), to persuade recipients of the information to, as needed and appropriate, change their attitudes or their behaviour with respect to a specific cause or class of risks; and
- consultation - to provide the conditions for a dialogue on risk issues so that all affected parties can engage in an effective, competent and democratic resolution of unacceptable risks.

Perception is an important consideration when communicating about risk. Attitudes towards risk are influenced by a number of biases that often result in personal risk perceptions being very different from those developed by experts. The conventional view of risk communication was that it need only educate other parties to endorse expert judgement concerning which risks are acceptable and which are not. The only challenge was to ensure that other parties were properly

informed of the experts' views. But this view has now been largely replaced by one which acknowledges that non experts are also in possession of relevant risk information, thus necessitating a two-way exchange of information between experts and the public. While experts and the public typically view risk in fundamentally different ways, each has something valuable to offer to the understanding and management of risk.

Typically risks are overestimated by the non-expert when one or more of the following applies (see Figure 9):

- risks are imposed rather than voluntary;
- industrial rather than natural;
- dreaded as opposed to being more benign;
- unknowable rather than knowable;
- controlled by others rather than controlled by those at risk;
- in the hands of trustworthy rather than untrustworthy parties; and
- managed in ways that are secretive and unresponsive rather than open and responsive.

At the personal level, people perceive risks in a business, social and relationship-oriented context. Such factors as difficulties in judging probabilities, sensational media coverage and personal experiences often lead to an underestimation or overestimation of risk. On the other hand, studies have shown that while experts usually focus on the probability of given situation failing, the layperson will moderate such considerations with qualitative characteristics of hazards, such as catastrophic potential, lack of control, delayed harm and other indirect consequences. The non-expert thus includes elements that play no part in a technical assessment of risk and would be considered completely unsuitable for such analysis. Yet from the non-expert's perspective, these elements are of crucial importance in perceiving, understanding and managing risks.

Overcoming these differences requires, first and foremost, a qualitative approach to risk communication, which not only takes into account a possible lack of trust between parties, but also attempts to establish appropriate mechanisms for two-way communication.

Six guidelines for effective risk communication are:

- don't withhold information;
- listen to people's concerns;
- share information and understanding;
- don't expect to be trusted without giving cause;
- acknowledge errors, uncertainties and gaps in information and understanding; and
- treat antagonists with respect.

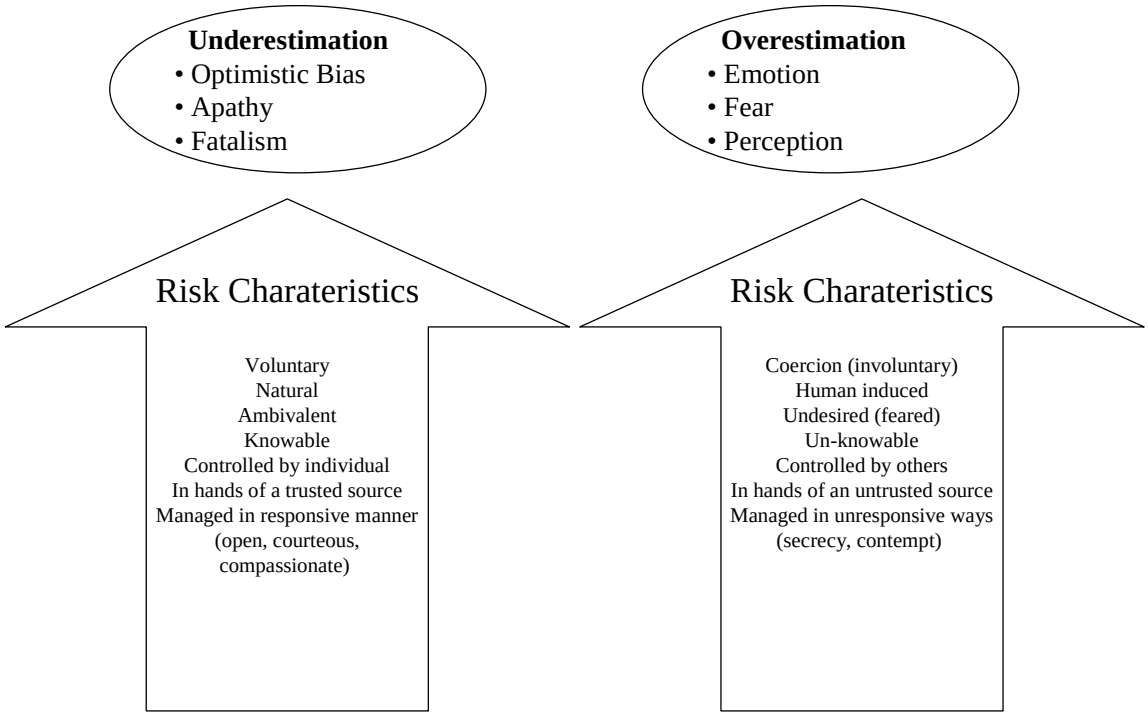


Figure 9. Factors associated with the over- and under-estimation of risk by the non-expert (after Sandman).

This section focuses on processes and measures that help ensure there is an enabling environment optimised for technology transfer. For technology transfer to be successful, adequate capacity must exist if all stages of the technology development and application process (Figures 2 and 8) are to operate to an acceptable standard.

Circumstances which are supportive of technology transfer include:

- open and competitive market;
- comprehensive and credible specifications on the technology performance;
- financiers who are at least technology neutral;
- the most cost competitive technology also has the most favourable environmental and social performance specifications; and
- policy risks are addressed.

To foster technology transfer, developing countries, and countries with economies in transition, should establish a clear development agenda based on a needs assessment, identify indigenous capacities, coordinate external resources, set up an effective consultation process and develop appropriate monitoring and evaluation systems. While developed countries tend to focus on the private sector and market forces, developing countries tend to stress the role of the public sector and intergovernmental agreements.

Collectively, governments have an important role to play in creating enabling environments for the transfer of ESTs. Policy actions can be taken at macro, meso and micro levels. Technology transfer should be integrated into overall national development frameworks as well as broader environmental, economic, social and health policies. Both national and international standards can enhance flows of technology, while risk communication and reduction are important in creating enabling environments (see *Certainty*).

Fostering Innovation, Applied Research and Development

The growing emphasis on sustainable production, consumption and development has generated demands for new technologies, as well as improvements in existing technologies. Considerable progress has been achieved through the introduction of cleaner production systems where there is a continuous application of strategies that reduce the environmental "footprint" of processes, products and services, in ways that increase overall efficiency and reduce risks to humans and to the environment. Cleaner production emphasises pollution prevention through reduced consumption of raw materials and energy, and no or reduced waste generation. This delivers co-benefits, including increased productivity and environmental, financial and other benefits to the

enterprise and the community. But we are now at the threshold to a new generation of technologies, where environmental performance considerations are fully integrated with economic, social and other operational issues and the system as a whole is sustainable (see *Context*).

Previous sections, including *Choice*, have also shown the importance of being able to select a technology that is consistent with the local circumstances within which it will operate, including selection of traditional technologies that have been better adapted to suit prevailing local conditions. Consideration should be given to not only matching the technology to the local circumstances, but to changing the latter through capacity building and other activities so that there will be an expansion in the number of suitable technology options.

Governments have an important role to play in fostering innovation, applied research and development activities that will bring new or modified technologies to the market. This is very much a consequence of the high up front costs of such activities, the need for supportive macroeconomic policies and the fact that much of the required infrastructure and institutional strengthening will bring little direct economic benefit to any one enterprise. Technology needs assessments and awareness raising programmes can also help create demand for appropriate technologies, thereby stimulating and focusing innovation, research and development in relevant areas where the private sector will be more keen to commercialise the outputs.

Developing and Enhancing Human Capabilities

The multidimensional nature of technology transfer creates a need for personnel with a diversity of knowledge, skills and practical experience. This in turn generates a need for educational and training institutions capable of producing such expertise on a sustained basis.

In addition to people with the requisite scientific and technical skills, there is a requirement for individuals who can contribute to the selection (e.g. capable of conducting technology needs assessments, technology assessments and using such tools as technology risk assessment and management, cost benefit analysis, environmental technology assessment and environmental impact assessment during the processes of procurement, management and financing of technologies.

There is also a need to identify the motivations that drive various stakeholders to engage in the technology transfer process and to replicate these motivations in other players, through education, training and other initiatives. Demands for improvements in technology performance will also be aided if members of the wider community are committed and able to develop and modernize in less wasteful ways than is the current development paradigm, and are willing to continuously adapt to new circumstances and challenges. This requires a long term approach to developing and delivering comprehensive and targeted awareness raising and educational programmes.

Ensuring Macroeconomic Policies are Supportive of Technology Transfer

Macroeconomic conditions that favour technology transfer include those which will deliver low inflation, stable and realistic exchange and interest rates, pricing that reflects the true (marginal and fully internalised) costs of material, energy, labour and other inputs, deregulation, free movement of capital, operation of competitive markets, open trade policies and transparent foreign investment policies. Fiscal policies should allow for the provision of direct financial support through appropriate loan arrangements, and economic incentives that facilitate the uptake and operation of ESTs at community to national level, and discourage the continued use of environmentally unsound technologies.

Enhancing Availability of, and Access to, Financing

At present banks and other lending institutions are somewhat reluctant to finance the transfer and uptake of ESTs. This issue can be addressed through the promotion of institutions, arrangements and mechanisms that can provide innovative financing, including micro-financing, green finance, secured loans, leasing arrangements and public-private partnerships (Labatt and White, 2002). Under such arrangements technology transfer can proliferate without government intervention.

Strengthened Legal Systems, Including Protection of Property Rights

As noted previously, the legal system should enhance the enabling environment through such measures as ensuring the protection of property rights and enforcing regulations and legal contracts. Investment is discouraged unless property rights are judged secure and there is certainty, speed and low cost in enforcement of disputed contracts. Transparent, participatory law making, and independent review are to be encouraged.

Accessible and Credible Demand-Driven Information

All technology stakeholders need ready access to targeted and credible information. Currently the absence of information on user needs, and of credible performance data, are major impediments to technology transfer. This can be addressed through establishment of institutions mandated to undertake performance assessments using internationally accepted protocols with appropriate standards, verification and certification. Guidelines and codes of practice can also ensure that the available information is used in ways that foster the diffusion of ESTs (see *Certainty*).

Information management systems and information networks and clearing houses (both electronic and print) will help ensure that the available information is accessed by relevant users.

Sustainable Markets for Environmentally Sound Technologies

A competitive and open market encourages ongoing, replicable technology transfers through the use of market-based incentives. Due to the essential role of the private sector in the long-term transfer of technology there is a need to foster engagement of the business and financial communities in technology transfer. The private sector requires dependable risk assessments, strong returns on investment, consistent and transparent rules from government, and a high potential for replication of the business opportunity.

Properly functioning markets for technologies generally require:

- access to reliable and relevant information;
- technology alternatives, all of which are consistent with documented needs and the operating environment;
- levels of risk commensurate with anticipated returns on investment;
- key players who are appropriately skilled;
- a system of property designation and protection;
- quality assurance systems;
- systems that minimize contractual and other legal risks;
- institutions that provide attractive financing arrangements and oversight of transactions;
- stable political, legal and fiscal regimes; and
- decision-making autonomy for buyers and sellers.

Access to Decision Support Tools and Related Methodologies

Informed choice, and decisions that deliver good economic, social and environmental outcomes, will help ensure the proliferation of ESTs. There is a growing number of such tools and methods (see *Choice*). Their increased use is to be encouraged through the preparation and dissemination of case studies and incorporation in codes of practice and guidelines.

Commitments that will lead to the increased and more effective use of ESTs should be based on cooperation to bring about changes, from the bottom up as well as from the top down. The former might lead to reforms implemented by communities, institutions, organizations, enterprises, and sectors in order to facilitate more extensive use of ESTs. Simultaneously, the international community can do more to support initiatives at the national and sub-national levels.

Policies and programmes that integrate the elements of capacity building, information and knowledge into comprehensive approaches for EST transfer and cooperation can achieve more than individual actions by themselves, and can contribute to the creation of an innovation culture. This should involve partnerships at all stages of the technology development and transfer process, and ensure the participation of private and public stakeholders, including business, legal, financial and other stakeholders within both developed and developing countries.

As an example of the bottom up approach, and perhaps as a first step at sub-national and national levels, undertaking technology needs assessments (Figure 4 and Box 1) will lead to identification of technology transfer projects that facilitate and accelerate the development, adoption and diffusion of sustainable technologies in particular sectors, enterprises, locations and communities and to recognition of capacity building activities that will enhance the enabling environment (see *Capacity*).

As noted earlier, a major impediment to the development, transfer and successful uptake of ESTs is the widespread lack of comprehensive and credible information on the performance of technologies. This shortcoming is, in part, a consequence of the absence of criteria, benchmarks and protocols that must be in place before a technology can be classed as "environmentally sound". Addressing this barrier provides a common ground for commitments from both governments and international organisations. At the national level, governments could follow the examples of the Philippine's Department of Science and Technology and Korea's Environmental Management Corporation, by establishing national or regional environmental technology verification programmes. At the international level, relevant organisations could do much to facilitate the preparation of the criteria, benchmarks and protocols which could subsequently be adapted for use in the national or regional programmes.

Another nexus is provided by the linkages between industry, commerce and trade organisations operating at international and national levels. These can promote leadership in the application of high standards for environmental performance and create awareness about products, processes and services that use ESTs through means such as eco-labelling, product standards, industry codes and developing environmental guidelines for export credit agencies to promote the transfer

of ESTs while ensuring that the transfer of obsolete technologies is discouraged. Governments should also encourage multilateral development banks to account for the environmental consequences of their lending

Initiatives that can be undertaken at national and sub-national levels, with support from regional and international bodies, include:

- intensive public education activities to ensure the wider community is committed and able to develop and modernize in less wasteful ways than is the current development paradigm, and are willing to continuously adapt to new circumstances and challenges;
- strengthening scientific and technical education institutions in order to help address technology needs;
- discouraging restrictive business practices and promoting open markets and fair competition in EST markets;
- increasing the certainty and responsiveness of legal systems and reduce regulatory risk by reforming administrative law and ensuring that public regulation is accessible to stakeholders and subject to independent review;
- protecting intellectual property rights and using licenses to foster innovation;
- encouraging capital flows that support direct investment, through the use of specialised credit instruments and capital pools as well as public/private partnerships;
- expanding research and development programmes aimed at improving access to ESTs that are appropriate in developing countries and adaptable to local conditions;
- simplifying and making transparent programme and project approval procedures and public procurement requirements;
- improving systems for the collection, assessment and sharing of specific technical, commercial, financial and legal information;

As part of its catalytic and facilitation role in creating and implementing strategies for environmentally sound transformation and change, UNEP and its partners are working together to develop and implement a strategic framework for promoting the adoption and use of ESTs. This involves harmonising approaches which move beyond local to global sustainability. The framework supports a process for assessing the environmental characteristics, benefits and risks associated with technologies and infrastructure.

UNEP is well-positioned to provide an effective platform for meaningful interaction and dialogue in support of the harmonisation of assessment approaches and methodologies related to ESTs. To demonstrate the benefits of ESTs, UNEP has established an EST Initiative with a number of partner organisations. A key objective is the transparent and credible acquisition and reporting of environmental performance information related to technologies. This involves differentiating between the supply side and the demand side of the technology equation (Figure 10), to determine specific needs and the requirements for appropriate decision support tools. This is important in ensuring that the users of EST are well-informed and given the necessary tools and information to make sound decisions. To enhance the uptake of technologies in developing countries, the users of EST information should be directly involved in the design of the information systems and decision support tools which support the application of ESTs.

Addressing the inadequacy of information and decision support tools used to quantify and qualify the merits of ESTs represents a significant challenge. The effectiveness of ESTs depends

on having both broad-based and expert input into their development, adoption and ongoing monitoring. Leverage and synergy through cooperation amongst governments, industry associations, corporations and the financial community is needed for investments in ESTs to occur. At the same time, systems for collecting, synthesising and feeding back information and knowledge on ESTs must be strengthened, deployed widely and maintained. Third party performance assessment mechanisms such as verification and certification can assist in meeting this need for transparent, credible information on which decisions can be based. Continuous review and improvement will be essential to ensure the establishment of an effective system that is responsive to changing social, economic and political realities.

To support this, the following next steps have been proposed as the basis for UNEP and its partner organisations in moving the EST Initiative forward:

1. Establishment of a mechanism and approach amongst participating organisations on how to assess technologies in a transparent manner.
2. Cooperation amongst participating organisations to define a meaningful set of environmental indicators and performance criteria relevant to the adoption and use of ESTs.
3. Augmentation of mechanisms and approaches for the provision, acquisition and dissemination of information on ESTs.
4. Documentation of technology performance assessment procedures and making this information available.
5. Identification and compilation of case studies to more clearly communicate the importance of ESTs.
6. Development of a communications plan for the EST Initiative, taking into account opportunities to promote the Initiative in a strategic manner by linking to key events.
7. Preparation of various “co-branded” products and fact sheets on selected topics, targeting decision-makers within local authorities, as well as banks, insurers and other financial institutions.
8. Further elaboration of the action plan and a process for harmonising performance assessment criteria, benchmarks and guidelines. This could lead to the establishment of a standard for assessing ESTs and could involve positioning the EST Initiative to eventually go forward as an ISO standard.
9. Establishment of an appropriate mechanism for monitoring and evaluating progress, and measuring success.

Conclusions

The foregoing discussion has highlighted the slow uptake of ESTs, provided an analysis of the reasons for this situation and suggested ways in which the situation might be remedied. Key actions that will foster technology transfer include:

- needs assessments, including identification of shortcomings in the enabling environment, with relevant organizations and agencies helping to address these;
- evaluation and strengthening of policies that influence the enabling environment;
- greater communication and interaction between key parts of government
- intra- and inter-governmental coordination, cooperation and assistance;
- protection of intellectual property rights and legal contracts;
- political support for programmes and institutions that foster technology transfer;
- seed investment programmes to stimulate private sector investment;
- capacity enhancement for major stakeholders;
- delineation of the roles of the private and public sectors in both developed and developing countries;
- economic incentives targeting industries that have the potential to make critical and major contributions to technology transfer; and
- ensuring that technology transfer initiatives are compatible with national sustainable development agendas;
- increase communication among technology transfer bodies across various MEAs with a view to leveraging limited financial and human resources on issues of common interest, integrating and strengthening regional and country level activities through information sharing and joint activities and providing a platform for multilateral approaches and consistency in technology transfer.

Activities that will lead to the increased and more effective use of ESTs should be based on cooperation to bring about changes, from the bottom up as well as from the top down. This calls for partnerships at all stages of the technology development and transfer process, ensuring active and equitable participation of private and public stakeholders, including business, legal, financial, and other stakeholders within both developed and developing countries.

UNEP has established an EST Initiative, including contributions from a number of partner organisations. The Initiative will address, amongst other things, the current widespread lack of comprehensive and credible information on the performance of technologies. This is seen as a major barrier to the increased uptake of ESTs, and one that requires interventions at both international and national levels if it is to be addressed successfully. The shortcoming is, in part, a consequence of the absence of criteria, benchmarks and protocols that must be in place before a

technology can be classed as “environmentally sound”. In a transparent, open and consultative approach UNEP is facilitating the preparation of criteria, benchmarks and protocols, with these being made available to governments, to support national and regional programmes that assess and verify the performance of technologies.

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List of Abbreviations

AIT	Asian Institute of Technology
APREN	Asia Pacific Environmentally Sound Technology Network
CBA	Cost Benefit Analysis
DICE	Describe, Identify, Characterise, Evaluate
EIA	Environmental Impact Assessment
EMS	Environmental Management system
EnRA	Environmental Risk Assessment
EnTA	Environmental Technology Assessment
EST	Environmentally Sound Technology
ESTIS	Environmentally Sound Technology Information System
EST-PA	Environmentally Sound Technology Performance Assessment
ETV	Environmental Technology Verification
EVT	Environmental Verification of Technology
GEC	Global Environmental Centre Foundation
ICT	Information and Communication Technology
IETC	International Environmental Technology Centre
IS	Information System
ISO	International Standards Organisation
LCA	Life Cycle Analysis
MEA	Multilateral Environmental Agreement
PM	Performance Measurement
ROAP	Regional Office for Asia and the Pacific
SEA	Strategic Environmental Assessment

SIA Social Impact Assessment

UN United Nations

UNCED United Nations Conference on Environment and Development

UNEP United Nations Environment Programme

WSSD World Summit of Sustainable Development

Glossary of Key Terms

Barrier – a challenge or impediment to success.

Economically Viable – life cycle costs are consistent with the life cycle benefits.

Enabling Environment – the systems and capabilities that foster the technology transfer process, including innovation, application of human knowledge and skills, policies, financing, legislation and regulations, information, markets and decision support tools

Environmentally Sound Technology – a technology that has the potential for significantly improved environmental performance, relative to other technologies.

Hard Technology – material products or services

Socially Acceptable – consistent with the values, priorities and aspirations of stakeholders.

Soft Technology – human capacities and skills, organizational and management procedures and information networks

Stakeholder – individual, organisation or institution with an interest in the outcome of an activity, or intended activity.

Sustainable Development – activities that improve the quality of life for human beings and their surroundings, and allowing them to prosper without destroying the resources and life-supporting systems on which humans, including future generations, depend.

Sustainable Technology – a technology that has the potential to be environmentally sound, economical viable and socially acceptable.

Technology – equipment, machines, accessories and infrastructure, as well as know-how, goods and services, and organizational and managerial procedures.

Technology Transfer – the suite of processes encompassing all dimensions of the origins, flows and uptake of know-how, experience and equipment amongst, across and within countries, stakeholder organizations and institutions.