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Guiding the Process of:

Overcoming Barriers to the Transfer and Diffusion of Climate Technologies

Version 01.1

Jørgen Boldt, Ivan Nygaard, Ulrich Elmer Hansen, Sara Lærke Meltofte Trærup

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Contents

Abbreviations

CEIT	Country with Economy in Transition
CHP	Combined Heat and Power production plant
CTI	Climate Technology Initiative
DCED	Donor Committee for Enterprise Development
EGTT	Expert Group on Technology Transfer
EIT	Economies In Transition
FDI	Foreign Direct Investment
GHG	Greenhouse gas
IEA	International Energy Agency
IPCC	Intergovernmental Panel of Climate Change
IPP	Independent Power Producer
IPR	Intellectual Property Rights
LDC	Least Developed Country
MDG	Millenium Development Goals
NAMA	Nationally Appropriate Mitigation Actions
NAPA	National Adaptation Programme of Action
NC	National Communication
O&M	Operation and Maintenance
PMCA	Participatory Market Chain Approach
PPA	Power Purchase Agreement
PV	Solar photovoltaic system (generating electricity)
RE	Renewable Energy
R-PP	Readiness Preparation Proposal
SBSTA	Subsidiary Body for Scientific and Technological Advice
SME	Small and Medium-sized Enterprises
TAP	Technology Action Plans
TNA	Technology Needs Assessment
TTD	Technology Transfer and Diffusion
TT:CLEAR	UNFCCC technology information clearing house

Essential concepts

Adaptation. Adjustment in natural or human systems in response to actual or expected climatic stimuli or their effects, which moderate harm or exploit beneficial opportunities. Adaptation is a process, not an outcome.

Adoption. The process by which a technology is selected for use by an individual, an organization or a society.

Barrier. A reason why a target is adversely affected, including any failed or missing countermeasures that could or should have prevented the undesired effect(s).

Capital goods. Machinery and equipment used in the production of other goods, e.g. consumer goods or electricity.

Consumer goods. Small-scale goods specifically intended for the mass market.

Diffusion. The process by which a new technology is communicated through certain channels over time among the members of a society, where the technology is gradually adopted by more and more members until a saturation point is reached within the society.

Enabling business environment. The critical factors that shape the market-chain environment and operating conditions and which are generated by structures and institutions that are beyond the immediate control of economic actors in the market chain.

Enabling environment. The set of resources and conditions within which the technology and the target beneficiaries operate. The resources and conditions should support and improve the quality and efficacy of the transfer and diffusion of technologies.

Hardware. The tangible aspects of technology, such as equipment and products.

Incentive. An instrument that is used to make a measure happen, e.g. a subsidy.

Innovation. The development of a technological system. The innovation chain involves both the processes of research and development and the commercialisation of the technology, including its social acceptance and adoption. However, this guidebook focuses on the later phases of innovation, not technical innovation in the sense of research and development.

Market chain. The economic actors who actually own and transact a particular product as it moves from primary producer to final consumer.

Measure. An actual change in the real world to achieve a goal, e.g. the erection of wind turbines to achieve reduced emissions of greenhouse gasses.

Mitigation. An action to decrease the concentration of greenhouse gasses, either by reducing their sources or by increasing their sinks.

Non-market technologies. Technologies which are not traded in a market.

Orgware. The institutional framework, or organisation, involved in the adoption process of a new technology.

Pathway. A channel or mechanism for the international transfer of technology.

P**ublic good.** A non-rivalrous and non-excludable good. Non-rivalry: consumption of the good by one individual does not reduce availability of the good for consumption by others. Non-excludability: no one can be effectively excluded from using the good.

Software. The processes associated with the production and use of the hardware, i.e. know-how (e.g. manuals and skills), experiences and practices (e.g. agricultural, management, cooking and behavioural practices).

Technology. Hardware, software and/or orgware.

Technological system. Network(s) of agents interacting in a specific technology area under a particular institutional infrastructure to generate, diffuse, and utilize technology.

Technology transfer. The broad set of processes covering the flows of know-how, experience and equipment that result from many day-to-day decisions on the part of the different stakeholders involved.

Vulnerability. The stress to which a system is exposed, its sensitivity and its adaptive capacity. The vulnerability of a society is influenced by its development path, physical exposures, distribution of resources and institutional setting. It is generally acknowledged that poor populations are more vulnerable and have less adaptive capacity to confront climate change.

1. Introduction

1.1. Background

Objectives and commitments regarding the transfer of technology exist under the United Nations Framework Convention on Climate Change (UNFCCC) and the Kyoto Protocol. The current Global Technology Needs Assessment (TNA) project (http://tech-action.org/) is designed to support 35 to 45 countries to carry out improved Technology Needs Assessments within the framework of the UNFCCC. The project is being implemented in two rounds, with 15 countries engaged in the first round and the remaining 20 to 30 countries to be included in the second round. In-country activities started in February 2010.

The purpose of the TNA project is to assist participant developing country Parties to identify and analyse priority technology needs, which can form the basis for a portfolio of climate technology projects and programmes to facilitate the transfer of, and access to, climate technologies and know-how through implementation of Article 4.5 of the UNFCCC Convention. Hence TNAs are central to the work of the Parties to the Convention on Technology Transfer and present an opportunity to track an evolving need for new equipment, techniques, practical knowledge and skills, which are necessary to mitigate GHG emissions and/or reduce the vulnerability of sectors and livelihoods to the adverse impacts of climate change. The main components of the project are:

1. Through country-driven participatory processes, to identify and prioritize technologies that can contribute to the mitigation and adaptation goals of the participant countries, while meeting their national sustainable development goals and priorities.
2. To identify barriers hindering the acquisition, deployment and diffusion of prioritized technologies and to develop enabling frameworks to overcome the barriers and facilitate the transfer, adoption and diffusion of selected technologies in the participant countries.
3. To develop Technology Action Plans (TAP) specifying a road map of activities (based on the enabling frameworks) at the sectoral and cross-cutting levels to facilitate the transfer, adoption and diffusion of selected technologies in the participant countries.

1.2. Scope

The present guidebook relates to the second component in the TNA project referred to above. The ambition has been to produce practical and operational guidance on how to assess the barriers to identified technologies in the countries concerned, and on how to address and overcome these barriers.

The targeted audience is the TNA National Teams and their consultants. The guidebook addresses the challenges after a TNA Team has identified, assessed and prioritized technologies for climate change, i.e. the process of overcoming barriers for the transfer and diffusion of technologies. It is important to stress that the guidebook is intended and applicable for concrete technologies, not for a whole sector (e.g. transport) or technology group (e.g. renewable energy).

As there is no pre-set answer to enhancing technology transfer, policy actions need be tailored to the specific context and interests. Therefore, the guidebook presents a flexible approach, identifying various options for analysts and decision-makers.

Technology transfer is defined (IPCC, 2000) as the broad set of processes covering flows of know-how, experience and equipment, and is the result of many day-to-day decisions on the part of the different stakeholders involved. The concept comprises the process of learning how to understand, utilize and replicate the technology, including the capacity to choose it and adapt it to local conditions and integrate it with indigenous technologies. Thus, a number of social, economic, political, legal and technical factors influence the flow and quality of technology transfer.

This guidebook deals with the transfer of proven technologies both between countries and within them. The transfer of technologies that are still being developed is not covered. Defining the diffusion of technologies takes no account of the origin of the technology concerned.

Most technology transfer happens without government intervention. This guidebook is about transfer and diffusion where facilitation by a government is needed. A sound road to a successful **government-facilitated technology transfer** can be described as a combination of processes, not necessarily appearing in a strictly consecutive order:

1. Identify, assess and prioritize technologies
2. Understand the economic and institutional framework
   - 2.1. Identify and analyse stakeholders
   - 2.2. Identify the enabling environment
   - 2.3. Identify service providers
3. Identify and analyse barriers
4. Elaborate measures to overcome barriers
5. Prepare technology transfer
   - 5.1. Select pathway to technology transfer
   - 5.2. Modify the technology
   - 5.3. Diffuse the technology
6. Evaluate the impact continuously

The above list is to some extent a timeline, but it should not be interpreted as such too rigidly. Some processes may be conducted in parallel, and the sequence may be altered. Also, the overall process never stops, but needs be repeated at regular intervals.

There is no pre-set answer to enhancing technology transfer. Interactions and barriers vary according to sector and type of technology, and countries have different priorities and framework conditions. Therefore, a flexible approach is required, and policy actions need to be tailored to the specific context and interests of each country.

In spite of the programmes for technology transfer that governments and development organisations have drawn up during the last three decades, and in spite of the huge amounts of research on processes leading to transfer of technology, there are still essential deficiencies in the understanding of processes leading to successful technology transfer.

It is even more difficult to develop guiding principles for adaptation than for mitigation, as the learning process of adaptation is in a much earlier stage, and also because adaptation generally requires less hardware, but more behavioural and institutional change, together with revaluing former practices.

Against this background, it has not been possible to fulfil all aspects of the aim. A challenging and uncertain process still lies ahead. So, even though the authors have attempted to synthesize pertinent information and present good learning cases, the guidebook should be considered a living document, which will be amended when justified by new insights. Learning from experience remains limited, and it is therefore of the utmost importance for the future development of the TNA Programme that users of this guidebook provide feedback to the authors, so that enhanced learning can be shared among the parties involved.

The TNA Guidebook Series
For more information on sector-specific issues, you may download other guidebooks from http://tech-action.org/
Of particular relevance are:

1. ''Technologies for Climate Change Adaptation: Coastal Erosion and Flooding'', November 2010.
2. The Transport Guidebook, to published in 2011

1.3. Guidebook overview

This guidebook adds to the information provided by UNDP and UNFCCC in 'Technology Needs Assessment for Climate Change' (November 2010) by focussing primarily on identifying barriers hindering the transfer and diffusion of prioritized technologies and on developing measures to overcome these barriers.

The guidebook is structured as follows:

Chapter 2 introduces the concept of technology used by this guidebook. The definition is quite wide, presumably wider than mainstream thinking.

The guidebook categorizes technologies according to how their transfer and diffusion may be hindered. Since barriers to a given technology are determined more by the surrounding framework than by specific features of the technology itself, the categorization is based on differences in framework conditions:

- consumer goods
- capital goods
- public goods
- non-market technologies

As an example, a consumer good (e.g. an efficient light bulb) traded in a market meets different barriers than a technology used in a large-scale public investment project (e.g. a bridge). The categorization may be useful when sharing experiences of technologies within a category.

Chapter 2 is completed by a description of the common processes characterising the diffusion of a new technology in a society, highlighting the most critical initial phase, where government facilitation is mostly needed.

Chapter 3 provides guiding principles on how barriers to the transfer and diffusion of climate technologies are identified and analysed. After a presentation of how the barrier analysis fits into the overall TNA process, the reader is taken through a stepwise process:

- identify all possible barriers
- screen the gross list of barriers to deselect the less important ones
- classify the remaining key barriers into a hierarchy of categories
- analyse the causal relations between barriers

Chapter 4 takes over from the end of Chapter 3 by translating the barriers into the measures to overcome the barriers. This is based on the concept that an exact understanding of the logic of the barriers and their interrelations makes it more-or-less straightforward to establish which measures are required.

A distinction is made between *measures*, which are actual changes in the real world to achieve a goal (e.g. the erection of wind turbines to achieve reduced emissions of greenhouse gasses), and *incentives*, which are policy instruments that are used to make the measure happen (e.g. duty exemptions on wind turbine equipment).

In preparation for policy decisions, the benefits, costs and other impacts of the measures and incentives should be assessed, since a measure or incentive which appears optimal analytically may not be feasible politically.

This part is completed by determining who should take action and who should pay. For a particular measure-incentive couple, the implementer and the payer may not be the same entity. For example, it may be the Ministry of Energy who is in charge of implementing a wind turbine programme, but it will be the Ministry of Finance who is in charge of developing the appropriate subsidy, possibly financed externally.

Chapter 5 deals with technologies traded in a market place, essentially the technology types 'consumer goods' and 'capital goods', in order to understand properly the particular framework conditions of such technologies. This analysis may be conducted prior or parallel to the barrier analysis described in Chapters 3 and 4, both to support that analysis and to prepare the subsequent steps, described in Chapter 7.

It is recommended to use the Market Mapping approach, in either a brief version or a lengthier version involving the key stakeholders.

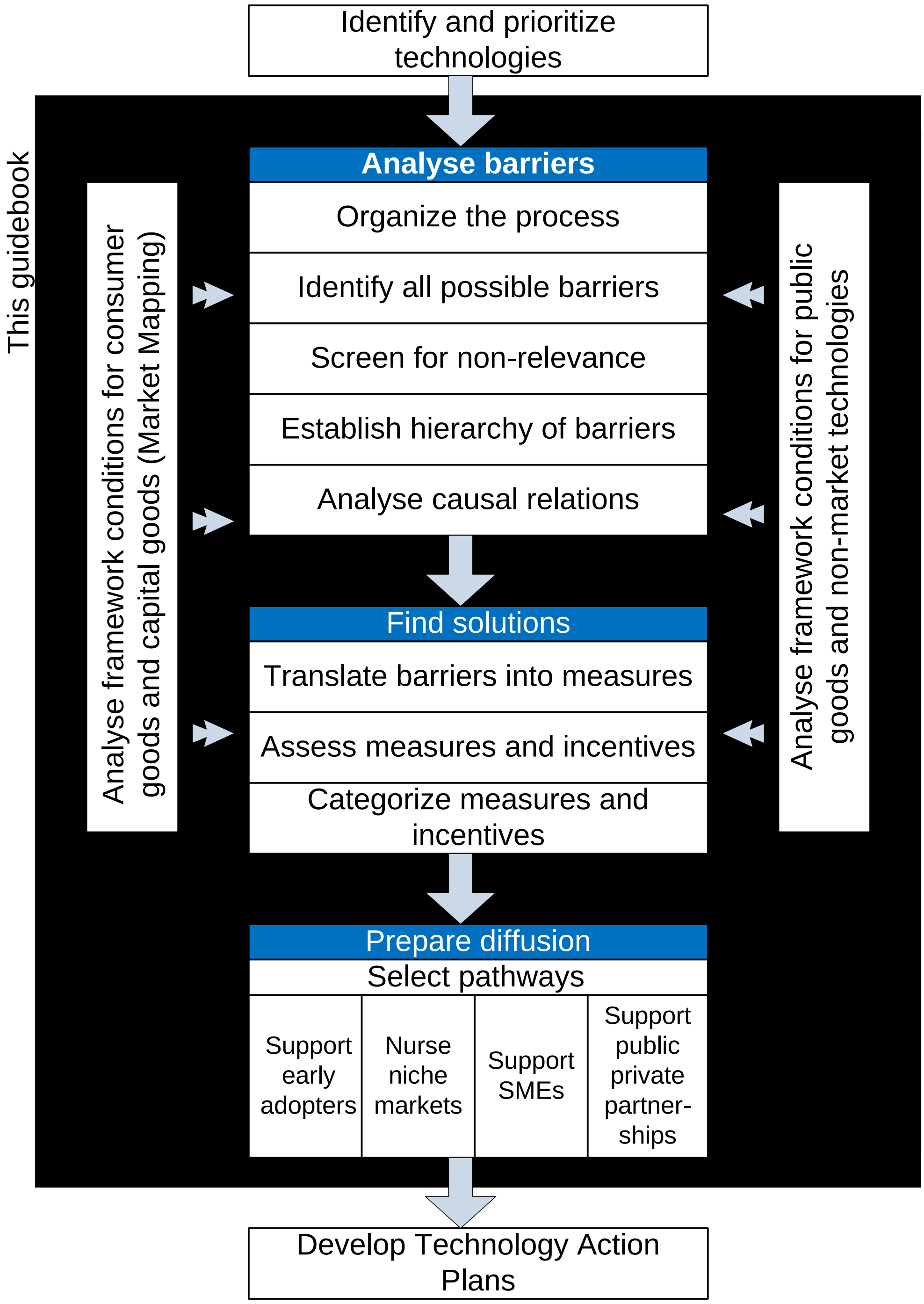
Chapter 6 is similar to Chapter 5, but addresses the technology types 'public goods' and 'non-market technologies'.

Chapter 7 contains a number of recommendations for governments to facilitate the actual diffusion of new technologies, in particular during the early and most difficult phases of diffusion.

It is recommended to focus on early adopters and possible niche markets as a means to kick-start the diffusion. It is also recommended that governments pay particular attention to the roles that small and medium-sized enterprises play in technology innovation, and to how government can facilitate technology diffusion by improving the framework for intellectual property rights and supporting the development of public-private partnerships.

Finally, **Chapter 8** summarizes the general recommendations for the government-facilitated transfer and diffusion of climate technologies.

The figure below illustrates the flow of the guidebook and the relations between the key topics:



2. Understanding technology

2.1. The technology concept

This guidebook makes use of the following definitions:

Climate technologies = technologies contributing to **mitigation and adaptation** goals

Technology = hardware + software + orgware

where

Hardware =	the tangible aspects, such as equipment and products.
Software =	the processes associated with the production and use of the hardware, i.e. know-how (e.g. manuals and skills), experiences and practices (e.g. agricultural, management, cooking and behavioural practices).
Orgware =	the institutional framework, or organisation, involved in the adoption and diffusion process of a new technology.

2.2. Technology types and economic frameworks

Technologies are transferred and used under different types of economic framework. Technologies may thus be categorized according to these types of framework, often with essential grey zones between categories. For the purposes of this guidebook, four generic types will be used:

- consumer goods
- capital goods
- public goods
- non-market technologies

In this way, technologies are not categorized according to their technical properties, but to the frameworks in which they are transferred and used. Thus defined, technology types are inseparable from their economic frameworks.

It is believed that within each type there are common features as to which barriers predominate and how these particular barriers need to be addressed, and therefore that it may be instrumental to distinguish between the technology types in the process of learning and when experiences from one technology are used for the purpose of another technology.

All technologies include elements of know-how, experience and equipment. This also goes for the technologies of the four types of economic framework, but one element may be predominant when a technology is transferred. For example, a consumer commodity is often conceived as a product or equipment, even though much knowledge is inherent in the product, whereas software is conceived primarily as knowledge, even though it may be an intrinsic part of some hardware. The technologies of the first three types of framework are primarily transferred as products or equipment, whereas technologies in the fourth market type are knowledge-dominated.

The four types of technology and their associated economic frameworks are:

Consumer goods
Small-scale goods specifically intended for the mass market.
Examples: solar home systems, energy-efficient air conditioners, drip irrigation tubes, seeds for drought-resistant crops.
Characteristics:
- high number of potential consumers
- interaction with existing embedded markets and requiring distribution, maintenance and installer networks in the supply chain
- large and complicated market chains with many actors, including import, assembly/production, wholesale, retailers
- distribution of barriers in all areas.

Capital goods
Machinery and equipment used in the production of other goods, e.g. consumer goods or electricity.
Examples: utility technologies, such as small-scale hydropower and increased water-reservoir technology, and technologies used in industrial processes, such as energy savings in agro-food industry.
Characteristics:
- limited number of potential sites/consumers
- relative large investment
- simpler market chain, i.e. few or no existing technology providers

Public goods
Examples: large-scale hydropower, sea dikes, infrastructure (roads and bridges, sewage systems), mass transport systems (metros).
Characteristics:
- very few sites
- large investment, government/donor funding
- public ownership or ownership by large international companies
- simple market chain; technology procured through national or international tenders.
- investments in large-scale technologies tend to be decided at the government level and depend heavily on existing infrastructure and policies.

Non-market technologies
Examples: consumer behaviour (energy savings, hygiene, transport), institutional change, manure management, genetic screening of water-borne pathogens.
Characteristics:
- technologies are not transferred as part of a market but within a public non-commercial domain.
- serves overall political objectives, such as energy saving and poverty alleviation
- donor or government funding
- information, capacity-building

In order to have brief names for the technology types, the term ‘goods’ embraces what is usually referred to as goods and services.

The typology with four technology types is a further development of the categories suggested in the TNA Handbook and the ENTTRANS study.[1]

The TNA Handbook (UNDP, 2010) distinguishes between small-scale technologies (household and/or community level) and large-scale technologies (larger than household or community level), and again between short-term (proven to be a reliable, commercial technology in a similar market environment), medium-term (pre-commercial in that given market context; five years to full market availability) and long-term technologies (still in an R&D phase or a prototype).

For the developing countries studied by ENTTRANS (2007) there are two economic frameworks (called market forms), one concerned with large-scale technologies which tend to be at the national level and depend heavily on existing infrastructure and policies, and the other at the small-scale technology scale interacting with existing embedded markets and requiring distribution, maintenance and installer networks in the supply chain.

The cases studied were:

- small-scale: biomass gasification cooking stoves, CFLs, and solar thermal heating.
- large-scale: concentrated solar power for grid or mini-grid electricity, wind turbines, energy efficiency in cement and steel industries, large biomass- or biogas-based generation.

The small-scale category is similar to the 'consumer goods' technology type, whereas the large-scale category is similar to 'capital goods' and 'public goods'.

Thus, in the context of the current guidebook, focusing on proven technologies, the ENTTRANS and the TNA Handbook definitions are quite similar.[2]

Chapters 5 and 6 discuss specific techniques and methods for barrier analysis related to the four technology types, albeit in two groups, Chapter 5 on commercial technologies (= consumer goods and capital goods) and Chapter 6 on public goods and non-market technologies.

2.3. Technology diffusion

Diffusion is the process by which a new technology is communicated through certain channels over time among the members of a society, where the technology is gradually adopted by more and more members until a saturation point is reached within that society.

Often, the diffusion concept is primarily applied to technology 'hardware', but it may as well be applied to technology 'software', i.e. know-how, experience and practices, and 'orgware'. In this guidebook, the word 'diffusion' comprises hardware, software and orgware.

Concepts equivalent to diffusion are deployment (typically used for hardware), dissemination (often used for information), replication and market penetration. In technology life-cycle literature,

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[1] ENTTRANS: 'Promoting Sustainable Energy Technology TRANSfers through the CDM: Converting from a Theoretical Concept to Practical Action', 2007. This is one of the very few extensive studies using the Market Mapping approach (as described in Chapter 5 of this guidebook) on climate technologies. The project was implemented (2006-2007) by a large consortium of institutions from the EU and developing countries.

[2] China (like a few other countries) is different from many countries in that the main companies who would buy large-scale technologies are government-owned, and therefore the main market actors are governed by government policy and regulations rather than by market pressures.

deployment is often understood as a set of initiatives that seek to accelerate investment in and use of near-commercial technologies, resulting in cost reductions and improvements in technology maturity and market acceptance. However, a technology that is commercially mature in one country (e.g. an industrialized country) may not yet be commercial in another country (e.g. a developing country).

For the purpose of this guidebook, the concept of 'diffusion' comprises the entire process from initial introduction until saturation, whether to begin with the technology is near-commercial or commercial in another country.

Diffusion processes generally follow an S-shaped curve, cf. Figure 2.1. Diffusion is also seen as a five-stage process: awareness, interest, evaluation, trial and adoption. These stages correspond to different stages of consumers' adoption classified as innovators (first to adopt), early adopters, early majority, late majority and laggards (last to adopt) according to the time of adoption since the technology is first introduced.[3]

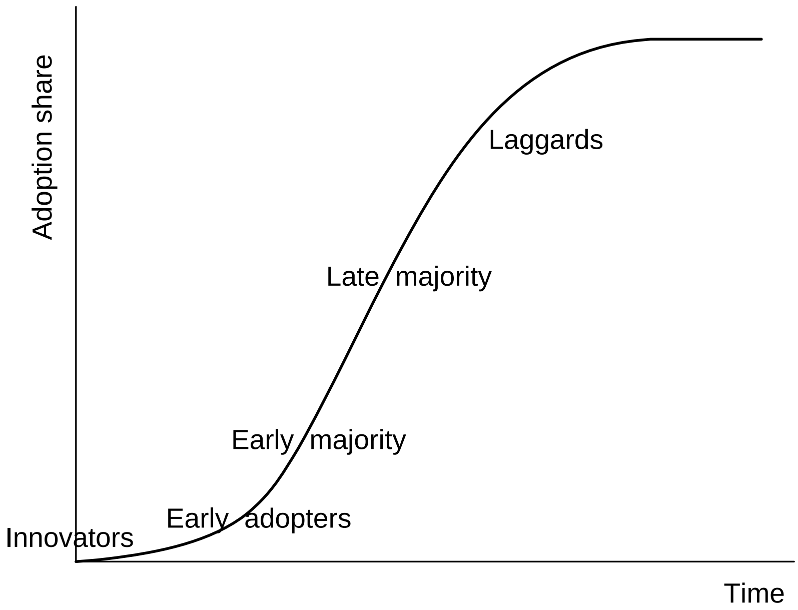

Figure 2.1. The S curve of technology diffusion

For government-facilitated diffusion, there may be a political desire to obtain diffusion within the shortest possible time, e.g. 60% adoption in 5 years. Generally, the faster the diffusion the more costly the incentives required, so rapid diffusion may not be the most feasible from an economic point of view. If the aim is to replace existing long-life goods (e.g. refrigerators or power plants), it may involve extra costs to install a new technology before the old ones have become worn out.

It is during the initial phase of diffusion, sometimes referred to as 'take-off' (innovators and early adopters), that the reliability, practicality and financial feasibility of the technology is demonstrated.

[3] A distinction is sometimes made between adoption and absorption, where adoption involves the mere usage of the technology, while absorption reflects the sustainability and efficacy of usage. In this guidebook the term 'adoption' covers both meanings.

This is a very difficult and critical phase to overcome. Despite being demonstrated and used abroad, local customers may not trust the solution as it has not been demonstrated locally, under the specific local conditions. Starting diffusion therefore needs special attention.

Another approach to understanding the process by which a new technology emerges, is improved and diffused in society is to study the **innovation** literature. It is worth noting that the innovation process is both an individual and a collective act. Viewed from the perspective of the individual firm, the entrepreneurial act is the central feature of innovation, but the determinants of technology choice are not only to be found within individual firms, but also reside in an ‘innovation system’, which both aids and constrains the individual actors. Such an ‘innovation system’ is the focus of this discussion.

The transfer of a new technology involves a process of innovation into an existing system. The innovation chain involves both the processes of research and development and the commercialisation of the technology, including its social acceptance and adoption. This guidebook focuses on the later phases of innovation, not the technical innovation, that is, the initial research and development. With this understanding, innovation may be thus likened to the initial phases of diffusion: cf. the S curve in Figure 2.1, where first a few individuals and then more and more of the social system adopts the technology.

Presentations of the key issues of innovation are given by Jacobsson (2000) and ENTTRANS (2007). Both documents have numerous references to primary sources. Below follows a brief extract.

In many studies, innovation has been studied from the point of view of an industrialised developed country with the innovation taking place within its existing systems. Technology transfer, on the other hand, involves innovation from one country to another, which may be either more developed or less developed.

Success in innovation relates to long-term and close interaction with external agents. It has also been realised that trust, loyalty and power relationships between the key players are important. This has led to the focus on ‘interactive learning’, which is the basis for the current focus on networks and mechanisms for innovation.

Studies have exposed different types of perceptions, which affect the decision to adopt the innovation and thus affect the overall rate of adoption:

- relative advantage: the perception of how much better the innovation is, relative to the status quo (the feasibility)
- compatibility: the perception of how well the innovation fulfils the person’s needs, values and past experience
- complexity: how easy it is to understand, use and maintain
- trialability: the ability to try out the innovation on a limited basis before adoption (e.g. through demonstration projects); and
- observability: how clearly can the results of the innovation be seen?

Government may influence such perceptions by providing information and raising awareness. Studies have also suggested the main government interventions to improve innovation within a country:

- formal rules in market regulations and planning
- informal norms rules and values that shape collaboration and competition
- strong and diversified systems
- well-developed structural and institutional support, e.g. legal, education, regulatory
- competence-building systems
- interactive learning systems where agents communicate and cooperate in the creation and utilisation of new economically useful knowledge; and
- capacity-building for learning for all levels of society

3. Identifying and analysing barriers

This chapter provides guiding principles on how barriers to the transfer and diffusion of climate technologies are first identified and afterwards analysed in order to establish a sufficient grounding for developing measures and incentives to overcome them.

By identification of barriers is understood the tracing of the reasons that hinder the diffusion of climate technologies. This includes the identification of any failed or missing measures that could have sustained the diffusion. The primary task is to understand the nature of the individual barriers together with the relationships between barriers, and to determine which barriers are more important than others, and which barriers are easiest to remove. Barriers about which not much can be done (e.g. rivers run dry for eight months in the year, global oil prices, EU trade barriers) should be ignored, as they cannot lead to any immediate political actions.

Just as a correct medical diagnosis is key to determining the right cure, a thorough understanding of the barriers to the diffusion of climate technologies is key to designing the appropriate portfolio of measures to overcome them. Barrier analysis is not an exact science, and a thorough understanding of the barriers may often be achieved by applying different approaches, or by combining the most appropriate elements of various approaches. This can help in focussing on the root causes of the barriers rather than symptoms.

Main steps of identifying and analyzing barriers and of developing measures to overcome them:

1. Organize the process; paragraph 3.1
2. Identify all possible barriers through literature survey, interviews and/or workshop brainstorms; paragraph 3.2
3. Screen the gross list of barriers to select the most essential; paragraph 3.3
4. Classify the remaining key barriers into a hierarchy of categories; paragraph 3.4
5. Analyse the causal relations between barriers; paragraph 3.5
6. Develop measures to overcome barriers by translating barriers into solutions; paragraph 4.1
7. Assess the cost and benefits of measures and incentives to determine, whether they comply with policy objectives; paragraph 4.2
8. Determine who shall take action and who shall pay; paragraph 4.3

3.1. Organising the process

A common institutional arrangement for a TNA project is described in 'Organising the National TNA Process: An Explanatory Note'.[4] The proposed institutional arrangement is illustrated in Figure 3.1.

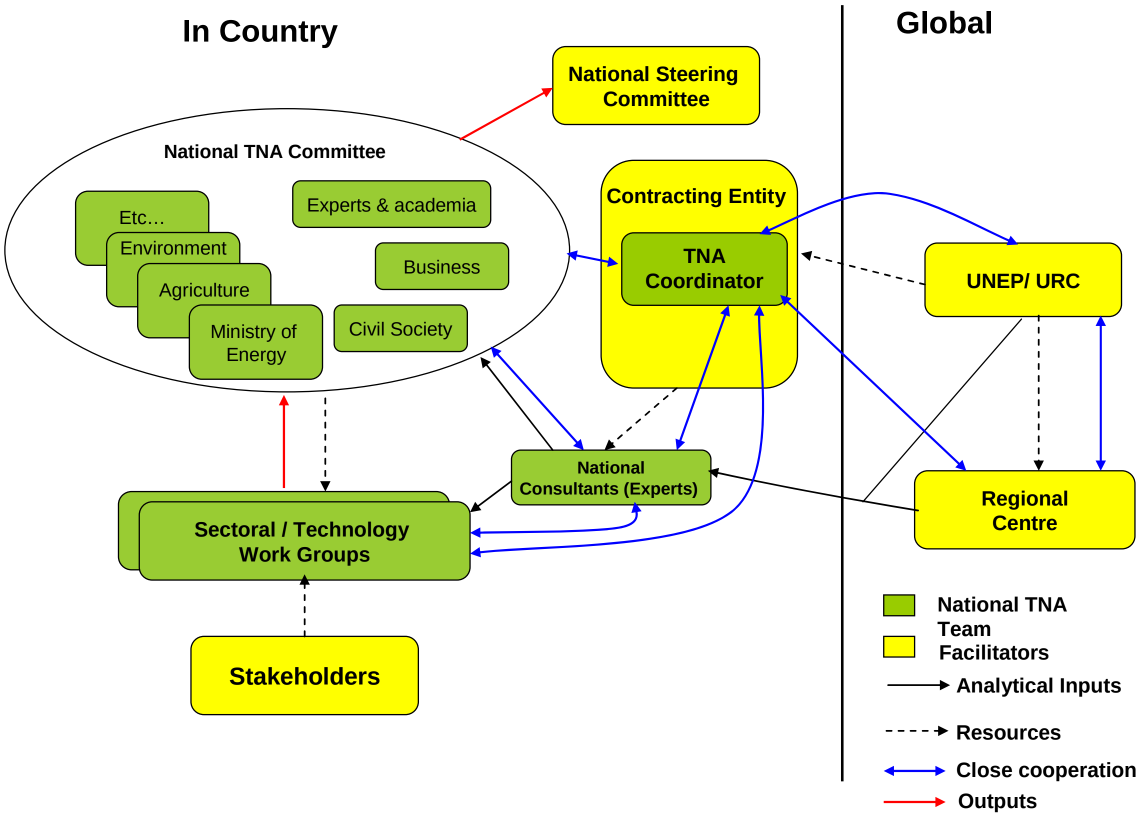

Figure 3.1. Technology Needs Assessment project: institutional arrangements.

In the TNA project, barrier identification and analysis should be conducted for a few selected technologies (approximately 4-8 mitigation technologies and 4-8 adaptation technologies). In most cases, these technologies have been selected by the sectoral work group through a multi-criteria analysis facilitated by the national consultant. The sectoral work group constituted by the TNA committee may include individuals drawn from government departments with responsibility for policy formulation and regulation, private- and public-sector industries, electric utilities and regulators, technology suppliers, finance, technology end-users (e.g. households, small business, farmers, technology experts from universities and consultants) and others (international organizations, donors).

Identifying barriers and measures to overcome them constitutes a new phase of the project, in which the consultant may again work in close cooperation with the sectoral work groups. In some cases, the consultant and the TNA team may chose to form specific technology groups, consisting of

[4] http://www.tech-action.org/Guidebooks/OrganizingNationalTNAprocess.pdf

representatives from the sectoral work groups with specific knowledge of the technologies in question. In order to build up trust and continuity, it is important that the groups remain the same throughout the process, from barrier analysis to identification and the proposal of measures for the action plan. For some elements of the barrier analysis, e.g. the Market Mapping technique, it may be convenient to include stakeholders as direct actors in the market chain.

3.2. Techniques for the identification barriers

An initial step in the process is to conduct a **desk-study** of policy papers and other pertinent documents to identify the primary reasons for why the technology is not currently in widespread use, and why neither the private nor public sectors have invested significantly in it. Relevant case studies are also important, in particular in adaptation, which builds heavily on local experience. The desk study is carried out by the consultant.

If time allows, this should be supplemented by site visits and **interviews** with experts and stakeholders. Another option in obtaining their views is to use questionnaires (cf. **Annex D**).

A central approach to barrier analysis is facilitated workshops with the technology work groups. The workshop facilitator may choose to start the workshop by using **brain-storming** as a means of identifying barriers.

For technologies which are expected to be diffused in large numbers under market conditions, the market mapping technique, described in Chapter 5, may be used to identify market barriers more systematically, while for technologies such as coastal protection and large-scale hydropower, which require political decisions at a high level, barriers should be identified mainly based on the insights provided by the technology workgroups. The categorisation of technologies according to the economic frameworks in which they are diffused is further described in Paragraph 2.2.

Valid ideas may be obtained from **studying generic barriers** (as in **Annex A**). The list of generic barriers may be useful in terms of ensuring that important barriers are not missed during the identification. However, in order not to shadow stakeholders' own thinking, generic descriptions should not be presented early in the process, but rather as food for second thought.

How to identify barriers:

1. Study recent policy papers, feasibility analyses, case studies etc.
2. Expert and stakeholder interviews, direct or through questionnaires (optional)
3. Workshop brainstorming by technology work groups
4. Compare with check list

3.3. Screening barriers

Barrier identification (paragraph 3.2) results in a gross list of non-prioritised barriers, from various documents, from various interviews and/or from an open-minded and non-preclusive recording of all ideas suggested by workshop participants.

When all conceivable barriers have been identified, the barriers need be screened according to their significance. Workshop participants may now argue for and against the listed barriers to reach agreement by consensus or majority. Most important is to identify the essential barriers, i.e. barriers which definitely need be addressed for TTD to occur, while the left-over barriers may be ignored in further processes. A simple sorting may thus include key and non-key barriers, keeping the objective in focus – the transfer and diffusion of a given technology.

Alternatively, the barriers can be screened through voting. All barriers are entered in random order, and each workshop participant is asked to give each barrier a mark, e.g. from 1 to 5, according to how important the barrier is from the participant's own perspective. All the barriers are then ranked after adding all the marks. Prior to the voting, the workshop may decide to delete, for example, the bottom third of the ranked barrier list.

Later in the process, when a more comprehensive understanding has been obtained, it may be useful to check the list of non-key barriers and assess whether some of them should be re-classified as key barriers.

It may be useful to apply more screening categories such as: killer (non-starter), crucial, important, less important, insignificant (easy starter). Changing WTO regulations is an example of a non-starter, since it is an extremely cumbersome challenge, if not impossible from the perspective of a single government.

Barriers may also be sorted according to who has the power to do something about it and who is driving change: e.g. the national government, local authorities, power utilities. However, this can wait until the measures to overcome barriers have been developed (cf. Chapter 4).

3.4. Decomposition

An initial analysis of the barriers that remain after screening can be done by discussing whether some barriers are actually composed of some of the other barriers, or whether one barrier is just a more concrete formulation or an overall barrier category.

Painuly (2001) has suggested decomposing barriers at four levels:

1. broad categories of barriers (e.g. economic and financial)
2. barriers within a category (e.g. high cost of capital)
3. elements of barriers (e.g. high interest rate)
4. dimensions of barrier elements (e.g. an interest rate of 15% per annum for households)

To conclude whether a barrier or a barrier category is relevant or not, the presence of at least one of its components at a lower level is necessary. Thus, this exercise may lead to further removals of barriers from the list that results from the screening process.

One advantage of decomposing a barrier is clarity on the reasons why a barrier exists that stakeholders may find easy to understand and respond to. Another advantage is that measures to overcome a barrier may be identified more easily.

Barriers can be categorized in various ways. Typical categories are:

1. **economic and financial:** lack of access to finance, high cost of capital, financially not viable, inappropriate incentives

2. **market failures:** poor market infrastructure, uneven playing field, inadequate sources of increasing returns, market control by incumbents
3. **policy, legal and regulatory:** insufficient legal framework, highly controlled sector, clash of interests, political instability, bureaucracy, rent-seeking behaviour
4. **network failures:** weak connectivity between actors, incumbent networks being favoured
5. **institutional and organisational capacity:** lack of professional institutions, limited institutional capacity
6. **human skills:** inadequate training, lack of skilled personnel
7. **social, cultural and behavioural:** consumer preferences and social biases, traditions, dispersed settlements
8. **information and awareness:** inadequate information, missing feedback, lack of awareness
9. **technical:** uneven technical competition, lack of standards and codes, lack of operation and maintenance (O&M), unreliable product
10. **other:** environmental impacts, lack of physical infrastructure

Annex A presents a detailed list of generic barriers for climate technologies.

3.5. Causal relations

The decomposition of barriers gives some insight into how they are related. This can be taken one step further by analysing causal relations between them.

Problems are often masked for a variety of reasons. Instead of wasting time and resources putting plasters on the immediately obvious symptoms of problems, we need to understand the 'true' problems before action can be taken.

One example of the symptoms approach is as follows: 'Errors are often a result of workers' carelessness' (therefore the solution is training and motivation). Conversely the true cause is: 'Errors are the results of defects in the system. People are only part of the process'.

Root cause analysis is a method of focusing on the 'root cause' of a problem. By directing corrective measures at the root causes, it is commonly believed that the likelihood of problem recurrence will be minimized. However, it is recognized that complete prevention of recurrence by a single intervention is not always possible.

Basically, root cause analysis asks why a problem occurs, and then continues to ask why it does so, until the fundamental problem is reached. Often, the root problem is an opportunity, as it contains information on how to eliminate or reduce it.

In order to identify relevant literature on the subject, some useful search phrases are: 'root cause analysis', 'fishbone technique', 'fishbone diagram', 'cause and effect diagram', 'the five why's'.

Root cause analysis: an example
Problem: 'high costs of local equipment'.

1. Why is the cost high? Because there are 'few local manufacturers'.
2. Why are there few local manufacturers? Because there are 'few good reference projects'.
3. Why are there few reference projects? Because there is 'a gap between industry and R&D' and because 'industry is hesitant with new technologies'.
4. If there is no immediate answer to why there is a gap between industry and R&D, and why industry is hesitant, then these two problems are the root causes of the problem 'high costs of local equipment'.

There may be other answers to the first question, why is the cost high? For example 'low market demand' and 'high cost of inputs'. Each of these explanations is then questioned, e.g.:

1. Why is market demand low? Because there is 'little awareness of technologies'.
2. Why little awareness? Because of an 'information gap' (existing information on new technologies does not reach potential customers).
3. Then the 'information gap' is also a root cause of the problem of 'high costs of local equipment'.

Logical Problem Analysis (LPA) is part of the Logical Framework Approach, LFA (Norad (1999); AusAid (2005)). This is a discussion and analysis technique, which enables a group of stakeholders to approach and delimit a problem area.

The main aim of the LPA is to arrange observed or alleged problems into a hierarchy of causes and effects as a basis for preparing a concrete and realistic action plan.

Each problem is linked to causes and effects, with direct causes below and direct effects above, so that multi-level cause-and-effect paths are created to form a 'tree' known as the problem tree or the causal factor tree.

The LFA method is a standard systematic design approach used by a large number of donors. Since this method is also generally well known among key stakeholders in most developing countries, it facilitates critical assessment both within the stakeholder community and subsequently by potential donors.

Figure 3.2 shows a simple problem tree. All problems are arranged around a starter problem. A starter problem is a problem considered by the group of stakeholders to be at the heart of the problem area. The starter problem is often a very generic or overriding problem. It is usually the first problem that comes to mind when asking the fundamental question, as in this example: Why do we have so few solar photovoltaic (PV) systems in our country?

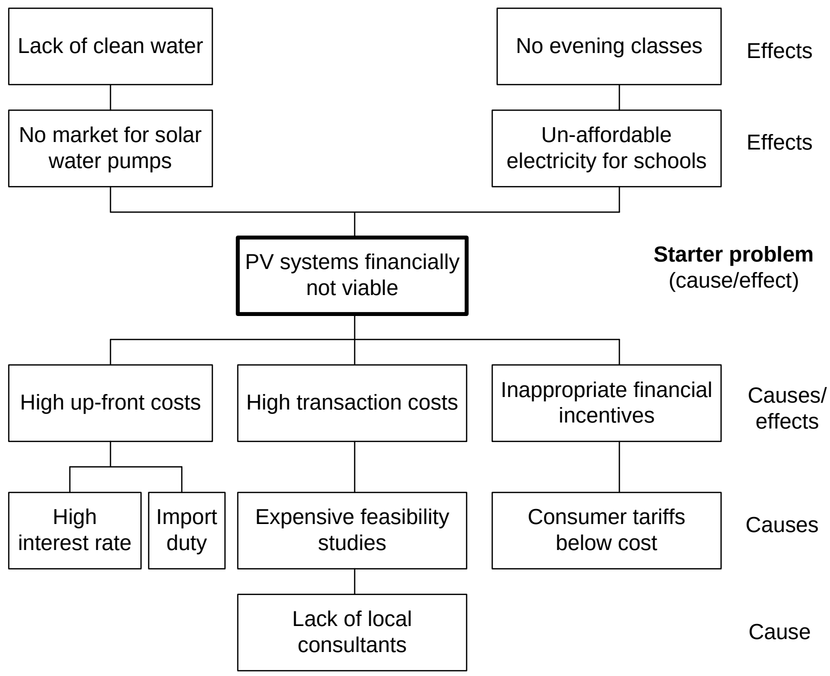

Figure 3.2. Example of a problem tree: solar photovoltaic (PV) systems.

In this example, a high import duty is a barrier to imported products and a means to protect local products, so what is a problem for some stakeholders may be a solution for others. Therefore, it is often useful to attach notes to the problem tree explaining such ambiguities. Also, this problem tree may be expanded to include separate causal streams for imported and local products.

All identified problems are ordered in a hierarchy of cause-effect relations (strings), with the starter problem in the centre, the direct causes below and the direct effects above the starter problem. Each new problem will be linked to causes and effects respectively, so that multi-level cause-effect paths are created to form the problem tree.

The problems situated at the bottom of the tree are called root problems or root barriers. Removal of a root barrier may delete or reduce effect barriers, although not necessarily automatically. For example, removal of the import duty will reduce the barrier of ‘high up front costs’, which may or may not be sufficient to make PV systems financially viable in some market segments.

Removal of the ‘import duty’ plus an essentially lower interest rate should cause a lowering of the up-front costs, which would cause PV systems to be financially viable in at least one of the two market segments included in the tree (water pumps and schools). If this is not the case, the tree needs be re-designed, since it should only include barriers which can be overcome.

The major advantages of the LPA are that it:

- ensures that fundamental questions are asked and weaknesses analysed
- brings together in one place all the key elements of a problem
- guides systematic and logical analysis of the inter-related key elements
- highlights linkages between problem elements and external factors

Bearing these advantages in mind as key objectives of the exercise, one should not exaggerate the fine-tuning of details in the problem tree.

The LPA should be carried out as a participatory process involving representatives of all key stakeholders. For practical and economic reasons, the identification of barriers (cf. Chapter 4) and the analysis should therefore be conducted as a single coherent process, i.e. by convening only one workshop, which may last more than one day. However, if the barrier identification has been thorough and the involvement of all essential stakeholders has been successful, and if resources and time are short, the TNA team or a consultant may conduct the barrier analysis. In this case the team may wish to circulate the result to the stakeholders for comments, to ensure quality and to safe-guard the spirit of cooperation with the stakeholders.

3.6. Technology types and barriers

Some barriers are common to all countries, regardless of size or type of technology, but there are also differences regarding the occurrence and importance of barriers under different economic frameworks.

From case studies in Chile, China, Israel, Kenya and Thailand, the ENTTRANS project (2007) found generic variations between small-scale and large-scale CDM technologies.[5] However, the differences in barriers between small- and large-scale projects are probably more a matter of degree than the result of a complete absence of the key factors in the case of large-scale technologies, and they will also depend on the type of technology as well as the context of implementation.

For a large-scale technology, the chain ends with the utilities and distribution companies, which already have their distribution networks and are not changing what they sell. Although small-scale technology designers are part of the market chain, there seems to be a much greater need for local and international engineering consultants for larger-scale technologies. Therefore, nearly all the barriers referred to are on the ‘enabling business environment’ side.

There is a greater range of stakeholders involved in the chain for small-scale technologies, and though the enabling business environment is important, there is also an emphasis on the support services and market chain. The main differences compared to large-scale technologies are in the need for retailers, sales agents, promoters, installers, service agents and wholesalers. This is the network needed to reach the much larger range of customers who have to be actively engaged in buying the new small-scale product. It therefore seems clear that the adoption of small-scale technology by the market will need either an interface to an existing network in order to reach customers, or the creation of such a network and interface with it. Programmes involving small-scale projects intended for transfer must ensure that this aspect is built into the programme design.

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[5] According to the Marrakech Accords (UNFCCC, 2002; Decision 17/CP.7, para. 6), projects can be considered small-scale CDM projects if they are either renewable energy projects with a maximum capacity of up to 15 MW, energy efficiency improvement projects reducing energy consumption by up to 60 GWh per year, or other projects reducing annual CO2-eq. emissions by 60,000 tonnes at maximum.

Further points were listed as follows:

Market chain aspects:

- The market chain for small-scale projects seems to be more complex in terms of the need for both small-scale suppliers and distributed customer base.

Enabling environment aspects:

- Poor infrastructure, especially for communication for small-scale project support.
- Weak policies and legal framework and enforcement apply to all sizes.
- For large-scale electricity supply, the concern is over tariffs.

Support services aspects, especially with regard to small-scale technologies:

- Poor extension services
- Social and cultural barriers
- Lack of spare parts
- Lack of media interest
- Gender participation and integration
- Monitoring and evaluation
- R&D.

4. Measures and incentives to overcome barriers

Having established a thorough understanding of the barriers (the diagnosis), the next step is to analyse how they can be removed or overcome (the cure). More often than not there is no silver bullet, meaning that overcoming a single barrier requires a portfolio of measures.

It is impossible to pinpoint the specific conditions required for best practice when considering how to overcome barriers to climate technologies, as each situation has many local, national and international influences on its successful outcome. Thus there is no 'one-size-fits-all' solution for successful technology transfer. Nevertheless there are many common features, and lessons can be learned from both successful and unsuccessful interventions.

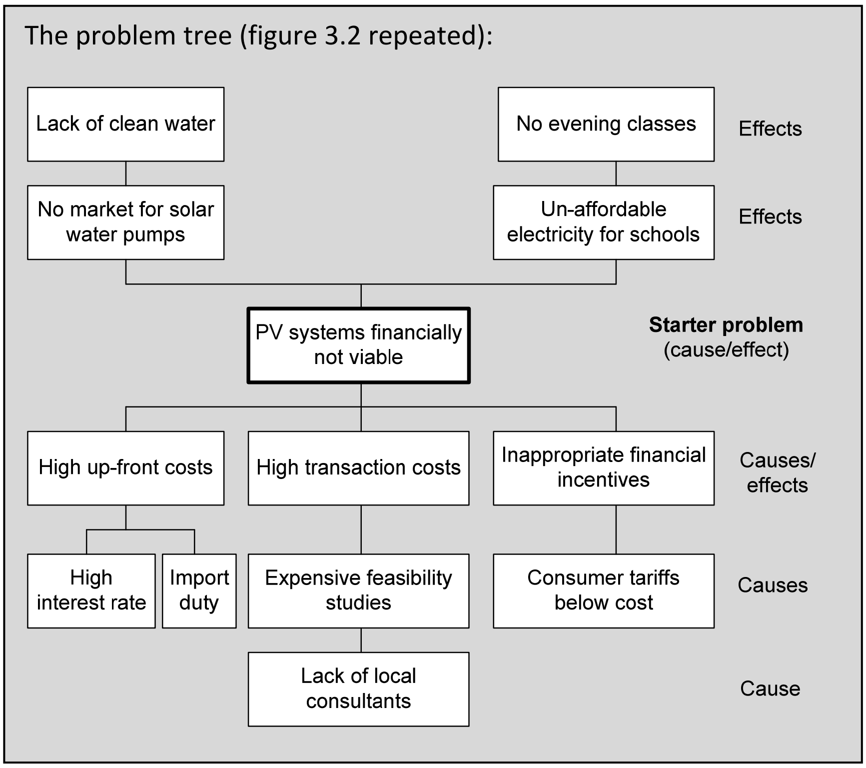
It can be quite useful to distinguish between measures and incentives in order to ensure that the people involved think in terms of concrete solutions. A *measure* is understood here as an actual change in the real world to achieve a goal, e.g. the erection of wind turbines to achieve reduced emissions of greenhouse gasses and distribution of bottled water to improve the health of vulnerable people, whereas an *incentive* is a policy instrument that is used to make the measure happen, e.g. exemptions from duty for wind turbine equipment and financial subsidies to water distribution companies.

An example: policy statements like 'the Government will increase rural people's access to electricity' are frequent in national action plans and programmes, while a proposed measure to fulfil this objective is inter alia '10,000 new solar home systems to remote villages before 2015'. On the face of it, this appears a very concrete measure, but if it is not followed by a binding commitment regarding which incentives will be introduced to ensure or facilitate implementation, it is in itself an empty measure. Incentives would include, for example, an investment subsidy, government support (direct finance or guarantee) to banks offering soft loans (low interest rate, grace period), and government-financed training of local craftsmen in installation and maintenance.

4.1. Translating problems into solutions

Paragraph 3.5 presents Logical Problem Analysis and illustrates it with a particular problem tree on solar PV systems. The Logical Framework Approach can bring the process a step further by reformulating all the problems as positive statements about a future situation in which the problems are solved, e.g. the 'pollution of X water source' becomes 'clean X water source', thus becoming an objective. At the same time, the cause-effect relations of the problem tree are converted into measure-result relations.

The figure shows a reformulation of the case problem tree into an objective tree:



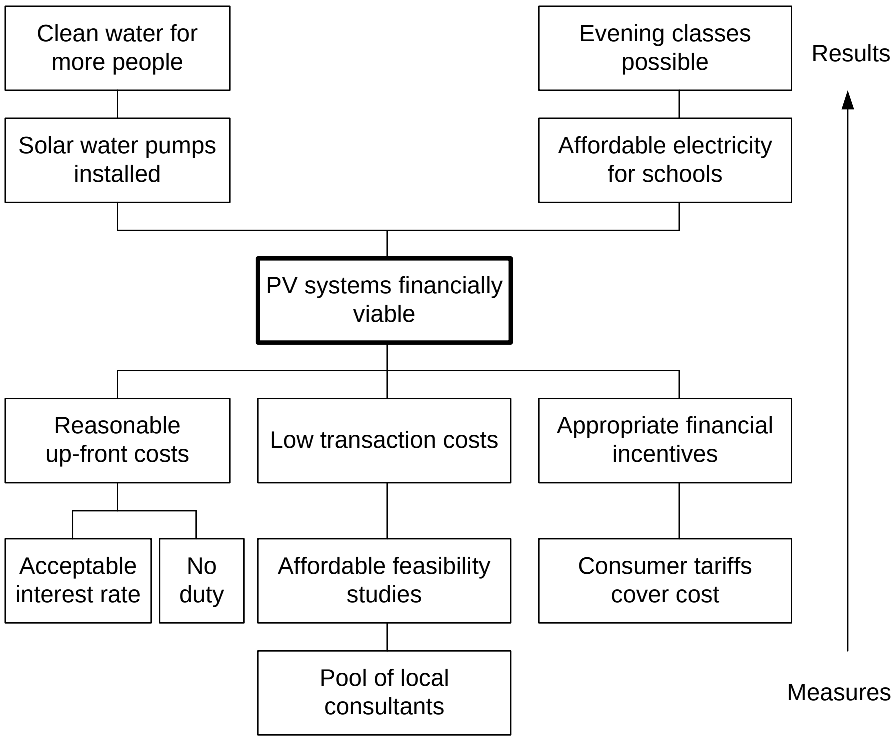


Figure 3.3. Example of an objective tree, a reformulation of the problem tree in paragraph 3.5 (Figure 3.2 is repeated here above the objective tree). Alternative to acceptable interest rate: a grace period of e.g. 5 years (no instalment is due during the grace period; only interest payments due). Alternative to increasing consumer tariffs: find some consumer segments with a higher than average willingness to pay.

The objective tree is a logically organized presentation of objectives. In principle, by implementing the objectives at the root of the tree, the implementation of all the measures above should automatically follow. However, reality is often more complex than that.

The objective tree is not a reflection of the 'real world', as is the problem tree, but rather an outline of what may be done to solve the problems.

Objectives are equivalent to what above were called measures. The objective tree does not tell what incentives are needed for the measures to occur, i.e. what kind of support would be needed to make the irrigation network function.

Once the objective tree has been established, the measures-end strings of the tree can be seen as different approaches or strategies. By overlaying (blacking-out) the strings to reveal one string at a time, each potential strategy can be reviewed, and its operational potentials can be discussed in relation to the interests and ambitions of the stakeholders and the available resources. Against this background, the most feasible strategy or strategies can be selected.

This implies that it is not necessary to remove or reduce all the essential barriers. In the example, PV systems may become feasible for water pumping by lowering the transaction costs, although the market for PV water pumping will be further increased by also adding more appropriate financial incentives.

It is important to include all objectives (i.e. address all the equivalent barriers) in a given measures-ends string, and if it turns out that just one essential barrier in a string cannot be overcome, then that string is not feasible. However, this does not mean that all activities to remove barriers are needed for successful transfer is to occur, as there may be other feasible strings.

To ensure a transparent selection process, relevant selection criteria must be established. The criteria will vary between different situations, but may include socio-economic cost benefits, job creation, environmental impact and gender impact. The selection may also be conducted by inviting stakeholders to indicate their preferred strategies. If consensus is not possible, a weighted point-ranking system may be applied.

4.2. Assessing measures and incentives

In order to prepare an optimum selection of measures and incentives by policy-makers, they should be assessed, i.e. their potential benefits should be compared with their potential effects. Most important is to assess the economic consequences for the society (a socio-economic assessment) and for the owners and users of the technology (a financial assessment). This is often done by means of a Cost-Benefit Analysis and/or a Cost-Effectiveness Analysis.[6] Policy-makers are usually focussed on obtaining the best value for money, and such assessments are thus necessary for the policy process. Again, it can be instrumental to differentiate between measures and incentives.

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[6] For methodologies, see the financing guidebook (UNFCCC, 2006) and the TNA Guidebook (UNDP, 2010; Annex 10).

Other criteria that may be considered are the impacts on resource use, environment, fiscal balance, trade balance and employment. It may also be useful to do a livelihood analysis[7] if that is relevant for the technology in question.

> **Example: What is the outcome of an assessment?**
> The measure is establishing on-grid wind turbines, and the incentive is a feed-in tariff.
>
> The effects of establishing wind turbines are many: the combination of high initial investment and no fuel costs will have a high effect on the trade balance now, but a very low effect later on. Effects of the feed-in tariff: if the premium is paid by the government, it will impact on the fiscal budget. If the premium is paid by the utilities (in reality a cross-subsidy), the general tariffs will increase, in principle effecting economic growth, trade balance, employment etc., but in practice insignificantly.
>
> Such impacts can be presented to the policy-makers in exact terms, with some uncertainties, possibly illustrated by sensitivity analysis.

If the result of an assessment shows that it is not feasible or otherwise acceptable to transfer and diffuse a particular technology, it may be necessary to review the identification and prioritisation of technologies and go through the subsequent steps once again.

4.3. Categories of measures and incentives

If a large number of measures and incentives have been identified, they may be classified along the same lines as the barriers (cf. Annex A). One reason for conducting a classification would be that it can ease comparison with similar efforts in other countries and add value to collective learning.

Generally, it is very useful to classify the measures and incentives according to who shall take action and who shall pay. For a particular measure-incentive couple, the implementer and the payer may not be the same entity. For example, it may be the Ministry of Energy or the Ministry of Water who is in charge of implementing a solar PV measure (solar home systems or solar water pumps), but it will be the Ministry of Finance who is in charge of developing the appropriate subsidy, in cooperation with other ministries and possibly external financial sources.

[7] E.g. see the DFID approach to sustainable livelihoods at http://www.nssd.net/references/SustLiveli/DFIDapproach.htm

Example: Incentives most commonly used to promote the diffusion of renewable energy (details in Annex C):

Financial incentives

- Production incentives (e.g. subsidy per produced kWh electricity)
- Standard power purchase agreements
- Investment subsidies
- Loan guarantees
- Set-asides
- Green marketing (e.g. a premium tariff on 'green' electricity)

Non-financial incentives

- Market liberalisation
- Improved infrastructure
- Improved access to the grid
- Obligations to generate or purchase 'green' electricity
- Voluntary agreements
- Competitive concessions
- Government assisted business development (e.g. by public-private partnership)
- Involving local communities and civil society
- Discouraging alternatives (e.g. environmental taxation of fossil fuels)
- Research, development and demonstration
- Testing and certification
- Information and education

4.4. The enabling environment

Governments and international agencies have a variety of policy tools for overcoming key barriers and creating enabling environments for technology transfer. Barriers and policy tools have been discussed broadly by IPCC (2000) according to ten dimensions of enabling environments, here copied from the Executive Summary:

1. ***'National systems of innovation.*** Technology transfers are influenced greatly by what have been called national systems of innovation – the institutional and organisational structures which support technological development and innovation. Governments can build or strengthen scientific and technical educational institutions and modify the form or operation of technology networks-the interrelated organisations generating, diffusing, and utilising technologies.
2. ***Social infrastructure and participatory approaches.*** Social movements, community organisations and non-governmental organisations (NGOs) contribute to the 'social infrastructure' that plays an important and enabling role in many forms of technology transfer. Governments can devise participatory mechanisms and adopt processes to harness the networks, skills and knowledge of civil society, including community groups and NGOs, to better meet user needs, avoid delays and achieve greater success with technology transfer.
3. ***Human and institutional capacities.*** There are many failures of technology transfer that result from an absence of human and institutional capacity. Although much of the focus on capacity building has been on enhancing scientific and technical skills, other skills for selecting, managing, adapting, and financing technologies are equally important. Capacity

building is a slow and complex process to which long-term commitments must be made. For adaptation there is a need: to strengthen scientific and policy institutions to enable the undertaking of assessments and, to access datasets, tools and techniques to produce outputs for nationally determined priorities.

4. ***Macroeconomic policy frameworks.*** Macroeconomic policies include direct and indirect financial support, energy tariff policies, trade and foreign investment policies, and financial sector regulation and strengthening.
5. ***Sustainable markets.*** Sustainable market approaches are important for renewable energy and energy efficiency technology transfer because these approaches promote replicable, ongoing technology transfers. Governments can conduct market transformation programmes that focus simultaneously on both technology supply (production technologies and product designs) and demand (subsidies, consumer education and marketing).
6. ***National legal institutions.*** National legal institutions are needed to secure intellectual property rights; reduce contract, property, and regulatory risks; and promote good governance and eliminate rent-seeking behaviour. To these ends, governments can strengthen national legal institutions for intellectual property protection; and strengthen administrative and law processes to assure transparency, participation in regulatory policy-making, and independent review.
7. ***Codes, standards and certification.*** The importance and the need for technical standards, codes and certification have been well recognised by the technical community all over the world. If standards and codes are absent, transaction costs can increase as each buyer must ascertain the quality and functionality of potential technologies individually, raising transaction costs.
8. ***Equity considerations.*** Equity in technology transfer can be enhanced by devising analytical tools and providing training for social impact assessment, requiring social impact assessments before technology is selected, and creating compensatory mechanisms for 'losers'. Governments may also wish to develop criteria for ensuring that technology transfer projects do not disempower or negatively influence weaker social groups in a society.
9. ***Rights to productive resources.*** Rights to productive resources can be affected by technology transfer, including land (agriculture, forestry), natural resources (forests, water, coastal areas), factories, and other productive resources. Successful introduction of new technologies or modification of resource use often depends on recognition of the existing forms of resource rights, or on taking steps to create an optimal resource rights regime.
10. ***Research and technology development.*** Developing countries' research and technology development efforts are often adaptive, following externally developed technology, thus suggesting the need for additional indigenous innovative capacity. Governments can develop science and educational infrastructure by building public research laboratories, providing targeted research grants, strengthening technical education, and directly investing in research and development'.

The above general description of the enabling environment is detailed with regard to technology types in paragraphs 5.8 (consumer goods and capital goods) and 6.3 (public goods and non-market technologies).

Sources of inspiration
The UNFCCC Secretariat has analysed the first 70 TNAs (UNFCCC, 2009). Some countries identified barriers to individual technologies, whereas others listed barriers by sector or barriers to ESTs in general.

Economic and market barriers were the most frequently identified barriers, followed by barriers relating to human capacity. Other barriers, in decreasing order of their frequency of identification, were information and awareness barriers, institutional barriers, regulatory barriers, and policy-related and technical barriers. Other barriers highlighted were the lack of transport infrastructure and poor soil quality (more details in the reference). See also the gross list of common barriers in Annex A.

IPCC (2000) includes a chapter ('Enabling environments for technology transfer', Chapter 4), which may be consulted.

The measures identified by the Parties to address these barriers were, inter alia: national involvement to attract foreign investments; increased participation of the private sector in technology transfer; removal of subsidies and price distortions; improvement of collaborative research and the development of environmentally sound technologies; and increased public awareness (more details in the reference).

IPCC (2000) presents 30 case studies. Several of these are relevant to the theme of this guidebook:
- Case 1 on indirect subsidy;
- Cases 4 and 16 on capacity development; and
- Cases 5 and 14 on PV in Kenya and India (subsidy linked to quality requirement).

Since 1996-7, the Global Environmental Facility has conducted three full-fledged operational programmes on barrier removal for energy efficiency and renewable energy (Martinot, 2000):

1. Removing Barriers to Energy Conservation and Energy Efficiency.
2. Promoting the Adoption of Renewable Energy by Removing Barriers and Reducing Implementation Costs.
3. Reducing the Long-Term Costs of Low-Greenhouse-Gas-Emitting Technologies.

5. Commercial goods and services

This chapter deals with technologies traded in a marketplace, essentially the technology types ‘consumer goods’ and ‘capital goods’, in order to understand properly the particular framework conditions of such technologies. Consumer goods are small-scale goods specifically intended for the mass market, while capital goods are machinery and equipment used in the production of other goods, e.g. consumer goods or electricity.

The analysis may be conducted prior or parallel to the barrier analysis described in Chapters 3 and 4, both to support that analysis and to prepare the subsequent steps, described in Chapter 7.

5.1. Market assessment techniques

Assessing the market potential for new technologies and the means for market penetration is a well-established discipline, which is seen in numerous variations. Most market assessments focus on the heart of the market – demand, supply and transactions – pinpointing demand-side weaknesses, supply-side weaknesses and market opportunities, and often leading to the formulation of a marketing plan. Numerous experienced consultants are available, and such consultants may assist the TNA Team in assessing the potential for the diffusion of priority technologies.

One approach, Market Mapping, is quite unique, but not as well established. As this approach offers features of particular relevance for technology diffusion in developing countries, it is described further in this chapter.

5.2. Market Mapping

Market Mapping is an analytical framework with which to understand market systems and an approach to market development that is both systemic and participatory. The Market Map is a very useful way to conceptualize, visually represent and communicate knowledge about the entire commercial and institutional environment in which specific market chains operate. The tool helps in exploring who are the market actors for a technology, what support services are available to them and the nature of the enabling business environment.

Market Mapping (or the Participatory Market Chain Approach, PMCA) as a tool has been developed by Albu and Griffith (cf. Albu, 2005, 2006) for application in the agricultural sectors of developing countries and for agricultural commodities.

The approach can be very useful for the technology types ‘consumer goods’ and ‘capital goods’ (cf. Paragraph 2.2), as demonstrated by several projects conducted by Practical Action (Albu, 2006; PISCES and FAO, 2009; PISCES, 2010). Experiences have been gained with agricultural consumer goods, such as milk, cheese, hibiscus, charcoal-dust briquettes, vegetable oil, spice dryers and ethanol stoves, and with bioenergy technologies (capital goods), such as jatropha electrification, biodiesel-based water-pumping, farm biogas, and charcoal and biomass supply to households and industries.

ENTTRANS (2009) have also applied the approach successfully to these two technology types. However, there is still much learning to do in sectors other than agriculture, so extreme caution is required if one wishes to employ the approach in a sector with substantially diverging features.

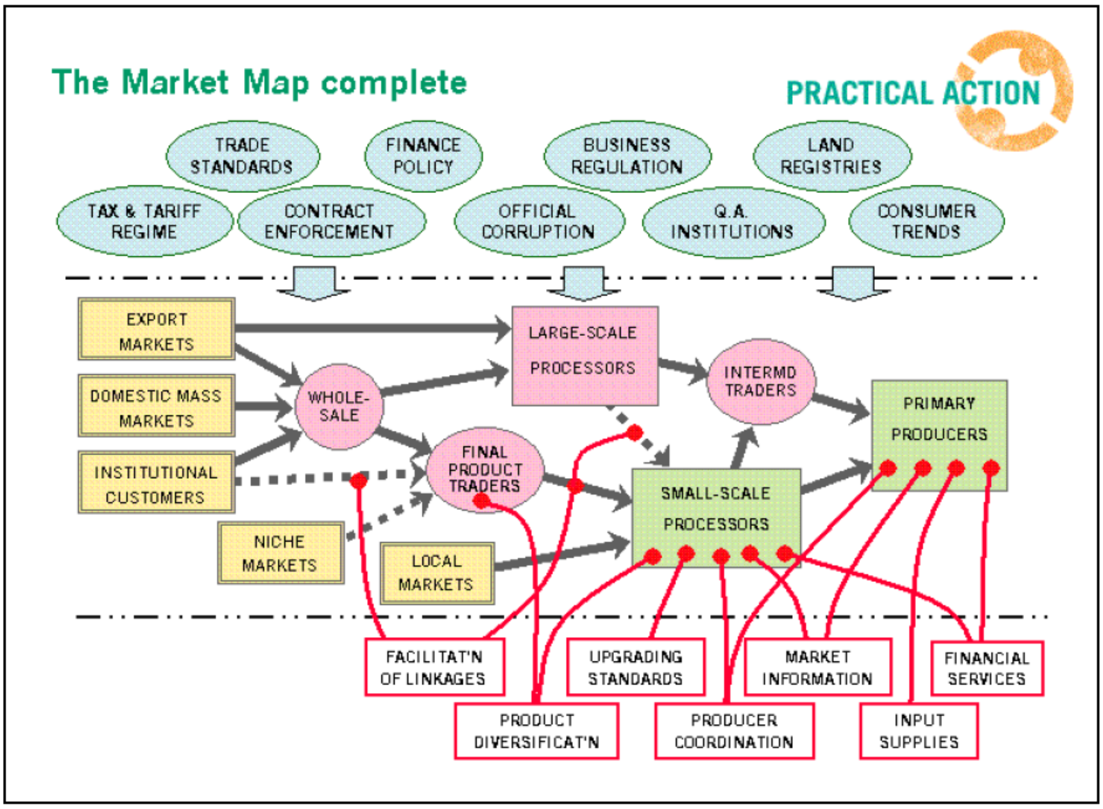
The approach may also be useful in the category 'non-market technologies', for example, the terracing of hilly farmland. The transfer and diffusion of this technology, which mostly consists of knowledge in the public domain in combination with practical experience, may in itself not occur in market conditions, whereas parts of the underlying rationale (e.g. increased crop yields) are market concerns (decreased soil erosion is not directly related to a market). In such cases it may be useful to develop a market map for the marketable products, as the process may reveal important relations between essential stakeholders, but this would then be a supplementary exercise rather than the core analysis.

However, there is no field experience of using the approach for 'non-market technologies', and therefore careful consideration is needed before any attempt is made to apply it. A market approach will place the economic stakeholders at centre stage, while others may conceptually be reduced to secondary stakeholders, even though they are more important for the outcome than the economic stakeholders. In such cases, a different technique than market mapping is recommended (cf. Chapter 6).

The analytical part of market mapping is similar to the much used value-chain analysis.[8] A particular virtue of market mapping is that it combines the analytical approach with a participatory approach, possibly leading to actual improvements in the market chain in its own right (cf. paragraph 5.5).

A generic example is shown in the figure below. Defying convention, the schematic shows the flow of income from left to right, with the flow of goods going in the opposite direction.

[8] A thorough manual is available at www.value-links.de/manual.html



The map has three components, separated by the horizontal dot-and-dash lines:

1. The central component is the **market chain** (the brown, pink and green boxes in the middle of the map), which comprises the economic actors who produce and transact a particular product as it moves from primary producer to final consumer.
2. The second component, the **enabling business environment** (the upper blue ovals in the map), is a charting of the critical factors and trends that are shaping the market-chain environment and operating conditions.
3. The third component, the **business and extension service providers** (the lower white squares in the map), is concerned with mapping the services that support, or could potentially support, the market chain's overall efficiency.

5.3. The market mapping process

Overall, the market mapping exercise can take place in a three-stage process, including:

a. the creation of a preliminary market map
b. a participatory process involving the market players
c. an action phase resulting from the formation of a functioning network of market actors based on the relationships formed and the trust engendered.

There are still limited experiences with using the market mapping approach. However, the recommended reference-documents (cf. the text box on the next page) give examples, based on actual experiences, of the operational challenges and solutions. A major challenge is bringing together disparate, competing, mutually suspicious and demanding business people, and motivating them to work for a common goal. It is therefore recommended that practitioners contact professionals with actual field experience in solving such challenges (cf. paragraph 5.5).

Sources of inspiration

It is recommended to consult the following documents for further details and guidance:

1. Albu, Mike, and Alison Griffith: 'Mapping the market: a framework for rural enterprise development policy and practice', *Practical Action*, 2005.
2. Albu, Mike, and Alison Griffith: 'Mapping the market: participatory market-chain development in practice', *Small Enterprise Development*, vol. 17, no. 2, 2006.
3. DFID (UK Department for International Development) and SDC (Swiss Agency for Development and Cooperation): 'The operational guide for the making markets work for the poor (M4P) approach', October 2008.
4. PISCES and FAO: 'Small-scale bioenergy initiatives', 2009.
5. ENTTRANS: 'Promoting sustainable technology transfers through the CDM: converting from a theoretical concept to practical action', 2007.

PISCES and FAO (2009) present fifteen market maps from concrete case studies dealing with small-scale bioenergy initiatives. The focus is on agricultural produce rather than technology. However, there are some elements pertaining to technology transfer:

- Case 7: Ethanol stoves in Ethiopia. One of the core technologies, the stove, has been developed and patented by a Swedish company, but is manufactured in Ethiopia. The manufacturer receives technology support from the Swedish company. The ethanol is produced by a local sugar company; no mention of distiller technology.
- Case 11: Ethanol stoves and micro-distilleries of ethanol in Brazil. Same stove technology as in case 7. The origin of the micro-distiller technology is not mentioned, thus no mention of TTD.
- Case 9: Biodiesel in India. Interesting combination of South-South (oil press from Kenya) and North-South (biodiesel process from Canada) TTD. Also, a local laboratory is engaged in technology innovation.
- Case 12: Biodiesel in Guatemala. See text box in Paragraph 5.5.

Similarly, PISCES and FAO has reported (PISCES, 2010) three cases of participatory market mapping to promote the sustainable use of bioenergy for improving energy access in Kenya and Sri Lanka.

ENTTRANS (2007) reported market maps for a number of low-carbon energy technologies in five case-study countries:

- concentrated solar power for grid or mini-grid electricity; Kenya.
- a biomass gasification stove for cooking in households or institutions; Kenya.
- large-scale imported electricity supply technologies (wind turbines); China.
- large-scale imported energy efficiency technologies (in cement industry); China.
- small scale solar heating and cooling; China and Thailand.
- large-scale technologies such as biomass- and biogas-based generation; Thailand.
- small-scale compact fluorescent lamps; Thailand.

5.4. Preliminary market map

A preliminary market map can be helpful as the basis for further discussions, in particular for identifying key stakeholders and their interrelations. It may be produced by a facilitating agency such as the TNA consultant, using existing literature and information gathered from key informants. This will not require much effort.

If there is a shortage of resources or time, the preliminary market map may be used as a final map, that is, as an alternative to the map produced by the participatory process described below. However, this will, of course, imply a loss of the important benefits (cf. below) that come from using the participatory approach.

When a preliminary map is produced as a preparatory step to the participatory approach, it is recommended that the map is not shown to the stakeholders, as it may act to anchor the participants in a particular model that differs from their own perceptions of the system.

5.5. Participatory market mapping

The participatory market chain approach (PMCA) can facilitate the collaboration that is necessary for improving linkages and efficiencies within the market chain, for effective lobbying on business environment issues and for coordinating activities where producers are numerous but small-scale.

The participatory process requires the market players:

(i) to identify tangible incentives to engage busy and sceptical actors in the exercise;
(ii) to form market opportunity groups of representatives through whom a large number of market actors can be represented; and
(iii) to conduct a PMCA to create a market map, while also facilitating efficiency, improving coordination, stimulating innovation and bolstering trust within the market chain.

Major events and processes of participatory market mapping

There is no single blueprint for the participatory approach. However, some rules of thumb have emerged as important components of successful change (Albu and Griffith, 2006). These include the following:

- Few entrepreneurs, least of all buyers, are attracted by the idea of attending a 'development project' meeting. They may suspect the facilitator's motives, e.g. fearing pressure to give their suppliers a better price. Tangible issues or intervention proposals (so-called hooks) that might attract the initial interest of wary actors are therefore absolutely necessary. The preliminary market map can help facilitators identify very specific issues of mutual interest, and turn these into proposals that will draw diverse actors into the process.
- Market opportunity groups offer a way to inform and build the confidence of producers, so empowering them to participate on a more equitable basis in both the PMCA workshops and any subsequent negotiated agreements.
- The convening of 'interest forums' has been an important tactic for engaging stakeholders and institutions, which, although outside the market chain, still have an important stake or influence, e.g. service-providers, policy-makers and other moulders of the business environment.
- PMCA workshops are the key events in operationalizing the market map, bringing together diverse market-chain actors to stimulate interest, bolster trust and facilitate collaboration in relation to linkages, services or the business environment. Typically the workshop involves participants in reflecting and building on the preliminary mapping in a joint effort to establish a common framework of understanding for action.
- Moving from analysis to action: the relationships, knowledge and trust generated are used to effect changes in the business environment and access to services.

Participatory market mapping involves:
1. identification of market stakeholders;
2. identification of incentives for engagement by these stakeholders in the technology diffusion process; and
3. meetings with stakeholders to generate a detailed map of the system in which they operate in order to identify opportunities to increase the efficiency of the operation of the market and opportunities for development and co-operation.

An essential outcome of the overall process is the possible creation of a network among the market actors themselves, improving the ground for introducing or generating innovation in products, processes and market access.

Case study: biodiesel in Guatemala
Participatory market mapping was used in introducing a cash-crop, jatropha oil seeds, for poor farmers (PISCES, 2009). The collaboration helped establish mutual understanding, trust and networking among participants. Farmers were grouped into co-operatives and similar organisations, a local industry purchased and operated the biodiesel production equipment, and large-scale investors bought the oil directly from the co-operatives or the industries. Furthermore, some universities and private research companies involved themselves in R&D. This kind of follow-on innovation often happens automatically, shortly after a new technology has entered a society.

Facilitating the participatory process requires skilled facilitators. Such facilitators are organized in a network, the SEEP (Small Enterprise Education and Promotion) Network, which may be contacted at www.seepnetwork.org (or seep@seepnetwork.org). Useful hints on good facilitation may also be downloaded from www.slideshare.net/marketfacil/state-of-the-practice-in-market-facilitation-2008, produced by the Market Facilitation Initiative (MaFI), a joint venture between the SEEP Network and the Livelihoods Network.

5.6. Identifying and analysing stakeholders

Stakeholders are individuals, groups, institutions and companies that have something at stake. Stakeholders have an interest in a particular decision, either as individuals or as representatives of a group. This includes people who influence a decision, or can influence it, as well as those affected by it.

Stakeholders may thus work for or against the planned changes in a system during all its main phases. It is therefore suggested that a stakeholder analysis is elaborated during the initial phase of the technology transfer process, and that the analysis is reviewed and amended if necessary during consecutive phases.

It is recommended that the stakeholder analysis be conducted by the consultant contracted by the TNA Team and presented to the Team for comments before starting the market mapping process.

This is to ensure that an optimum composition of stakeholders is invited to participate in the market mapping exercise.

A basic stakeholder analysis includes four main elements:

1. Identify and list all persons, groups, institutions and companies affected by the problem area or environment.

   The 4R's approach (Relationships, Rights, Responsibilities and Revenues)[9] is valuable in helping identify and categorize stakeholders. It may be supplemented with yet another R for risks, including voluntary and involuntary 'risk-takers' and 'risk-bearers', as suggested by the World Bank.[10]

   IPCC (2000) and ENTTRANS (2007) recognise a diversity of stakeholders in the process and identify the following key actors:
   - technology developers, including research organisations
   - technology owners and suppliers
   - product buyers and users
   - financiers and donors
   - market intermediaries, including consultants, NGOs, community groups, trade organisations
   - information providers
   - government agencies
   - educational institutions
   - international organisations

   Many stakeholders have probably been identified during the preceding technology prioritisation process. However, when dealing with specific market chains for particular technologies, there would be a need to replace some stakeholder representatives with stakeholders operating directly in the market chain. For example, a representative from a manufacturers' association should be replaced by representatives from concrete traders and manufacturers of solar water heaters if the market chain concerned revolves around solar water heaters.

   Also, some stakeholders may disturb a concrete market mapping process, and should therefore not be invited. If, for example, farmers are asked to select colleagues to represent them, they will often choose some with proven leadership skills, good negotiation skills and the ability to read and write and to argue issues convincingly. Then the interests of poor and marginalised farmers may not be represented or effectively articulated. This will obviously pose a problem if the marginalised farmers are the target group.

2. Identify the main interest of each stakeholder in relation to the problem area. The interest can be economically, politically, personally or geographically delimited.

[9] The 4 R's approach developed by IIED (International Institute for Environment and Development). http://www.policy-powertools.org/Tools/Understanding/docs/four_Rs_tool_english.pdf
[10] 'Options Assessment Sourcebook', World Bank Report 264/03, July 2003.

The stakeholder analysis will need to clarify the different interest groups who actively support, oppose or would be affected by the new technology, including: (i) ministries, departments and agencies; (ii) enterprises; (iii) interest groups such as trade unions; (iv) civil society organisations and consumer groups; (v) other sub-groups within the general population. It should show the different perspectives of each group, and it should show where different perceptions may lead to failures in the required reforms. It should also cover an assessment of how key groups within institutions may affect the policy options being considered for technology deployment and diffusion.

3. Categorize the stakeholders in clusters of related interest and name the clusters. The linkages in the Market Map may be useful for this purpose.

   An important feature of the Market Map is that it maps the linkages between the stakeholders within the Market Chain, as well as between Market Chain participants and service providers. It may thus serve as an important tool for illustrating which types of stakeholder need be engaged in technology diffusion and deployment.

4. Within each cluster, analyse the significance of stakeholders for the problem area, e.g. interests, fears, strengths, weaknesses and their influence on the problem area and/or how they may be affected by an intended intervention.

Actual and perceived imbalances of power within the market chain can impede the participatory process. Building up trust is therefore important to facilitate the open sharing of information and reduce transaction costs. Albu (2005) gives valid advice on how to build such trust.

5.7. The market chain

The central component of the market map, the market chain, maps the economic actors who actually own and transact a particular product as it moves through the market chain from primary producer to final consumer. By better understanding the contribution that each actor in the chain brings to the product, the aim is to identify inefficiencies, inequities and losses that can be remedied, or added-value that can be captured.

Actors taking legal possession of (parts of) the product should be mapped as part of the market chain, whereas other actors belong to the enabling business environment (paragraph 5.8) or the business service providers (paragraph 5.9).

A clear objective of the market map approach is to help stakeholders realise mutual benefits by improving the ‘systemic efficiency’ of the chain. Key to this is helping stakeholders become more aware of functions and processes along the chain that are needed to satisfy more lucrative or reliable markets.

Thus, an important aspect of the market mapping technique is the emphasis on the participation of stakeholders in the process of elaborating the market map.

5.8. Identifying enabling business environments

The second component of the market map is a charting of the critical factors that are shaping the market-chain environment and operating conditions, but that may be amenable to change. These 'enabling business environment' factors are generated by structures and institutions that are beyond the immediate control of economic actors in the market chain.

The purpose of charting the business environment is to understand the elements that are affecting the entire market chain and to examine the powers and interests that are driving change. This knowledge can help determine avenues and opportunities for realistic action to improve the enabling environment via concerted lobbying, coordinated campaigns and advocacy.

According to Albu (2005), the enabling business environment encompasses the following:

Relating to market demand:

- consumption trends (prices, volumes and quality expectations)
- taxes, subsidies and tariff regimes

Relating to transformation activities, i.e. the costs of doing business:

- infrastructure constraints and investment policies
- transport policies and licensing
- technological development
- trade regime (import/export)

Relating to transaction activities:

- systems of finance
- gender roles in business and finance
- registration of land and property
- legal requirements for contracts
- commercial law and practices
- business licences and regulation
- standards quality control and enforcement

For new entrepreneurs wishing to enter the market with a new technology, a major barrier is often the transaction costs and the amount of time needed to obtain approvals from numerous authorities. To reduce this barrier, government may establish a 'one-stop shop', i.e. a single office where the entrepreneur can receive all necessary information and applications, as well as submit applications to the various authorities. Another, not necessarily alternative measure to reduce this barrier is to elaborate an investor/project-developer handbook or website, including information on all pertinent requirements and procedures.

Valid information on business environments is available at www.businessenvironment.org/dyn/be/besearch.home, operated by the Donor Committee for Enterprise Development (DCED).

5.9. Identifying support services

In most effective market chains, the economic actors who form the chain are supported by inputs from other enterprises and support organisations. The third component of the market map is concerned with mapping these services that support, or could potentially support, the market chain's overall efficiency. This includes identifying particular service needs and their locations within the market chain in order to understand the opportunities for using and further developing services to improve market-chain efficiency or equity.

The range of services that can potentially add value is huge and include:

- input supplies
- market information
- marketing support
- financial services
- legal services (contracting)
- transport services
- engineering (support for product development and diversification)
- human skills development
- quality assurance (monitoring and accreditation)
- business advise (business-plan and bargaining support)

It is important to recognize that service options are not confined to conventional government extension services and private fee-based services. There are also embedded services, where services are incorporated within a commercial transaction for another product, e.g. pest control advice offered to a contract farmer by a trader.

In practice, differentiating between the enabling environment and the support services is not always clear cut, and different countries or groups may view them differently, so that there may be an overlap between them (cf. ENTTRANS (2007), para. 6.1.2). Most obvious overlapping topics are:

- financial services
- legal services
- professional engineering services; and
- government planning and support, including R&D, codes and standards

For the outcome of the participatory process, it is not overly important whether one function is mapped as part of the enabling environment or the support services, so there is no need to go through lengthy discussions. More important is that all essential stakeholders, functions and relations are mapped, and that the map does not become very complex in an attempt to reach scientific correctness.

Valid information on business development services (BDS) is available at www.bdsknowledge.org/, operated by the Donor Committee for Enterprise Development (DCED).

Country teams can determine how current and planned government initiatives and donor programmes are addressing barriers (cf. paragraph 3), and then identify possible refinements to these programmes and new initiatives that would help to address these barriers (cf. paragraph 4).

6. Public goods and non-market technologies

This chapter deals with technology types 'public goods' and 'non-market technologies' (cf. definitions in Section 2.2) in order to understand the particular framework conditions for such technologies. The chapter supplements the general descriptions of how to identify and analyse barriers in Chapter 3 and how to formulate measures and incentives to overcome barriers in Chapter 4. For public goods and non-market technologies, the stakeholder identification and analysis may be conducted in a manner equivalent to the description in paragraph 5.6 for marketed technologies.

6.1. Public goods

Public goods in this context comprise mitigation and adaptation technologies such as large-scale hydropower schemes, sea dikes, flood defence, infrastructure such as roads, bridges, fresh water and sewage systems, and mass transport systems such as metros.

Governments can play a role in supporting people and businesses to overcome some of the barriers involved here, create an environment conducive to the appropriate technology decisions and increase the opportunities for technology diffusion. Transforming an agricultural production system into a system that is more resilient to climate change such as integrated farming is a longer term adaptation strategy which may be supported by public good subsidies. This, for example, could include subsidies for the TTD of insurance, irrigation or new crop varieties.

Technologies in this category may be traded in a market place like consumer goods and capital goods, as they are purchased by public entities from private constructors and manufacturers. However, the market is often not as liquid, as the public entities purchase their goods through a tendering process, which may be restricted to a limited number of invited national and international construction companies.

Large-scale public goods projects will generally be preceded by thorough analyses such as cost benefit analyses, feasibility studies and environmental impact assessments, which are all outside the scope of the present guidebook. Selection of technologies to be included in the TNA project will most often be based on input from such studies in a national context.

While a public entity, such as a ministry or a government agency, has the power to take decisions on such projects, a main barrier will often be finance. One way of overcoming this barrier will often be loans from international finance institutions.

As procurement is normally based on government decisions, there are in general no market barriers, as for consumer goods and capital goods, and therefore most barrier categories (cf. Annex A) may be irrelevant in this case. However, besides the financial barrier, there might be a number of negative effects in, e.g., establishing big hydropower schemes. Besides high variations in economic performance, this could be effects such as moving local and often indigenous and tribal people, conflicts over water resources with neighbouring countries, safety issues, sedimentation, water logging, loss of forest and wildlife habitat, loss of aquatic biodiversity, upstream and downstream fisheries, services of downstream floodplains etc.

These negative effects are ‘cost elements’ in the cost benefit analysis, and should of course be minimized. Some of these negative effects may also turn out to be real barriers, as political pressure by local people and international NGOs may influence government and international financial institutions. On the other hand, such barriers cannot be dealt with by improving the enabling environment, as discussed for consumer goods and capital goods.

6.2. Non-market technologies

Non-market technologies are transferred and diffused in non-market conditions, whether by governments, public or non-profit institutions, international donors or NGOs. With regard to identifying barriers to transferring these technologies, this category is similar to public goods, but while the hardware element is high in the public goods category, non-market technologies are dominated by the software and orgware elements of technology (cf. the broad technology definition in paragraph 2.1). Non-market technologies comprise both mitigation and adaptation technologies. Examples are early warning systems, vaccination systems and energy saving by behavioural change.

Non-market technologies can be divided into three main groups within which technologies share some characteristics in terms of barriers and how to overcome them.

The first group comprises technologies provided by institutions. Examples are early warning systems for drought, seasonal forecast of rain for optimal planting, new vaccination systems due to climate change and the introduction of genetic screening of water-borne pathogens. Before deciding on implementation, a cost-benefit analysis will be needed to address the relevance, but if the intervention is considered beneficial, implementing the service is mainly dependent on access to finance and a government decision to implement it.

The second group comprises institutional change with the objective of reducing vulnerability and improving rural livelihoods. Examples are microfinance institutions, seed banks, forest management groups and village development groups.

While new institutions evolve in competition with existing institutions, they are not diffused aint market conditions, but initiated and supported by development actors, such as government agencies, donor agencies and NGOs. Barriers to such institutions becoming sustainable and actually playing the roles that donors and governments have attributed to them are many. Examples of barriers are capture by local elites, struggle over external resources, misappropriation of funds and strategies of dependency on continued donor finance.

Such barriers can be reduced by various means, such as improved information, better training, economic support and governance. Better project preparation through rural appraisal techniques may improve the understanding of the complex relationship between donor projects and recipients at the local level, enable the achievement of ownership of technologies by the community, and ensure that lessons learned from past community-based projects are considered, synthesised, assimilated and disseminated.[11]

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[11] For this purpose, it may be useful to apply the approach called Participatory Rural Appraisal or the Framework Tool for Technology Receptivity, developed by SouthSouthNorth (2007).

The third group comprises behavioural change at the individual level. Examples are energy-saving measures, such as turning off the light or the air conditioning when you are not present, changing from individual cars to public transport and bicycles, improved hygiene made necessary due to climate change, use of mosquito nets and changing farm practice.

The barriers to behavioural changes are both complex, multiple and difficult to overcome. Examples are culturally embedded practices, tradition, social esteem, pride, laziness and religious beliefs.

There are some general measures for this category, such as information and training, but also taxes and tax reduction in order to encourage behavioural change further may be applicable in a number of cases. In some cases a measure may consist in distributing free goods, such as energy-efficient light bulbs and mosquito nets.

Incentives in terms of information, training and the distribution of free goods need to be prioritized by the TNA consultant and the technology group (cf. paragraph 3.1) based on existing evidence of the impact of such incentives in other countries. Some guidance on this may be found in the relevant technology guidebooks on technologies (cf. paragraph 1.2).

Example: local farmer associations involved in adaptation and local development.
1) Practices of adaptation to drought and heavy rainfall in four villages in South Africa and Mozambique have been analysed by Thomas (2005). Thomas shows that, by working together in voluntary associations, villagers have been able to spread the risks of adopting new technologies and experiment with new crop varieties on their own terms.
Agricultural projects which utilised local knowledge and had a market base were the most successful. Knowledge transfer from other regions was facilitated through government training.

2) McGray (2007) has reported a number of cases of adaptation from around the world.

3) There is a body of research revealing the difficulties in creating local institutions by donor intervention. Examples of literature are Nygaard (2008), Engberg-Petersen (2002), Creve (2002).

Social barriers to adaptation are concerned with the social and cultural processes that govern how people react to climate variability and change. The IPCC[12] has noted that, to date, 'social and cultural limits to adaptation are not well researched'. Nevertheless, Jones (2010) has provided valid recommendations for adaptation policy interventions that seek to recognise, address and overcome social barriers to adaptation. These recommendations can be divided into four main clusters.

The first cluster includes *awareness raising, education and empowerment*. Initiatives on facilitating TTD will be less likely to succeed if they do not empower and inform individuals who remain confined in their adaptive behaviour and have limited access to key resources. This includes both general awareness-raising, but also, e.g., the representation of marginalised groups within institutional decision-making.

[12] IPCC: 'Climate Impacts, Adaptation and Vulnerability: Contribution of Working Group II to the Intergovernmental Panel on Climate Change Fourth Assessment Report', 2007, p. 737.

The second cluster is related to *mainstreaming measures to overcome social barriers*. Here, the obstacles that social barriers present to limiting the success of planned TTD should be integrated into wider adaptation policy frameworks. Rather than simply mentioning social barriers within the various frameworks, initiatives to address those barriers should be incorporated into practical, structural and, most importantly, output levels.

A third cluster is related to addressing *adaptation in parallel with other issues*. Disaster risk reduction, social protection and climate adaptation deal with similar underlying drivers of vulnerability and face similar social barriers. Therefore, there is a need to recognize complementarities and interrelations, as well as the ways in which each approach incorporates and deals with social barriers. This would help to address and overcome the limitations such barriers pose for adaptation. This cluster relates to the enabling framework, described in paragraph 6.3.

Finally, the last cluster supports the need for *informed autonomous adaptation and recognition of the role of community-based adaptation*. Given that many of the barriers and restrictions mentioned will apply to aspects of autonomous adaptation in particular, it is only through working at the community level, and by appreciating, informing and supporting appropriate and logical autonomous actions at this level, that restrictive and maladaptive elements within local institutions are likely to be overcome.

6.3. Enabling environments

The context for improving the quality and efficacy of the transfer and diffusion of climate technologies implies multi-facetted enabling environments in both developed and developing countries. The enabling environment for public goods and non-market technologies is of a different nature than the enabling business environment for marketed goods (paragraph 5.8). This is even more the case for adaptation practices by low-income rural communities.

An enabling environment in this sense should be understood as the set of resources and conditions within which the technology and the target beneficiaries operate. Such conditions include policies and appropriate infrastructure. For example, in a situation where an adaptation technology seeks to accommodate storm risks in a coastal area by building storm shelters, the storm shelters are of little use if the early warning system and communication infrastructure do not exist. In such a case, the technology (storm shelters) needs broader capacity-building in creating the communication infrastructure and early warning systems, which are themselves adaptation technologies. The enabling environment, resources and conditions should support the quality and efficacy of the transfer and diffusion of climate technologies. Therefore, strengthening the enabling environment should be viewed not simply as the conditions which the technology builds upon, but as a crucial collection of conditions and technologies that need to be given attention and which need to be in place for the efficient outcome of any transfer and diffusion of technology.

As noted in paragraph 4.4, the enabling environment for technology transfer comprises a number of high-level issues and capabilities, as well as being supportive of the wider sustainable development means that foster the technology transfer process. This is shown in Table 6.1. It highlights the multiple dimensions of the enabling environment. Longer term interventions at national and sub-national levels, often with support from the international community, are required to create and strengthen the enabling environment.

Enabling Environment for Sustainable Development		Enabling Environment for Technology Transfer and Diffusion		Key barriers and Opportunities to Implementation
· Favorable macro-economic condition · Robust and responsive legal and regulatory regimes · Available and affordable financing · Climate proofed national development strategy · Empowered and equitably involved stakeholders · Equitable allocation of rights, responsibilities and benefits · Needs-driven and targeted information		· Research and technology development · National systems of innovation · Social infrastructure and participatory approaches · Human and institutional capacities		
· Functional and environmentally sound technologies	→	· Macroeconomic policy framework · Sustainable markets · National legal institutions		
· Relevant and applicable standards, codes, methodologies, and tools · Supportive human and institutional capacities		· Codes, standards and certification · Equity consideration · Rights to produce resources		
Examples				
<u>Water sector technologies</u> Expanded rainwater harvesting; water storage and conservation techniques; water re-use; desalination; water-use and irrigation efficiency	→	National water policies and integrated water resources management; water-related hazards management	→	Barriers: Financial, human resources and physical barriers; Opportunities: integrated water resources management; synergies with other sectors
<u>Agricultural sector technologies</u> Adjustment of planting dates and crop variety; crop relocation; improved land management, e.g. erosion control and soil protection through tree planting	→	R&D policies; institutional reform; land tenure and land reform; training; capacity building; crop insurance; financial incentives, e.g. subsidies and tax credits	→	Barriers: Technological & financial constraints; access to new varieties; markets; Opportunities: longer growing season in higher latitudes; revenues from 'new' products

Table 6.1. The table displays the multiple dimensions and causalities of enabling environments. Longer term interventions at the national and sub-national levels, often with support from the international community, are required to create and strengthen the enabling environment for sustainable development and for the transfer and diffusion of climate technologies. The table is based on IPCC (2007) and ADB (2005).

7. Kick-starting actual technology diffusion

Having identified and analysed the barriers to TTD, as discussed in Chapter 3, and understood the specific framework conditions (Chapters 5 and 6), a solid foundation has been laid for determining how actual TTD can best be facilitated.

As explained in Paragraph 2.3, it is the initial phase of diffusion, when the reliability, practicality and financial feasibility of the technology are to be demonstrated, that is the most critical phase. The present chapter therefore highlights how to overcome barriers to the initial diffusion. Some of the suggestions and recommendations may be included in the Technology Action Plans.

In preparing the diffusion of the selected technology, it is often essential that both the demand for and the supply of the technology is nourished (demand-pull plus technology-push). The demand side is discussed in paragraphs 7.3–7.4, while the supply side is discussed in paragraphs 7.5–7.8.

7.1. Pathways for international technology transfer

This paragraph addresses the policy options available to encourage international transfer of technology. The pathways, also called channels or mechanisms, for transfer will depend on the country context, sector and type of technology. There are several pathways through which the various stakeholders can interact in order to transfer technologies. The most common include:

- Trade in goods and services.
- Direct trade in knowledge via licensing.
- Foreign direct investment (FDI). Money invested in production by a foreigner rewarded with part-ownership (stocks) of production. For example, a foreign corporation may finance a factory in return for stock certificates, giving a share of the profits from production and some voting rights in the enterprise management.
- Joint venture. A contractual agreement joining together two or more parties for the purpose of executing a particular business undertaking. All parties agree to share in the profits and losses of the enterprise.
- Sub-contracting.
- Equity investment. Money that is invested in a firm by its owner(s) or holder(s) of common stock (ordinary shares), but which is not returned in the normal course of the business. Investors recover it only when they sell their shareholdings to other investors, or when the assets of the firm are liquidated and the proceeds distributed among them after satisfying the firm's obligations.
- Fee-for-service. The service provider owns the installation, and the consumer pays a regular fee.
- Franchising. An agreement whereby one party (the franchisor) provides another (the franchisee) with the right to carry on a business under a system or marketing plan and using a trade mark or symbol owned by the franchisor in return for a fee paid by the franchisee.
- Concession. A business operated under a contract or license associated with a degree of exclusivity in business within a certain geographical area, granted by the government or a public entity. An example is a contract between the authority owning public service infrastructure (e.g. roads, power, water, telecommunications) to a private party, allowing the

latter to operate the public assets and retain the revenues for a specified period (usually 20-30 years).

- Donation; official development assistance (ODA) and government assistance programmes
- Cooperative research arrangements and co-production agreements.
- Movement of people, including exchange of scientific and technical personnel.
- Science and technology conferences, trade shows and exhibits.
- Education and training (of nationals and foreigners).
- Open literature (journals, magazines, books, and articles).

Each pathway represents different types of flows of knowledge, money, goods and services among different sets of stakeholders. Each pathway has very different implications for the learning that occurs and ultimately the degree of knowledge transfer that takes place beyond simple hardware transfers.

IPCC has classified pathways into three primary types (IPCC, 2000; paragraph 1.6, page 57):

1. government-driven pathways are technology transfers initiated by government to fulfil specific policy objectives;
2. private-sector-driven pathways primarily involve transfers between commercially oriented private-sector entities and have become the dominant mode of technology transfer;
3. community-driven pathways are those technology transfers that involve community organisations with a high degree of collective decision-making.

For a government, the key issue is whether the pathway is driven by government or not. Governments are in direct control of some important technologies, and these will require government-driven pathways. In such cases governments can use direct interventions.

For private-sector and community-driven pathways, the government's role is more a matter of setting frameworks for and facilitating smooth passage through pathways. If, for example, it has been decided to pursue the pathway 'direct sales' as a primary measures for TTD, the right column in Table 7.1 indicates what government can or should do to facilitate TTD. That would essentially be to reduce import duties and improve the system for standards and certification. The other issues mentioned (advertising, product compatibility) leaves little room for government action.

At a general level, experience and theory do not provide unambiguous guidance regarding the benefits of alternative pathways. Much depends on the capacities to absorb and adapt technologies, and other factors. However, Hoekman (2004) offers extensive discussion and some 'rules of thumb' about the predominant pathways, i.e. trade in goods and services, foreign direct investment, direct trade in knowledge via technology licensing and the movement of people. The analysis argues that:

- International technology transfer is predominately mediated by national policies rather than by international disciplines.
- The relationships between the various pathways of technology transfer are complex. Trade and FDI are often complements, whereas FDI and licensing may be either complements or substitutes. Movement of people is often needed to allow trade, licensing or FDI to occur or to increase the efficiency of such transactions.
- Open trade policies are critical for developing countries in attracting technology. But openness is not sufficient: there also needs to be an absorptive capacity and the ability to adapt foreign technology, both of which are related to human capital endowments. The implication is that the liberalization of trade and open FDI policies need to be complemented

by policies to strengthen domestic R&D programmes, private and public research laboratories and universities, and a sound basis of technical skills and human capital accumulation for countries to take full advantage of technology transfer.

- The nature of international technology transfer and appropriate policies follow a technology ladder. Many middle-income developing countries are at the duplicative imitation stage, hoping to absorb free or cheap foreign technologies into labour-intensive export production and evolve higher value-added strategies over time. Licensing is a key source of technology transfer for these countries.
- The poorest countries have barely stepped on to this stage of the ladder. Given weak business environments and absorptive capacity, licensing is not a realistic option for LDCs. Instead, the emphasis should be on using trade to benefit from foreign knowledge and acquiring technology through FDI. With this pathway, foreign enterprises generally transfer technological information to their subsidiaries or local joint-venture companies, some of which may 'leak' into the host economy. Government's role is then to optimize this so-called spillover effect.
- Given the limited guidance offered by theory, it is helpful to revisit briefly the history of successful efforts to move up the technology ladder. Japan is a pre-eminent example of a country that developed technological capacity rapidly. Korea is another technology follower that encouraged learning via duplicative imitation of mature technologies that foreign firms had permitted to enter the public domain or were willing to provide cheaply. Brazil, Mexico, Malaysia and the export-intensive regions of China and India are other examples of movement from 'pure' to 'creative' imitation.

Much has been written about why multinational corporations choose one pathway over another. Some of the key issues are summarised below (IPCC, 2000; paragraph 1.6):

PATHWAY	KEY ISSUES AND FACTORS AFFECTING CHOICE OF PATHWAY
Direct sales	Import duties Advertising Product compatibility Standards and certification After-sales service and training Distributor capabilities Degree of system integration required before use by final user Insurance and product liabilities
Turnkey contracts	Domestic technological capabilities International competitive bidding Import duties Buyer training Rent seeking behaviour
Wholly owned subsidiaries	Acceptable financial risks Foreign investment policies of government Expected size of domestic market Export duties Repatriation of profits
Joint ventures	Acceptable financial risks Ensuring protection of intellectual property Expected size of domestic market Product adaptation Partner identification, appraisal, and negotiations Foreign investment policies of government

	Export duties Repatriation of profits
Licensing agreements	Intellectual property protection Future domestic market and strategic interests of MNC Acceptable financial risk
Multilateral development lending	Need for and viability of carrying out structural economic reforms Guarantees and credit worthiness of government and borrowers Economic and financial rates of return from investments Procurement procedures
Development aid and other grant financing (like GEF)	Donor country political agenda Multilateral agency priorities Recipient country capacity to make informed choices Range of stakeholders' involvement in recipient country
Twinning, conferences, symposia, and other person-to-person pathways	Ability to attend conferences, symposia Availability of counterpart resources Access to information and communication means Intellectual property protection

Table 7.1. Key issues and factors affecting choice of technology transfer pathways.

In the process of selecting among the optional pathways, it may be useful to study the measures-results strategies that were the eventual result of the objective-tree analysis (cf. paragraph 4.1).

7.2. Financing technology transfer

In addition to the transfer of technology funded by the private sector as a part of market processes, there are a range of efforts and programmes that address and support the diffusion of technology to mitigate climate change and adapt to its consequences:

- EGTT (2009) presents an overview.
- UNFCCC has prepared a guidebook in financing technology transfer: 'Preparing and presenting proposals: a guidebook on technology transfer projects for financing' (2006).
- IPCC (2000) includes a chapter ('Financing and partnership for technology transfer', Chapter 5), which also may be consulted.

7.3. The essential role of early adopters

A key challenge in facilitating the initial diffusion is to identify candidate innovators and early adopters (cf. paragraph 2.3). Most technology transfers happen within the private sector, but governments may play a crucial role through direct support to innovators and early adopters or by duty exemptions, tax holidays or support to manufacturing facilities. Governments or local authorities may also stimulate the interest of potential early adopters, e.g. by 'green procurement'.

For the purposes of this guidebook 'early adopters' and 'prime movers' are used almost synonymously, although a distinction can be made. An early adopter adopts the new technology entirely for his or her own sake (unwillingly motivating others to follow the good example), while a prime mover actively persuades others to adopt the technology for commercial or other reasons.

Early adopters thus pave the way for the early majority (cf. Figure 2.1 (Paragraph 2.3)), often by providing a good example to their neighbours. Therefore, a high concentration of the early majority is often seen in geographical proximity to the early adopters, and from there further adoption spreads geographically. To facilitate such a development, it can thus be instrumental to motivate and support early adopters in a concentrated geographical area, in order to enhance the mouth-to-ear effect among neighbours.

In general, the emergence of a new technological system is a long, uncertain and complicated process. Since the construction of a new system often involves the destruction of an incumbent one, actors within this system can be expected to try to obstruct the development of the new one, for example in the political arena. Hence, strong actors, or groups of actors, who can promote the new technology need to emerge. In other words, 'prime movers' are key actors in the creation of new technological systems. They perform four important tasks in promoting the new technology: raise awareness, undertake investments, provide legitimacy and diffuse the new technology. The key issue is how such actors emerge (Jacobsson, 2000).

Often, prime movers are located within the capital goods industry. A strong local capital goods industry can have additional beneficial effects on the local rate of diffusion in at least three ways. First, the capital goods industry often acts as an educator of users. Secondly, a strong local supplier industry is in a favourable position to satisfy the sometimes specific demands of the local market. Thirdly, a developed supplier industry can more easily influence the institutional set-up through the sheer force of its economic importance (Jacobsson, 2000).

The role of a prime mover may be played not only by individual actors; a constellation of actors is another possibility if a number of actors share an interest in promoting a new technology. The prime movers of renewable technologies, which are often small-scale and decentralised, might be clusters of smaller firms organised in new networks, which perhaps are specific to each renewable energy technology. For instance, one could well imagine that suppliers of solar collectors form networks with construction firms, as well as with housing co-operatives (Jacobsson, 2000).

For consumer goods and non-market technologies, the innovators and early adopters are often among the young and highly educated.

7.4. Niche markets and application areas

A niche market is a focused, targetable portion of a market where new technologies can benefit from learning opportunities. A business that focuses on a niche market is addressing a need for a product or service that is not being addressed by mainstream providers or is not attractive to mainstream consumers.

In the context of TTD a niche market is a segment in which a technology which, in general may, be considered too costly or too risky may be the first choice for several customers. By focussing on such market segments, the technology infrastructure may be developed so that a broader marketing strategy can become feasible afterwards.

Ghosh (2006) suggests a possible approach which involves a focus on specific 'application areas' that satisfy a set of criteria that are critical to large-scale deployment, and then tailoring the scaling up strategy to the characteristics of the user groups for each application. Exemplified by biomass gasifiers in India, four broad application categories are suggested:

1. enhancing process-heat delivery efficiencies in small and medium-sized enterprises (SMEs)
2. substitution of traditional and inefficient biomass burning in informal enterprises
3. captive power supply in enterprises where there is an availability of excess and waste biomass, which in some cases may be cheaper than grid power and offer higher reliability
4. electric power supply in rural areas

Moving from categories 1 to 4, the technology becomes increasingly advanced, i.e. more complex, more expensive and with more market barriers.

Although, the concept of the ‘niche market’ has been developed for a market context, it may also be applied for non-market technologies, i.e. new technologies that are initially introduced in segments of the society, where the chances for success are greater than in other segments, in order to achieve a learning effect and enhance the growth of expectations. Increase in expectations arises as growing uptake reduces uncertainty and both users and suppliers become gradually more confident about the quality, performance and longevity of the technology. For example, technology target communities in each country have a unique set of characteristics in terms of livelihood strategies, access to resources and services, opportunities for diversification of livelihoods and local governance processes and structures. One aim in enhancing TTD is to demonstrate models of best practice for selected technologies in areas where there is good experience from previous development interventions that can be scaled up and replicated across a range of climate and socio-economic contexts.

The concept of ‘application areas’ is equally applicable to non-market technologies. Well-known examples are the installation of solar PV systems in remote rural settings and on islands, where the alternative energy supply is extraordinarily expensive, or where there are customers with a high willingness to pay, e.g. rural dispensaries (for vaccine cooling) and telecommunication.

Theories of niche markets and cases of best practice can be found in the strategic niche management literature.[13]

7.5. Modifying the technology

Transfer may require modification of the technology to local conditions.

IPCC: ‘*that a transfer is not achieved until the transferee understands and can utilize the technology. A test of this criterion is the ability of the transferee to choose and adapt the technology to the local socio-economic environment and raw materials, and to sell to someone the original technology with improvements*’.

[13] See, for example, http://alexandria.tue.nl/extra2/200511821.pdf and http://www.ou.nl/Docs/Faculteiten/MW/MW%20Working%20Papers/GR%2006-03%20Caniels%20en%20Romijn%20maart%202006.pdf

Thus, a potential barrier is ensuring the existence of at least one stakeholder who can take up the new technology, and a competent change agent to provide necessary technological service. This question may have been answered by the previous stakeholder analysis. Otherwise, an update would be needed, with this particular scope.

The technology may be modified without significant local capacity for technological innovation, as long as the copying capacity is adequate. But for substantial and sustainable growth and employment to happen, some innovation capacity may be required. In that case, capacity-building is a crucial determinant for success. This encompasses both human capacity (technical, financial and regulatory skills) and organizational capacity (e.g. new institutions or new regulatory frameworks). Cf. Martinot (2000), pp. 16-19.

A technological system consists of 'network(s) of agents interacting in a specific technology area under a particular institutional infrastructure to generate, diffuse, and utilize technology. Technological systems are defined in terms of knowledge or competence flows rather than flows of ordinary goods and services. They consist of dynamic knowledge and competence networks' (Jacobsson, 2000). A technological system is thus made up of a number of elements:

- actors and their competence, technical as well as other types of competence.
- networks, which constitute important modes for the transfer of tacit and explicit knowledge. Networks are conducive to the identification of new problems and the development of new technical solutions (often user-supplier networks), and more general information-diffusion networks. Being strongly integrated in a network increases the resource base of the individual firm and therefore the extent of its freedom. At the same time, the network constrains the individual firm and sets limits to its technology choice.
- institutions, which can be both 'hard' ones, such as legislation, the capital market or the educational system, and softer ones, such as culture.

The development of such a technological system should be an inherent part of the diffusion process.

Cases where capacity-building has played a pivotal role in TTD:

- hydrocarbon refrigeration in India (IEA, 2001, p. 21-24)
- energy efficiency centres in transition economies (IEA, 2001, p. 25-31)

7.6. The development of small and medium-sized enterprises

Micro, small and medium-sized enterprises (SMEs) play a central role in any economy, including adopting and diffusing new technologies. They are a major source of entrepreneurial skills, innovation and employment.[14] However, they are often confronted with market imperfections. SMEs frequently have difficulties in obtaining capital or credit, particularly in the early start-up phase. Their restricted resources may also reduce access to new technologies or innovation. Therefore, government support for SMEs is crucial.

The last ten to twenty years have revealed substantial literature on 'business development services (BDS) market development', i.e. on creating diverse, sustainable, client-responsive services even where existing markets are weak. The goal of the approach is to enable SMEs to buy services of

[14] SMEs represent 99% of all enterprises in the European Union, and the average European enterprise employs no more than six people.

their choice from a wide selection of private-sector suppliers. The role of governments and donors is seen to be facilitating this process through interventions that build sustainable market institutions and social structures – but not to undermine the emergence of these institutions and structures by directly delivering or subsidising services.

The Donor Committee for Enterprise Development (DCED; www.enterprise-development.org) has collected and published much of this literature on the inter-agency website for the exchange of information on value chains, linkages and service markets: www.bdsknowledge.org.

DCED also operates a sister website on business environment reform: www.businessenvironment.org.

7.7. Intellectual property rights

The private sector is playing an increasingly important role in international investment and technology development. This growing role has been supported by the liberalisation of markets, the development of stronger domestic legal and financial systems, and tariff reductions under the Uruguay Round of the GATT. In the context of transferring technologies related to consumer goods and capital goods, a particularly important and complex set of issues are those relating to intellectual property rights (IPRs), i.e. patents, trade secrets, manuals, copyrights and trademarks.

Overall the literature is diverse concerning the relationship between IPRs and technology transfer. Stronger IPRs may foster innovation and vertical technology transfer, but could impede the horizontal dissemination of certain technologies through private-sector and community-driven pathways.

The great majority of IPRs are owned and continues to be generated in the industrialised world. Developing countries and their companies tend to have fewer resources to purchase licences and fear that stronger IPRs will impede their access to such technologies.

The empirical literature on IPRs and technology transfer suggests the following (Hoekman, 2004):

- Patent applications from foreign nations are strongly associated with productivity growth in recipient countries.
- International trade flows, especially in patent-sensitive industries, respond positively to increases in patent rights among middle-income and large developing countries. However, trade flows to poor countries are not responsive to patent rights.
- The evidence on patents and inward FDI shows positive impacts among middle-income and large developing countries. However, in poor countries, patents do not expand FDI.
- Strengthening IPRs shifts technology transfer from exports and FDI toward licensing and positively affects knowledge inflows. These findings apply only to recipient countries with strong imitative abilities; the impact is zero in other countries.
- The sophistication of technologies transferred rises with the strength of IPR protection and domestic capacities to absorb and improve technology, as foreign firms become more willing to transact more advanced products and processes.
- The poorest countries are unlikely to benefit from strong IPRs. Stronger patent rights may be expected to raise considerably the rents earned by international firms as IPRs become more valuable, obliging developing countries to pay more for the average inward flow of

protected technology. These are also countries where technology transfer is likely to be small at best, given their limited absorptive capacity. The implications are that in poor countries policy should aim at lowering the costs of imports of IPR-intensive goods and technology, and raising the capacity to absorb and adapt technologies.

Steps governments can take to use IPRs to improve the transfer and development of climate technologies include the following:

1. The 1994 WTO Agreement on Trade Related Aspects of Intellectual Property (TRIP) is leading to increased homogeneity of laws around the world in accordance with minimum standards. Under Articles 30 and 31 of TRIP, member countries may provide for compulsory licensing of patented inventions, i.e. use the invention without obtaining permission. Generally, compulsory licensing programmes require the user first to seek a license, and if no license is given, then a limited non-exclusive right to practice the invention domestically may be awarded by the government, with an obligation to pay reasonable compensation to the patent owner.
2. Article 8.2 of TRIP recognizes that countries may wish to adopt policies to prevent the abuse of IPRs by rights holders or the use of practices that ‘adversely affect the international transfer of technology’.
3. As countries move up the income and technology ladder, they will gain more from IPRs. These are necessary for licensing and will benefit home entrepreneurs and innovators. Based on the experience of Asian economies, developing countries should adopt standards for patentability, novelty and utility that are stricter (i.e. they raise a higher bar to patenting) than those found in the United States and EU.[15] This is currently not constrained by TRIP, which does not specify any of the substantive criteria on the basis of which IPRs are awarded.
4. For some developing countries that are seeking access to patented climate technologies, one option might be for license fees to be paid for by an international funding source such as the GEF and/or through bilateral or multilateral arrangements.
5. Many of the technologies for addressing climate change are not protected. This applies both to ‘soft’ technologies, such as better energy management or agricultural practices, and ‘hard’ technologies, such as building insulation. As countries do not necessarily need cutting-edge technology to satisfy specific needs, particularly with respect to clean technologies, governments can support the exchange of public domain information regarding such technologies.

7.8. Public-private partnerships

Technology transfer aimed at fostering mitigation and adaptation responses to climate mitigation and adaptation responses to climate change will be most effective where it engages all key stakeholders in designing and implementing TTD actions.

Public-private partnerships are becoming increasingly important, because the relationship between government and private finance has changed considerably in recent years in many countries. These partnerships can involve a mixture of governments at the national and local levels, private

[15] An outstanding example is the support mechanisms managed by Japan’s Ministry of International Trade and Industry (MITI), which was established in 1949 and has contributed substantially to Japan’s transformation from a developing to a fully industrialized country.

companies, financial institutions and non-governmental organisations. Examples include voluntary agreements, technology partnerships, information dissemination to the financial sector and support for the development of innovative financial instruments. These areas have been broadly described by the IPCC (2000, paragraph 5.5.3).

Cases where public-private partnership has played a pivotal role in TTD:

- renewable energy development programme, India (IEA, 2001, p. 49-52)
- the Technology Cooperation Agreement Pilot Project (TCAPP; launched by the U.S. Government; cf. IPPC (2000, paragraph 5.5.3)).
- lessons from Thailand and the Philippines have been reported by Forsyth (2005).

Case study: GEF projects promoting renewable energy and energy efficiency

The GEF experiences of projects promoting energy efficiency and renewable energy since 1996-97 have been collated and analysed by Martinot (2000). The study assessed whether project outputs have been sustainable, i.e. have been replicated beyond the scope of the original project. Several factors contribute to project sustainability and replication:

- ability to meet user needs
- favourable technology performance
- availability of maintenance services and spare parts
- demonstrated cost recovery
- permanence and viability of new institutions
- retention of skilled personnel
- continued operation and viability of financing mechanisms or services
- participation of local stakeholders

These factors suggest that it may take several years to build up sustainable programmes.

Case study: the EC-ASEAN Cogen Programme

A long-term agreement between the European Union (EU) and the Association of Southeast Asian Nations (ASEAN) dating back to 1980 was established with the aim of increasing economic cooperation between these regions. Within this overall framework, the EU–ASEAN Cogen Programme was completed from 1991 to 2004, with the purpose of enhancing the adoption and diffusion of proven biomass cogeneration technologies from Europe into ASEAN countries. As such, the programme provides an appropriate and successful example of an international cooperative initiative with the objective of continuing to increase the adoption of low-carbon technologies in the energy sector of certain developing countries.

The objective of the EU–ASEAN Cogen Programme was to develop national planning capacities to adopt similar initiatives through the provision of technical assistance to relevant institutions in the process of implementing the program. It also aimed at facilitating and providing business opportunities for private companies in both regions to engage in technology transfer activities. The programme focused particularly on the implementation of cogeneration technologies in the ASEAN wood and agro-industries, utilizing biomass residues from these industries in order to substitute fossil fuels in their energy consuming processes.

The first phase of the program (1991–1994) was an identification phase for what was to become Cogen II. It aimed at increasing the awareness of EU technologies in the ASEAN market and providing information to EU suppliers for the opportunities in ASEAN. The first phase, however, also succeeded in implementing seven demonstration projects.

The second phase (1995–1998) focused on the completion of 16 full-scale demonstration projects promoting further reference projects. The Cogen coordinating team worked as a business facilitator and thereby laid the basis for an accelerated dissemination of biomass cogeneration technologies in Cogen III through already established company relations.

The purpose of Cogen III (2002–2004) was to secure further deployment and demonstrate the ability to replicate such initiatives in ASEAN. Eight additional projects were implemented, most with a higher capacity than the earlier projects. Training and capacity building of representatives from private companies and government agencies was a central aspect. To this end, a number of seminars, conferences, matchmaking events, site visits and individual consultations were provided by the Cogen team. Strategic management tools and models for the purpose of coordinating efficient implementation of future projects were also introduced.

8. Overcoming barriers: a brief summary

This guidebook has addressed the process of overcoming barriers to the transfer and diffusion of technologies. Although there is no pre-set answer to enhancing technology transfer and diffusion, the present chapter summarizes some general recommendations on how the opportunities for successful technology transfer and diffusion may be increased.

1. For several technologies the challenges may be immense, conceived as next to impossible to overcome, so for the purpose of gradually increasing the learning of how to facilitate the actual transfer and diffusion of technologies, it is recommended that the TNA Team begins with technologies that only need modest government intervention to become successfully transferred and diffused, in order to achieve positive experiences with the entire process and to avoid frustration from aborted attempts.[16]

2. Identification of barriers can be done quickly by taking inspiration from a gross list, as in Annex A. However, it is advised: 1) to conduct a desk-study of policy papers and other pertinent documents to identify the primary reasons why the technology is not currently in widespread use; 2) to supplement this with expert and stakeholder interviews (either directly or by using questionnaires); and 3) to conduct a workshop with key stakeholders (Chapter 3). Then Annex A can used for checking whether any essential barriers have been forgotten or ignored.

3. The next step is to analyse the identified barriers. This can begin by ranking the barriers according to significance (paragraph 3.3) and/or classifying them into a hierarchy of categories (paragraph 3.4).

4. More important is to understand the linkages between barriers, including which barriers are symptoms of problems and which are 'true' problems. For this purpose, root cause analysis (paragraph 3.5) may be applied. A cheap solution is to let the TNA Consultant do the analysis, but a better result can be achieved by involving stakeholders in a half-day workshop. A more thorough approach is to do a Logical Problem Analysis (paragraphs 3.5 to 4.1). This will need about a full-day's workshop, but an added benefit is that this method can also be used to translate the problems into solutions. In doing so, by the end of the day stakeholders' views will have been collected on which measures are needed to overcome the barriers.

5. It can be quite useful to distinguish between measures and incentives in order to ensure that the people involved are thinking in terms of concrete solutions. A measure is understood here as an actual change in the real world to achieve a goal, whereas an incentive is an instrument that makes the measure happen (cf. paragraph 4.2).

6. In order to prepare an optimum selection of measures and incentives by policy-makers, they should be assessed, i.e. their potential benefits should be compared with their potential effects (paragraph 4.2). Most important is to assess the economic consequences for the society (a socio-economic assessment) and for the owners and users of the technology (a financial assessment). If the result of an assessment shows that it is not feasible or otherwise acceptable to transfer and

[16] If, for example, a government wishes to promote the diffusion of solar photovoltaic technologies for electricity generation, this will be easier for off-grid solar home systems than grid-connected systems, since the latter may be less feasible economically and also involves extra challenges in elaborating grid-connection rules and a tariff system.

diffuse a particular technology, it may be necessary to review the identification and prioritisation of technologies and go through the subsequent steps once again.

7. To prepare the ground further for policy decisions, measures and incentives should be classified according to who is to take action and who is to pay (paragraph 4.3).

8. Steps 1-7 are general steps, which may be applied for every technology, but technologies are different, and steps 9-11 may be conducted prior or parallel to the barrier analysis described in Chapters 3 and 4, both to strengthen that analysis and to prepare the subsequent steps 12-15.

9. For a technology that is transferred through a market chain, it is suggested that an analytical tool be used to understand properly the market system prior to the analysis of barriers hindering the introduction of the technology into the local market. It is recommended to use the Market Mapping approach (Chapter 5) for consumer goods and capital goods. The need for a thorough market assessment is not equally important for public goods.

10. A quick and cheap solution is to produce a preliminary market map (paragraph 5.4). This can be produced by the TNA consultant using existing literature and information gathered from key informants. But if there are sufficient budget and time, it is suggested that the participatory market approach be applied (paragraph 5.5), involving the market players. In this way, the market map will be of better quality. But more importantly, the participatory market chain approach can facilitate the collaboration that is necessary for bolstering trust and improving linkages and efficiencies within the market chain, as well as for effective lobbying on business environment issues and in coordinating activities. An essential outcome of the overall process is the possible creation of a network among the market actors themselves, improving the ground for introducing or generating innovation in products, processes and market access. Thus, this approach will be part of the solution, not only an analytical tool.

11. A different approach is needed for public goods and non-market technologies. The transfer of technologies in the ‘public goods’ category is simpler than for ‘consumer goods’ and ‘capital goods’ (paragraph 6.1). For non-market technologies it is of particular importance to take adequate account of the technology receivers (paragraph 6.2).

12. When an international transfer of the technology is needed, a proper pathway for the transfer should be selected, e.g. foreign direct investment or trade in goods or knowledge (paragraph 7.1). Experience does not provide unambiguous guidance, but there are some ‘rules of thumb’, in particular regarding what appears to be most appropriate for middle-income developing countries and the poorest countries respectively. The role of government is to ensure the enabling policy framework.

13. In preparing the diffusion of the selected technology, it is often essential that both the demand for and the supply of the technology is nourished. To support the demand side, it is recommended to focus substantial attention on the most critical phase of diffusion, the so-called ‘take-off’ (cf. Paragraph 2.2), in particular by identifying candidate early adopters (paragraph 7.3). These may be found in particular niche markets (paragraph 7.4), or they may be more dispersed.

14. In support of the supply side, it is recommended that the technology be modified so that it adapts to the local socio-economic environment. To do this with local resources requires a

technological system of both human and institutional capacity (paragraph 7.5). A comprehensive technological system is not built overnight, but the specific capacities related to the particular technology may be sufficiently enhanced within a time frame which is appropriate for the technology transfer in question. For this purpose, a carefully tailored capacity development programme is needed.

15. Highly dependent on the type of technology, the supply side may also be supported by improving the business development services for small and medium-sized enterprises (paragraph 7.6), supporting domestic companies in solving issues related to intellectual property rights (paragraph 7.7) and fostering public-private partnerships (paragraph 7.8).

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Annex A. Generic barriers to the transfer and diffusion of climate technologies

This annex presents a gross, but not exhaustive list of generic barriers, based on a range of sources.

Barriers can be explored and analysed at four levels (Painuly, 2001):

1. broad **categories** of barriers (e.g. economic and financial)
2. **barriers** within a category (e.g. high cost of capital)
3. **elements** of barriers (e.g. high interest rate)
4. **dimensions** of barrier elements (e.g. 15 % per annum for households)

For some categories it may be useful to insert a fifth level between levels 1 (category) and 2 (barrier), grouping barriers with common features in clusters. However, a four-level categorization has been used consistently in this Annex.

The definition of categories is very much a matter of taste and can therefore be done in numerous ways. ENTTRANS (2007) categorized all barriers according to the different aspects of the market map: market chain aspects, enabling environment aspects, and support services aspects. The categories used in this annex are more in line with traditional thinking. A central consideration has been to formulate a system, which is practical in relation to bringing the technology transfer process forward.

The distinctions between the categories are not clear cut and cannot be, simply because there are essential overlaps and linkages. For example, institutional and technical barriers will sooner or later appear as economic and financial barriers. Description of such complexity is difficult, and the system of categories has primarily been defined for ease of presentation – and hopefully for ease of understanding.

A way to use the barrier list is first to do your own barrier identification, and afterwards to use the list for checking whether any essential barriers have been forgotten or ignored.

The following format is used:

Barrier category

Barrier

Barrier element

- with explanations in parenthesis (…).

The fourth level, dimensions of barrier elements, has been left out.

1. Economic and financial

Lack or inadequate access to financial resources

Lack of financing instruments and institutions

Under-developed or distorted capital market (poor creditworthiness, poor recovery regulations)

Lack of venture capital

Lack of access to credit for certain consumers

High cost of capital

- Scarcity of cheap capital (high interest rates due to high risk perception by financial institutions)
- Government policies on cost of capital (e.g. high tax on profits)

Financially not viable

- High up-front costs
- High resource costs (material, labour, capital)
- High modification and implementation costs
- High discount rates (customers have a strong preference for the money they have today over the same amount of money tomorrow; in particular, private manufacturers and very poor people have a short economic horizon, while utilities have a longer horizon; discount rates for climate technologies may be higher than usual due to risk or uncertainty being perceived as high)
- Use of payback time criterion limits consideration of overall economic lifetime benefits
- Low affordability amongst rural and peri-urban dwellers
- Inadequate resource base (due to actual lack or fierce competition for resources)

High transaction costs

- Gathering and processing information (feasibility studies; due diligence)
- Technology acquisition, implementation etc.
- Bureaucracy, procedures and delays
- Costs underestimated in economic analysis

Inappropriate financial incentives and disincentives

- Favourable treatment to conventional energy and large-scale projects (subsidies, low taxes)
- Insufficient incentives to develop climate technologies
- Split incentives (the decision-maker, e.g. a property developer of collective dwellings, receives little or no incentive, whereas the users, e.g. the tenants, receive the benefits of energy savings)
- Non-consideration of externalities (negative externalities (pollution, damage from this) from conventional energy not considered in pricing, positive impacts of climate technologies not valued)
- Taxes on climate technologies (high import duties on equipment, duty exemption limited to small products, other direct or indirect taxes on climate technologies)
- Difficult or expensive to export profits
- Non-tariff barriers on import/export of climate technologies
- Consumers pay below marginal cost
- Average cost pricing is done

Uncertain financial environment

- Uncertain electricity tariffs (e.g. non-transparent tariff adjustment procedure)

Uncertain macro-economic environment

- Volatile inflation rate and high price fluctuations
- Unstable currency and exchange rates
- Balance of payment problems and uncertain economic growth.

2. Market failure/imperfection

Poor market infrastructure

- Poorly articulated demand
- Difficult procurement (by consumers; e.g. inconvenient product location)
- Missing or under-developed supply channels (e.g. logistic problems)
- Disturbed or non-transparent markets
- Lack of liberalization in energy sector
- Mismanaged energy sector

Underdeveloped competition

- Insufficient number of competitors (property developers and rental market have no incentive to invest)
- Regulations prohibiting entry in the energy sector
- Unwieldy requirements for entry
- Lack of level playing field (fair competition)
- Market control by dominant incumbents implies that the selection process may not involve a free choice by customers.

Restricted access to technology

- Technology not freely available in the market
- Lack of product visibility

- Technology developer not willing to transfer technology
- Problems in import of technology or equipment due to restrictive policies, taxes etc.

Inadequate sources of increasing returns
- Economies of scale and experience for new technologies cannot be achieved
- Economies of scale only at high investment level
- Market size small (small market potential, low density of consumer demand, limited or difficult access to international market)
- Low ability or willingness to pay among consumers

Market control by incumbents
- Well-established and more competitive or cheaper alternatives
- Barriers created by existing suppliers.
- Monopolistic or quasi-monopolistic utility model (prevents new market entrants)

Lack of reference projects in country

Unstable market situation, which hinders the procurement of international technological investment from donors

Fair trade policies

3. Policy, legal and regulatory

Insufficient legal and regulatory framework
- Absence of laws and bylaws on climate technologies (contract law, IPR protection)
- Complex procedures, e.g. power generation permits, custom formalities
- Legislation may favour incumbent technology
- Lack of governmental faith in climate technologies, unsupportive policies,
- Inadequate or unwieldy regulations for climate technologies
- Lack of coherent economic policies (e.g. alignment of fiscal policy with tax regimes)
- Absence of plans and programmes (e.g. rural electrification plan or programme)
- Inappropriate balance between the protection of IPR and the promotion of technology transfer
- Unclear arbitration procedures

Inefficient enforcement
- Missing or ineffective executive and regulatory bodies
- Insufficient willingness or ability to enforce laws and regulations
- Lax attitude

Policy intermittency and uncertainty
- Uncertain governmental policies (= political risks for investors)
- Lack of long-term political commitment
- Stability of laws (frequent amendments)

Clash of interests (struggle in the political arena between proponents of new and incumbent technological systems)
- ESTs go against the perceived interest of the dominant actors in the sector
- ESTs perceived as a threat to utility monopoly and to utility profit

Highly controlled energy sector (may lead to lack of competition and inefficiency)
- Government or utility monopoly of energy sector
- Private sector entry restricted (e.g. independent power producers)

Red tape (bureaucracy)

Rent-seeking behaviour and fraud

4. Network failures

Weak connectivity between actors favouring the new technology
- Stakeholders dispersed and poorly organised
- Multiple stakeholder collaborative learning and knowledge transfer activities absent or weak
- Insufficient coordination between relevant ministries and other stakeholders
- Insufficient cooperation between industries and R&D institutions
- Absence of trade associations and effective consumer bodies (problems and views on barriers cannot reach the policy-makers effectively; no or weak lobbying to facilitate technology transfer)

- Incumbent networks are favoured by legislation etc.
- Difficult access to external manufacturers
- Lack of involvement of stakeholders in decision-making
  - Stakeholders’ consultation culture missing
  - Difficult communication
  - Fear of opposition

5. Institutional and organisational capacity

- Lack of professional institutions
  - Lack of institutions or mechanisms to generate and disseminate information
  - Lack of institutions to promote and enhance market
  - Need for specialized agencies at planning level and operational level (ESCOs)
  - Lack of a regulatory body in the energy sector
  - Lack of institutions to support technical standards
- Limited institutional capacity
  - Lack of interest or capacity in existing institutions
  - Limited institutional capacity to solicit ideas and encourage potential entrepreneurs
  - Limited R&D culture (R&D facilities missing, lack of capacity for R&D, lack of appreciation of R&D role in technology adaptation)
- Small size of local companies (limited ability to absorb new techniques and information)

6. Human skills

- Inadequate training facilities
  - Lack of experts to train
  - The educational system may fail to react quickly enough to the emergence of new generic technologies
- Inadequate personnel for preparing projects
  - Lack of domestic consultants (to reduce transaction costs)
  - Lack of experts in negotiating IPR contracts
- Lack of skilled personnel for the installation and operation of climate technologies
  - Lack of entrepreneurs (relatively low profitability, unwieldy or restrictive regulations; may lead to lack of competition and supply constraints)
- Lack of service and maintenance specialists

7. Social, cultural and behavioural

- Consumer preferences and social biases
  - Aesthetic considerations, product lacks appeal
  - High discount rates of consumers (mentioned under ‘Economic and financial’)
  - Lack of social acceptance for some climate technologies (e.g. landfill or manure gas for cooking may not be acceptable)
  - Technology stigmatisation (a technology is perceived as ‘for the poor’, e.g. mud-stoves)
- Traditions and habits
  - Resistance to change, due to cultural reasons
  - Need for users to modify behaviour (e.g. solar cookers certainly require people to modify their cooking habits)
- Lack of confidence in new climate technologies
  - Unknown product, due to inadequate information, lack of local participation
  - Technology seen as alien and of no use
- Dispersed or widely distributed settlements
- Inadequate understanding of local needs
  - Lack of stakeholder involvement
- Gender participation

8. Information and awareness

- Inadequate information
  - Poor dissemination of information to technology users (on product, benefits, costs, financing sources, potential project developers etc.)
  - Poor infrastructure for communication of small-scale project support
  - Lack of market information
  - Lack of knowledge or access to climate technologies resource assessment data, implementation requirements
  - Lack of agencies or agencies ill-equipped to provide information
- High risk perception of climate technologies
  - Uncertain new technology
  - Uncertain benefits
  - High investment risks
  - Irreversibility of investment and a lack of flexibility of plant and machinery for other usage
  - Perception of complexity
- Lack of media interest in promoting technologies
- Language
- Feedback mechanism lacking or inadequate
- Lack of awareness about issues related to climate change and technological solutions

9. Technical

- Product not reliable
  - Lax quality control
  - Poor documentation of reliability
  - Need to modify and demonstrate unfamiliar products to local conditions
- Poor O&M facilities
  - Lack of skilled personnel
  - Slow after-sales service
  - Limited availability of spare parts (few suppliers, long supply routes)
  - Need to import spare parts
- Inadequate standards, codes and certification
  - Lack of institutions or initiatives to set standards
  - Lack of facilities for testing and certification
  - Insufficient quantity and quality of controlling and measuring equipment
  - Standards not obligatory
- Technical risks
- Uneven technical competition
  - Lack of scale and experience
  - Poor performance in relative terms
  - Weak infrastructure (ESTs may need strong physical infrastructure such as roads and electric grid)
- System constraints
  - Capacity limitation with grid system (e.g. intermittent RET electricity)
- Complexity of new technology, insufficient expertise

10. Other Barriers

- Environmental impacts
  - Local pollution
  - Ecological aspects
  - Competition for resources
- Divergent plans, incentive structures and administrative requirements from different donors, finance institutions and government branches

Annex B. Technologies for climate adaptation

Till now most interventions and discussions regarding the transfer of climate technologies have focussed on mitigation technologies, one reason being that many professionals have only a vague idea of what adaptation technologies actually are. In the context of this guidebook, it therefore appears relevant to facilitate a clearer and more concrete understanding of adaptation technologies: what are they, and which particular features necessitate diverging approaches?

Adaptation is defined as initiatives and measures to reduce the vulnerability of natural and human systems against actual or expected climate change effects. Various types of adaptation exist, e.g. anticipatory and reactive, private and public, and autonomous and planned. Vulnerability is the degree to which a system is susceptible to, and unable to cope with, the adverse effects of climate change, including climate variability and extremes. Vulnerability is a function of the character, magnitude and rate of climate change and variation to which a system is exposed, its sensitivity and its adaptive capacity.

The vulnerability and capacity of societies to adapt to climate variability and change is determined by a number of different factors, such as income levels, education, institutions, health status, knowledge, and skills and technology, to mention just a few. Consequently, most adaptation measures are carried out as part of larger sectoral or national initiatives involving, for example, planning and policy development, integrated coastal zone management, water resource management, health programmes etc. On the other hand, actions which contribute to adaptive capacity may also be unrelated to climate change concerns, for example, education and poverty reduction. Consequently, the strengthening of adaptive capacity is a precondition for the design and implementation of adaptation strategies, and technology is one among many elements that are commonly scarce in a developing country setting.

Nationally, many countries have conducted vulnerability and adaptation needs assessments as part of their National Communications, proposed adaptation projects for funding in National Adaptation Programmes of Actions (NAPAs), and made submissions on approaches and strategies for adaptation under the Nairobi Work Programme. Furthermore, some TNAs have been conducted that include climate change adaptation. These activities, conducted at the national level, provide essential background materials and a starting point for more specific and improved technology needs assessments for climate change adaptation. However, aspects of technology needs assessments in the area of adaptation to climate change are relatively little developed, and there are a number of prevailing challenges.

Although most initiatives and measures for adaptation to climate change involve some form of technology, adaptation issues are rarely characterized along technology lines. Also, given the blurred boundaries between adaptation and sustainable development, few technologies can be defined as technologies for adaptation per se, with the exception of genetically designed seed varieties and coastal engineering technologies.

A common practice of mitigation has been the transfer of technologies from developed to developing countries. Transfers for adaptation may not follow the same patterns. Climate adaptation is often the continuation of an ongoing process in which the same techniques for adaptation have been used for generations (as, for example, building houses on stilts to cope with floods), but face barriers to their further implementation and use. Recognizing that adaptive capacity is highly heterogeneous within a society or locality, much of the current understanding of human adaptation to climate change comes from local-level studies. Such studies can establish broad lessons on the adaptive capacity of individuals and communities, lessons that feed into adaptation planning. In many cases, adaptation technologies already exist to some extent. Examples include addressing the changing climate by storing water in dams so that it can be available during drought periods, or improving seed varieties with traits to improve their tolerance of stress, salinity, drought and extremes of temperature.

The entry point for identifying, prioritizing and implementing adaptation technologies is primarily impact assessments and their inter-linkages with development priorities, where the most vulnerable sectors and regions or communities constitute the basis for adaptation technology assessments. A number of climate-risk screening tools, approaches and exercises have been developed to support efforts in mainstreaming climate change into development planning, including guidance on the identification, prioritization and implementation of adaptation options. A good overview of existing tools and their applications is provided in Olhoff (2010).

A sector categorization is most commonly used when addressing technologies for adaptation, which is why it is the one chosen for the TNA guidance for adaptation. Table B.1 below provides a comprehensive list of adaptation technologies for different sectors.

Sector	Adaptation technologies
Agriculture	Systematic observation and seasonal forecasting, introduction of drought-resistant crops, crop management, land management, improved water use and availability, including rainwater harvesting, leakage reduction, hydroponic farming, building of shelter-belts and wind-breaks to improve the resilience of rangelands, capacity-building of local authorities, adjustment of planting dates and crop variety, spatially separated plots for cropping and grazing to diversify exposures, early warning systems.
Water resources and hydrology	Water transfer, water recycling and conservation (soft technologies to support the preparation of on-line, searchable flood-risk maps), water harvesting, increase reservoir capacity, desalination, erection of protection dams against avalanches and increased magnitude of potential debris flows stemming from permafrost thawing, changes in livelihood practices (e.g. by the Inuit), including changing hunt locations, diversification of hunted species; use of Global Positioning Systems (GPS) technology; encouragement of food sharing.
Coastal zones	Dykes, sea-walls, tidal barriers, detached breakwaters, dune or wetland restoration or creation, beach nourishment, indigenous options such as walls of wood, stone or coconut leaf, mangrove afforestation, early warning and evacuation systems, hazard insurance, practices such as using salt-resistant crops, building codes, improved drainage, desalination systems.
Health	Vector control, vaccination, impregnated bed nets, health education, greater care with water storage, using appropriate clothing, taking siestas in warm climates, using storm shelters, air conditioning, health education, early warning systems, implementation of heat health alert plans, including measures such as: opening of designated cooling centres at public locations; information to the public through local media; distribution of bottled water to vulnerable people; operation of a heat information line to answer heat-related questions; availability of emergency medical service vehicles with specially

	trained staff and medical equipment; disease monitoring and prevention and treatment, access to health services and health alert information
Infrastructure	Urban planning to improve the efficiency of combined heat and power systems and to optimize the use of solar energy, minimize paved surfaces and plant trees to moderate urban heat island effects and reduce the energy required for air conditioning, limit developments on flood plains or potential mud-slide zones, establish appropriate building codes and standards, provide low-income groups with access to property, use physical barriers to protect industrial installations from flooding, climate proofing of investments.
Forest and ecosystems	Supporting implementation of adaptation technologies, modelling movements of species due to climate change and the vulnerability of habitat to rises in sea level.
Finance	Internalise information on climate risks and help transfer adaptation and risk- reduction incentives to communities and individuals: Capital markets and transfer mechanisms alleviating financial constraints to the implementation of adaptation measures, including bank loans, e.g. for purchase of rainwater storage tanks, setting up crop insurance; creation of local financial pools (as alternative to commercial crop insurance), setting up revolving credit funds, fostering risk prevention through implementing and strengthening building standards, planning risk-prevention measures, developing best practices, and raising awareness of policyholders and public authorities. Adopting forward-looking pricing methods in order to maintain insurability (not yet implemented).

Table B.1. Examples of adaptation technologies for different sectors (source: WTO-UNEP Climate change and trade, 2009)

Table B.1 illustrates the wide range and multifaceted nature of available options for adaptation in different sectors. It is also clear from the above that many adaptation technologies are not new and that many have been utilized for generations to cope with climate variability and improve livelihood resilience to socio-economic stresses.

Other categorizations may, however, be more appropriate in different contexts, e.g.:

a. When in the adaptation process they are implemented; technology needs for *anticipatory adaptation* may be different from the ones suitable for *reactive adaptation*.[17]
b. The innovation level of the technology, including: (i) *traditional technologies* which by definition relate to familiar methods and techniques to cope with climate variability at the community level that have been tested for generations; given their local and historical roots, it is recommended that these be taken into account as much as possible; (ii) *modern*

[17] Anticipatory adaptation includes measures such as crop and livelihood diversification, seasonal climate forecasting, community-based disaster risk reduction, famine early-warning systems, insurance, water storage and supplementary irrigation. Reactive or ex-post adaptation measures include emergency response, disaster recovery and migration-reactive or ex-post adaptations, for example.

technologies, for example, new crop hybrids and systems of drip irrigation making better use of limited water; and (iii) *future technologies*, for example, malaria vaccine.

c. The climatic zone in question: tropical, arctic, floodplain, mountains etc.
d. The actors involved: individuals, community organizations, private sector, local government, international donors etc.

Annex C. Incentives to diffuse renewable energy technologies

Incentives to promote the diffusion of technologies are often sector-specific, and it therefore makes little sense to describe incentives in generic terms. Nevertheless, many incentives can be used in several sectors. As one example of a taxonomy of incentives, this annex focuses on renewable energy technologies.

There are several types of incentive, e.g. financial and non-financial, and incentives are targeted at different sections of the energy sector, e.g. the supply side and the demand side.

In practice various incentives are often introduced simultaneously so that they supplement one another. For instance, the effect of a new tax on electric water-heaters can be increased by simultaneously offering consumers information on solar water-heaters.

All relevant parties in the different areas of supply and demand must be actively involved when incentives are being formulated and combined. Otherwise, important opportunities could remain untapped.

The following main points should be taken into consideration when selecting incentives:

- The incentives should be as cost-effective as possible both for the energy sector and society as a whole.
- As far as possible the incentives should be self-regulating and independent of bureaucracies. Where possible new initiatives should be based on and interact with the interests and the technical, economic and organisational resources of the different parties themselves.
- The incentives should aim at ensuring a gradual shift in the existing energy system, so that no sudden or considerable difficulties appear in any of its sectors.

These main considerations are not always compatible. For this reason, selecting the incentives, their formulation and administration requires careful balancing of the various considerations.

Financial incentives

It is not only important that renewable energy use be increased, but also that this growth be sustainable. Large subsidies can foster a tremendous use of renewable energy, but since most subsidies are not sustainable, it is important for the technologies to become cost-competitive for sustainable and commercial markets to be developed.

If the goal is to *maximise renewable energy generation*, then a fixed incentive or set-aside should apply to all technologies. This minimises the incentive payments for the maximum use of renewable energy, and it allows for future cost reductions of technologies which are currently too expensive to be deployed. This would encourage biomass power, but solar PV, solar thermal electric or wind would not be deployed until cost-competitiveness was reached through decreasing technology costs or the discovery of excellent resources. Because this goal is not technology-specific, it allows for a new renewable energy technology to come on board and does not compel the use of expensive technologies or inadequate resources.

If the goal instead is to deploy and *begin the commercialisation of certain technologies*, then individual incentives or set-asides can be set for each technology. As an example, small incentives could be used to promote biomass power, with much larger incentives for more costly yet still promising technologies such as PV. This is a more costly and comprehensive program that should be carefully assessed, because the amount of funding needed to make PV cost-effective for utilities is quite high on a per MW basis in comparison to biomass.

One incentive (likely to be a financial incentive) is likely to be the primary driver for renewable energy development. Supporting incentives will be needed to fill the remaining gaps in overcoming barriers to the development of renewable energy. For instance, a primary incentive which focuses on overcoming the cost-effectiveness barrier may still need financing mechanisms to overcome the high capital investment barrier.

There are many methods for governments to promote renewable energy. A summary is presented in the table below.

Tool	Advantages	Disadvantages
Production incentives	Easy to implement Easy for developers Encourages renewable energy production.	Does not directly address high first cost barrier Can be abused if incentive too high
Investment incentives	Overcomes high first cost barrier	Encourages investment, not production
Renewable Set-Asides	Allows control over amount of renewable capacity added, Competitive bidding encourages cost reductions	Can be very bureaucratic. Bids may be controlled by one entity May lead to lumpiness in installations
Power Purchase Agreements	Long-term, standard agreements help developers and facilitate investment	Difficult to achieve when the electricity supply industry is in the process of restructuring
Environmental Taxation	Correct energy prices, including costs of environmental impacts, provide a more level playing field for renewables	Taxes are often politically unfavourable
Externality Adders	Allows for full-cost accounting in power planning	Implementation does not always follow planning
Research, Development and Demonstration	Builds long-term foundation for technological and industrial development	Difficult to pick a technological winner to invest RD&D in

Tool	Advantages	Disadvantages
Government Assisted Business Development	Builds market infrastructure	
Green Marketing	Allows choice in power purchases	May be under-subscribed

Of these, the methods that have been most successful in promoting renewable energy development are investment incentives, production incentives and set-asides. Some options, such as environmental taxation, RD&D and green marketing, have been helpful, but have not had the same impact. Other options, such as the establishment of standard power purchase agreements, may be a necessary condition for renewable energy promotion, but they may not be sufficient.

Production incentives

A production incentive provides a financial incentive for the generation of electricity from renewable energy. Some of the problems with this approach include the disincentive for cost-competitiveness. One way to finesse this is to design a diminishing incentive over time. Another way to limit excessive profits is to give an incremental subsidy above conventional energy costs.

If a production incentive is used, it is recommended that:

1. The level of a production incentive should be carefully designed to encourage cost-competitiveness and efficiency in power production. This could be a function of technology, location and time of generation. The electricity regulator would have to set this in a way that encourages least economic-cost electricity generation. The full avoided economic cost of generation would be the ideal level for this production incentive. As a starting point or in the absence of quantified external costs, purchase by the generator of negative units at the wholesale electricity price could be considered. The purchase of negative units at the applicable wholesale tariff would effectively mean sale by the generator of the units at the same price as the wholesale tariff (including whatever time of use or other structure the tariff might have). There would be no premium to the renewable energy (RE) generator per unit, nor any profit to the distributor reselling the units. In this way, there is no difference between the price paid to the generator and the price at which the distributor sells the electricity. The distributor would have to be obliged or given some other incentive (like green pricing) to buy this energy.
2. The program should be periodically monitored and evaluated to readjust the incentive level in order to encourage renewable energy generation and discourage abuse of the incentive.
3. The incentive rules and regulations should be clearly stated so that developers and investors can easily develop projects and acquire financing.

The production incentive also does not necessarily offset the large capital investments and correspondingly high initial risks of renewable energy development. In order to deal with these problems, supporting incentive measures, such as long-term, standard power purchase agreements and special financing mechanisms may be necessary. These are discussed in the next section.

Power purchase agreements

Clearly, one of the most important mechanisms for grid-connected renewables is the establishment of standard, reliable, long-term power purchase agreements. This is a key component for the success of renewable energy on the grid. It must be clear to the private sector and their financiers that they can hook up their power plant to the grid and receive a certain payment for energy over a set period of time.

In a period in which the electricity supply industry and/or the electricity distribution industry is being restructured, it may be very difficult, if not impossible, to obtain long-term contracts.

Investments subsidies

Investment subsidies and tax credits have proved easy to abuse and have been replaced with other types of incentives in some countries. Therefore investment subsidies generally should not be used as a primary driver for renewable energy development. Investment subsidies are notable for overcoming one of the main barriers to renewable energy: high capital investment costs. However, financing mechanisms (access to credit, revolving credit funds, soft loans, etc.) can also overcome this barrier and are less conducive to abuse. Investment subsidies may still be very useful in promoting small-scale technologies for residential and small commercial or industrial enterprises, which have little access to good financing. If they are to be used, very careful oversight is necessary to guard against abuse.

Investment subsidies encourage the installation of renewable energy capacity. But if the power plants are sited in areas where resources are not good, if proper O&M is not carried out, or if bad designs are installed, then the result could be a large amount of installed capacity but little electricity generated.

Loan guarantees

The high investment costs of renewable energy are a significant barrier, and the finance sector needs to be examined to determine whether special finance mechanisms are needed. This will be especially necessary if investment subsidies are not used. With the recent economic crisis, preferential finance for power plants and preferential loans or tax breaks for renewable energy businesses may be necessary to encourage the private sector. Along these same lines, loan guarantees can help to reduce the financing risks and thus lower costs.

Set-asides

A set-aside is a block of energy supply, e.g. 50 or 200 MW, that is earmarked for renewable energy capacity. A transparent solicitation procedure can be used to select the most competitive projects, or standard offers can be set, with energy suppliers meeting capacity on a first-come, first-served basis.

Such a demonstration programme on a limited scale can be done without either setting unwarranted precedents or changing the current cost of electricity.

The establishment of full-scale demonstration projects will fulfil several objectives:

- significantly help resolve the concerns of energy-sector stakeholders
- support the practical learning processes
- bring international technology and experience to the country
- create show-cases for the country’s citizens for how clean air, clean water and sustainable energy systems can be obtained

The winning projects will receive financial support, e.g. a subsidy per kWh or a guaranteed fixed electricity tariff, to ensure attractive paybacks.

To prepare a bid for power capacity requires that the project be fully developed to the stage of banking and contracting with potential electricity buyers. This preparation can be very costly. Therefore it is very important that the bidding conditions are clear and reliable, so that the bidders can trust that their bids will be treated fairly and that the conditions offered are stable and viable. The bidding process should therefore go through a pre-qualification stage before real bids are invited. During the pre-qualification process, the bidders will outline their project, justify the fuel resources available and prove the investor’s financial viability.

Many project developers can be predicted to face a lack of available expertise for solving the unfamiliar technical problems related to the project preparation phase. It is therefore recommended to establish a team of experts to assist the bidders with information and counsel to help increase the quality of the tenders. The team should be established as a special unit within the responsible ministry.

The services offered to project developers may take the form of either direct technical assistance or financial assistance to employ a consultant to carry out a pre-feasibility study.

The technical assistance should comprise:

- resource availability analysis, e.g. availability of bagasse as a reliable fuel.
- legal and regulatory issues
- commercial issues (power purchase agreements, fuel contracts)
- financial issues; as some developers (power companies, multinationals) have ready access to cheap finance, whereas typical RE owners (e.g. a sugar factory or a wood industry) can only obtain much more expensive finance, the special unit could provide guidelines for project financing, including financial risk assessment
- sector experience
- technical issues (e.g. available cogeneration technologies, contacts to equipment suppliers, complementary fuels)

To ensure sufficient diversity of the programme, the projects may be grouped into separate categories, so that no one technology will eclipse the others. The programme may, for example, distinguish between the following technologies:

- bagasse-fired combined heat and power production (CHP) plants
- CHP’s in the wood and pulp industry
- wind farms
- mini hydro

- micro-hydro
- solar thermal power generation

Among the problems identified with current set-asides include bureaucratic and expensive bidding processes, with a ‘lumpiness’ in installations, discouraging development of the less mature technologies.

However, the benefits of this mechanism may be worth the trouble to implement them. The key advantage of using a competitive set-aside is that it encourages cost-competitiveness with regard to renewable energy technologies. This is important because, in addition to reducing the cost to the utility and end-user, it also demonstrates to government policy-makers and the public that renewable energy technologies can become cost-effective. Another important advantage is that the government can easily determine and control the installed capacity of renewable energy generation.

Green marketing

Green pricing programs allow specified types of generators, determined by size and type of energy used, to obtain a higher payment than is generally the case. The extra costs to the utility are recovered through a special sales tariff for green electricity, which is offered to customers wanting to support renewable energy through their energy bill.

Green marketing appears to be effective in some countries and is becoming increasingly popular. However, it perpetuates the idea that renewable energy is expensive and needs support. It does not aim to decrease the cost of renewable energy, but may coincidentally have this effect in real terms in the long run.

The motivation for setting ‘green tariffs’ is based on the assumption that there are certain electricity customers who would be willing to pay a premium for electricity produced in a way which is deemed environmentally sustainable. This financial incentive should be provided for the generation of green energy. An alternative to a green tariff is to increase the taxed component of non-sustainable energy, thus raising electricity tariffs to the point where green-generated energy becomes cost effective.

This offers a unique opportunity to developers of independent power producers (IPP) in that, by virtue of the higher tariffs, the income stream from a sustainable energy plant can exceed that of other generation options and offers the potential to increase the profitability of the project. If the capital and operational costs of two different IPP plants are equal, but one can sell its electricity at a higher tariff by generating it in a sustainable manner, the green option will be the preferred one. It was indeed this mechanism which was used as an incentive for the development of much of Europe’s renewable energy IPPs.

In order to market green energy, a number of criteria must first be satisfied.

- the electricity generation sector must be open to competition
- the transmission system must be accessible to all suppliers
- electricity distributors must not be locked into a supply contract with a single generator
- customers must have a choice of suppliers

- a certification system for electricity must be in place to ensure that electricity sold as green has indeed been generated in a sustainable manner

The last point is very important in terms of the structure of the electricity market. The actual mechanism used to promote green energy will have a deep impact on the market's structure and development. The different options followed in Europe and the different effects that result have shown that there is currently no ideal model which will lead to an increased uptake of sustainable energy without skewing the market in an inefficient manner. The conditions described above are those that would be found in a liberated electricity market with competition at least in generation and distribution.

Non-financial incentives

Liberalisation of the energy market

The single most important facet of a country's regulatory approach is its attitude to liberalisation – the opening up of its energy market to private and international finance, expertise, ownership and control. On the face of it, any measures that relax government control over the power industry and encourage private investment and reform would seem to be positive for sustainable energy investment, since reform attracts international investment and expertise, encourages competition and efficiencies, and provides governments with capital to reinvest in renewable energy sources (amongst other things). However, in some countries concerns have been raised about the adverse impacts that increased competition has had on equity and environmental goals, as well as the ability of a competitive market to ensure sustained investment and security of supply at low prices in the long term. Different advantages and problems for sustainable energy development may be experienced at each stage of liberalisation.

Aside from the obvious environmental effects, renewable power production has three main differences from non-renewable power production that must be considered in the context of any process of liberalisation:

- first, there is a relative lack of expertise and experience in designing, building and maintaining renewable technology
- secondly, whether it be a large hydro-power plant or a small photo-voltaic cell, renewable power production requires a higher initial investment and does not produce as quick a return on investment as non-renewable plant
- thirdly, the power produced is, by its nature, not as reliable and steady as that produced by a traditional power plant, since it relies on natural inputs such as sunlight

These three factors give renewable power sources a natural, initial disadvantage in the types of regulatory structure that are seen in liberalised markets.

Generally, there are four distinct stages to liberalisation: commercialisation, unbundling, privatisation and competition (both wholesale and retail), although in practice, two or more of these stages may be combined in one piece of legislation, and one need not necessarily follow the other.

Commercialisation and corporatisation
When a government decides to commercialise a state-owned enterprise, it essentially relinquishes detailed control in favour of autonomy for the enterprise and a focus on efficiency and cost-cutting.

Under commercialisation, government maintains ownership but removes subsidies and preferential fiscal policies and requires full recovery of capital, operations and maintenance costs. Corporatisation entails the formal and legal move from direct government control to a legal corporation with separate management.

A commercialised body that is focused on costs will need to find the least expensive route to supply rural areas, since generally they are the areas least well supplied at present and are thus in need of investment. This could have a positive impact on investment in distributed renewable generation since, in general, it will cost less to install sustainable power sources such as photovoltaics or wind turbines than it will to connect remote areas to a central grid supplying conventionally-produced electricity. In addition, a non-privatised body will still retain its social obligations, and this may cause it to favour renewable energy sources over conventional ones.

Therefore liberalisation to this stage could have a positive effect on renewable usage in distributed developments for scattered or rural populations. There may not, however, be any significant effect on the level of investment of bulk reticulated renewable generation investment, other than a possible improvement in the ability to adopt new technologies due to the improved commercial focus.

Unbundling

In a pure sense, unbundling (or restructuring) energy services is accomplished by breaking up the components of traditional bundled services, assigning existing costs to the various service components, and developing prices based on these costs. Unbundling the electricity sector brings about the separation of the industry into generation, transmission, distribution and supply.

International experience indicates that the conditions and tariffs which independent power producers can gain access to the transmission system and use to ‘wheel’ power for sale directly to electricity users fundamentally affects the independent power producers’ choice of technologies in grid-connected applications. Transmission access (including fair cost structures enabling access) has the potential to stimulate the development of new renewable power generation. Because renewable resources are location-specific, developers of renewable power generation depend on access to transmission lines to sell power to the grid. Moreover, transmission access gives renewable power producers the ability to sell power to locations where, and at times when, it is more highly valued than by the local utility.

Despite legal and physical access to transmission lines, renewable power producers may not have equal access to transmission capacity because of unfavourable terms of contract. Producers of intermittent generation may be charged more per kilowatt-hour to transmit power than their dispatchable competitors. Transmission access charges may be based on a generator’s maximum rated capacity or what it actually generates during peak periods. Moreover, the site-specific nature of renewable energy may be a drawback under some transmission pricing schemes. Tariffs may be based on distance or contract paths, regardless of actual transmission costs.

Privatisation

Privatisation is the sale of public bodies to the private sector, leading to an emphasis on both cost reduction and revenue maximisation, as profitability becomes the key performance measure.

It is sometimes argued that privatisation without first creating a competitive market will be detrimental to end-use customers since it is likely to mean a guaranteed private monopoly income for the new owners of the previous state monopoly.

Technology preferences for investments in new generation result partly from the differences in financing available to public utilities, private utilities and independent power developers. Finance for investments is given in the forms of 'balance sheet financing' and 'project financing'. Both forms require that the project proposed for financing is profitable. The difference is the security that is offered to the lender. In balance sheet financing, the lender (e.g. a national or regional power company) relies on its overall financial position to repay the loan. In project financing, the loan is given to the particular project company that has been set up, and the lender relies on the cash flow of the project for repayment of the loan.

For various reasons, IPPs (independent power producers) have a dominant position when it comes to using renewable energy. Their projects depend on project financing. Independent power developers therefore face a higher cost of capital and a shorter repayment period than the vertically integrated utilities.

Other things being equal, the cost of energy from a capital-intensive renewable project to either a private utility or an independent power producer is generally higher than to a public utility.

Because of these financial considerations, independent power producers prefer generation options that have relatively low capital costs per megawatt, a short construction time in order to yield revenue quickly, high efficiency and the ability to be operated most of the time.

Power purchase agreements (PPAs) can also affect the financing for renewables, depending on the extent to which provisions in these agreements are geared to the characteristics of renewable generation options. Since most independent power projects have been thermal to date, the terms of standard PPAs are often geared to such projects. Payment schedules and other terms in PPAs may create incentives for independent power producers to choose relatively low capital-cost-per-megawatt technologies over options with comparable life-cycle costs but higher capital costs. PPAs often generate fixed price payments to developers over a limited period of time. Adequate payment schedules are particularly critical for capital-intensive power generation options. Independent power producers must attract private debt financing on the strength of the PPAs. They must often recover their capital investments over the fixed-price contract period, which is generally less than the facility's life span. This is harder to do for IPPs of capital-intensive generation options, putting them at a disadvantage relative to developers of fuel-cost-intensive options.

Renewable energy faces other barriers in obtaining long-term power contracts. The transaction costs incurred to participate in the bidding process may favour certain technologies. Per megawatt, the costs of preparing a bid for a thermal project are less than for a renewable project. Thermal projects can be readily determined and are not particularly site-specific, allowing bids to be prepared more quickly and cheaply. Producers of power from renewable energy resources may find the transaction costs of negotiating PPAs prohibitive.

There is likely to be a general reluctance to invest in less profitable areas, such as rural areas where distributed generation investment is most common, whatever the type of power source to be used. Traditional power purchase structures that might be implemented on privatisation also cause a problem for renewable sources since they favour non-renewable power sources producing a predictable, steady flow of energy. Thus privatisation could have a negative impact on renewable investments.

Competition
Once unbundling has taken place, competition can be introduced into one or more of the sectors.

International experience indicates that wholesale competition is not likely to favour renewables in bulk power markets. Compared with long-term bilateral power purchase agreements, short-term or spot markets make it more difficult to finance and develop renewable generation options. For one thing, renewable projects bidding into spot markets are harder to finance than generation projects with low capital costs. Lenders are reluctant to provide debt capital for renewable energy projects, especially in countries where spot markets have yet to establish a track record. Since lenders require power projects to demonstrate steady, predictable cash flows to meet debt-servicing requirements over several years, the revenue risk created by unpredictable spot markets effectively precludes financing.

Retail competition is also likely to affect the ability of renewables to compete in bulk power markets. The incentive to retain and attract customers that is created by retail competition makes electricity suppliers seek opportunities to minimise rates and to differentiate themselves from competitors. Some retail suppliers are trying to differentiate themselves by marketing 'green' (environmentally friendly) electricity generation. This market niche is smaller in developing countries because environmental consciousness is generally lower and electricity costs tend to look larger in the household or business budgets.

Improved infrastructure

A basic pre-condition for developing a free market is that the required physical infrastructure is in place. If, for example, palm-oil derivatives were to compete with diesel as a fuel for vehicles, there needs to be a substantial infrastructure supporting this market.

Currently, diesel has a virtual monopoly in both transport infrastructure and outlets. The monopoly can be broken by financial instruments (subsidising the new entrant to the market) or by legal instruments that oblige the owners of the existing infrastructure to create a fair market place.

Access to the electric grid

National energy laws must allow IPPs to set up renewable energy systems and sell their generated power to the grid operators. The key question for grid access is whether IPPs should have unlimited access to sell their output to the grid operator, or whether limits to either annual capacity additions or total installed capacity should be imposed. The answer depends on the balance between, on the one hand, the government's wish to promote renewable energy and, on the other hand, its wish to keep down the cost of subsidies.

An IPP license may be obtained from the national electricity regulator.

Competitive concessions

A competitive concession is granted to a private company in a province through a tendering process, with priority given to building and operating solar photovoltaics, wind, hydro-powered micro-turbines and diesel generators for a limited number of years.

Obligations to generate or purchase green electricity

In some countries, the government has obliged the power utilities to generate electricity based on renewable energy sources, kick-starting a significant technological development.

Where suppliers are unable to meet this obligation, they may be allowed to purchase green certificates from another supplier to show that that supplier has made up the shortfall. Otherwise, the suppliers may buy themselves out of the obligatory green quota by paying a penalty. In other words, companies that have excess renewable capacity will be able to ‘sell’ it to other providers, thus giving them a financial incentive to increase their renewable sources, whilst also providing a ‘stick’ to ensure that companies do not rely too much on others, since these green certificates are likely to attract a high premium.

An essential part of the green certificate system, which is promoted by some countries, is to oblige utilities to fulfil given quotas for renewable energy. Utilities can fulfil such commitments in several ways: by developing their own renewable power plants, by negotiating bilateral agreements with independent producers, or by purchasing green labels on the open market.

Voluntary agreements

In 1998, the Federation of Energy Companies in the Netherlands (EnergieNed) created a Green Label System for electricity generated by renewable energy. The green labels are purchased by members of EnergieNed. There is no legal footing, the system is based on a voluntary agreement, and there is no ecotax exemption for green labels. If the industry does not meet a certain target, agreed with the government, an optional measure in the Dutch electricity act will be implemented. This measure requires final users to consume a certain amount of green electricity.

Public-private partnerships

Some individual countries have built up an impressive level of global knowledge and understanding about renewable sources. One of the ways in which this has been made possible is through the development of innovative alliances to help share their expertise between public and private bodies.

By establishing national knowledge centres, experiences will be obtained by the sector itself sharing knowledge of successes and failures of full-scale projects in commercial operation.

Involving local communities and civil society

Mexico has had a Rural Electrification program, whereby the government charged the national power utility with responsibility for rural electrification, using photovoltaics where possible. Only local authorities participated in the scheme, avoiding any intervention by foreign institutions. The various governments – federal, state and municipal – made funds available and planned the overall strategy, while the public utility concessionaire handled standardisation and monitored the technical characteristics of the equipment. Government agencies did the project planning, development and management, and, following a competitive tender, private industries supplied, installed, maintained and trained the users of the system, i.e. the local community. The community provided technical support, agreed to use the system properly and underwrote maintenance costs etc.

Overall, such schemes are deemed successful, but there were a few problems. First, the system quality was exaggerated prior to installation, which led to an expectation–reality gap. Secondly, there were problems with the installation standards. Thirdly, consumers were unused to the technologies and damaged the systems by using them wrongly.

Some countries, however, have developed measures which should mitigate such problems via technical back-up and education bodies. For example, in India, the Ministry of Non-Conventional Energy Sources developed a network of nodal agencies at the state level, complemented by measures to involve local agencies and the private sector – all overseen by the National Planning Commission.

A highly successful scheme in Denmark – the Wind Guilds – is credited with being of major assistance in the successful development of Denmark's wind turbine generation. As part of the Danish wind power initiatives started in the 1970s, Wind Guilds were set up to own and operate turbines. Members of the Guild originally had to live within 3 km of the site in order to help mitigate concerns about noise, environmental effects etc.

Discouraging alternatives

Often, the coupling of renewable 'encouraging' regulation with non-renewable 'discouraging' regulation is the key to the success of the former. This is usually done through financial disincentives, e.g. eco-taxing, but there are also other means.

A very stringent means to discourage technologies or fuels is actually to ban them or to introduce a temporary moratorium on their production and use.

Testing and certification

Barriers to the development of renewable production include the practical implications of building and testing prototypes, coupled with the perception that the new technologies may not be reliable in the absence of industry standards. Governments can help to overcome this by providing facilities and funding for the testing and certification of new technologies and thus developing a reliable standard.

Information

In most countries there is a strong need to increase awareness among the public, the private sector and government officials on the applications and benefits of renewable energy.

Education

Primary education, higher learning and vocational training all need new curricula that match the changing technological and economic environments.

Annex D: Questionnaire on barriers to the diffusion of a climate technology

A template

Specific questionnaires need be tailored with regard to two aspects: technology and stakeholder. E.g. one questionnaire might be devised for policy-makers and NGOs on wind energy, another for manufacturers and traders on solar water heaters.

Replace the abbreviation CT (climate technology) with the name of the technology in question.

Not every stakeholder needs to respond to questions in all categories.
Questions should be tailored according to the interests of the stakeholders, and non-pertinent questions should be avoided.

All example questions in this template should be considered as sources of inspiration. They are only illustrative and should not be understood as rigid suggestions.

1. Information on the respondent

Name:

Organisation / Department:

Designation:

Particular interest in the technology: *E.g. manufacturer, trader, user, legislator.*

2. Economic and financial issues

Some problems are listed below. Please rank them in order of importance.
No. 1 is most important, 2 second most important etc. Cross if not applicable.
Please feel free to add more items to the list and add detailed descriptions to the items.

Barrier	Rank
Difficult to obtain loans	
High cost of loans (high interest rate, short maturity)	
The CT is too costly	
High cost of preparing the investment (transaction costs)	
Insufficient/inappropriate incentives	
Favourable treatment of alternative technologies	
Uncertain financial environment (e.g. electricity tariffs)	
Uncertain macro-economic environment (e.g. inflation rate, currency exchange rate)	

When do you typically want your investment in CT to be paid back? ……… years.

Did you ever try to obtain a loan to purchase CTs? Yes No

If yes, were you able to get it? Yes No

If no, what do you think were the reasons?

3. Market failure/imperfection issues

Some problems are listed below. Please rank them in order of importance.

Barrier	Rank
Under-developed supply channels	
Non-transparent market	
Small market size	
Unstable market situation	
Underdeveloped competition	
Economy of scale difficult/impossible to be achieved	
Mismanaged sector	
Technology not freely available in the market	
Lack of reference projects in the country	

4. Policy, legal and regulatory issues

Do you think organizations such as AAA, BBB, and CCC are working satisfactorily in line with the policy intentions of the government?

Yes No

Does the approach of these agencies need to be modified to accelerate the programme?

Yes No

Are the existing regulations adequate for promoting the CT programme?

Yes No

Are there some regulations that are obsolete and create problems in projects operating smoothly?

Yes No

If yes, please specify.

In the light of experiences so far, do you think the CT policy needs to be updated?

Yes No

If yes, broadly what are the areas that may need a re-examination.

What do you think are the barriers that need to be looked into, e.g. by enacting new legislation? Please rank the barriers in the list below in order of importance.

Barrier	**Rank**
Insufficient legal and regulatory framework	
Insufficient enforcement	
Unstable and uncertain policies	
Struggle in the political arena	
Highly controlled sector	
Problems in land acquisition	
Problems in getting clearances	
Bureaucracy	
Corruption	

5. Network failures

Some problems are listed below. Please rank them in order of importance.

Barrier	**Rank**
Weak connections between stakeholders promoting the new technology	
Strong networks of existing technologies favoured by legislation	
Difficult access to external manufacturers	
Lack of involvement of stakeholders in decision making	

6. Institutional and organisational capacity

Are there sufficient professional institutions?   Yes   No

If no, which type of institutions do you miss?

Do the existing institutions have sufficient capacity for your purpose?
Tick if the approach needs to be upgraded for the CT programme:

	Agency AAA	Agency BBB	Agency CCC	Others (specify)
Professional approach				
Technical expertise				
Accessibility				
Sensitive to programme needs				
Others (if any)				

Do you have any specific recommendations for any of the following agencies?

AAA

BBB

CCC

Others

Do you think some other organisations should be involved in the programme?

Yes No

If yes, what are the organisations and what are your suggestions about the roles they could play?

Did the AAA (*name of organization/agency*) help you in the project?

Yes No

If yes, are you happy with the AAA's role?

Yes No

Reasons for your satisfaction/dissatisfaction.

	No	Yes
Professional approach	( )	( )
Technical expertise	( )	( )
Easy access	( )	( )
Others, if any		

Do have any specific recommendations to AAA to improve the overall program?

Do you think some other organisations should be involved in the in the programme?

Yes No

If yes, what are your suggestions and what role they could play?

Are the existing regulations adequate for promoting the programme?

Yes No

If no, are there hurdles that need to be addressed by enacting some legislation? Please specify.

Are there some regulations that are obsolete and create problems in the project operating smoothly?

Yes No

If yes, please specify.

Are the various organisations involved in the programme sensitive to your needs and concerns?

Yes No

If no, please specify the expectations from the other organisations.

7. Human skills

Some problems are listed below. Please rank them in order of importance.

Barrier	Rank
Lack of skilled personnel for manufacturing and installation	
Lack of skilled personnel for preparing projects	
Lack of service and maintenance specialists	
Uneven technical competition (more experienced competitors)	
Inadequate training facilities	

8. Social, cultural and behavioural issues

Some problems are listed below. Please rank them in order of importance.

Barrier	Rank
Traditions and habits	
Consumer preferences and social biases	
Lack of confidence in new ESTs	
Dispersed/widely distributed settlements	
Lack of understanding of local needs	

9. Information/awareness issues

Do you have sufficient information on climate technologies?

Yes No

If yes, have you installed them in your *industry/institution/home*?

Yes No

If no, what are the reasons for not installing? Please mark 3 for very important, 1 for not important, 2 for in between:

Problem	Mark
Poor or lack of information about its costs and benefits	
Media not interested in the technology	

EST not easily available in the market	
High initial cost	
High operation and maintenance cost	
Waiting to know more about its performance and durability	
Lack of credit facilities	
Inadequate subsidy	
The CT is not important for our needs	
Non-availability to required specifications	
Lack of technical expertise for maintenance	
Not interested	
Others, if any	

Do you think there is insufficient awareness about climate technologies among other stakeholders (consumers, entrepreneurs, NGOs etc.)?

Do you think that conservative attitudes by stakeholders are hampering the introduction of climate technologies?

Do you think there is lack of commitment among stakeholders for a successful climate technology programme?

Do you think more demonstration projects need to be designed?

10. Technical issues

Some problems that are encountered in the climate technology programme are listed here. Please rank them in order of importance.
No. 1 is most important, 2 second most important etc.
If required, feel free to add more items to the list.

Problems	**Rank**
Difficulty in getting equipment and spare parts	
Available technology / equipment quality is not good	
Problems in getting clearances	
Poor operation and maintenance facilities	
Inadequate standards, codes and certification	
New technology is too complicated	
Lack of infrastructure facilities (please specify)	
Others (please specify)	

11. Overall assessment

Do you think there is enough interest and involvement by entrepreneurs in climate technologies?

Are you satisfied with the progress of the climate technologies so far?

If no, what are the main barriers in your opinion (rank them):

Technical
Information and awareness
Economic and financial
Institutional
Regulatory
Market
Social

12. Other issues

Please feel free to comment on any relevant issue which you think is missing above.
E.g. environmental impacts.