Promoting Sustainable Energy Technology Transfers through the CDM:

Converting from a Theoretical Concept to Practical Action

Deliverable 2: Final Report ENTTRANS project

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Acronyms

AIT	Asian Institute for Technology
A/R	Afforestation /Reforestation
CC&D	Cambio Climático y Desarollo
CDM	Clean Development Mechanism
CDM EB	CDM Executive Board
CNG	Compressed natural gas
CO_2	Carbon dioxide
COP	Conference of the Parties to the UNFCCC
COP/MOP	Conference of the Parties serving as the Meeting of the Parties to the Kyoto Protocol
DNA	Designated National Authority
DOE	Designated Operational Entity
EDI	Energy Delta Institute
EPU-NTUA	National Technical University of Athens - Department of Electrical and Computer Engineering
ETAP	Environmental Technology Action Plan
EU	European Union
EU ETS	EU Emissions Trading Scheme
GHG	Greenhouse gas
ICTAF	Interdisciplinary Center for Technological Analysis and Forecasting
ITDG EA	Intermediate Technology Development Group East Africa
JIN	Foundation Joint Implementation Network
KUST	Kunming University of Science and Technology
NPV	Net Present Value
PCN	Project Concept Note
PDD	Project Design Document
PIN	Project Identification Note
PPC	Public Power Corporation S.A.
QELRC	Quantified emission limitation and reduction commitment
RES	Renewable Energy Sources
TNA	Technology Needs Assessment
UEDIN	University of Edinburgh
UNFCCC	United Nations Framework Convention on Climate Change

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~~1.~~Foreword

This document is the final report of the study "The Potential of Transferring and Implementing Sustainable Energy Technologies through the Clean Development Mechanism" (acronym: ENTTRANS), which has been carried out during 2006-2007 as a Specific Support for Policies Action under the EU 6th Framework Programme (contract: ENTTRANS SSA-022673). For this work an international consortium was formed with ten partners (see ENTTRANS consortium and advisors, below).

The objective of ENTTRANS was to analyse how transfer of sustainable energy technologies to developing countries could be supported through the Clean Development Mechanism (CDM) of the Kyoto Protocol. The CDM has two objectives. On the one hand, CDM projects are meant to assist industrialised countries in achieving their Kyoto Protocol commitments in a cost-effective manner, while on the other hand, projects should assist developing countries in achieving sustainable development. A typical CDM project would thus involve both a transfer of a low-carbon technology to a developing country which is in accordance with its domestic needs and priorities, and a transfer of Certified Emission Reductions to the industrialised country that invests in the CDM project. The starting point for the ENTTRANS study was the observation that in actual CDM practice most attention has thus far been paid to the transfer of low-cost emission reduction credits.

In order to analyse how the CDM could address both transfers, the ENTTRANS study assessed, for five potential CDM host countries, how the choice of a technology in a CDM project could be based on developing countries' energy service needs and priorities. Subsequently, a set of technologies could be identified which would both address these needs and priorities, and contribute to reduction of greenhouse gas emissions. After that, the implementation chains for these technologies were analysed in the countries concerned and how the CDM could help improve technology implementation aspects, *e.g.*, by providing extra financial returns on investment, building additional (human) capital for technology operation and maintenance, and acting as a tool to demonstrate technologies that stakeholders in the countries have not yet been familiar with. This action was based on an extensive stakeholder consultation.

Next to an extensive set of deliverables and overall support to building awareness in the case-study countries of technology transfer aspects and the CDM contribution to sustainable development, ENTTRANS has delivered two specific tools to support international policy and decision-making. First, the ENTTRANS study developed an Energy Service Needs Assessment (ESNA) approach as a widely applicable tool for future energy technology decision-making in developing countries (and in developed countries). ESNA uses regular technology needs assessment insights but emphasises that technology transfers should be based on countries' energy service needs and priorities and that this assessment requires a participatory approach with energy and environment decision and policy-making stakeholders in the countries.

A second key output of ENTTRANS is the approach to systematically map technology implementation chains and markets in the case-study countries in terms of market actors, relevant legislation, and enabling business environment. With this approach it can become clear(er) where in a country technology transfer is hampered by blockages and/or supported by incentives.

We believe that both outputs could be important tools to support the work of, *e.g.*, the Expert Group on Technology Transfer of the UNFCCC and individual countries when assessing their technology transfer and CDM policies both at the side of investor countries and developing countries.

For our organisation, Foundation JIN, it was an honour to co-ordinate this study and it was a pleasure to work with our consortium partners University of Edinburgh (UK), Asian Institute of Technology

(Thailand), Public Power Corporation (Greece), Interdisciplinary Center for Technological Analysis and Forecasting (Israel), National Technical University of Athens - Department of Electrical and Computer Engineering (Greece), Intermediate Technology Development Group East Africa ('Practical Action', Kenya), Cambio Climático y Desarollo (Chile), Energy Delta Institute (the Netherlands), and Kunming University of Science and Technology (China), as well as our advisors Peter Kalas and Lubomir Nondek.

Finally, we would like to thank Mr Domenico Rossetti di Valdalbero, Mr Gilles Lequeux, Mr Mats Ericsson and Mr Mathieu Grisel of the European Commission (DG Research) for the pleasant co-operation and support.

Paterswolde, 15 February 2008

Catrinus J. Jepma and Wytze van der Gaast

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1. Introduction

The Kyoto Protocol of 1997 contains quantified emission limitation or reduction commitments for greenhouse gases (GHG) for a group of industrialised countries (listed in Annex B of the Protocol, UNFCCC, 1998). These commitments have been expressed as national GHG emission budgets (so-called assigned amounts); the budgets have been assigned for the period 2008-2012 and have been expressed as percentages of countries' emission levels in 1990 (or a different base year as for some countries with economies in transition). Developing countries have not been assigned with such budgets and, therefore, they do not have quantified commitments.

The Protocol contains the possibility for industrialised countries to increase their emission budgets through so-called emissions trading. This means that they can purchase from other countries credits which are based on GHG emission reductions achieved. One way to trade emission reduction credits is that countries with a surplus within their emissions budget (*i.e.* actual emissions lower than budget) sell this surplus to other countries, which have surpassed their budget limits. Another way to purchase emission reduction credits is by investing in projects in other countries. The emission reductions achieved through such projects are partly or fully transferred as credits to the buying countries which add these to their assigned amounts. From the viewpoint of the credit buying countries, the main rationale for becoming involved in such projects is the differences in marginal emission reduction costs between countries. By investing in a project in a country where emission reduction costs are relatively low, an industrialised country could fulfil its Kyoto Protocol commitments at lower costs.

The Kyoto Protocol has established two mechanisms for project-based emissions trading. The first one is called Joint Implementation (JI) and enables industrialised countries (with assigned amounts) to jointly establish projects. The emission reduction credits of JI projects are added to the emission budgets of the investor countries and deducted from host countries' assigned amounts. As a result, JI projects do not increase the overall emissions budget of all countries listed in Annex B. The second mechanism is the Clean Development Mechanism (CDM), which enables project co-operation between industrialised and developing countries. The GHG emission reductions resulting from CDM projects can be sold as credits to an industrialised country. In order to make sure that a CDM project results in a CO_2-neutral deal, *i.e.* the increase in the assigned amount of the industrialised country buying the credits is equal to the CO_2-eq. emission reduction claimed by the project participants, rules have been established by the CDM Executive Board (CDM EB) for the accounting of these emission reductions.

In addition to the GHG emission reduction objective, CDM projects, according to the definition of the mechanism in the Kyoto Protocol (UNFCCC, 1998; Article 12.1), must also support the sustainable development of the host countries. According to the *Marrakech Accords* of 2001, which provide further details on the modalities and procedures for the Kyoto Protocol, it is the prerogative of the host countries to assess whether CDM projects support their sustainable development (UNFCCC, 2002). As such, under the CDM sustainable development is considered a country context-specific aspect which could differ across countries. This does not mean that industrialised countries cannot play a role in supporting the contribution of CDM projects to sustainable development. After all, industrialised countries could decide that they only want to participate in projects with a large contribution to local economic development and with low or no negative impacts on the local environment, economy and society. For instance, as part of its CDM programme, the Netherlands Government used, during 2001-2005, a list of priority project categories which they considered to contribute most to sustainable development (VROM, 2003). In 2005, when the CDM market development accelerated (after the entry-into-force of the Kyoto Protocol on 16 February of that year) and competition among industrialised countries for acquisition of emission reduction credits quickly became stronger, the Netherlands Government decided to also purchase credits from projects that were not in the list of priority projects (Netherlands Ministry of Foreign Affairs, 2007).

Given this double-aim objective of the CDM – GHG emission reduction and enhancing sustainable development – a typical CDM project would bring together industrialised countries' demand of GHG emission reduction credits and developing countries' demand for sustainable (energy) technologies and other means to achieve development goals. Ideally, a CDM project would therefore be based on a clear assessment of both the GHG emission reduction potential and the technology needs and development priorities in the host country.

Such an assessment would involve the following steps. First, it would need an analysis of the energy services which have the highest priority in a host country. This could vary from improvement of energy services in urban areas and/or rural areas to improved cooking facilities to reduce negative effects on health of traditional biomass-based cooking. Second, low-carbon technologies could be explored which would be suitable for the prioritised energy services. Third, it is important to analyse the circumstances under which these technologies can be implemented in the country, which can be done by exploring their implementation chains. Possible elements of the latter are: the actors that play a role from the import or construction of the technology to the end-users in the country; 'energy culture'; country-related investment risks; CDM capacities at government level, including the functioning of the Designated National Authority (DNA); custom procedures and import tariffs; legislation; clean energy subsidies; training requirements; and property rights.

From this a picture would emerge of the blockages and incentives that exist in a country for the introduction of a technology. Possible problems are the requirement to pay an import tariff over a new technology, conflicting government policies, lack of access to the grid for decentralised energy plants, insufficiently defined property rights, *etc*. However, implementation of low-carbon technologies could also be hampered because stakeholders are insufficiently familiar with these technologies so that only those technologies would be identified as promising and suitable for fulfilling a country's development priorities that country stakeholders have knowledge of and experience with.

In both situations, the CDM could play a supportive role. CDM projects offer the possibility to improve the economics of a technology implementation project (through the value of the CO_2 emission reductions resulting from the technology implementation) and could help a country to develop a strategy with sustainable energy technologies and streamlined implementation chains for these. The CDM also offers opportunities for demonstrating technologies that stakeholders in the countries are unfamiliar with, so that after or during the project's lifetime, implementation of these technologies can take place in the country as a spin-off from the CDM projects.

With the above in mind, the objective of this study is to:

1. Identify for five case-study developing countries, using a questionnaire, energy service needs and priority technologies to meet those needs and in the process explore the perceptions within different countries;
2. Analyse implementation chain circumstances for these priority technologies in the case-study countries by, among others, assessing technology implementation blockages and incentives; and
3. Analyse how the CDM could help in supporting the improvement of technology implementation chains in CDM host countries.

The analysis has been supported by case studies in five developing countries – Chile, China, Israel, Kenya and Thailand – which are located in different parts of the world and have different economic and energy profiles. For each case-study country, a group of stakeholders, with representatives of business community entities (electricity production and distribution, and technology development), as well as key CDM stakeholders (developing country CDM experts, project participants, bi- and multi-lateral CDM programme officials, financial sector experts, risk management experts, *etc.*), were consulted to identify countries' sustainable development priorities and possible sustainable energy technologies. Subsequently, together with stakeholders it has been analysed how implementation chains could be streamlined in order to facilitate the transfer of the priority technologies and what role the CDM could play in this respect.

The main outputs of the study therefore are:

1. An assessment for the case study countries of their sustainable energy needs and priorities, and technologies suitable to fulfil these. Part of this output is a supporting review of technologies which could be or are being applied for electricity generation and energy efficiency improvements in developing countries, including the availability of financial mechanisms.

~~3.~~2. An assessment for the case study developing countries of likely factors affecting the roll out of the technologies including skills shortages, data shortages, informal support networks, fuel supply chains, financial mechanisms for funding at the different scales and levels of risk.

~~4.~~3. An assessment of minimum requirements of CDM policy and project implementation at the national and international level for individual technologies and the extent to which potential CDM host countries meet these, including opportunities for small-scale renewables and large-scale energy-sector CDM projects.

~~5.~~4. A review of the potential for diffusion under the CDM of new technologies through policy and institutional frameworks developed in consultation with host countries.

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The structure of this report is as follows. Chapter 2 describes the methodology used for the study. Chapter 3 presents an overview of the present CDM state-of-play (as per October 2007) and analyses the penetration of different technologies in the pipeline of CDM projects. From this Chapter a first impression is obtained of why some technologies have been successful under the CDM thus far and why others have not.

Chapter 4 discusses the method of Energy Service Needs Assessments (ESNA) which has been development by ENTTRANS. Chapter 5 reports on the stakeholder assessments carried out in the five case-study countries, using ESNA, and reports on the outcome of interviews held with stakeholders from these countries in terms of the countries' energy service needs and priorities and suitable technologies. Chapter 6 discusses technology transfer and implementation aspects and reports how these have been discussed with stakeholders in the case study countries. Chapter 7 describes experiences with diffusion and implementation of low-carbon energy technologies within the EU. Finally, Chapter 8 presents insights and implications for technology transfer and the CDM from the study. It discusses capacity building needs in developing countries for technology implementation and CDM project development, as well as the possible support that the EU could provide in this context and how through reforms of the CDM the mechanism would be better able to support transfers of sustainable energy technologies to developing countries.

Part I

Study Context: Methodology and CDM State of Play

2. Methodology

The research approach for this study consists of both a review of existing knowledge, experience and activities, and the collection of new knowledge based on a stakeholder assessments of sustainable development needs and technology transfer aspects in the five case study countries. For an assessment of existing information a literature review has been carried out using such sources as: the several proposals prepared by international researchers on an international climate policy regime for the period after 2012 ('post-Kyoto') with a particular focus on their technology orientation; reports on clean energy and development by national governments, multilateral organisations (*e.g.* World Bank, OECD/IEA, Climate Technology Initiative (CTI), Intergovernmental Panel on Climate Change (IPCC)), UN bodies (UNDP, UNEP), and non-governmental organisations (environmental and research-based NGOs); official documents on technology transfer by UN Conventions on Biological Diversity (CBD) and Climate Change (UNFCCC); reports prepared by the European Commission; and reports provided by international networks for sustainable energy technology knowledge and capacity building (*e.g.* REN21, REEEP).

For an overview of CDM projects that are in the pipeline (projects under validation, validated and submitted to the CDM EB for registration, or already registered and ongoing) the UNEP/Risø database has been consulted (Fenhann, 2007), as well as the overview of the CDM EB which contains registered projects and projects for which registration has been requested.[1] The main difference between these two databases is that the first one also collects data of projects for which project design documents have been submitted to an independent entity which has been designated by the CDM EB to validate that these projects have been designed in accordance with the modalities determined by the COP-MOP-1 (UNFCCC, 2005).

Table 2-1 shows the technologies relevant for energy use and production that have thus far been applied in the CDM project pipeline. In Chapter 3, it is analysed, next to an overall assessment of the CDM pipeline, including non-energy related projects and technologies, how different technologies have penetrated the CDM pipeline thus far.

This overview of the present distribution of technologies under the CDM provides useful input into the activities needed to explore how the transfer of sustainable energy technologies to developing countries could be strengthened through the CDM. Such a strengthening could have two effects:

- Within a particular technology category, to broaden the transfer of this technology to countries where the technology has thus far been underrepresented in CDM projects.
- Within a particular host country, to broaden the transfer of technologies which thus far have not been applied in CDM projects in that country.

[1] http://cdm.unfccc.int/projects/index.html.

Table 2-1. CDM Energy technology categories

Technology category	Technology types
Biogas	Biogas flaring, biogas power, and palm oil solid waste
Biomass energy	Agricultural residues, bio diesel, bagasse power, black liquor, MSW combustion, forest biomass and residues, gasification of biomass, industrial waste use
Cement production	No specification given
Coal bed/mine methane	No specification given
Energy distribution	No specification given
Energy efficiency households	No specification given
Energy efficiency industry	Building materials, cement, coke ovens, iron and steel, chemicals, petrochemicals, paper, textile, glass, mining, non-ferrous metal
Energy efficiency own generation	Building materials, cement, coke ovens, iron and steel, chemicals, petrochemicals, paper, textile, glass, mining, non-ferrous metal
Energy efficiency service	No specification given
Energy efficiency supply side	Bagasse, food, textiles
Fossil fuel switch	Liquefied natural gas, natural gas
Geothermal energy	No specification given
Hydro energy	Existing dam, new dam, run-of-river
Landfill gas	Combustion of MSW, composting, landfill gas flaring, and power production
Solar energy	Solar cooking, solar water heating, and solar PV
Tidal energy	No specification given
Transport	Fuel switch to natural gas or bio diesel engines
Wind energy	No specification given

Source: UNEP Risø Centre, after Fenhann (2007)

In order to be able to assess the potential of a technology in a country, irrespective of the role of the CDM, it is important to find out:

1. Whether the technology is suitable for the country, given the resources needed (*e.g.* sun for solar-based technology, wind for wind energy, oceans for tidal wave energy, *etc.*), the research and development status of the technology in general and in the country, and related investment and operation and maintenance costs for the technology;
2. Whether the technology is in accordance with the sustainable development needs and priorities of the potential CDM host country;
3. Whether the technology, if in principle suitable for the country and in accordance with its needs and priorities, can be implemented under the current implementation chain circumstances.

These aspects have been assessed by the following three activities.

First, the categories of low-carbon technologies as well as some of sub-categories in Table 2-1 (*e.g.* different solar applications such as cooling and cooking, large and small-scale hydro power, different applications of biomass and waste management) have been described in further detail in order to present their state-of-play. In addition, other technologies have been added which have thus far not been used under the CDM, such as CO_2 capture and storage, more efficient coal-based power production technologies, hydrogen, energy towers, and heat pumps for heating and cooling. Although the final list of 39 low-carbon, sustainable energy technologies prepared is not exhaustive, it contains those technologies that have been applied under the CDM and been identified by different literature sources as important technologies towards a low-carbon energy future (*e.g.* Abare, 2006; Martinot, 2006; Matysek *et al.*, 2006; WADE, 2003; World Bank, 2005; World Coal Institute, 2004).

Each technology has subsequently been described by paying attention to the following aspects:

- General description of the technology and its applicability.
- Importance of the technology in meeting sustainable development objectives (both in industrialised and developing countries).
- Status of the technology: R&D, requirements for a successful implementation, implications for transfer of the technology to developing countries, and known implementation barriers (For example, with respect to power generation, the development and the stability of distribution networks has to be taken into account, *e.g.* large wind farms require back-up coal or gas-fired capacities and a stable distribution network (in order to prevent black-outs). On the other hand, micro-wind or solar photovoltaics is an ideal solution for off-grid applications (underdeveloped network and/or remote sites)).
- Financing requirements of the implementation of the technology: investment and operation and maintenance costs, as well as financing opportunities.
- Future market potential of the technology.

ENTTRANS Deliverable 5&6 (combined) contains the report with technology descriptions, including technological state-of-play, market potential, and finance requirements (325 pp.).

Second, in order to determine whether a technology is in accordance with the sustainable development needs and priorities of a potential CDM host country, for the five case study countries Energy Service Needs Assessments (ESNAs) have been organised containing the following steps, which have been identified from a literature study of Technology Needs Assessment (TNA) approaches developed and applied by UNDP, CTI and UNFCCC (Bonduki, 2003; CTI, 2002; UNFCCC, 2006):

1. An assessment of a country's main energy technology needs and priorities for the medium to the longer term (*e.g.* up to 2020). Examples of such needs and priorities could be: (improved) provision of electricity for industrial appliances; (improved) provision of electricity for agricultural production; (improved) provision of electricity for households, both in rural communities and urban communities; (improved) provision of electricity for service sectors; (improved) heat delivery for industry; (improved) heat delivery for households; (improved) heat delivery for service sectors; energy for cooling purposes (*e.g.* medicines); energy for cooking; and municipal solid waste management.
2. An assessment of low-carbon energy technologies (from the technology description document mentioned above) which would be suitable and appropriate for fulfilling these energy service priorities, as well as an assessment of their sustainable development benefits and disbenefits.
3. With respect to the latter, the technologies have been assessed in terms of:
   - **Economic benefits**: energy supply diversification and reliability, replicability potential in the country, lower dependency on imported fuels, grid stability, energy price stability, *etc.*
   - **Environmental benefits:** improvement of local air quality, GHG emission reduction, land protection, improved water quality, solid waste management, ecological conservation, *etc.*
   - **Social benefits:** increased socio-economic welfare, poverty alleviation, health improvement, better education, empowerment through training, *etc.*

These TNA steps have been organised in the form of questionnaires with stakeholders in the five case study countries (see Annex I). Each question could be answered by giving ranks from 1 (low priority or suitability, *etc.*) to 5 (very high priority, suitability, *etc.*). Where needed, the questionnaires have been translated into the language of the case-study country. The outcomes of the questionnaires are presented in Chapter 5.

Third, the implementation chain circumstances have been explored for those technologies which have been selected as being well in accordance with the energy needs and priorities of the countries with large sustainable development contributions. Examples of implementation chain aspects could be: limited affordability of the technology, the existing domestic legal/institutional framework, existing energy subsidy policies, bureaucracy (*e.g.* in favour of conventional energy sources), non-transparent decision-making procedures, large-scale state-ownership of enterprises, availability of cheaper but less sustainable alternative technologies, non-transparent investment climate, lack of investment protection, lack of technically educated human resources resulting in insufficient know-how and maintenance expertise (incl. problems with spare parts), *etc.*

The approach used for exploring technology implementation chains was that of *Market Mapping*, which was pioneered in developing countries by Albu and Griffiths (2006) to extend the *Sustainable Livelihoods* approach to the market for rural farmers. The approach is participatory and allows a 'map' of the relevant market to be drawn in terms of:

- the market chain **actors** who own a project or technology as it moves through the implementation chain: *e.g.* product traders, local markets, intermediary traders, processors, producers, and end users;
- the **business environment** in terms of infrastructure and policies, institutions and processes that shape the market environment: *e.g.* trade policy, contract enforcement, tax and tariff policy, corruption, regulations for business, trends, registries; and
- the **business and extension service** partners that support the market chain's operation: *e.g.* market information, financial services, market advisors, project preparation skills.

It describes the market system for a technology or product allowing gaps, blockages or barriers in the system to be identified, as well as opportunities. It brings together the market actors thereby enabling more long-term progress to be made as networks are formed. In the technology transfer context of the CDM, it has allowed placing the barriers and investment aspects based on actual CDM projects. It allows investigation of questions such as: what does the implementation of the underlying technology of a CDM project look like in a developing host country; who are the implementing actors; how stable are laws and their enforcement; and how well is the domestic financial sector able to provide the funding for the investment?

This market mapping or implementation chain assessment has been carried out for this study by organising national workshops in the five case study countries. The workshops have provided an opportunity to analyse a number of simulation projects to see which steps are needed throughout the implementation chains within the countries to successfully implement (possibly new) low-carbon technologies. The workshop outcomes are presented in Chapter 6 and provide inputs for the analysis of what it means to transfer technology under the CDM, with respect to both the technology and the country context.

An important aspect for the overall, participatory approach of the ENTTRANS study is the role of national stakeholders in the case-study countries. Stakeholders have been selected from: government departments with responsibility for energy, environment and development; local governments; representative national and international companies or bodies in other GHG intensive sectors; companies, industry and financial institutions involved in the manufacture, import and sale of environmentally sound technologies; international organizations and donors; NGOs involved with the promotion of environmental and social objectives; institutions that provide technical and scientific support to both governments and industry, *e.g.*, academic organizations, industry R&D, think tanks, consultants, *etc.* More details about the list of stakeholders for each case-study country are provided in Chapters 4 and 5.

The relevance of insight in technology implementation chains for the CDM is that the technologies identified during the ENTTRANS stakeholder assessments have in common that they could contribute to GHG emission reduction if they replace a fossil fuel based alternative or replace less efficient fossil fuel-based equipment, or, in the case of waste management, capture GHG emissions that under business-as-usual circumstances would have remained unmanaged. Therefore, projects implementing these technologies could become eligible under the CDM.

As explained in Chapter 1, the CDM could play an important role to support the transfer of sustainable energy technologies to developing countries as it enables additional revenues for project participants based on the GHG emission reduction of a project (which could increase the credibility of the investment so that, *e.g.*, banks are more willing to provide loans) and since a project could contain a training component for local employees, *etc.* Although countries could already improve the investment climate for technologies through improvement of implementation chains, it must be realised that such improvements will not make technology transfers automatically feasible, since there may remain inefficiencies that a country may not be able to remove by itself. For instance, there may still be problems with acquiring funding to import and properly install technologies, training employees to manage and maintain the sustainable operation, maintenance, and purchasing spare parts. In addition, since familiarities with new low-carbon technologies may be low in some countries, the CDM could provide opportunities for demonstrating such technologies.

As explained above, the case-study analysis for this study has been carried out in five countries: Chile, China, Israel, Kenya and Thailand. These countries have been selected because of their different profiles in terms of geographical location, energy profile, population size, and economic profile. Chile has been an active CDM host country since the year 2000 with 42 projects in the pipeline (as per October 2007) and with an efficiently operating DNA. China is presently the CDM frontrunner among host countries with 820 projects in the pipeline and with an extensive CDM policy since 2005. Moreover, China could and in some cases has already become an important producer of low-carbon technologies to other countries in the world. Israel hosts 19 projects and is an interesting case study countries in the Mediterranean as it has been active in developing technologies that are particularly suitable for warm regions, *e.g.*, energy towers in deserts. Kenya has recently become a CDM host country in the sub-Sahara African region with a large potential for hydropower and which has recently discovered coal. Finally, Thailand is an example of a host country with an active government policy for supporting clean energy production, but which has long been reluctant to host CDM projects. Given the limitation of resources for this study, it was not possible to select more countries, but the countries selected cover, given their profile, the several different categories of (potential) host countries.

3. The State of Play with the CDM

3.1. Introduction

At COP-3 (Kyoto, Japan, December 1997), the CDM was introduced in the Kyoto Protocol on the basis of a proposal by the Government of Brazil to establish a fund which would collect payments from industrialised countries (Annex I Parties) that fail to comply with their QELRCs and then arrange financial and technology transfers to developing countries (non-Annex I Parties), *e.g.*, for adaptation measures (IISD, 1997). During the negotiations in Kyoto this Brazilian proposal developed into the CDM, based on the concept of project-based emissions trading but with a specific focus on sustainable development in developing countries.

The CDM has officially been operational since the year 2000. Although the Kyoto Protocol officially entered into force in February 2005, projects which had started before that date could retroactively claim emission reduction credits. As per October 2007, the CDM pipeline consists of 2551 project activities (projects that have been officially registered as CDM activities by the CDM EB or that are in the process of validation by a designated operation entity), which together are estimated to reduce over 2.2 billion GHG emissions up until 2012 (when the Kyoto Protocol commitment period ends) (Fenhann, 2007). In addition to the possibility of using these credits for compliance with the Kyoto Protocol commitments, the emission reductions from CDM projects can be used by EU installations and companies that have CO_2 emission caps under the EU emissions trading scheme (EU ETS). Through the purchase of these credits, they can increase their emission allowances under the ETS.

CDM projects can generate GHG emission reduction credits during a crediting lifetime of seven years, which can be renewed twice. At maximum, a project can thus have a crediting lifetime of 21 years.[2] The renewal of the crediting lifetime after each period of seven years can be granted by the CDM EB if the project developers can demonstrate that the project will also for the next period of seven years result in real and additional CO_2-eq. emission reductions.

3.2. The CDM pipeline

3.2.1. Overview of projects and countries

Table 3-1 shows the twenty developing countries that host most CDM projects (as per October 2007). It can be seen from the table that China, India, Brazil and Mexico are the leading host countries with a combined share of 78% of the total project pipeline. This large share is mainly due to the large number of projects that are presently under validation in these countries. In terms of registered projects, the four countries have a share of 52%. From the table it also becomes clear that the top-10 only has two countries from Latin America and none from Africa; South Africa is the only country from the African continent represented in the top-twenty. Of the ENTTRANS case study countries, China, Chile, Thailand and Israel are represented with 820, 42, 39, and 19 projects, respectively. Kenya presently has three projects under validation.

[2] UNFCCC, 2002, Decision 17/CP.7-Annex, para.49. However, CDM projects in the field of carbon sequestration through afforestation and reforestation activities can, due to the generally longer lifetime of such activities, have a crediting period of 60 years at maximum.

In terms of division of projects across regions, Asia and the Pacific have 1860 projects in the CDM pipeline (72% of all), Latin America has 601 projects (24%), North Africa and the Middle East have 34 projects (1.5%), Sub-Sahara Africa has 33 projects (1.5%), and Non-Annex I Europe and Central Asia have 23 projects (1%). For each region, the dominance of one or two countries is clear: China and India dominate the Asian region; Brazil and Mexico have most projects in Latin America; Armenia and Moldova host most projects in the European/Central Asian region; and in the Middle-East and African regions Israel and South Africa dominate.

Table 3-1. Top-20 developing countries in terms of number of hosting CDM project (as per October 2007)

	Total projects	At validation	Requested registration	Registered projects
1 China	820	672	30	118
2 India	757	422	53	282
3 Brazil	235	106	21	108
4 Mexico	174	72	10	92
5 Malaysia	66	39	11	16
6 Indonesia	49	38	2	9
7 Philippines	47	33	0	14
8 Chile	42	20	2	20
9 South Korea	36	18	3	15
10 Thailand	37	32	2	3
11 Colombia	21	14	1	6
12 Honduras	21	5	4	12
13 South Africa	21	9	2	10
14 Israel	19	12	0	7
15 Argentina	19	9	0	10
16 Peru	18	10	1	7
17 Ecuador	18	8	1	9
18 Sri Lanka	17	10	3	4
19 Guatemala	14	7	2	5
20 Vietnam	11	9	0	2

Source: UNEP Risø CDM/JI Pipeline Analysis and Database" after Fenhann, www.cdmpipeline.org.

Figure 3-1 gives an overview of the distribution of CDM projects per project type (as per October 2007). Hydropower, biomass-based energy generation, wind energy, and 'energy efficiency own generation' projects are most popular with a combined share in the project pipeline of 67%. The categories shown in the Figure together represent 95% of the present CDM project pipeline; other project categories not included in the Figure are: HFC emission reduction[3], energy efficiency in the service sector and households,

[3] Hydrofluorocarbons (HFCs) have a purely anthropogenic origin and are used in industrial products, such as in refrigerators and airconditioners. Their global warming potential is 11 700 times as large as that of CO_2.

fugitive gas capture, improvement of energy distribution systems, afforestation and reforestation, solar systems, transport, reduction of perfluorocarbons (PFC; related to aluminium production), tidal wave energy, and geothermal energy production.

In comparison to the pipeline in October 2006, biomass, hydropower and wind energy have remained important categories, but '*energy efficiency own generation*' has shown a significant growth. The latter category generally refers to projects at industrial plants, such as iron and steel and cement plants, and coke ovens, where mainly waste heat is reused for electricity production or heating purposes (either for on-site use at plants, or delivery to the grid).

Most of the *hydropower* projects/project plans can be found in China (372 or 60% of all hydropower projects in the pipeline). India is a host country for 74 hydropower projects (12%) and Brazil (50 projects; 8%) follows third. In Latin America, which has 120 hydropower projects in the pipeline, the division of projects is more equally distributed than in Asia. Next to Brazil, Peru (11 projects), Ecuador (9), Guatemala (9), Honduras (9), Chile (8 projects), and Panama (7) have a considerable share in the continent's hydropower project pipeline. In Asia, hydropower projects are largely concentrated in China and India (together hosting 93% of all Asian hydropower projects). They are followed by Sri Lanka (11 projects) and South Korea and Vietnam (both 6 projects). In the other regions, Armenia hosts 4 out of 7 hydropower projects in 'Europe and Central Asia', Kenya, South Africa and Uganda are responsible for the 3 hydropower projects in sub-Sahara Africa, and Egypt hosts the only hydropower project in the region 'North Africa and Middle East'.

Biomass energy projects show a similar pattern in the sense that Asia and Latin America dominate the pipeline, but within Asia, the leading country is India (253 projects; 75%) followed by China and Malaysia (24 and 22 projects, respectively). In Latin America, three-quarter of the biomass energy projects are located in Brazil (80 projects), followed by Honduras (8) and Chile (7). In the other regions, 4 projects are planned in sub-Sahara Africa (South Africa 2, Kenya and Mauritius 1 project each), and the Middle East has 2 projects, located in Israel.

The third largest category, *wind energy*, shows a clear domination by China and India, which together host 87% of the entire global CDM wind energy project pipeline (India hosts 136 projects; China 134). They are followed by Mexico (8), South Korea (8), and Brazil (7).

Almost all projects in the category *energy efficiency for own generation* take place or are planned for implementation in Asia (230 out of the global total of 235 projects in this category). Of these projects, China is the host country for 149 projects (63% of global total), followed by India (77 projects, 33%).

Some other striking figures (in addition to the above figures) are that Mexico is the leading host country in the categories of *agriculture* (60% share in global pipeline for agricultural CDM projects) and *biogas use* (25% of global pipeline, followed by India and Thailand with 18% and 16%, respectively). India hosts most projects in the categories of cement industry activities (21 of 28 global projects in this sector), industrial energy efficiency (90 of 119 global projects), projects aiming at a switch from one fossil fuel to another (29 out of 80 global projects, followed by China with 22, and Brazil with 12 projects), projects that improve the efficiency of energy production (15 out of 27 global projects), fugitive gas capture (10 out of 20 global projects), forestry (3 out of 11 global projects), solar (3 out of 8 global projects), and transport (together with Colombia, 3 projects each).

China leads the categories of coalmine methane/coalbed methane recovery projects with 40 out of 43 global projects, N_2O[4] emission reduction (21 out of 44 global projects), and HFC emission reductions (11 out of 19 global projects in this category, followed by India with 5 projects). Brazil and India host most

[4] Nitrous oxide (N_2O) is a GHG which is naturally released from oceans and rainforests through bacteria. Anthropogenic emissions of N_2O originate from use of fertilisers, fossil fuel combustion and chemical processes using nitrogen, such as cleaning sewage water.

projects in the category of landfill gas capture (both 28 projects out of the global total of 177), but the dominance of these countries in this category is less than in the former categories with a combined share of 31% only.

From this overview, it can be concluded that in terms of number of CDM projects, Asia and Latin America are the leading continents, with China and India clearly dominant in Asia and Brazil and Mexico hosting most projects in Latin America. However, the shares of Brazil and Mexico in the Latin American project pipelines per category are generally smaller than the shares of India and China in Asian portfolios; in Latin America, also Chile, Argentina, Colombia, Ecuador and Peru have a considerable share in the project pipelines. Within Asia, China's numerical domination is mainly based on the performance in the categories of hydro, wind and 'energy efficiency own generation', whereas India's portfolio is broader with a leading share in more categories, in particular biomass energy and wind energy. In the other regions, South Africa and Israel are the leading countries with 21 and 19 projects respectively, which most projects in the categories of landfill gas capture and N_2O reduction.

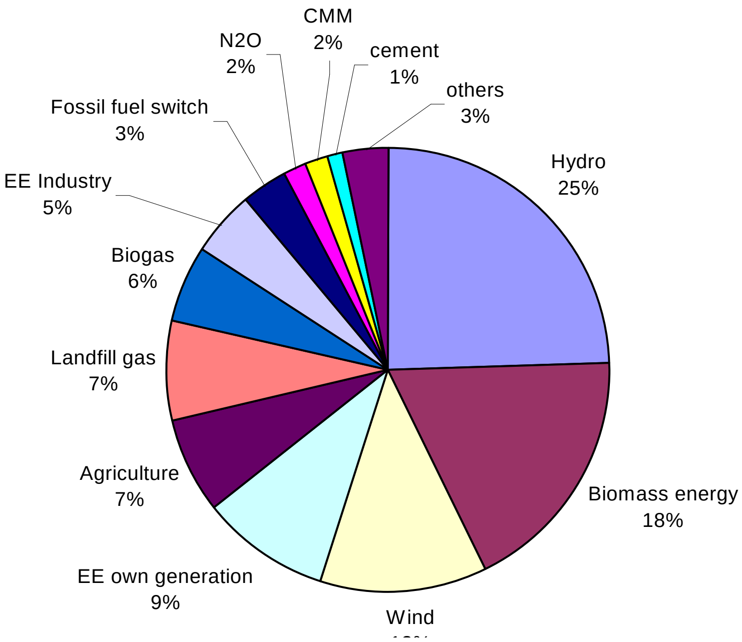

Figure 3-1 .CDM project types (# of projects)

Source: UNEP Risø CDM/JI Pipeline Analysis and Database" after Fenhann (2007) www.cdmpipeline.org.

An overview of the number of expected emission reductions of GHGs (*i.e.* expected certified emission reductions or CERs for use during the first commitment period of the Kyoto Protocol, up to the year 2012) is shown in Figure 3-2. A first aspect that attracts attention is that the distribution of expected CERs from the present CDM project pipeline is different from the distribution of projects across categories. For instance, there are only 19 HFC emission reduction CDM projects in the world which are responsible for 25% of the expected emission reductions. These projects, which, as mentioned above, largely take place in China, generally have a very large emission reduction potential since the global warming potential of hydrofluorocarbons is 11,700 times as large as for CO_2. Therefore, each tonne of HFC reduction delivers 11,700 CERs for trade under the CDM. A similar story can be told for N_2O emission reduction CDM projects in industrial sectors: there are 44 projects in the global CDM portfolio (2%) but since their global warming potential is 310 times that of CO_2, the emission reductions result in an expected amount of 11% of all expected CERs up to 2012.

Although to a much smaller extent, also the share of coalmine/coalbed methane capture in terms of expected CERs is higher than in terms of number of projects. For this category, too, the GHG reduced (methane) has a higher global warming potential than CO_2 (23 times stronger). The relatively large share of fossil fuel switch projects in terms of CER delivery (7% versus 3% in terms of number of projects) is mainly due to a number of very big natural gas-based combined cycle power generation projects in China and India. For instance, the Torrent Power Limited Natural gas-based project (1147.5 MW capacity) in Akhakhol, Gujarat, India, has an expected delivery of CERs up to 2012 of over 15 million (average CER delivery for the entire pipeline up to 2012 is 1 million CERs).

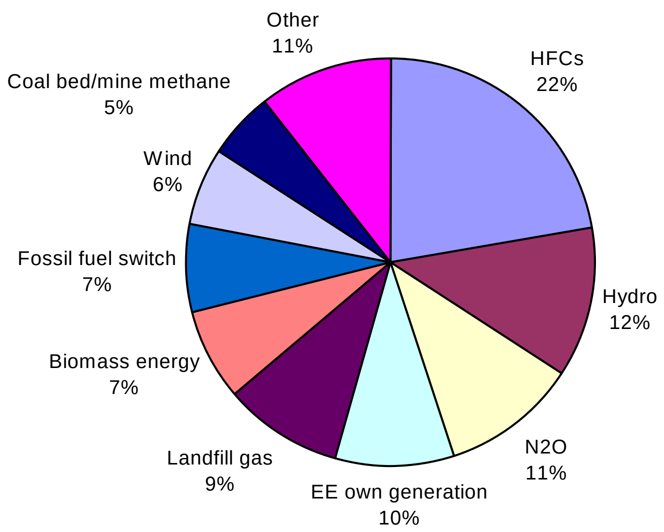

Figure 3-2. Emission reductions per project category

Source: UNEP Risø CDM/JI Pipeline Analysis and Database" after Fenhann, www.cdmpipeline.org.

Table 3-2 compares the shares of host countries in terms of expected CERs and number of projects. From the Table it can be concluded that the share of Asian countries in the CDM pipeline in terms of CERs is even larger than in terms of number of projects (79.4 versus 73%). This is mainly due to the fact that the majority of projects reducing emissions of GHGs with a high global warming potential are located in Asia (see above). For the Asia-Pacific region it is striking to conclude that China is expected to deliver about half of all CERs presently in the pipeline, compared with a pipeline share of 32% in terms of projects.

Combining Figure 3-2 and Table 3-2 with the analysis above of countries' share in the project pipeline leads to the conclusion that China is a leading host countries in the four project categories that are expected to deliver most CERs by 2012: HFC emission reduction, hydro power production, N_2O emission reduction and 'energy efficiency own generation'. HFC and N_2O emission reduction projects contribute strongly to CER generation due to the high global warming potential of these gases (see above), whereas in the 'energy efficiency own generation' category there are a number of projects in iron and steel plants in China that due to their very large scale deliver large GHG emission reductions. In the hydropower category in China, most projects are run-of-river projects which deliver fewer CERs than the HFC, N_2O and 'energy efficiency own generation' projects, but there are a few hydropower projects which have constructed large dams and some large scale run-of-river projects reduce over 1 Mt CO_2 cumulatively during the period up to 2012.

India's CDM pipeline share in terms of CERs is remarkably smaller than in terms of number of projects (15.7% versus 30%). As has been observed above, India is a leading host country is several categories (in more categories than China), but the projects in these categories (biomass energy, wind power, energy efficiency in industry and the energy supply side, and fossil fuel switch) generally have lower CO_2-eq. emission reductions than HFC and N_2O emission reduction projects, and the landfill gas and coalmine/coalbed methane capture projects, in which China is a leading country. Moreover, many of the biomass energy CDM projects in India (*e.g.* agricultural waste, rice husk and bagasse based energy production) are of a small-scale with only few projects leading to a CO_2-eq emission reduction of over 100 kt per year.

In Latin America, the distribution of shares in the CDM pipeline in terms of number of projects and CERs is largely similar, with Brazil and Mexico leading in both cases.

Although since 2005 industrialised countries have shown a strong interest in investing in CDM projects that reduce GHG emissions with a high global warming potential, nowadays a trend can be observed that the share of renewable energy projects is growing, both in terms of project activities and amount of CERs expected during the Kyoto Protocol commitment period 2008-2012.

Table 3-2. Comparison of regions and selected countries in terms of number of CDM projects and expected CERs by 2012

	Number of projects		2012 kCERs	
Latin America	**601**	**24%**	**352,181**	**15,6%**
Argentina	19	1%	29,046	1,3%
Brazil	235	9%	155,494	6,9%
Chile	42	2%	38,282	1,7%
Colombia	21	1%	18,002	0,8%
Ecuador	18	1%	4,798	0,2%
Guatemala	14	1%	6,823	0,3%
Honduras	21	1%	3,787	0,2%
Mexico	174	7%	60,081	2,7%
Peru	18	1%	12,095	0,5%
Asia & Pacific	**1,860**	**73%**	**1,788,331**	**79,4%**
China	820	32%	1,187,602	52,7%
India	757	30%	353,397	15,7%
Indonesia	49	2%	30,699	1,4%
Malaysia	66	3%	55,024	2,4%
Philippines	47	2%	12,016	0,5%
South Korea	36	1%	101,394	4,5%
Sri Lanka	17	1%	3,234	0,1%
Thailand	37	1%	16,101	0,7%
Europe and Central Asia	**23**	**1%**	**9,202**	**0,4%**
Armenia	7	0%	1,904	0,1%
Moldova	6	0%	3,152	0,1%
Sub-Sahara Africa	**33**	**1%**	**61,393**	**2,7%**
Kenya	3	0%	2,145	0,1%
Nigeria	2	0%	25,026	1,1%
South Africa	21	1%	22,885	1,0%
Tanzania	2	0%	2,808	0,1%
Uganda	2	0%	319	0,0%
North Africa & Middle-East	**34**	**1%**	**42,280**	**1,9%**
Egypt	7	0%	13,751	0,6%
Israel	19	1%	8,503	0,4%
Morocco	5	0%	2,153	0,1%
Total	**2,551**	**100%**	**2,253,387**	**100,0%**

Source: UNEP Risø CDM/JI Pipeline Analysis and Database, after Fenhann (2007), www.cdmpipeline.org.

The data in Table 3-2 are also presented in **Figure 3-3** which shows the total amount of expected CERs up to 2012 from projects presently in the pipeline. Around 80% of these CERs will be generated in five countries (China, India, Brazil, South Korea, and Mexico). The figure also shows the increase in CER since mid-2005, after the entry-into-force of the Kyoto Protocol, as well as the large share of CERs from China (as explained above).

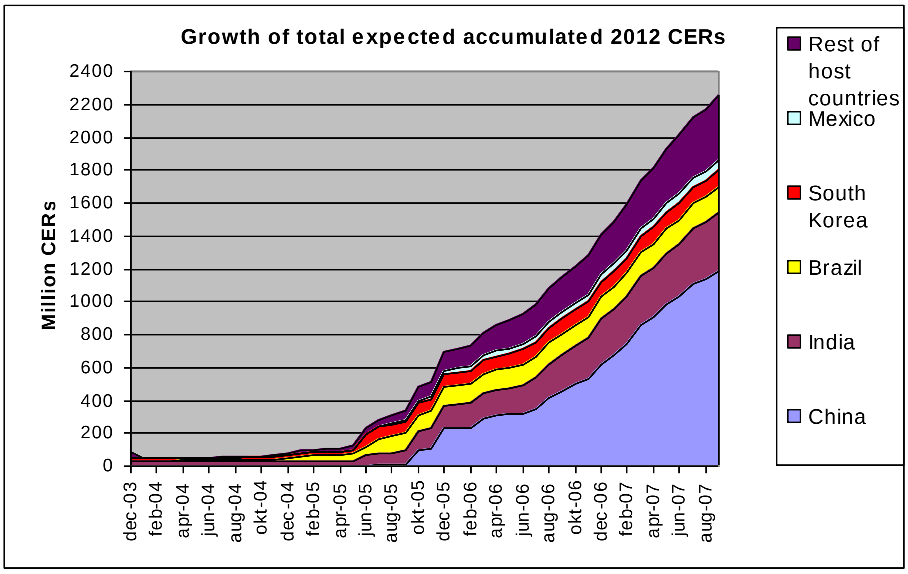

Figure 3-3. Growth of total expected accumulated CERs up to 2012 based on present pipeline

Source: UNEP Risø CDM/JI Pipeline Analysis and Database, after Fenhann (2007), www.cdmpipeline.org.

In order to acquire a more detailed picture of the division of CDM projects and expected CERs across the CDM host countries that follow the leading countries mentioned above, Table 3-3 has been compiled, which has been derived from Table 3-2 by taking out the figures for Brazil and Mexico in Latin America, China and India in the Asia-Pacific region and South Africa in sub-Sahara Africa. From this list, a 'top-15' on the basis of number of projects in the pipeline has been shown, as well as four special case countries, which have a small share in the CDM project pipeline (even when leaving out the large CDM host countries), but which have a much larger share in terms of CER delivery (note that the percentages shown in the table are related to the pipeline totals *without* the projects and CER totals for China, India, Brazil, Mexico, and South Africa). Note, however, that South Africa's share in the CDM pipeline is smaller than that of some of the countries shown in Table 3-3, but it has been taken out because of its domination in the pipeline for region (around 75%).

The Table shows that the Asian countries Malaysia, Indonesia, and the Philippines are the largest in this group, followed by Chile, Thailand and South Korea. Israel is the only country in the category of Middle East and North Africa represented in the Table, and sub-Sahara Africa is not represented at all in this top-15. Malaysia and Indonesia have most projects in the fields of biomass energy (*e.g.* palm oil energy projects) and landfill gas capture. Malaysia has benefited a lot from support by the Danish development agency DANIDA (Netherlands Ministry of Foreign Affairs, 2007) and collaboration with the Canadian organisations Terra Bio Plus and Landfill Gas Canada. Most projects in the Philippines are in the field of biogas use and flaring within the agriculture sector and are almost all small-scale activities (see below). A similar pattern can be found in Chile, although it has more hydropower (run-of-river) projects and the scale of the projects is generally larger (see also Chile's larger share than Philippines in terms of expected CERs: 8 versus 3%). For Thailand, the CDM has been a rather new mechanism as the Government only adopted a final structure for approving projects in the country in October 2006. Several Thai projects were waiting for CDM recognition by the Thai Government, which eventually took place in February of 2007 (ERI, CEERD, and JIN, 2007). In the Thai pipeline, 22 out of 37 projects are biogas power activities (mainly in the agriculture sector); about half of the projects is small-scale. South Korea has a large amount of renewable energy projects in its portfolio, including wind, hydro, solar and tidal wave energy. Finally, Ecuador's, Honduras', Sri Lanka's, Vietnam and Guatemala's pipelines are largely dominated by hydropower projects.

Further interesting cases shown outside the top-15 in Table 3-3 are:

- Egypt which has, among its seven projects, two large-scale projects in the field of landfill gas capture and N_2O emission reduction, leading to 2.3 and 6.7 million CERs by 2012, respectively.
- Pakistan, which has two large projects in the field of cattle waste management and N_2O abatement (6.9 and 6.3 million CERs by 2012, respectively).
- Nigeria which has two CDM projects aiming at recovery of fugitive gas (methane) in the oil and gas industry, which would otherwise have been flared (around 10 and 15 million CERs per project up to 2012).
- Qatar, which hosts one oil field gas recovery projects with an emission reduction potential up to 2012 of 13.7 Mt.

Therefore, although in terms of number of project these four countries are not included in the 'top-15', their contribution to CO_2-eq. emission reduction is relatively large.

Table 3-3. Comparison of countries in terms of number of CDM projects and expected CERs by 2012, without inclusion of large host countries

		Number of projects		2012 kCERs	
Malaysia	Asia	66	12%	55,024	12%
Indonesia	**Asia**	49	9%	30,699	7%
Philippines	Asia	47	9%	12,016	3%
Chile	Latin America	42	8%	38,282	8%
Thailand	Asia	37	7%	16,101	3%
South Korea	Asia	36	7%	101,394	21%
Colombia	Latin America	21	4%	18,002	4%
Honduras	Latin America	21	4%	3,787	1%
Argentina	Latin America	19	3%	29,046	6%
Israel	Middle East and North Africa	19	3%	8,503	2%
Peru	Latin America	18	3%	12,095	3%
Ecuador	Latin America	18	3%	4,798	1%
Sri Lanka	Asia	17	3%	3,234	1%
Guatemala	Latin America	14	3%	6,823	1%
Vietnam	Asia	11	2%	8,896	2%
	Total*		**79%**		**75%**
Egypt	Middle East and North Africa	7	1%	13,751	2,9%
Pakistan	Asia	3	1%	14,102	3,0%
Nigeria	Sub-Sahara Africa	2	0%	25,026	5,3%
Qatar	Middle East and North Africa	1	0%	13,748	2,9%

**i.e. CDM pipeline without totals for China, India, Brazil, Mexico, South Africa*

Source: UNEP Risø CDM/JI Pipeline Analysis and Database, after Fenhann (2007), www.cdmpipeline.org.

With respect to the use of projections of CO_2-eq. emission reductions from CDM projects and therefore CERs, it must be noted though that the present experience with ongoing CDM projects has show that some projects perform worse than expected, whereas other perform better than envisaged in their project design documents. For instance, Michaelowa (2008) shows that for landfill gas capture projects the gap between expected and realised emission reductions can be very large: in several cases, only 10 to 15% of the estimated methane reduction credits could be verified and subsequently issued. This low performance ratio can partly be explained by the problem that it is often difficult to accurately estimate how much methane has actually been built up in the course of time. Often, data on past delivery of waste to landfills does not exist and must be derived from present data based on, *e.g.*, recently installed weighbridges. For HFC-23 emission reduction projects, this ratio is around 75%, whereas for N_2O emission reduction project even more CERs are generated than expected.

Fenhann (2007) compares on a monthly basis the difference between initially expected CO_2 emission reductions and eventually verified emission reductions and issued CERs (according to the CDM procedure, see below, an external designated entity verifies the emission reductions achieved, after which the CDM EB, based on this verification, issues CERs to the buying entity or country). In his estimate in October 2007, he showed that of the total pipeline of 2551 projects, 247 projects are ongoing *and* have delivered 83 million CERs. For these projects, in total 93 million CERs had been expected according to their project design documents, which implies a CER issuance success rate of 89.3%. According to Fenhann (2007), about one quarter of the 247 projects considered have an issuance success rate of between 80 and 100%. Another quarter of the projects perform even better than 100 (*e.g.* the N_2O projects mentioned above), whereas around one-third of the projects perform at 40 to 80% of their expectations. Around 14% of the projects perform below 40% of the expected emission reductions in the project design documents.

The performance rates of CDM projects has also led to downward corrections of the stock prices of two CDM broker companies, Ecosecurities and AgCert. Early November 2007, Ecosecurities warned investors that its revenues and profits would miss expectations and cut its carbon offset pipeline by a fifth as it would generate less CERs from ongoing CDM projects than initially envisaged and contracted (Ecosecurities CDM project pipeline was cut from 456 projects to 402 projects whereas its pre-2012 CER total was adjusted from 163 million to 130 million.[5] Because of the lower delivery rate, Ecosecurities had to buy CERs at the often much higher spot market rates (as per October around €16 per CER, see also below) in order to be able to deliver CERs to their clients. On 6 November 2007, Reuters News reported a 46% decrease in the price of the company shares at the London Stock Exchange.[6] For similar reasons, AgCert's share price dropped by 75% during the first week of December 2007. In reaction to these developments, carbon market advisor IDEACarbon adjusted its expectations of CER delivery until 2012 by almost 10% (Reuters Carbon Community, 2007). According to a market comment by Reuters Carbon Market Community (2007), market entities also claim that delivery of CERs has been delayed by the ongoing CDM EB issuance bottleneck and growing project quality scrutiny (MacGiffin, 2007).

It is also important to underline that the numbers presented above as such do not fully reveal the chances of a long-term success of a country as a CDM host country. For instance, as Ellis and Kamel (2007) argue, a country with a smaller share in the pipeline but with projects with a high replicability potential may in the longer run turn out to benefit more from their CDM projects than countries with a larger share but with more 'ad-hoc' projects. In the first case, the projects could have spin-off effects towards the rest of the economy and function as demonstrations of new technologies.

3.2.2. Position of ENTTRANS technologies in CDM pipeline and methodology submissions

The above market overview has shown, among others, a categorisation of CDM projects in terms of technology categories. As explained in the Final Report of ENTTRANS, for this study almost 40 low-carbon energy technologies have been assessed, some of which have already been applied in CDM projects, whereas other technologies have thus far not yet been used by CDM project developers. **Table 3-4** gives an overview of the number of CDM projects for each technology.

From the Table it becomes clear some of the technologies covered by the ENTTRANS assessment (biomass combustion, small-scale hydro power, hydropower through dams, run-of-river large-scale hydro, wind energy, small-scale co-generation, and energy efficiency in the cement industry) have been applied on a rather large scale (*i.e.* over 100 projects) whereas several other technologies have not been used in CDM projects at all or to a small extent only (*e.g.* cooking technologies, several solar-based technologies, biomass gasification, and use of municipal solid waste for production of electricity). For this study, the list in technologies shown in Table 3-4 has been included in a questionnaire used for the interviews with energy and environment policy stakeholders in the five case-study countries, in order to learn from them how

[5] http://www.reuters.com/article/environmentNews/idUSSP33853720071107.
[6] http://www.reutersinteractive.com/Carbon/80617.

suitable these technologies would, in their view, be for fulfilling the energy service needs and priorities in the countries.

Table 3-4. Involvement of ENTTRANS technologies in CDM pipeline (October 2007)

	Technology	# Projects	Main countries	Registered
1	Carbon Capture and Storage	-	-	-
2	Improved Cook Stoves (EE households)	1	1 India	-
3	Cook Stoves Based on Ethanol/Methanol and Biomass Gasification	-	-	-
4	LPG and LNG for household and commercial cooking	-	-	-
5	Solar Cookers	2	Indonesia, India	2
6	Charcoal production for cooking and heating *(charcoal production, but not explicitly for cooking/heating*)	-	-	-
7	Biogas for cooking and electricity *(see biomass gasification)*	-	-	-
8	Liquid biofuels for transport	1	1 India	-
9	Fuel switch: coal-to-gas	N.A.	-	-
10	Biomass combustion for electricity and heat *(large-scale and small-scale; incl. co-firing)*	410	247 India, 70 Brazil, 23 China	156
11	Biomass gasification	7	6 India, 1 Sri Lanka	-
12	Coal min/bed methane recovery	43	40 China	4
13	Energy towers	-	-	-
14	Geothermal electricity production	10	El Salvador, Indonesia, Philippines (2)	5
15	Hydro dams for large-scale electricity supply (existing and new dams)	136	104 China, 10 Brazil, 5 India	14
16	Small-scale hydro energy	329	170 China, 57 India, 11 Sri Lanka	99
17	Run of river for large scale electricity supply	150	98 China, 14 India, 13 Brazil	32
18	Hydrogen	-	-	-
19	Methane capture at landfills for electricity and heat	67	21 China, 7 Brazil, 6 South Korea	26
20	Combustion of MSW for district heat or electricity	3	1 China, 1 India, 1 Brazil	-
21	Gasification of MSW for large-scale electricity/heat	2	2 India	1
22	Ocean, wave and tidal energy	1	South Korea	1
23	Solar lanterns	-	-	-
24	Solar PV	5	South Korea	2
25	Wind energy	313	138 India, 134 China, 8 Mexico/S- Korea	112
26	Energy savings in buildings (*EE Service + 4 EE households)*	16	9 Brazil (8 rej.), 3 India, 3 Moldova	5
27	Energy efficiency and saving in the cement industry	124	70 China, 41 India, 3 Thailand /Brazil	25
28	Small-scale CHP production	128	91 India, 16 Brazil, 5 Malaysia	46
29	SC PC steam power plants	N.A.	-	-
30	IGCC power plants	N.A.	-	-
31	Compact fluorescent lamps (2 EE households)	2	2 India	-
32	Hybrid technology	N.A.	-	-
33	Heat pumps for space heating/cooling and water heating	-	-	-
34	Solar cooling and hybrid systems with heating and hot water	1	1 India	-
35	Solar thermal (CSP)	-	-	-
36	Oil-based conventional steam power plants	-	-	-
37	Energy efficiency and saving in the agri-food industry	7	2 India, 2 Vietnam, 2 Mexico	1

3.2.3. Project scale

Finally, the CDM project pipeline can be analysed from the perspective of whether a project is of a large or small scale. In the *Marrakech Accords*, which, among other issues, contained modalities and procedures for the CDM (UNFCCC, 2002), a distinction was made between large and small-scale CDM projects.[7] Projects can be considered small-scale CDM projects if they are either renewable energy project activities with a maximum output capacity up to an equivalent of 15 MW, or energy efficiency improvement projects reducing energy consumption (both at supply and demand side) by up to 60 GW/h per year, other projects reducing annual CO_2-eq. emissions by 60 ktonnes at maximum. The idea behind this distinction was that for small-scale CDM projects simplified procedures for the accounting of their GHG emission reductions could be used, which would reduce transaction actions during the project preparations (project preparation, monitoring, validation and certification).[8]

Nondek *et al.* (2001) have shown that transaction costs are critical factors for small-scale JI/CDM projects which are more vulnerable to uncertainty related to carbon market development (Nondek *et al.*, 2001). They have proposed either bundling of small projects combined with standardisation of the monitoring, validation and certification methodologies, or creation of programmes managed by national energy or environmental funds. Availability of sufficiently trained domestic experts has been identified as another cost cutting prerequisite. In this respect, combination of micro-loans with national/regional programmes promoting small-scale CDM projects seems to be interesting (*e.g.* local Internet providers using photovoltaic panels or small wind turbines).

At COP-8 in New Delhi (India), one year after the *Marrakech Accords*, a decision was taken on what such simplified procedures would look have to look like, which was translated into simplified baseline and monitoring procedures by the CDM EB (CDM EB, 2004). As per October 2007, 1109 out 2551 projects were small-scale CDM activities (43.5%), which are expected to generate around 8% of CERs until 2012.

Most small-scale projects are in the category of renewable energy projects with a capacity of less than 15 MW: 64%. Within this category, most projects are in the group of renewable electricity generation for a grid (over 80%). Mostly, these projects are so-called greenfields because they are new plants or installations that produce power for a grid and that, by doing so, replace capacity that would otherwise (*i.e.* in the absence of the project) have produced for the grid. Other projects in this category are activities where thermal energy is produced from, *e.g.*, waste material for on-site use at a factory or farm (around 15%). The remaining activities within this category are projects generating electricity and mechanical energy for on-site use. The leading host countries in the category of renewable energy small-scale projects are India (264 projects) and China (164). In India, these projects are mainly in the field of hydropower, wind power, and biomass energy. China most of these projects are hydropower activities.

Around 10% of the small-scale projects are in the category of energy efficiency improvement with energy savings of less than 60 GWh. Within this category, most projects are in the field of energy efficiency and fuel switching measures for industrial facilities (*e.g.* waste heat recovery, replacing old equipment with new ones, *etc.*). India is the leading host country in this category, followed by Malaysia and Mexico.

The third category, maximum 60 ktonnes CO_2 reduction, contains the remaining quarter of small-scale CDM projects. The leading project type in this category is small-scale methane recovery (55% of projects in this category), followed by avoidance of methane production from biomass (16%), and methane recovery in

[7] UNFCCC, 2002; Decision 17/CP.7, para 6.c.i.

[8] Note that for project categories II and III the upper limits were initially 15 GW/h and <15 $ktCO_2$-eq, respectively. Later, the CDM EB increased these limits to 60 GW/h and 60 $ktCO_2$-eq., see http://cdm.unfccc.int/methodologies/SSCmethodologies/approved.html.

waste water treatment (10%). Mexico and Philippines are leading host countries in the field of small-scale methane recovery, by hosting several biogas flaring projects in the agriculture sector.

Figure 3-4 shows the division of projects across size intervals, where the size is defined as a project's expected CO_2 emission reductions per year. It shows both small and large-scale CDM projects. The Figure more or less reflects the above-mentioned division between small and large-scale projects (43 versus 57% in terms of number of projects in the pipeline). Although the Figure shows that most projects reduce less than 50 ktCO_2, there are several small-scale projects that reduce more 50 or even 100 kt CO_2 per year. The latter are projects in the first or second small-scale CDM category, where they are included because they have an installed capacity of less than 15 MW or energy saving of 60 GW per hour, while their CO_2-eq. emission reduction is higher than 60 kt CO_2-eq. (*e.g.* the Carhuaquero IV Hydroelectric Power Plant in Peru reduces 172 kt CO_2-eq. per year with an installed capacity of 9.7 MW; Bagepalli CDM Solar Hot Water Heating Programme reduces 109 kt CO_2-eq. per year).

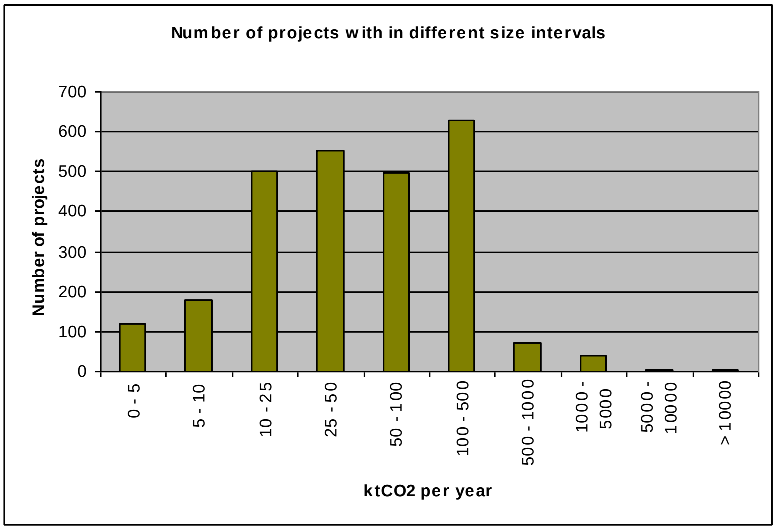

Figure 3-4. Number of CDM projects in the global pipeline with different size intervals.

Source: UNEP Risø CDM/JI Pipeline Analysis and Database, after Fenhann (2007), www.cdmpipeline.org.

The above division between small and large-scale CDM projects would suggest that small-scale projects have been able to play a considerable role in the CDM pipeline so far. However, several authors have argued that many (very) small activities that have the potential to reduce GHG emissions cannot be implemented cost-effectively because the transaction costs related to project design, validation and verification costs are too high to be compensated by the project revenues (even when including the CERs) (Ellis, 2006). Well-known examples of these activities are compact fluorescent lamps that replace incandescent light bulbs, green transport plans and agricultural activities, such as biogas installations for farmers.

In order to also incorporate these activities in the CDM, the concept of programmatic CDM has been developed which involves the aggregation of a number of relatively small emission reduction activities in developing countries into a larger bundle (or programme), which is then prepared and submitted to the

CDM EB as a single CDM activity with one set of methodologies for baseline determination and monitoring of the project performance.

As Hayashi (2006) mentioned, many renewable energy projects (in particular in rural areas) and energy efficiency improvement projects (in particular in the built environment) are small, although their replicability potential is large. Enabling these activities under the CDM in a bundle or programme would thus contribute strongly to sustainable development in the host countries.

Aggregation under the CDM is not a new phenomenon. For instance, methodological aggregation has been applied through the adoption of baseline methodologies, which can be used for a multitude of projects, *e.g.* baselines that are calculated using (weighted) average GHG emissions for sectors. Furthermore, the CDM EB has merged baseline and monitoring methodologies, which have been developed over time into consolidated methodologies and which can be used for all projects of the same type. Another reason for bundling of small projects is the possibility to create portfolios with similar projects, which generate CERs with decreased risk. The performance related risk for individual projects is often underestimated by foreign institutional investors (Nondek *et al.*, 2001).

At the policy level, the topic of recognising programmes as stand-alone CDM projects was surrounded by uncertainties, especially in relation to the possible inclusion of government policies in CDM host countries. This uncertainty was based on the question whether a government, which would like to improve the energy efficiency in households, would be allowed to develop such a policy as a CDM project (thereby selling the emission reductions as CERs). At COP/MOP-1 (2005), guidance had been given about the scope of CDM programmes. In Decision 7/CMP.1 it was stated that a local/regional/national policy or standard cannot be considered as a CDM project, but that project activities under a programme of activities can be registered as a single project activity. Although not precisely clear on the difference between a policy and a programme, this decision in principle opened the door for bundles of activities in the fields of, among others, compact fluorescent lamp projects and air conditioning improvements in residential dwellings, but also technology implementation in industrial sectors. At its second session in November 2006, the COP/MOP decided that local/ regional/national policies or standards cannot be considered as a CDM project. However, COP/MOP-2 decided that project activities under a programme of activities could be registered as a single CDM project, provided that all activities within the programme would comply with the regular CDM modalities and procedures.

At its thirty-second meeting held on 20-22 June 2007, the CDM EB took a decision on CDM Programmes of Activities under the title "Guidance on the Registration of a Programme of Activities as a Single CDM Project Activity". In a second document, procedures for registration of such programmes of activities and issuance of their CERs are explained.[9] An interesting aspect of this decision is that a programme's physical boundary may extend to more than one country. A programme must be proposed by a co-ordinating or managing entity which will be the official project participant acting on behalf of the programme's activities. The duration of a programme will not exceed 28 years, but the participating individual activities will have crediting lifetimes, just as regular CDM projects, of seven years with the possibility of renewal of the project plan twice to a maximum of 21 years (or a crediting period of ten years at maximum without the possibility of renewal). During the lifetime of a programme, activities can still join, but their individual crediting lifetimes are maximised by the time left between entering the programme and its overall finishing date, again with a maximum of 21 years. For afforestation and reforestation (A/R) programmes, the maximum crediting lifetime is 60 years. Finally, the CDM-EB decided that each CDM programme activity shall be monitored, but also stated that the monitoring method to be used could be based on random sampling.

[9] Annex 38 and 39, respectively to the EB's Meeting Report, see http:// cdm.unfccc.int/EB/032/index.html; see also http://cdm.unfccc.int/EB/028/eb28_repan15.pdf.

CERs are traded at different prices depending on the status of the project and the risks involved. For instance, CERs that are sold to a buyer before the underlying GHG emission reductions have been achieved (*i.e.* in a forward transaction) carry a risk of non-delivery (see the discussion above on CER performance ratios of projects). Therefore, prices for these forward CERs are generally lower than CERs already issued because the latter are based on achieved and verified emission reductions (see Box 3-1).

Box 3-1. From CO_2 emission reduction to Assigned Amount Unit or EU Allowance

After having been registered by the CDM EB as a CDM activity, CDM project participants can ask a designated operational entity to verify and certify the GHG emission reductions achieved. Once certified, the emission reductions can be issued as CERs by the CDM EB to the investor.

As a first step in the issuance process, the CERs are placed in the pending account of the EB. At this stage, the Board deducts from the amount of CERs a fee of 2% which is partly used to cover administrative expenses and partly deposited in an adaptation fund to support developing countries vulnerable for the consequences of climate change (UNFCCC, 1997, Article 12.8). Subsequently, the remaining CERs are put in the GHG registry of the investing country (or in the registry of the host country if the CDM activity is unilateral, see elsewhere in this Chapter) from where they can be added to the investor country's assigned amount or transferred to a company within that country for compliance with the EU emissions trading scheme (ETS) commitments. The latter forms the connection between the Kyoto Protocol's CDM on the one hand (where the governments of the Parties are the end of the CER transfer chain), and the EU ETS on the other hand.

In order to establish the connection between CDM projects and the assigned amount registries of industrialised countries, the International Transaction Log (ITL) will be constructed under the Kyoto Protocol. Through the ITL all CERs (as well as other emissions trading credits under the Kyoto Protocol, such as from JI projects or green investment scheme emissions trading) can be transferred between countries and tracked and traced using serial numbers. For enabling trade of CERs on the EU ETS market, the ITL will be connected to the EU Community Independent Transactions Log (CITL). On 15 August 2006, the completion of the ITL, which is due for January 2008 at the latest (as the Kyoto Protocol commitment period will start by then), was awarded by the UNFCCC to the Belgian company Trasys.

As per early October 2007, CER prices were as follows (GTZ Climate Protection Programme, 2007). GHG emission reductions realised by a CDM project, certified by a designated operational entity, and issued by the CDM EB are traded at prices between €16 and 18 per CER (= 1 tCO_2-eq. emission reduction). CERs expected from projects that have been registered by the CDM EB (*i.e.* project that have successfully completed their design stage and that comply with all EB requirements) are considered low-risk projects and are traded at €11 to 15 per CER in forward contracts. CERs from projects that have not yet been registered but still at validation or in the process of registration, have prices of between €6 and 8. All these prices are for CERs based on emission reductions achieved or expected to be achieved before 2012 (*i.e.* to be used for compliance with the Kyoto Protocol commitments). CERs based on expected emission reductions after 2012, *i.e.* based on projects that are planned to continue after the Kyoto Protocol first commitment period, are presently traded at prices between €1.5 and 5. The latter price obviously reflects the uncertainty related to future scarcity of emission reduction credits as clarity about the future climate policy regime after 2012 is still lacking (compare: the clarity about the second EU ETS trading period allocations has resulted in a forward market trading price of €22 per tonne CO_2-eq.) (ABN AMRO, 2007).

3.3. CDM success factors

Based on the information in Section 3.2 it can be concluded that the distribution of CDM projects between host countries is biased towards a relatively small number of developing countries. To a large extent, this phenomenon can be explained by the size of these countries and their economies which provide a larger scope for emission reduction activities in energy production, industrial sectors, and demand-side management. However, China, India, Brazil, South Korea and Mexico have also been able to smoothen their CDM project identification and approval procedures at an early stage (*i.e.* before or shortly after the entry-into-force of the Kyoto Protocol in 2005), so that could quickly approve identified projects. Moreover, these countries offered several large-scale project opportunities which are generally attractive as they enable investors to spread project transaction costs across a larger number of CERs. Simply put, if in two countries hurdles need to be overcome before project implementation, then the most attractive country to choose would be the one with the big projects with relatively low transaction costs. However, a country with potential projects of a smaller scale could, in theory, successfully compete with a large country if its CDM governance structure and domestic project implementation chains were more efficient.

An example of a study which analysed major barriers for CDM projects is Nondek and Arquit Niederberger (2005). They analysed major barriers identified by CDM stakeholders in 18 countries which passed through the World Bank's JI/CDM National Strategy Studies programme (JI/CDM NSS) (Nondek and Arquit Niederberger, 2005). Two distinct groups were identified with respect to their capacity development phases. Countries in the first group were between the conceptual and policy-building stage, while countries in the more advanced second group were approaching implementation stage (project development, revenue optimisation, *etc.*). It was shown that although existence of DNA and familiarity of national experts with CDM project development is a key factor regardless size of the country, those human resources can be more easily organised efficiently used in larger countries.

This leads to the identification of the following two key factors for successful CDM project implementation in developing countries:

1. Host countries' arrangement of the CDM system, including ways to co-operation with other entities and countries in projects and the set-up of the designated national CDM authority (DNA), and
2. Implementation chains for projects and technologies in the countries.

These factors are discussed in further detail below.

3.3.1. Forms of CDM and role of DNA

The traditional way of developing CDM projects is that an entity from an investor country co-operates with an entity from the host country, under the supervision of both governments. This form of bilateral co-operation was practiced mostly during the pilot phase for the Kyoto flexibility mechanisms, called Activities Implemented Jointly (AIJ, which lasted from 1995 to approximately 2000).

In the course of time, also multilateral CDM co-operation gained importance, especially through the activities of the World Bank which have now developed into the World Bank's Carbon Finance Programme.[10] Multilateral CDM funds collect investment money from governments and non-governmental entities which are interested in buying CERs, and invest this money into CDM projects. The advantage for the CER buyers is that they do not need to enter into the project preparation and implementation activities themselves but can leave this to the Funds' specialists.

With bilateral and multilateral co-operation, it is common practice that the CER buyers or their representatives (under multilateral co-operation) are involved in the project as of the early stages of the activity. For instance, in a bilateral CDM context, an investor country interested in buying CERs explores the possibilities of becoming engaged in CDM projects (*e.g.* through a tender). Project developers subsequently offer project ideas to the investor country from which a number of ideas are selected. These ideas are worked out into full CDM proposals and require the approval of the host country. Once approved, the project proposal will have to be validated by a designated operation entity and subsequently

[10] See http://www.carbonfinance.org

registered by the CDM EB. In case of multilateral CDM, the fund selects the projects on behalf of the investor countries by which it has been contracted (some investor countries participate in the approval process). Contractual arrangements with the host country participants are subsequently made by the multilateral fund.

In actual practice, however, there are several CDM projects for which the CER buyers are not yet known by the time the project is implemented. Such cases are referred to as unilateral CDM projects, *i.e.* projects that have been approved by the host country government, implemented, and for which CERs a buyer is sought only upon certification of the emission reductions and/or issuance of the CERs to a buyer (which could take place annually or by the end of the project's crediting lifetime).

The roots of unilateral CDM can be traced back into the AIJ pilot phase. In 1995, Costa Rica introduced Certifiable Tradable Offsets (CTOs) for its forest management programme as a unilateral anticipation of an international crediting system. A national umbrella finance fund administered the projects. By selling only a part of all possible reductions as CTOs, the fund could bear the risks of project delay or failure. International investors could buy the CTOs and Costa Rica was able to realise projects according to its own economic necessities and political preferences. This particular system highlighted an important window of opportunity for unilateral action.

It is difficult to exactly calculate how many of the present CDM projects can be labelled as unilateral CDM, since many projects have been established in co-operation with specialised intermediary companies from industrialised countries. In many cases, these companies have developed project portfolios which include emission reduction activities in a particular developing country. Before the project starts, the companies pay the host country partners a price for expected CERs and sell the CERs later to countries with Kyoto Protocol commitments or EU ETS companies against spotmarket prices. The risk of project failure is thus taken over by these brokers but they also have opportunities to sell CERs at higher prices. For instance, CDM intermediary company Ecosecurities have a portfolio of projects for which it purchases CERs at 30 to 40% of the price paid for CERs at spot markets (Bryan, Garnier&Co, 2006). In order to have the CERs eligible for trade after their certification, the companies must ask an approval of the project by their own government, which, since most of these brokers are London-based, is often the UK Government. This also explains why in several CDM overviews, the UK is shown as the largest CDM investor countries; not because it will use the CERs for its own Kyoto Protocol compliance, but because it approves the CERs traded by London-based brokers. It has been estimated that about half of the present CDM pipeline consists of such unilateral projects (*i.e.* without a known buying country) (ERI, CEERD, JIN, 2007). Note that for the brokers this project portfolio approach can be risky, as the experiences of Ecosecurities and AgCert, described in the former Section, have shown.

For some time, it was unclear whether unilateral CDM would be legally possible, given that the *Marrakech Accords* require a written approval of voluntary participation from the DNA of each Party involved in a CDM project. However, the moment at which an investor country would have to provide this approval was not defined. At its 18th meeting, on 25 February 2005, the CDM EB supported the idea of unilateral CDM and *"agreed that the registration of a project activity can take place without an Annex I Party being involved at the stage of registration"*[11]. This basically implies that it has now become possible to set up CDM projects whereby:

- some, or even all equity, comes from host country actors;
- only the approval of the host country DNA is required prior to CDM EB registration; and
- CER buyers only become formally involved when the first CERs become available for sale.

Several authors have argued that unilateral CDM would have the benefit that projects are better in line with the host countries' sustainable technology needs (Nondek *et al.*, 2001; Figueres, 2004; Laseur, 2005; Jahn *et*

[11] See: http://cdm.unfccc.int.

al., 2004). Another benefit could be that unilateral CDM provides developing countries that have not been able to participate in the CDM on a large scale thus far, with an opportunity to also enter the CDM market. Unilateral CDM could open a promising window of opportunities for ambitious businesses and consultants in developing countries to take initiatives to get the CDM machinery really going, without being dependent on procedural involvement by 'competing' experts in industrialised countries (Jepma, 2005). Local consultants can learn to perform the tasks that are presently mostly executed by experts from the North. In fact, *"[…] it may help non-Annex I Party country participants to get rid of the feeling of being patronized by foreign CDM consultants"* (2005).

In addition, transaction costs could be reduced because the experts from the developing countries are most likely not only cheaper, but probably also better informed about the situation in their home countries and may have different risk perceptions so that for them the minimally required internal rate of return may be lower than for a foreign investor. This could largely reduce CDM transaction costs; especially search costs (*i.e.* a local non-Annex I entity would generally be better aware of investment opportunities) and negotiation costs (*i.e.* negotiations would only involve talks about prices and quantities since unilateral CDM projects would have no or considerably less risks in terms of project risk and delivery risks). The potential reduction in transaction costs due to unilateral CDM could also stimulate the development of small-scale CDM projects (see above for a discussion of small scale projects).

Unilateral CDM also offers CDM project developers in developing countries the possibility to keep the CERs in their own accounts and sell them at the point of issuance at spot market prices. Selling CERs after the realisation of the emission reductions implies supplying risk-free carbon credits on the market. At that point, spot market CERs would have the same low risk profile as EU ETS allowances. This creates arbitrage opportunities for developing country entities, among others through the Linking Directive. In this 'pure' type of unilateral CDM, CERs are thus not sold through forward contracts to international brokers but are kept within the country. The Costa Rican CTO system could serve as a model for managing such unilateral projects and programmes.

Generally, however, unilateral CDM is surrounded by two important disadvantages. First, although developing country entities would have the possibility to sell CERs at a later stage, and thus can benefit from higher prices, they also run the risk that the CER price will drop or that the project fails. Second and partly as a consequence of the higher price and project performance risks, unilateral CDM could lead to a bias towards purchasing technologies that stakeholders in the host countries are familiar with and that require less training and operation and maintenance costs (Liu Deshun, 2001). Without the agreed purchase of the CERs from a project by an Annex I Party entity at an agreed forward price, it could become more difficult for the host country project participants to attract funding (*e.g.* loans) from domestic or international financial institutes to purchase an international state-of-the-art technology and/or to acquire spare parts during the project lifetime. Instead, in order to reduce the upfront risks and increase the internal rate of return, the project developers may decide to purchase domestic technologies for the unilateral project, which could be less advanced than the international state-of-the-art and with which the governments and stakeholders in the country are more familiar. As such, unilateral CDM could lead to lost opportunities to support host countries' sustainable development.

Implications for the CDM project cycle

The development, implementation and completion of a CDM project follows a project cycle with a number of steps, which are in accordance with the *Marrakech Accords* (UNFCCC, 2002). The first step is the identification of a project by either an entity from the host country, or from abroad. Under regular bilateral CDM deals, potential CER buyers typically ask for a Project Idea Note (PIN). Once the PIN is accepted by the investor country (in most cases this means short listed from longer list of project ideas; for PIN acceptance it is also generally recommended that the host country government has given its approval to the project idea), a Project Concept Note (PCN) is generally requested which requires more detailed information from the project developer, including a clear calculation of the expected GHG emission reduction and contribution to sustainable development in the host country. Once the envisaged CER buyer has accepted the project, the project participants will sign an emission reduction purchase agreement (ERPA), which is the basic contractual arrangement of the amount of CERs that will be transferred to the buyer once the emission reductions have been certified. It usually also includes a price for the CERs.

For validation by a designated operational entity and registration of the project by the CDM EB, the PCN needs to be elaborated on into a Project Design Document (PDD), which is the basic format for submitting the project plan to the CDM EB. The role of the host country government could be rather passive during this project development stage, but a project cannot be submitted for registration to the CDM EB without a formal approval from the host country's DNA. For this, the host country DNA must submit a *Letter of Approval* for the project, which does not only confirm the host country's voluntary participation in the activity, but also states that the project contributes to the host's sustainable development.[12] If any Annex I Party is officially involved as a project participant at this stage, a Letter of Approval from that Party's DNA is required as well.[13] During the validation of a project by a designated operational entity, a public comment period of 30 days is foreseen and the entity takes comments into consideration.

Subsequently, a CDM project plan, accompanied by a Letter of Approval from the DNAs of the participating countries and validated by the designated operational entity, can be officially registered by the CDM EB.[14] For this registration, the project developers need to pay a fee, which is proportional to the size of the project. As explained above in this Chapter, usually annually or biannually, the project's generated GHG emission reductions are to be verified and certified by a designated operational entity, after which the CDM EB can issue the CERs to the investor country.

The CDM project cycle contains several points of uncertainty which implies risks for the project developers. One risk category is the position of the host country government towards the project. This is why most CDM buyers under bilateral or multilateral deals want to receive from the host country governments *Letter of No Objection* to the project prior to the Letter of Approval (Laseur, 2005). Another risk would be the validation and registration of the project and the delay that may be caused by the workload of the CDM EB (see elsewhere in this Chapter). A final risk during the project design phase is whether the full financing of the overall project investment will be secured.

During the implementation phase, there are risks related to the performance of projects. For instance, a project's state-of-the-art technology may encounter technical problems during the installation, and operation and management phases. Sometimes, projects may have to be stopped for a few weeks or months, so that the contracted forward CERs will have to be adjusted downwards, which is sometimes even accompanied by clauses for non-delivery. There could also be other risks related to regular foreign direct investments, such as host country political and legal risks.

These CDM related investment risks must be considered within the host country context and are generally perceived differently by CDM project investors, depending on their objectives with a project. For instance, according to Nondek *et al.* (2001), CDM project investors can be categorised as either direct investors increasing the net present value of their investment, or investors mainly interested in acquiring CERs, or

[12] This is in accordance with Kyoto Protocol Art.12.2.

[13] The *Marrakech Accords* require the approval from the DNA "*of each Party involved*" (UNFCCC (2001), Draft decision -/CMP.1 (Article 12), Annex, §40a). Notably, Annex I Party approval cannot be circumvented, but only delayed.

[14] The extent of initial DOE validation fees approximately varies from €5,000 to €30,000, depending on various factors, among which the most important are: the project's complexity, the time needed, and the costs of site visits. Source: personal communications with DOE representatives. Site visits are more likely to be necessary if a project's baseline is based on existing actual or historical emissions (UNFCCC (2002), Draft decision -/CMP.1 (Article 12), Annex, §48a) than if it is based on emissions data of a technology (*ibed.*, §48b) or similar projects (*ibed.*, §48c) .

large institutional investors like governments, international financial institutions, *etc*. Generally, host country risk profiles depend upon many factors and can be expressed according to a composite investment ranking (Fankhauser and Lavric, 2003).

With a view to the revenue side of the projects, project participants may face risks related to the follow-up of the Kyoto Protocol (see above under 'CER prices'). For projects that envisage delivering credits beyond 2012 (*i.e.* projects that have chosen a 21-year crediting lifetime for the GHG emission reductions), it is very important that the emission reductions to be achieved then will still be tradable as CERs to countries with commitments. Also the CER price remains uncertain as it largely depends on the eventual demand and supply figures for GHG emission titles during the Kyoto Protocol commitment period 2008-2012: *e.g.*, how large will the Russian surplus of assigned amounts become; will Canada enter the CDM market as a substantial buyer; how many CERs do EU installations need for compliance with their EU ETS targets?

Through learning by doing, with an increasing number of projects in a host country, these risks could probably already be mitigated to some extent. For instance, specialised institutes could emerge which would be able to assess domestic investment risks and know their way towards the CER buyers, as well as when to sell the CERs. In general, a country that wants the CDM to work throughout its economy is likely to install a DNA that can do a lot more than passively executing its formal responsibility of appraising incoming CDM project proposals. However, having to manage increasing responsibilities obviously puts supplementary strains on the already-limited resource base of most developing countries. Castro and Figueres (2002) have proposed that a DNA should preferably first occupy itself with the prescribed evaluation and approval functions and only later, as experience accumulates, take on the additional responsibilities that are needed for unilateral CDM. Jahn *et al.* (2004) have also emphasized the advantage that some host countries have had from their previous experiences with AIJ and CDM project development.

Role of DNA

Each country that wants to become involved in a CER transaction must establish a DNA for the CDM.[15] The DNA has regulatory tasks in terms of approving CDM projects (a host country DNA must have approved the project before it can be registered by the CDM EB; an investor/buyer country DNA must approve of the project before the CERs can be issued to that country), determining criteria for project selection and approval, reporting on a country's CDM involvement to the CDM EB, and ensuring that the projects have been implemented on a voluntary basis (Castro and Figueres, 2002). From the CDM practice, it has become clear that developing countries with well-designed and transparent procedures for project approval have been more successful in attracting projects than projects with long-lasting, complex and non-transparent DNA procedures. In the case of Thailand, for instance, the former DNA process required that each CDM project proposal had to be approved by the Cabinet of Ministers. In October 2006, this procedure was simplified by reducing the number of 'decision making layers' in the procedure and maximising the approval time for project design documents to 30 working days.

According to ERI *et al.* (2007, Chapter 3), most CDM host countries have a two-step approval procedure with screening of project ideas and a final approval of project design documents. The initial screening is meant to inform project developers about the feasibility of a project as CDM activity in the country and therefore could help avoid wasting time and resources to fully develop a project idea that might not be approved in the end (Castro and Figueres, 2002). Some developing countries, however, such as Brazil, only consider a project after a DOE has validated it, which implies an additional risk for project developers as they have to pay for the validation without knowing for sure whether the project will be approved by the Brazilian DNA.

[15] UNFCCC, 2002, Decision 17/CP.7, Annex, para 29; see for an overview, http://cdm.unfccc.int/DNA

An important factor in the success of a DNA is that it finds a balance between speed and quality. The pressure on the DNAs in the host countries with the largest share in the CDM pipeline (*e.g,* China, India, Brazil) is very large, as, in some cases, they have to assess over 100 project plans per year on their suitability with CDM criteria and contribution to sustainable development. Assessing a PDD (with an average size of 50-60 pages) requires specialised knowledge of a range of technologies and how these have an impact on countries' sustainable development. Moreover, host countries are free to determine criteria for CDM projects' contribution to sustainable development, which could theoretically lead to procedures in which project approval is quickened by applying fewer criteria for sustainable development.

Determining projects' sustainable development contribution differs between countries and one indication of this has been given by a study on the expected sustainable development contribution of CDM projects in which the Netherlands Governments acts as an investor. The study (Netherlands Ministry of Foreign Affairs, 2007) is based on over 40 CDM projects in ten project categories and 18 host countries. Based on the analysis, host countries assess, through their DNAs, projects contribution to sustainable development in the following ways:

1. Use of specific lists of **sustainable development criteria** when judging proposed CDM projects.
2. Assessment of whether projects meet the **needs and priorities** in terms of energy service and economic welfare improvement or poverty alleviation. This category resembles the first category but does not contain clear checklists with sustainable development criteria.
3. Assessment of projects with a view to possible **negative environmental impacts** and whether they are in accordance (*i.e.* comply) with **national and/or local government legislation**.

Of these categories, the former two require project participants to specifically address a number of criteria and/or specifically support national or local needs and priorities. In the latter case, the contribution to a government's strategy to phase-out fossil fuels and increasingly deploy renewable energy resources may qualify as such. In the third category, the DNA assesses projects in a more passive way by checking whether they do not have negative environmental impacts in the countries and whether they are in accordance with applicable legislation.

Of the 18 countries included for analysis, eight countries have published specific criteria for the sustainable development contribution that CDM projects must deliver: Brazil, China, Colombia, India, Indonesia, the Philippines, South Africa, and Sri Lanka. These criteria can be found on the Internet sites of the countries' DNA (explicitly in the case of South Africa, India and Indonesia) or have been presented by DNA representatives at workshops and conferences.

In the cases of Brazil, India, Indonesia, the Philippines and South Africa, projects must meet economic (*e.g.* job creation, lower dependency on fossil fuels, improvement of the balance of payments, increased security of supply, *etc.*), environmental (improvement of local/national environmental circumstances), and social criteria (*e.g.* job quality improvement, welfare improvement of local community, local infrastructure, *etc.*). India and Indonesia have added to this list technological development through the transfer of state-of-state technologies under CDM projects, which are suitable for in the countries and have replicability potential. In other cases (*e.g.* China, Colombia), reference is made to the optimisation of the use of natural resources, adoption/transfer of cleaner energy technologies, poverty alleviation and employment generation. Finally, Sri Lanka has indicated that projects must deliver new and proven technologies, and contribute to environment and welfare improvement.

A number of host countries analysed in the sample assess projects on how they contribute to their sustainable development needs and priorities (*e.g.* electricity for rural or urban communities, heating, waste management, heat, *etc.*):

- *Costa Rica*: renewable energy and reduced dependence on fossil fuels.
- *Honduras*: energy security of supply, both for rural and urban communities.

- *Jamaica*: reduced dependency on imported fossil fuels, increased energy security of supply.
- *Moldova*: national commission to judge how projects contribute to national needs and priorities.
- *Nepal*: main objectives are increased access to energy (especially rural areas), poverty alleviation.
- *Nicaragua*: reduced dependency on fossil fuels, increased use of hydropower, poverty alleviation.
- *Peru*: renewable energy, waste management, employment generation.

Of the host countries analysed, Argentina, Chile and Ecuador largely assess CDM projects on whether negative environmental impacts are to be accounted for and/or whether they are in accordance with national laws and regulations. In particular, Chile has embedded sustainable development criteria in its national legislation and projects' contribution to sustainable development is monitored with the help of national laws. This does not imply, however, that the countries included in the first two categories do not check whether projects do not have negative environmental impacts, but in their cases projects are assessed more actively on what they contribute in addition to what is minimally required. **Table 3-5** summarises the categorisation of host countries' assessments of projects' sustainable development contribution from most elaborate (left) to minimal application (right).

Table 3-5. Host country assessment of CDM projects in terms of sustainable development contribution

Sustainable development criteria (Operational approach)	Needs & Priorities (Country-context specific)	Environmental Impact Assessment / national legislation (Compliance driven)
Brazil	Costa Rica	Argentina
China	Honduras	Chile
Colombia	Jamaica	Ecuador
India	Moldova	
Indonesia	Nepal	
Philippines	Nicaragua	
South Africa	Peru	
Sri Lanka		

Next to the mandatory regulatory role of DNAs in terms of judging whether proposed CDM projects contribute to host countries' sustainable development (the criteria for which countries can determine for themselves) and giving a final approval to projects before official registration by the CDM EB, DNAs may also decide to perform promotional functions, which are optional and not mandated by international rules (*i.e.* Marrakech Accords, COP-MOP, and the CDM EB). Through such promotional activities, the DNA could play an active role in promoting the country as an attractive CDM host country. Such promotional DNA functions could consist of (ERI *et al.*, 2007):

- Managing data on projects carried out in the country, so that these could serve as examples/demonstrations for other investors who might be interested in projects in the country.
- This database management activity could be supported by an active Internet site and a newsletter, as well as seminars and training.
- Building of market networks for the country and/or region, including actions to co-ordinate different

policies and programmes related to sustainable development.

- Providing assistance to project developers in terms of providing data for baseline calculations, such as CO_2 emission factors for grids and data on existing plants and/or recently built plants.
- Support to the development of domestic project development support, as well as of domestic operational entities to be designated by the CDM EB for project plan validation and project performance verification.
- Design of model contracts and support to local entities in building negotiation capacity.
- Marketing of the project opportunities within the country, such as identification of potential projects and making this information available to potential investors, *e.g.*, through participation in carbon fairs and exploring opportunities via the DNA Internet site.

In actual practice, the development of tasks of DNAs generally shows a sequence of starting with the regulatory role first, then, once the organization has been settled, expanding activities to a more detailed assessment of sustainable development contribution of projects, and after that starting to develop a outreach programme aiming at promoting CDM projects in the countries and attracting investors (Castro and Figueres, 2002; Findsen, 2005).

Finally, two issues should be mentioned with respect to these DNA roles. First, DNA role expansion is often constrained by capacity limitations (and training requirements for stakeholders and staff) and countries may only be willing to expand a DNA if it knows that a considerable number of CDM projects may result from that with a significant contribution to local sustainable development. Several DNAs in the Latin American and Central Americas regions have actively performed promotional functions and have benefited from that in terms of project development (see **Table 3-2** and **Table 3-3**) (see ERI *et al.,* 2007, Chapter 3).

Second, there could be a conflict of interest if the DNA both wants to promote project investment opportunities and must approve them as CDM projects. This could lead to situations in which the DNA approves of projects that either are not fully in accordance with domestic sustainable development criteria, or that do not comply with CDM EB accounting rules, such as additionality of the GHG emission reductions claimed, or both. Consequently, projects may not contribute to the national sustainable development strategy (which could be enhanced if lobby groups would put pressure on DNA approval procedures) and/or may not be approved by the validators or rejected by the CDM EB when registration of the project is requested. The latter could create frustration among investors and cause a boomerang effect because the DNA's creditability among project developers will decrease. It has therefore been suggested (Lee (ed.), 2004) to split DNA activities in two parts, *e.g.*, by assigning the regulatory tasks to a government department that is responsible for climate policy (since this department is generally most knowledgeable of climate change and environmental issues), and assigning the promotional tasks to another department or even contract a non-governmental agency for this task. For example, the Peruvian DNA, the National Environmental Council (CONAM: *Consejo Nacional del Ambiente*), has been entrusted with only regulatory functions whereas promotional functions have been assigned to the National Environmental Fund (FONAM: *Fondo Nacional del Ambiente-Perú*) (Chaparro, 2006; Figueres and Olivas, 2002). However, as Ellis *et al.* (2004) argue, since governance structures and responsibilities are different across countries, efficient DNA structures are also likely to vary.

3.3.2. CDM technology implementation chain aspects

The above Sections have shown that most CDM projects are presently located are planned to be implemented in a small group of host countries. It has also been shown that in some countries a few technologies are clearly dominant (*e.g.* hydro and wind power in China; biomass energy in India; landfill gas capture in Brazil), whereas these technologies are lagging behind in other countries. Generally, it is assumed that the distribution of projects among host countries is largely determined by the potential for (large-scale) GHG emission reductions at relatively low costs and by how smooth a country's CDM institutional procedures function; countries with smooth DNA procedures and action project promotion activities are more attractive to do CDM business with. However, DNA procedures and basic CER potential may not tell the entire story since also a country's overall investment climate and potential to implement new technologies is important. Therefore, for a complete insight into the potential of developing countries to host CDM projects in different project categories, also technology implementation conditions need to be explored.

When discussing barriers and implementation chain inefficiencies, a distinction must be made between aspects that can be resolved by a CDM project and those that are more fundamental of nature and need a broader set of activities within the host country. The main difference between these two categories is that the first aspects can be overcome by the value of the CERs that a project generates and possibly specific training support for operation and maintenance of the technology concerned, whereas the second category contains aspects relates to existing legislation, compatibility with the country's energy, production and consumption 'culture', corruption, absence of clear property rights, *etc.*, which cannot be sufficiently improved by the CDM projects and the CER revenues.

CDM project developers usually carry out analysis of project-specific barriers when they need to show why and how the CO_2-eq. emission reductions are additional to what would have happened in the absence of the project. This additionality is important in order to guarantee that a CDM project is a CO_2-neutral activity, *i.e.* emissions of CO_2-eq in an industrialised country with commitments under the Kyoto Protocol are offset by an equal amount of CO_2-eq. emission reduction under a CDM project, expressed as CERs. In case emission reductions under a CDM project would have taken place anyway, with or without the CDM status, there are no additional emission reductions and therefore no offsetting of emissions in the buying country.

In order to show that a project's emission reductions are additional, PDDs must contain an additionality assessment. For this assessment, the CDM EB has developed a standardised tool, which is available for project partners at the UNFCCC Internet site.[16] It consists of five steps, including an investment analysis (which explores whether a proposed CDM project would have been financially attractive without the CER revenues) and a barrier assessment. With respect to the latter, project developers must establish that there are realistic and credible barriers to a business-as-usual implementation of the project. For instance, it must be shown that alternative activities that have been carried out in the country could only be implemented with grants or other non-commercial financial terms. Another investment barrier would be non-availability of private capital on national or international capital markets for the project investment due to market risks.

In terms of technical CDM project barriers, the additionality tool identifies: lack of skilled and/or properly trained labour to operate and maintain the project's technology, unfamiliarity with the technology as it is not available in the country and the project is thus a 'first of its kind' activity, and lack of legislation to make implementation of the technology mandatory or economically attractive. Project developers must demonstrate in the PDD how through the CDM status of the investment, these barriers can be overcome. Examples of the latter are:

- The project contains a training programme to train local employers how to operate the technology and manage its maintenance;
- The project is financially acceptable in terms of a sufficient internal rate of return, but its revenues (*e.g.* renewable electricity sold to the grid) are fully denoted in local currency; banks could be reluctant to provide loans to such investments, but the denotation of the CERs in hard currency (*e.g.* € or USD) enhances the credibility of the project and could trigger banks to provide loans.

[16] http://cdm.unfccc.int/methodologies/PAmethodologies/AdditionalityTools/Additionality_tool.pdf

- A proposed energy efficiency and/or environmentally sound measure is not mandatory in the country and there is no economic rationale to carry out the investment. The value of the CERs could provide the required incentives (which is often the case in the HFC emission reduction projects mentioned above).
- People are not familiar with the technology, as it has never been implemented before in the country, and have wrong perceptions about it. Wind energy could be an example since the technology is new to several countries and it has been perceived (according to stakeholder reports in PDDs for wind power projects, see cdm.unfccc.int) as being disturbing in terms of noise, horizon pollution, and interference with radio and TV signals. Realistic environmental impact assessment procedures and communication with stakeholders can reduce the above risks (Netherlands Ministry of Foreign Affairs, 2007). In a number of cases (China, Jamaica and Philippines), the wind turbines were even considered tourist attractions. On the other hand, construction of large wind farms is limited by the stability of distribution network and availability of buffering coal or gas fired capacities.

The latter example already shows that some barriers cannot easily be resolved be adding a monetary value to the investment profile of projects. A study by Ellis and Kamel (2007) assesses whether and to what extent the CDM development in 'underrepresented' CDM host countries (*i.e.* developing countries with a small share in the CDM pipeline, see **Table 3-2**) can be explained by barriers to developing projects. They follow a similar distinction as made above between specific CDM barriers (DNA operation, project identification and GHG accounting, including validation and verification) and barriers that are of a more general nature such as political and economic stability of a country and its regulatory framework. Ellis and Kamel (2007) have identified the following examples of barriers related to technology implementation processes within host countries:

- Stability of laws in host countries and the ability to enforce these;
- Tax policies and import tariffs, which in some countries make alternatives to sustainable energy technologies relatively cheap by subsidising fossil fuel consumption and taxing clean technologies (*e.g.* through import tariffs);
- Inconsistent government policies, such as subsidies for clean power production (through feed-in tariffs), while at the same time levying an import tariff on the technologies needed for the power production;
- Unclear ownership structures for the technology and the CERs;
- The extent to which decentralised energy and cogeneration plants will acquire access to the grid; and
- The possible problems with power production permits, complex custom formalities (in particular in sub-Saharan countries), and corruption.

One approach to explore the overall implementation chain aspects, both in terms of blockages and incentives, for a particular product or technology in the country is *Market Mapping*, which has been developed by Albu and Griffith (2006). This tool maps out the relevant market for a product or technology and is particularly aimed at distribution of products and technologies in the rural areas in developing countries. The key elements of the market maps are:

- The **market chain actors** who own a product or technology as it moves through the implementation chain: *e.g.* product traders, local markets, intermediary traders, processors, producers, and end users;
- The **infrastructure and policies, institutions and processes** that shape the market environment: *e.g.* trade policy, contract enforcement, tax and tariff policy, corruption, regulations for business, trends, and registries; and
- The **business and extension service partners** that support the market chain's operation: *e.g.* market information, financial services, market advisors, and consumer organisations.

Although the market mapping exercise by Albu and Griffith has not been carried out specifically for the CDM, it can be a very useful tool to better understand the implementation chain of a CDM project in a developing country. It would, for instance, enable placing the above-mentioned barriers and investment aspects in a CDM project market map: what does the implementation of the underlying technology of a CDM project look like in a developing host country; who are the implementing actors; how stable are laws and their enforcement, and how well is the domestic financial sector able to provide the funding for the investment?

The aim of including an analysis of implementation chain aspects for low-carbon technologies is to explore how developing countries could optimise the circumstances of hosting CDM projects and accompanying technologies. The CDM experience described above has shown that streamlining CDM governance structures is a necessary but not sufficient condition for being a successful CDM host country. A country that both has its DNA promotion and procedural functions in order and improves its investment climate for CDM project technologies by, *e.g.*, removing policy inconsistencies (*e.g.* sustainable technologies taxed and non-sustainable energy use subsidised), making permit systems less complex, reducing customs bureaucracy, clarifying property rights, and enhancing law enforcement has a higher chance to attract state-of-the-art low carbon technologies than countries with good DNA structures but insufficiently streamlined investment circumstances.

The concept of market mapping and its participatory (*i.e.* with national stakeholders) application in the case study countries are further discussed in Chapter 6 of this report

3.4. Key points from this Chapter

- CDM project division is skewed toward a small group of developing host countries (China, India, Brazil, Mexico and South Korea). Asia and Latin America together have a share in the global CDM project pipeline of almost 95%. Sub-Sahara Africa only has a few projects and most of these are in South Africa. For CDM project investors the general investment climate in host countries is decisive when taking into account performance related risks.
- Most projects are in the category of renewable energy and biomass energy production, whereas in terms of expected CER delivery, HFC, PFC, CH_4 and N_2O emission reduction projects have a relatively large market share, which is mainly due to these gases' high global warming potential.
- An important factor for the success of a country as a CDM host country is the organisation of the DNA. Although many developing countries have now announced the establishment of a DNA to the CDM EB, there are large difference between countries in terms of these DNA offices are equipped (number of staff, their training background and professionalism) with most Asian and Latin American DNAs being relatively efficient, although some of them have in the meantime had to reform and streamline their procedures, whereas several African DNAs are operated by a limited number of staff who are also responsible for other environmental issues and therefore do not have time to fully focus on the CDM.
- DNAs can also extent their required tasks (establishing sustainable development criteria for projects and carrying out project approval procedures) to promotional tasks. This, however, could lead to conflicts of interest because the aim to attract more CDM projects could lead to a less robust project proposal check and approval decision-making. Involving more governmental departments could help prevent such conflicts of interest, but this could make the procedure less efficient.

- CDM projects must be additional to business-as-usual circumstances which project developers must prove by showing additionality of GHG emission reductions. However, some barriers to technology implementation cannot be removed by solely adding the hard-currency denoted CER revenues to the investment capital and by offering training programmes for operation and maintenance to local employees. In such cases, a further assessment of the implementation chain of a technology in the country is needed in terms of finding blockages and incentives for low-carbon technologies. Once these blockages and incentives have been identified, strategies could be formulated to improve the implementation chain, including how the CDM could support this improvement.

Part II

Technology Needs Assessments

4. Assessing Countries' Energy Service Needs and Technologies

4.1. Technology needs assessment: experience and literature

The origin of transferring sustainable energy technologies in the context of the international climate co-operation and in particular from industrialised countries to developing countries lies in Article 4.5 of the UNFCCC:

> "The developed country Parties and other developed Parties included in Annex II shall take all practicable steps to promote, facilitate and finance, as appropriate, the transfer of, or access to, environmentally sound technologies and know-how to other Parties, particularly developing country Parties, to enable them to implement the provisions of the Convention. In this process, the developed country Parties shall support the development and enhancement of endogenous capacities and technologies of developing country Parties. Other Parties and organizations in a position to do so may also assist in facilitating the transfer of such technologies." (UN, 1992)

In the context of the *Marrakech Accords* of 1991, a decision was adopted by the seventh Conference of Parties to the UNFCCC (COP-7) on a framework for meaningful and effective actions to enhance the implementation of UNFCCC Article 4.5.[17] As part of this decision, an expert group on technology transfer was established with the objective to analyse ways to facilitate the transfer of environmentally sound technologies to developing countries. In this decision COP-7 called upon assessments of technology needs in order to determine the mitigation and adaptation technology priorities of developing countries (and countries with economies in transition). These technology needs assessments (TNA) involve, according to the decision, "different stakeholders in a consultative process to identify the barriers to technology transfer and measures to address these barriers through sectoral analyses."[18]

The purpose of a TNA is to identify technologies that are needed or prioritised in meeting a country's sustainable development needs. One example of a TNA exercise within developing countries has been shown in the *"Synthesis Report on Technology Needs identified by Parties not Included in Annex I to the Convention"* by the UNFCCC Subsidiary Body for Scientific and Technological Advice (SBSTA), presented at its twenty-fourth session in 2006 (UNFCCC, 2006). The report was based on TNAs undertaken by 23 non-Annex I Parties (Africa: 8; Asia and the Pacific: 6; Latin America and the Caribbean: 6; and Europe: 3) and 26 initial *National Communications to the UNFCCC* by developing country Parties. Most of the Parties (92%) indicated that their technology priorities are in the energy sector (mainly renewable energy, combined heat and power and demand-side management); 79% of the countries (also) included industry sector technologies in their priority list; about half of the countries included transport sector technologies in their assessments.

Of the case-study countries for ENTTRANS, the following countries submitted TNAs to the UNFCCC: Chile, China, and Kenya. Countries were advised to perform their TNAs through a number of steps, although not all countries were able to do so (*e.g.* for reasons of limited budget). The TNAs for Kenya, China and Chile were performed by the steps shown in **Table 4-1**.

[17] FCCC/CP/2001/13/Add.1, Decision 4/CP.7, Annex.
[18] FCCC/CP/2001/13/Add.1, Decision 4/CP.7, Annex, para. 3.

Table 4-1. Overview of process followed by Chile and Kenya in conducting their TNAs for SBSTA-24

	Chile	Kenya	China
• Select target area (mitigation or adaptation)	X	X	X
• Conduct initial review	X	X	X
• Set criteria for prioritising technology needs	X	X	X
• Select key sectors (*e.g.* energy, transport, LULUCF, agriculture, waste management, industry)	X	X	X
• Prioritise technologies	X	X	X
• Identify barriers for technology implementation	X	X	X
• Identify measures to overcome barriers	X	X	X
• Identify capacity-building needs		X	
• Describe stakeholder participation		X	X
• Identify next steps		X	X
• Project proposals (for introduction of preferred technologies)		x	x

Source: UNFCCC, 2006.

Table 4-2 and **Table 4-3** provide summaries for the three countries in terms of the selection of key sectors within the target area of mitigation.

Table 4-2. Target areas and key sectors covered by the TNA reports (summary of TNA report SBSTA-24)

	Chile	China	Kenya
• Energy	x	x	x
• Transport	x		
• LULUCF			x
• Agriculture			x
• Waste management			x
• Industry	x	x	x
• Adaptation capacity			
Comments taken from SBSTA report	• District heating as priority area • No stakeholders mentioned / identified in TNA • Barriers: economic / technical	• Coal is main fuel for power generation • Stakeholders mentioned, identified and their role described in TNA (mainly national experts) • Broad range of barriers mentioned technology-wise	• Much of the population is rural and agriculture main economic activity • Kenya is a net sink of GHGs because fossil fuel emissions are balanced by forest and tree re-growth • No sustainable development policies but climate change issues in development programme • Stakeholders: various agencies, institutions, governments, NGO, private sector

* LULUCF: Land use, land-use change & forestry

Table 4-3. Commonly used sustainable development criteria for prioritising technology needs

	Chile	China	Kenya
Development benefits			
• Employment generation		x	x
• Wealth		x	
• Utilization of local resources	x	x	
• Rational use of energy		x	x
• Health improvement			
• Food security			
• Capacity building			
• Environmental sustainability			
• Gender equality			
• Socio-economic importance			x
Climate change			
• GHG reduction		x	x
• Preservation of sinks			
• Adaptation potential			
Economic criteria			
• Investment costs		x	x
• Maintenance costs			
• Investment lifetime		x	
• Replicability	x	x	
• Social acceptance			x
Environmental protection			
• Minimum environmental impact			
• Pollution reduction		x	
• Recovery of water resources			
• Re-use and recycling potential			

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In terms of technological options identified in the TNAs, it was generally recognised by the participating countries that their presently used technologies for energy generation, transport, and industrial production are generally "outdated and inefficient and that they would benefit from access to the efficient technologies available elsewhere." (UNFCCC, 2006, p.18) Particular priority technology categories mentioned by the countries were renewable energy technologies, co-generation, demand-side management measures, and advanced fossil-fuel combustion or gasification technologies. Among other countries, Chile and Kenya mentioned mini- and micro-hydropower plants as priority technologies. Kenya was also among the countries that mentioned the need for demand-side management, especially for commercial lighting and refrigeration. China identified advanced their preference for fossil-fuel technologies and supply chain improvements, such as fuel preparation and control of fugitive gases. Chile mentioned improved stoves and ovens as a need (using charcoal, biomass, liquefied petroleum gas). In cement production, Kenya mentioned the need to replace wet cement production with 'dry-based' (and more efficient) technologies. In transport, China specifically mentioned the need for improvement of mass transport systems (railway networks and other transportation).

In terms of barriers to technology transfers, Chile mainly mentioned economic/market-based and technical barriers. Kenya mentioned inefficient market structures (*e.g.* lack of financial resources, lack of incentive, incompatible prices, subsidies and tariffs), limited awareness of technologies, policy and regulatory inconsistencies, institutional limitations, and technical problems as barriers to technology implementation in the country. China mentioned the same categories of barriers as Kenya, but added lack of trained workers for the operation and maintenance of new technologies.

Of the measures suggested to address barriers, regulatory measures were mentioned most often by all non-Annex I Parties that conducted a TNA (almost 80% of the country TNA reports mentioned this), followed by policy measures, raising awareness among population and stakeholders (70%), measures to improve market conditions for technologies (70%), technical and institutional measures (both around 55%), human capital improvement (45%), and infrastructure improvement (mentioned in 25% of the TNAs).

The UNFCCC (2006) shows a clear example of how a TNA could be prepared with involvement of stakeholders. As explained in Chapter 2, the approach of ENTTRANS follows a similar line of thinking in the sense that local stakeholders are asked what they consider needed for their own country in terms of energy technology needs. However, ENTTRANS has prepared a more harmonised approach across the case-study countries since all stakeholders were selected from a harmonised set of categories and were all given a similar questionnaire. Finally, the UNFCCC (2006) report does not address how the CDM could play a role in addressing the needs and measures identified by the countries. The latter is the key objective of this study.

In the above, some basic elements of a TNA have been introduced: key sectors or services are identified and for these sectors/services preferred technologies are explored, as well as barriers to their implementation and how to overcome these. The main advantage of a TNA approach is that it places a strong emphasis on the domestic circumstances in a country and explores what people and institutions within a country consider important. As such, a regular TNA approach would be very suitable for developing countries when assessing and selecting CDM projects on their territory.

In the literature, there are a number of sources that explain the steps in a TNA. For example, UNDP, together with the Global Environment Facility (GEF) and the Climate Technology Initiative (CTI), prepared a handbook for "Assessing Technology Needs for Climate Change." (Bonduki, 2003) The handbook is aimed at helping countries find ways of encouraging technology transfers that would contribute to a low-carbon sustainable energy economy. CTI also published their own report with "Methods for Climate Change Technology Transfer Needs Assessments and Implementing Activities." (CTI, 2002) Other models for TNA have been prepared by UNEP and the UN Commission on Sustainable Development (UNCSD) (Zou JI, 2002).

Although all models incorporate the TNA steps and elements mentioned above, there are differences between them in terms of starting points and the sequence of actions. For instance, the CTI model starts, after having established a group of stakeholders, with establishing criteria for selecting technology transfer priorities, followed by defining priority sectors and sub-sectors. Within these sectors, market information (incentives, financial market structure, market actors, energy companies, *etc.*) is collected and subsequently priority technologies are selected. For these technologies, barrier assessments are carried out and actions to overcome these barriers explored and recommended.

The *UNDP TNA Handbook* starts with an assessment of sectors that are affected by both climate change mitigation and adaptation. Examples of the sectors mentioned in the handbook are energy production and transmission, transport, climate technology industries, built environment, and health. The handbook suggests that priority sectors are selected on the basis of the information in the IPCC Assessment Reports[19] which show the possible effect of climate change on each sector by region and outline possible technological options for adaptation and mitigation. Within the prioritised sectors, technologies are assessed based on criteria, such as: development benefits, reducing harm to the environment, social acceptability and suitability for country conditions, relevance to climate change (GHG emission reduction, adaptation, and sink enhancement potential), market potential (costs, commercial availability, replicability, and potential scale of utilisation within the country), potential for policy intervention to improve technology uptake through pricing and regulatory policies. After that, for the prioritised technologies barriers and policy needs are identified, such as institutional and legal obstacles, market distortions, split incentives, limited access to capital, *etc*. Finally, given these barriers, policy actions can be recommended.

[19] http://www.ipcc.ch

The UNEP and UNCSD models for TNA differ from the above-mentioned models in that the UNEP model takes a technology as a starting point, examines the reasons why it should be implemented, and explores possible alternatives. Subsequently, the model explores the effectiveness of the technology concerned in terms of, *e.g.*, materials and waste, environmental impacts, health and safety impact, and social efficiency. Then, decision makers in the technology implementation process are identified and this process itself is explored. The aspect of identifying targets and sectors before selecting priority technologies is less important in this model.

In the last example given in this overview, the UNCSD model for TNA, the first main step is to assess capacity building needs in a country for technology transfer, followed by implementation of prioritised capacity building actions, including the definition and implementation of sustainable energy technology transfer projects. For the entire model, an ongoing dialogue among national stakeholders, governments and financing institutions is foreseen.

4.2. Energy needs assessment approach applied by ENTTRANS

From the literature review in the former section, a basic structure for a TNA can be derived as is shown in **Table 4-4**. For the ENTTRANS study, the aspects in **Table 4-4** have been applied as follows. The enabling environment has been largely created by the terms of reference for the study,[20] including the funding made available by the Sixth Framework Programme of the EU.[21] This has enabled the study consortium to undertake in the five case-study countries around 30 bilateral interviews with energy and environmental policy stakeholders as well as organise stakeholder workshops in each of the five countries. The presence of expert institutes from the case-study countries in the consortium made it possible that stakeholder consultations could be carried out in the national languages of the countries.

Stakeholders selected in the five countries were selected from the following groups of people responsible for or involved in energy and climate policies in the countries:

- Government officials (including local governments) with responsibility for energy, environment and development policies, including regulations, promotion of industry, trade and foreign investment,
- Consultants,
- Energy and Environmental non-governmental organisations (NGOs),
- Energy agencies, related to governments and involved in policy implementation,
- Industry supply chain companies,
- Industry associations,
- International donor organisations,
- Local (grassroots) organisations,
- Consumer groups, and
- Academic organisations, industrial R&D organisations.

Awareness building was carried out by inviting media representatives to the workshops and to deliver presentations on ENTTRANS at international and national conferences and workshops.

[20] The Description of Work, Annex I of the contract 022673 - SSA – ENTTRANS under FP6.
[21] http://ec.europa.eu/research/fp6/

Table 4-4. Basic TNA structure based on literature assessment

Enabling environment	• Selection of stakeholders • Funding for the overall TNA process • Communication with stakeholders: bilaterally or via workshops • Building awareness among larger public
Selection of target areas	• Adaptation or mitigation or both • Sectors (*e.g.* energy, transport, industry, waste management, agriculture, built environment) • Within these sectors, sub-sector or energy services (*e.g.* energy for urban population, energy for rural population, cooling for hospitals, cooling in buildings, cooking, *etc*)
Criteria for selection of suitable technologies	• How would a technology fit in the objective of supporting the country's priority areas, sectors and/or sub-sectors and services, both with a view to the medium and to the long term? • A technology's overall contribution to sustainable development of country: economic contribution, environmental and social contributions.
Applicability of technology in country	• Identification of implementation barriers to technology implementation in the country • Identification of solutions to remove these barriers
Capacity building	• By improving information exchange among stakeholders and information campaigns in other media, awareness of priorities and needs can be increased • By creating market networks and institutions, implementation of a particular technology can be replicated and the overall climate for technology transfer in the country be improved
Creation of project portfolios	• To support the implementation of priority technologies, projects can be formulated to demonstrate the working of the technologies in the country. • Finding of financial sources for these projects.

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However, it was felt that for this study an *energy service* needs assessment (ESNA) rather than a *technology* needs assessment (TNA) should be conducted with the developing country stakeholders and then the technologies to meet those needs could be examined only after full discussion and awareness raising of all the possibilities for large scale and small scale decentralised technologies. This process would allow policy makers and industry players to become familiar with these new medium and long-term technology possibilities for innovation of low carbon systems. Awareness raising should take the form of information dissemination coupled to programmes of visits to existing demonstrations of technologies and also demonstration of reliability and practicality at the country level for very new technologies. Once this process of introduction and acceptance by policymakers and industry has been carried out, then a TNA can be carried out for inclusion of low carbon technologies in a) country energy strategies and plans, and b) introduction to the country technology market.

ENTTRANS has focussed on mitigation types of action only given that the terms of reference for the study narrowed the scope for action to decentralised energy systems, increased efficiency of fuel conversion activities, and carbon capture and storage. Within these three areas, a broad range of sub-sectors or *energy services* have been identified for the study:

- Electricity for industrial appliances;
- Electricity for agricultural production;
- Electricity for households, both in rural communities and urban communities;
- Electricity for service sectors;
- Heat delivery for industry;
- Heat delivery for households;
- Heat delivery for service sectors;

- Energy for cooling purposes (*e.g.* medicines);
- Efficient design of buildings;
- Energy for cooking; and
- Municipal solid waste management.

All these services have in common that they could be delivered by technologies which switch from centralised to decentralised systems or switch from fossil fuels to renewable energy sources or from one fossil fuel to another fossil fuel with a lower carbon content. Carbon capture and storage can be linked to some of these services, in particular when the CO_2 can be captured during the energy production process, such as in the case of switching from conventional pulverising coal technologies to cleaner coal-based technologies with a connection to a CO_2 capture technology. Transport was originally not included in this basic list of technologies but in the bilateral interviews several stakeholders added this service, given the potential in the transport sector for fuel switch.

The selection of technologies in ENTTRANS has been rather broad by identifying from a range of literature sources (*e.g.* Abare, 2006; Martinot, 2006; Matysek *et al.*, 2006; WADE, 2003; World Bank, 2005; World Coal Institute, 2004) clean, sustainable energy technologies that might be applicable (see **Table 4-5** and Deliverable 5&6). Subsequently, each case-study country partner has crossed out those technologies that are not applicable at all for the country (*e.g.* carbon capture and storage if the country does not have a suitable nearby reservoir or aquifer for storing of captured CO_2). The list has been included in the questionnaire used for bilateral stakeholder interviews (see Annex 1).

Table 4-5. Sustainable, low-carbon technologies selected for ENTTRANS study

Energy service	Technology
Electricity production	• Fuel switch: coal-to-gas • Biomass combustion for electricity and heat • Biomass gasification • Energy towers • Geothermal electricity production • Hydro dams for large-scale electricity supply (existing and new dams) • Small-scale hydro energy • Run of river for large scale electricity supply • Hydrogen • Ocean, wave and tidal energy • Solar lanterns • Solar PV • Wind energy • Small-scale CHP production • SC PC steam power plants • IGCC power plants • Oil-based conventional steam power plants • Concentrating solar power • Hybrid technology • Biogas for cooking and electricity (see biomass gasification)
Heating	• Biomass combustion for electricity and heat • Small-scale CHP production • Heat pumps for space heating/cooling and water heating • Solar thermal • Charcoal production for cooking and heating
Cooking	• Improved Cook Stoves • Cook Stoves Based on Ethanol/Methanol and Biomass Gasification • LPG and LNG for household and commercial cooking • Solar Cookers • Charcoal production for cooking and heating • Biogas for cooking and electricity (see biomass gasification)
Cooling	• Solar cooling and hybrid systems with heating and hot water • Heat pumps for space heating/cooling and water heating
Energy efficiency	• Energy savings in buildings • Compact fluorescent lamps • Solar cooling and hybrid systems with heating and hot water • Energy efficiency and saving in the agrifood industry • Energy efficiency and saving in the cement industry
Municipal solid waste	• Methane capture at landfills for electricity and heat • Combustion of MSW for district heat or electricity • Gasification of MSW for large-scale electricity/heat
Transport	• Liquid bio fuels for transport
Methane capture	• Coal min/bed methane recovery
CO_2 capture	• CO_2 capture and storage technologies, including enhanced oil or gas recovery

In ENTTRANS, the steps of selecting priority areas in terms of energy services and identification of suitable technologies have been carried out through literature review of technologies, descriptions of the case-study country contexts (in terms of energy policy, economic profile, energy resources, climate and CDM policy and participation, *etc.*, see Chapter 5), and bilateral interviews with the above-mentioned energy and climate stakeholders in each of the five countries.

The questionnaire aims at exploring what sustainable development benefits country stakeholders consider needed in their countries, and, given the CDM objective of maximising a combined GHG emission reduction and sustainable development contribution target, what technologies are considered suitable for the countries. Initially, the questionnaire consisted of five questions relating to:

1. Energy service needs and priorities,
2. Technology appropriateness and suitability,

3. Sustainability benefits from the selected technologies (from 2),
4. Implementation barriers for the selected technologies (from 2) and likelihood of overcoming these, and
5. Role of the CDM in technology transfer context.

In order to test the feasibility of asking these five questions within a reasonable period of time (45 minutes to one hour at maximum), the first draft of the questionnaire was tested by a group of students from the University of Groningen, the Netherlands, during a study trip to Thailand in May 2006. Under supervision of ENTTRANS partner AIT, they visited a number (about twenty) of 'test stakeholders' (AIT staff, students, companies, *etc.*) after which they supported AIT with the part of the interviews to be held in Thailand. From these tests it became clear that the questionnaire in its initial form was too long and it was decided to focus the interviews on the first three questions, which would give an overview of energy technology needs and priorities and which technologies would deliver the largest contribution to sustainable development.

The questions 4 and 5, which mainly dealt with the elements of applicability of the technology in a country and capacity building in **Table 4-4**, were then moved to the workshops held in the second year of ENTTRANS on technology implementation chains and how the CDM could help improve these for priority technologies (the remaining questionnaire is shown in Annex 1). The latter is the topic of Chapter 6 which focuses on the element of capacity building in **Table 4-4** by applying the concept of market mapping in order to describe technology implementation chains, including blockages and incentives for low-carbon technologies.

Before describing the outcomes of the stakeholder assessments of technology needs within the case-study contexts, some limitations to the concept of ESNA in general and applied under ENTTRANS in particular must be mentioned. First, for each case-study country in ENTTRANS around 30 stakeholders have been interviewed with help of the questionnaire. Although this group in each country has brought together considerable knowledge of a country's needs and energy and climate context, the number is too little for extensive statistical analysis. The results presented in the next chapter are therefore mainly qualitative interpretations of the answers given and feedback provided by stakeholders.

Second, during the interviews it could sometimes be observed that stakeholders' perceptions of particular developments differed from actual practice (*e.g.* when government officials mentioned that a electricity provision for a particular was no priority issue anymore because problems are thought to have been solved, whereas other stakeholders gave a high priority to this sector because they were aware of still existing problems). Moreover, in some cases, stakeholders gave a higher priority to technologies that they were more familiar with; there seemed to be tendency to give lower scores to unfamiliar technologies.

Third, since the case-study countries have been selected based on their different profiles as CDM host countries, inter-country analysis is complicated as differences in terms of priorities and technologies found between, *e.g.*, China and Kenya are difficult to compare since the countries are entirely different from each other. However, in a follow up action, the scope of the analysis might be broadened to countries with comparable contexts. For example, results for Kenya may be useful for neighbouring countries in East-Africa, such as Uganda and Tanzania.

Despite these limitations, the strength of the approach lies in the fact that resources have been available to have in-depth discussions with key stakeholder, via both interviews and stakeholder workshops. As such, the approach enables a disclosure of best available knowledge of low-carbon energy technologies and their implementation chain in each country.

5. Energy Needs Assessments in Case Study Countries

5.1. Introduction

After the introduction to and the review of the literature on TNA and the explanation of the ESNA tool applied by ENTTRANS in Chapter 4, this chapter reports on the application of the first part of the ESNA concept in the five case study countries, *i.e.* the assessment of needs and priorities and suitability of corresponding technologies with the help of a questionnaire. The second part of ENTTRANS (assessment of technology implementation chains in each country) will be the topic of Chapter 6.

As explained in Chapter 4 the questionnaire used for the analysis in this Chapter contains three main questions about, respectively, the priority energy services in the countries, the suitability of low-carbon sustainable energy technologies in the countries and the sustainable development contribution of each technology within the context of the case study countries. The questionnaire analysis with country stakeholders has been supported by a brief analysis of the country contexts in terms of energy, economic, and climate policy profiles. Through such analyses, a first assessment can be made of countries' energy mix with dominating energy sources and technologies, indigenous energy resources, and the need to import energy from other countries.

Regarding the questionnaire, it must be remarked that respondents have been asked to rank energy services (question 1), technology suitability (question 2) and sustainable development contribution of selected technologies (question 3) on a scale of 5 to 1, with '5' meaning 'very high' and '1' meaning 'very low' (the answer '0' would mean 'not relevant for the country'). The ranking method used is a cardinal interval scale, which means that respondents were not asked to rank services in order of priority (as with ordinal scale), but to give their opinions in terms of how important a particular energy service is for the country or how suitable they think a particular technology would be. A rank '4' would thus not say that a technology is second best for the country, but that its contribution to the country's sustainable development could be high (not 'very high' as with '5', but neither 'medium' as with '3'). It also implies that if one energy service or technology receives a five, the second best could be ranked, *e.g.*, '2' if stakeholders consider their contribution low.

5.2. Chile

5.2.1. Country context

Chile is an open economy that has been growing during the past decade by an average rate of 3.9% per annum. The mining of copper and several other minerals is a vital element of the Chilean economy. Other strong sectors, also based on natural resources, are agriculture (Chile is one of the world's largest fruit exporters), forestry (about 20% of the land surface is covered with forests), and fishery. The economic growth has been accompanied by a similar growth pattern, which is projected to continue into the future. In terms of energy supply, Chile has a significant share of hydroelectricity in its power production portfolio, which is complemented by coal and natural gas imported from abroad.

According to Chile's *First National Communication to the UNFCCC* (Government of Chile, 2000), the country's CO_2 emissions in 1994 amounted to about 95 Mt of which about one-third came from the energy sector and two-thirds from non-energy sectors. As shown in Table 5-1, Chile's extensive forest area and other natural sinks (mainly vegetation) causes absorption of 87.8 Mt CO_2 in 1994 so that the country's net

CO_2 emissions were about 7.4 Mt. The emissions of CH_4 and N_2O amounted to 6.5 and almost 8 Mt in terms of CO_2-eq. which was mainly caused by non-energy sectors. The transportation sector is responsible for most of Chile's CO_2-eq. emissions (37%), followed by manufacturing and construction (26%) and energy production (24%). Commercial, residential, institutional, and agriculture activities were responsible for about 13% of emissions (Government of Chile, 2000).

Table 5-1. Aggregate balance of CO_2 sources and sinks (Mt CO_2), 1994

Sector	Emissions	Sequestration	Net Balance
Energy	37	0	37
Non-energy	58	87.8	-29.8
Totals	95	87.8	7.2

Source: Government of Chile, 2000

One specific feature of the Chilean energy situation is the substantial share of domestically produced hydroelectricity in the country's primary energy mix. In 2004, hydropower had a share of 17% in the energy mix. The share of oil (almost fully imported) was 35.3% and natural gas had a share of 24.3% (of which 80% is imported). Firewood (domestic) and coal (mainly imported) made up the remaining shares of 14 and 9.3%, respectively (Sanhueza, 2006). The overall energy import dependency in Chile is close to 70% (Sanhueza, 2006). Natural gas is mainly imported from Argentina via several pipeline connections, and oil is sourced from Argentina, Brazil, Angola and Nigeria. Concerns on security of natural gas supplies have recently arisen, due to recent and frequent natural gas supply reductions via pipelines from Argentina, where "between 20% and 50% below contracted daily volumes" (USGS, 2005) have been supplied.

Chile consists of thirteen administrative regions (see **Figure 5-2**).[22] The country's main inland border is with Argentina in the East and Peru and Bolivia in the North to Northeast. The population is highly urbanised and primarily lives in the central area/regions in and around the Region Metropolitana. Chile has four power grid systems and several stand-alone power production units, which in 2006 produced 57,555 GWh of electricity (see **Table 5-2**). In 2006, about 70% of Chile's electricity is supplied to and consumed within the central area of the country to the *Sistema Interconectado Central* (SIC) power system (40,340 GWh production in 2006, with a 70/30 division between hydro and thermal). The country's second largest power grid system is *Sistema Interconectado del Norte Grande* (SING) with 13,236 GWh produced in 2006, mainly has thermal power production units installed. The SING power grid supplies electricity mainly to the mining companies and urban demand and consists of few power generating units with large capacities.

[22] Chile's 13 administrative regions are from north to south: I: Tarapaca, II: Antofagasta, III: Atacama, IV: Coquimbo, V: Valparaiso, RM: Region Metropolitana, VI: Libertador General Bernardo O'Higgins, VII: Maule, VIII: Biobio, IX: Araucania, X: Los Lagos, XI: Aisen del General Carlos Ibanez del Campo, XII: Magellanes y Antartica Chilena.

Table 5-2. Installed power production capacities in Chile (2006)

Grid	Installed Capacity (MW)	Thermal Gen. (%)	Hydro Gen. (%)	Wind Gen. (%)	Total Share (%)	Power Generation (GWh)	Power Gen. (%)
SING	3601,9	99,6[23]	0,4	0	26,7	13.236	23,0%
SIC	8669,5	44,8[24]	55,2	0	64,3	40.340	70,1%
Magallanes	64,7	100[25]	0	0	0,5	140,4	0,2%
Aysen	33,5	41,5[26]	52,5	6	0,25	224,6	0,4%
Non-integrated power production	1109,7	92,2	7,8	0	8,25	3.614,3	6,3%
Total	13479				100	57.555	100,0%

Source: Comision Nacional de Energia, 2007.

After natural gas supplies from Argentina to Chile came on stream in 1997 the use of natural gas for power generation in Chile increased significantly and multiple new gas-fired power units where installed, thereby sometimes replacing old and inefficient coal fired units. Thermal power generation in Chile predominantly takes place in the Northern and upper central part of the country. However, the 2004 Argentina energy crisis caused a 20 to 50% reduction of daily deliveries of natural gas to Chile, especially the SING system experienced significant difficulties in keeping power production up to acceptable levels and at reasonable prices, even leaving significant natural gas fired capacity idle.[27] The SING system is characterised by a relatively low flexibility with mainly large-scale coal and natural gas fired thermal power plants. Mining industries consuming most of the power generated in this grid were exposed to supply shortages and increasing energy prices. Consequently, the share of coal in power production – after a significant decline in the period from 1999 to 2001 – has risen again somewhat, due to these security of supply concerns, in recent years (see **Figure 5-1**).

[23] Fossil fuels, such as Coal, oil and diesel are used for combustion in turbines.
[24] Mainly coal, but increasing share of natural gas and reducing share of diesel-fired power generation.
[25] About 85% natural gas fired with diesel fired turbines making up the remainder.
[26] Mainly diesel-fired units.
[27] A 36,3% share in total installed capacity in Chile for natural gas-fired power plants and 16,5% for coal fired power plants, combined with the roughly equal share of both fuels in electricity production (resp. 23,1% and 22,5%); there is an indication that the load factors of the natural gas fired power plants (for the year 2006: CNE, 2007) were relatively low and thus capacity stands idle, given the natural gas supply uncertainties.

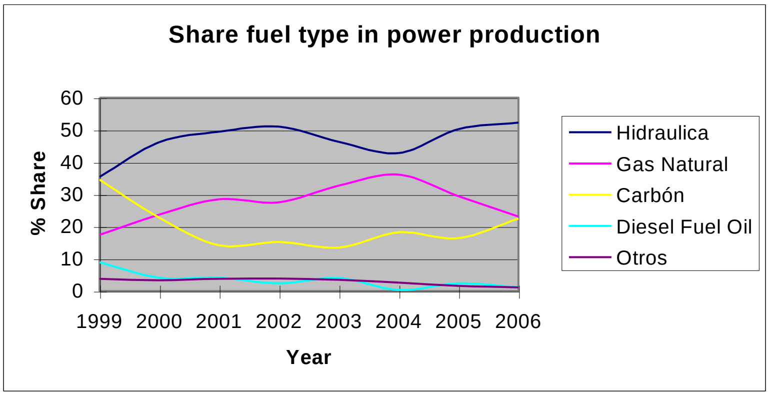

Figure 5-1. Share per fuel type (incl. hydro) in power production in Chile (1999-2006).

Source: CNE, 2007.

Figure 5-2. Chile and its four integrated power systems (SING: North, SIC: Upper central, Aysen: Lower central and Magellanes: South)

5.2.2. CDM profile

CDM projects carried out in Chile need to comply with the country's existing environmental and socio-economic standards laid down in national legislation. The environmental impact of a CDM project in Chile is assessed by the regional authority in the region where the project will be implemented (regional Commission for the Environment). In case a project involves more than one region, an environmental impact assessment report must be submitted for review and approval to the National Environmental Commission (CONAMA). CONAMA reviews the environmental impact assessment process and declares whether or not a project complies with the applicable national rules and regulations.

CONAMA was established in 1994 and has been functioning as the country's DNA for the CDM since May 2003, in co-operation with PROCHILE (the agency that promotes external commerce), which is responsible for the promotion of CDM projects in Chile, and COR.FO (the Economic Development Agency), which acts a facilitator for CDM activities by promoting regulations and feasibility studies that create incentives for CDM projects in the renewable energy sector. Clear sustainable development criteria for CDM projects do not exist in Chile. The main consideration when judging a project is that if it does not have a negative impact on the environment, or can compensate for that impact, it contributes to the country's sustainable development.

CONAMA intends to let CDM projects contribute to the domestic needs and priorities (in particular, security of energy supply) (Netherlands Ministry of Foreign Affairs, 2007). Chile has several renewable energy options with significant GHG abatement potential that are 'waiting' to become financially and economically competitive. Within the open market economy of Chile, it must be noted that private investments are the driving force behind projects in the field of power generation and other sectors. According to CONAMA, the CDM could also strongly contribute to energy efficiency, especially for heavy industries, such as cement production and copper mining. In addition, the potential of small-scale CDM hydropower in Chile as indicated by a number of key stakeholders is significant, although limitedly exploited. **Table 5-3** presents an overview of the pipeline with CDM projects in Chile as per October 2007.

In October 2007, it became clear that the Government of Chile is considering the implementation of a programme of activities (see Chapter 3) under the CDM based on the distribution of compact fluorescent lamps (CFL) within the country. The idea is to give two CFLs each to lower-income households free of charge. The programme will be developed together with the Inter-American Development Bank.

Table 5-3. CDM project pipeline for Chile, as per October 2007

	Registered	Requested review	At validation	Rejected	Correction requested	Registration requested	
Afforestation			1				
Agriculture	4		3	1			
Biogas			2				
Biomass energy	4		3				
EE supply side	1						
Fossil fuel switch	1						
Fugitive gas capture			1				
Hydro	4		4				
LGC	6	1	6				
N_20	1						
Wind			1				
Total	**21**	**1**	**20**	**1**	**0**	**0**	**43**

Source: UNEP Risø Centre, after Fenhann (2007)

5.2.3. Energy Needs Assessment

In Chile, during September 2006 and May 2007, 30 stakeholders were interviewed and asked which energy service would need to be paid most attention to, which low-carbon technology would be most suitable for the Chilean context and what sustainable development contribution each of the highly ranked technologies would deliver.

Of the listed energy services in question 1 of the questionnaire, energy efficiency in industry, electricity provision for households (rural areas) and electricity for industry were considered by stakeholders as important priorities (with average scores of 4.4, 4.2, 4.2, and 4.0, respectively). Energy efficiency in industry (cement, iron&steel, agro&food (*e.g.* sugar), and chemical sectors) was given the highest score by 23 out of 30 stakeholders, while electricity for industry was considered a very important energy service by 20 stakeholders. Electricity provision for the agriculture sector was considered of medium to high importance (average of 3.8), as well as municipal solid waste management (3.68) and heat for industry (average of 3.56).

About one-third of the Chilean stakeholders interviewed mentioned, when asked which services they consider of importance in addition to the energy services listed in Question 1, that energy efficiency or fuel switch technologies in the transport sector are important to very important in Chile. Some stakeholders just mentioned that they missed transport in the list, but did not think that it is an important energy service for Chile.

Other energy services added by stakeholders to the list of question 1 and considered important to very important by the stakeholders, are: energy efficiency in the production of minerals, which is, as mentioned above, an important economic sector in Chile; refrigeration in the agro-industry, desalination technologies, demand-side management at households and the service sector (schools and hospitals).

It was also analysed how the energy service needs and priorities were distributed across the groups of stakeholders. Among the people from academic institutions interviewed (five persons), all services listed in question 1 were on average considered imported to very important, with an average score of 4.3. Representatives of consulting organisations (6) were more selective when assessing the importance of different energy needs and priorities for Chile. In their view, energy efficiency in industry and electricity for households have the highest priority (important to very important), followed by heating for industry and municipal solid waste management (important). Electricity for agriculture and services, heating for households and services, and energy for cooling purposes was considered of medium importance.

Government representatives (8 interviewed) attached the highest priority to energy for cooling (3.8), and electricity for agriculture and households in rural areas (between medium importance and important). Not surprisingly, industry respondents (7) found energy efficiency in industry very important (4.9 average score), followed by electricity for industry and households, and heating for industry (important). Finally, the representatives of several organisations (NGOs and international organisations such as UNIDO; 4 interviewed) were of the opinion that electricity for industry and energy efficiency improvement in industry very important, followed by municipal solid waste management (between important and very important) and electricity for agriculture. Heating was given low importance scores (average 1.5) and the other services were considered by these interviewees as being of around medium importance.

Overall, the answers to question 1 from Chilean stakeholders show that, as said above, electricity for households and industry, energy efficiency in industry and municipal solid waste are important energy services for the country. These answers are in line with the growing concern in Chile about energy delivery through imports (*e.g.* disrupted natural gas from Argentina, see section 5.2.1) and the consequences this may have for security of electricity supply for households and industry. Heating and cooling generally receive lower scores from Chilean stakeholders.

When comparing the scores across stakeholders, it can be seen that the interviewees from academic and research institutes consider more services important to very important than stakeholders from governments do; the latter group generally gave lower (around medium importance) scores to the energy services listed in the question. Of the other stakeholder groups, the consultants gave answers that were closest to the overall average scores found for Chile; industrial stakeholders gave high importance score for energy services related to industry's energy use.

In question 2, stakeholders were asked which technologies they considered suitable for the energy services explored in question 1. The most suitable technology for Chile that came out of the interviews was energy saving lamps, such as CFL (average score of 4.65) followed by sustainable design of building technologies and passive cooling technologies (4.54 and 4.39, respectively). These three technologies, aiming at reducing energy demand, were mainly considered very suitable for the priority of increased security of electricity for households. Use of biomass (from forest residues and agriculture waste) for electricity, capture of landfill gas, wind power, methane combustion, mini/micro hydropower, and energy conservation technologies in the agro-food (*e.g.* sugar) cement, iron & steel, and chemical sectors, geothermal power, solar thermal, and biogas technologies were considered suitable (scores between 4 and 4.36). The wind power and biomass boiler technologies were even ranked as very important (5) by around half of the stakeholders. With the methane combustion from coal seams and oil it must be remarked that about one-third of the stakeholders indicated that they were too unfamiliar with the technology to be able to give it a rank, which created a bias in the high score since the stakeholders that were familiar with the technology also considered it important to very important. This pattern was largely found for the different stakeholder groups, with the difference that governmental stakeholders, academic stakeholders and consultants focussed more on technologies to increase electricity security of supply for households and industry when considering suitability, whereas industry stakeholders had a clearer preference for focussing on energy efficiency improvement technologies in industry.

Low importance in terms of electricity production was given to coal-to-gas conversion, oil-steam improvement, coal-steam improvement, energy towers, and coalmine methane technologies, although the latter score was biased downwards since over one-third of the stakeholders were not familiar with the technology, whereas stakeholders who were familiar with it gave it a low score.

Finally, stakeholders considered sustainable development aspects of the technologies considered 'important/suitable' and 'very important/very suitable' in question 2. On average, stakeholders suggested that the preferred technologies would deliver large sustainable benefits, although they considered benefits in terms of economic and environmental aspects of slightly more importance than social benefits.

5.3. China

5.3.1. Country context

On 30 August 2002, the Government of the People's Republic of China (hereafter China) approved the Kyoto Protocol. China had already been a Party to the UNFCCC since 5 January 1993. In the development of the CDM, China has played a prominent role: in 1997, when the CDM was introduced in the Kyoto Protocol, the support of China and India for a compromise on a global project-based emissions trading scheme was decisive for the establishment of the CDM. Between 1997 and 2005, China placed much emphasis on the CDM's technology transfer potential, which made the country generally hesitant to accept land use, land-use change and forestry projects under the CDM.

According to China's Initial National Communication on Climate Change to the UNFCCC, population growth, increasing urbanisation, changing patterns of economic development and consumption, technological progress, and changes in forestry are the principle factors behind the future development of GHG emissions in China. It is stated that, on the one hand, GHG emissions will grow due to an increase in economic activity, but, on the other hand, the growth rate in GHG emissions could be reduced through technological development and the Government's strive for sustainable development.

Tentative estimates suggest that China's annual GHG emissions in 2004 amounted to about 6,1 Gton/CO_2-eq. (CO_2: 5 Mt). According to China's National Climate Change Programme, from 1994 to 2004, the annual growth rate of GHG emissions was around 4% and the share of CO_2 in total GHG emissions increased from 76% to 83%. Of the total annual GHG emissions approximately 3 Gt/CO_2 originate from large point stationary emission sources. Figure 5-3 shows the overall picture of large CO_2 emission point sources (over 100 ktCO_2 per year) in China. The Figure shows a strong eastward bias of stationary CO_2-sources in China, where most of the relevant industrial processes are located: *i.e.* power plants, refineries, iron and steel manufacturing, hydrogen, ethylene, cement and ammonia production.

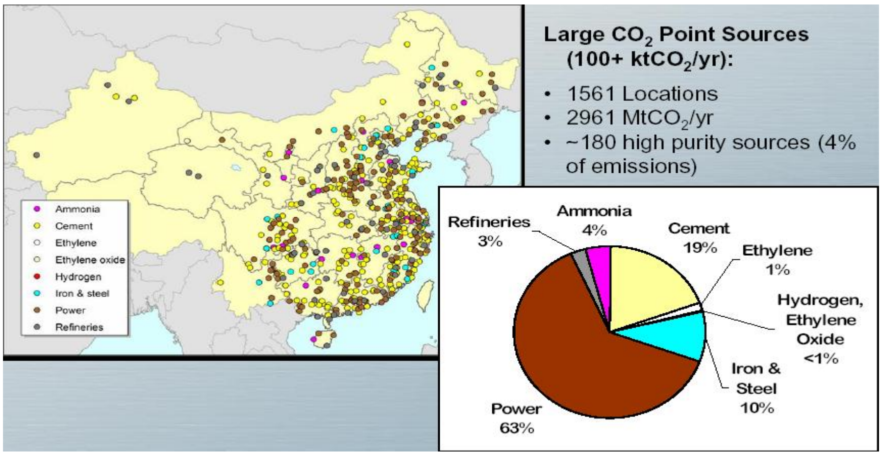

Figure 5-3. Large point stationary emission sources in China, by source type (preliminary).

Source: Batelle, 2005.

The power sector has the largest share in CO_2 emissions, which is mainly caused by the large dependency on domestic coal supply. One important trend in relation to coal consumption in China is that whereas in 1985 the share of power and heat in the country's total coal consumption was 22%, by 2004 this share had increased to 55% (see Figure 5-4). The dominance of coal-use in China (about two-thirds of primary energy consumption, see Figure 5-5) causes nearly 75% of China's CO_2 emissions of which the power sector alone contributes over one third.

In terms of coal end use it can also be observed that the spread of coal use across economic sectors is broader than in for instance a country like the USA. Whereas US coal consumption is largely focussed on power generation (90%), in China only 55% of coal is used for production of electricity.

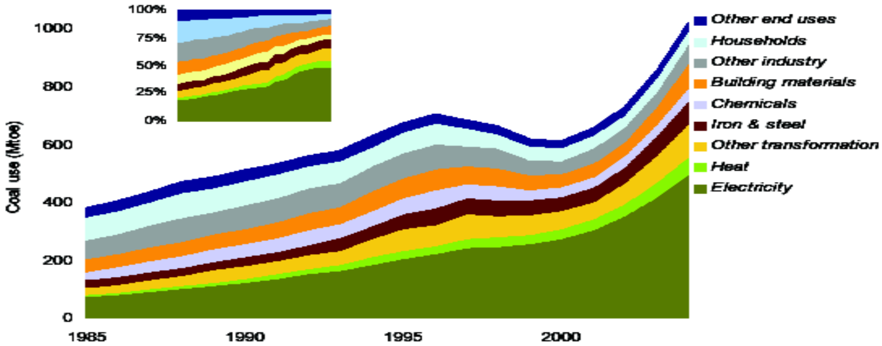

Figure 5-4. Coal use by transformation and end-use sectors in China, 1985-2004

Source: IEA, 2006.

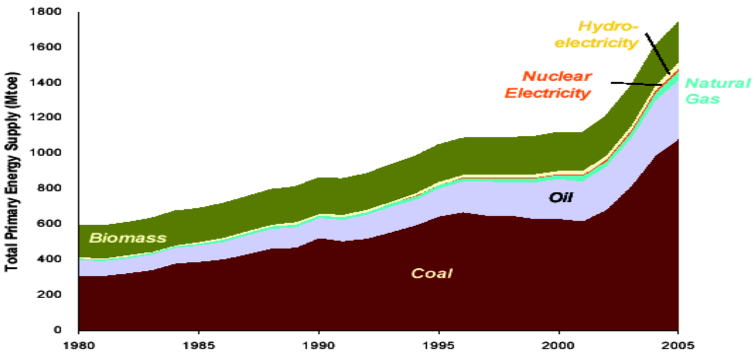

Figure 5-5. Total primary energy supply in China, 1980-2005

Source: IEA, 2006.

Table 5-4 shows some key social and population data for China.

Table 5-4. China's population (1980-2005) and key social indicators

	1980	1985	1990	1995	2000	2005
Population by the end of the year (in ten-thousand persons)	98705	105851	114333	121121	126743	130756
Urban(%)	23.71	26.21	26.41	29.04	36.22	42.99
Rural(%)	76.29	73.79	73.59	70.96	63.78	57.01
Natural growth rate(%)	1.187	1.426	1.439	1.055	0.758	0.589
Residential electricity consumption		132 kWh per person per year				
Persons below poverty line*		30 million				
Persons without electricity		23 million				
Persons per vehicle		79				

*This level is defined as persons earning less than $0.20 per day (in exchange rate value).

Source: 2001 China Statistical Yearbook, 2005 China Statistical Yearbook

In China's present 11th Five-Year Plan (2006-2010) resource conservation, and energy saving in particular, are indicated as important aspects of the country's national policy. In the plan, there are only two quantitative development goals: China's per capita GDP in 2010 must be twice as high as in 2000; and the energy volume consumed per unit of GDP should drop by 20%. Consequently, sustainable development and rational energy consumption have become important targets. In order to support these targets, the central government of China has decided that ten major energy-saving projects will be launched during the 11th Five-Year period:

1. **Upgrade coal-burning industrial boilers** (kilns): In China 500, 000 medium-sized and small boilers are operational with an actual efficiency of around 65%. 90% of these are coal-based. Proposed measures are in the fields of using better quality coal, renovation of boilers, and improvement of management and operation of the boilers.
2. **Co-generation**: Through co-generation heat efficiency can be increased by 30% as compared to separated generation. A key focus in this respect is on centralised heat supply, which has been translated in the objective that by 2010, centralised heat supply should cover 40% of heat service delivery in urban areas (which was 27% in 2002).
3. **Make use of exhaust heat and pressure**: Through application of coke dry quenching techniques in iron and steel enterprises power can be generated from the pressure difference in blast furnaces. Residual heat recovery in coal burning in industrial applications can be used as an extra energy source. Finally, in this context, China aims at increasing the capture of coal-bed/coal-mine methane for energy use.
4. **Save and replace petroleum**: Specific steps proposed are to replace fuel oil (light oil) with clean coal, petroleum coke and natural gas in the industries of power, petroleum and petrochemical industry, metallurgy, construction material, chemistry and transportation. Also, measures to save petroleum use are planned, as well as an operation plan for cleaner energy use in transport.
5. **Energy conservation in electrical motors**: In the 11th five-year period, China plans to support highly efficient electrical motors and those applying rare earth permanent magnets; launch systematic optimisation and renovation of high-efficiency wind turbines, pumps and compressors, and promote the technologies of speed-adjustable of frequency conversion and automated system control.

6. **Optimisation of the energy system**: In major industries, energy systems are planned to be optimised by improving production processes, carrying out technical renovations and improving management. Target sectors are: metallurgical, petrochemical industry, and the chemical industry.
7. **Energy conservation in buildings:** The target is to reduce energy consumption by 50% in residential and government buildings, which will be done by: speeding up the reform in heat-supply systems, tightening efforts in promoting building energy efficiency technology and related products. Meanwhile, existent buildings will be renovated in the northern regions, as well as existing hotels throughout the country.
8. **Efficient lighting:** Lighting causes around 13% of the total power use in China. Some 70 to 80% of power can be saved by replacing ordinary incandescent lamp with high-efficiency energy-saving fluorescent lamp. Replacing traditional electromagnetic ballast with electronic ballast can save 20 to 30%. In traffic lights, 90% of power use can be saved by replacing candescent lamp with light emitting diode (LED).
9. **Energy conservation in governmental departments**: Governmental institutions have had a strong increase in energy consumption, which is planned to be reversed by reconstruction of buildings, including improvement of heating, air-conditioning and lighting systems, applying higher efficiency standards for newly constructed buildings.
10. **Monitoring and technical service system**: The country will improve the capability of the energy saving monitoring centres of provincial level or in major energy-consuming industries, through upgrading monitoring equipment, strengthening personnel training and popularising contractual energy management. It will also monitor and manage energy conversation by law.

A main overall concern expressed by the Government of China is energy security of supply, which could be enhanced by the above energy saving measures but also by increasing domestic energy production and diversifying international energy purchases. Domestic energy resources to be further used, according to the present Five-Year Plan are: coal, petroleum, natural gas, hydraulic power and renewable energy sources. A ESNAcarried out for China through an interview with a Chinese DNA representative confirms the above observations. It shows that, in terms of sustainable technology needs and priorities, China's highest priority is in the field of energy efficiency in industry, followed by technologies for electricity production in industry and households. With respect to electricity production, clean coal technologies are considered important by the Chinese government. Finally, sustainable technologies for municipal solid waste management are part of China's priorities.

5.3.2. CDM profile

In June 2004, China presented its *Interim Measures for the Operation and Management of the CDM* which includes the selection of the *National Development and Reform Commission* (NDRC) as the DNA. A second version of these measures was adopted on 12 October 2005. NDRC takes decisions on CDM projects proposed for implementation in China based on the recommendation by the *National CDM Board*. This Board is co-chaired by NDRC and the Ministry of Science and Technology, and is furthermore represented by the State Environmental Protection Agency, the China Meteorological Administration and the Ministries of Foreign Affairs, Finance, and Agriculture. The DNA requires 60 days at most for the process of approving a CDM project proposal.

According to the website of the Chinese DNA (http://www.ccchina.gov.cn), the priority areas for CDM projects in China are: energy efficiency improvement, development and utilisation of new and renewable energy, and methane recovery and utilisation. In 2005, the Government of China launched a new *Renewable Energy Law*, which imposes a national target to increase the use of renewable energy sources (hydroelectricity, wind power, solar energy, geothermal energy and marine energy) to 10% of the total energy mix by the year 2020. In 2003, the share of the renewables in China's energy production was 3%.

Table 5-5 shows the CDM projects for China as per October 2007. As already explained in Chapter 3, most CDM projects are in the field of hydropower followed by energy efficiency improvements by use of residual heat in industry (EE own generation), and wind power projects. In total, China has 859 projects in the pipeline. As explained in Chapter 3, should all projects currently in the pipeline perform as expected in the projects' design documents, then 1.2 billion CERs can be expected by the year 2012. Assuming an average price of €10/CER (based on the market prices as per October 2007 of €17.5 per CER for spot market transactions and €6 for medium-risk forward CDM contracts), then Chinese partner could earn €12 billion from CDM projects, which is about €2 billion per year. However, the CERs represent in most cases only part of the total investment required for a project, so that in terms of investment capital transferred to China the €2 billion/year figure could be much higher. It must be noted though that in other cases, such as the HFC23 emission reduction projects, CER revenues are far higher than the actual investment costs. Moreover, the Chinese government requirement that 51% of projects' equity (in joint ventures) must be possessed by Chinese partners in combination with the fact that technology for several Chinese CDM projects is produced domestically makes a precise foreign direct investment impact from CDM projects in China difficult to establish. For the purpose of comparison, in 2006, Chinese foreign direct investments amounted to €55 billion, which is about 25 times as big as the potential annual CER value of the Chinese CDM pipeline.

According to the German development bank *KfW Bankengruppe* and the German government agency for international economics (BFAI), China's investment climate for the CDM is satisfactory with a favourable general investment climate, but with quite heavy governmental influence in Chinese economic sectors and in CDM project preparation and implementation, as well as frequent legal uncertainty and insufficient protection of property rights. It can also be noted that buyers of Chinese CERs are extremely divers, with carbon fund participation, private sector institutions, Japanese industrial groups, and European energy suppliers.

Finally, it must be noted that the 2% share of proceeds from the CER revenues (which is required to be paid to host countries as per Article 12.8 of the Kyoto Protocol) has to be paid to the Government of China. These shares of proceeds can be used to cover administrative costs of the CDM in a host country and can be used for investing in protection against adverse effects of climate change. In addition, China has a taxation schedule for the CERs with the tariffs depending on the type of project. Renewable energy, afforestation, and methane capture projects face a 2% tax for their CER earnings, whereas CER revenues from N_2O emission reduction projects are taxed for 30% and HFC and PFC emission reduction projects for 65%. These tax revenues are placed into the China CDM Fund (supervision of Ministry of Finance) for CDM capacity building and loans for CDM projects in the country.

Table 5-5. CDM project pipeline for China, as per October 2007

	Registered	Requested review	At validation	Correction requested	Registration requested	
Biogas			6		1	
Biomass energy	6	1	16		1	
Cement			1			
CMM	5	1	31	1	1	
EE industry			2			
EE own generation	8	2	144		3	
EE supply side			2			
Fossil fuel switch		2	18		2	
HFC23	9		1		1	
Hydro	37	2	354	1	7	
LGC	7		20	2		
$N_2 0$	2	1	18			
Reforestation	1		1			
Solar			2			
Wind	50	5	83		1	
Total	**125**	**14**	**699**	**4**	**17**	**859**

Source: UNEP Risø Centre, after Fenhann (2007)

5.3.3. Energy Needs Assessment

Since the regional variety in China is very large, an assessment of technology needs and priorities for the entire country using the participatory ESNA model developed for this study (see Chapter 4) is difficult and time consuming. In order to have a representative cross section and cross-region coverage for China, while keeping the interview workload manageable over such a large and diverse country, it was decided to select some stakeholders from central government and international organisations and then focus on two typical provinces with different economic profiles and different types of two regions (south and north). Yunnan in the Southwest (where the study partner Kunming University for Science and Technology is located) was an obvious choice for the less developed area (in 2005 its GDP was RMB yuan 347.2 billion or around €33 billion). However, the choice of a developed province was not straightforward. Initially, the Guang Dong province was considered, but it was decided that this was not a representative province since it has relatively little coal and a mild climate. Gansu was also considered because of its large wind and solar power potential, but eventually the Shandong province (Shandong = 'East of mountains') was chosen because it has a strong heat demand during the winter and cooling demand during the summer (see Figure 5-6). In addition, it has abundant coal reserves and has had a relatively advanced economic development with a GDP in 2005 of RMB yuan 1.85 trillion (€175 billion). This selection also reflects the division between east and west China, with the western part being relatively less developed. It would have been useful to also focus on a transitional province between these two extremes, but this was not feasible within this study.

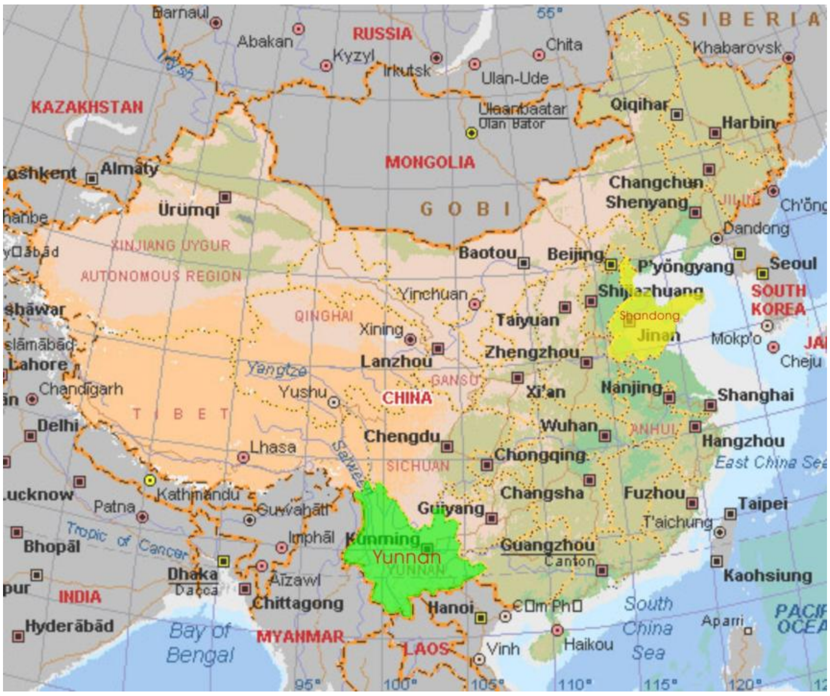

Figure 5-6. Location of Yunnan (capital: Kunming) and Shandong (capital: Jinan)

Source: Encyclopedia britannica 2001 Deluxe Edition CD

The climates in both provinces vary greatly with warmer winters and cool summers in Yunnan and exactly the opposite pattern in Shandong. Due to this, the Shandong province needs heating during the winter and cooling during the summers, whereas in Yunnan this is not needed (see **Table 5-6**). Being a plateau area, Yunnan is located in a mountainous area and has a large potential for hydropower. Together with coal, hydropower is the main energy source in Yunnan. Due to its location in the north coastal plane area, Shandong has less potential for hydropower and relies for its energy sources on coal, oil and combustion power.

Table 5-6. The properties of the selected provinces for the ESNAinterviews

Province	Economic situation	Heating in winter	AC in summer	Coastal area	Hydroelectric abundance	Main energy source
Yunnan	Relatively less advanced	No	No	No	Yes	Hydropower, coal
Shandong	Advanced	Yes	Yes	Yes	No	Coal, oil, combustion power

For the interviews, stakeholders were selected from both provinces and from the central government and international organisations with offices in China (see **Table 5-7**). In total 22 stakeholders were interviewed for each of the two provinces as well as 12 from national and international organisations, so that the total number of people interviewed was 54. In addition, fifteen selected part-time graduate students at KUST with different backgrounds and who were from different parts of China were also interviewed and they form a subgroup within the analysis. The interviews took place from September 2006 to March 2007.

Table 5-7. Stakeholders interviewed for ESNAin China

NATIONAL/INTERNATIONAL

- 1 Central government
    - Climate Change and the CDM
    - Energy policy
    - Technology transfer
    - Environment
    - Development
    - Finance
    - Trade and Industry
- 0 National Industry associations
- 1 International organisations such as UNDP, UN Habitat, and donors such as UK DFID, GTZ, *etc,* and NGOs such as WWF

YUNNAN	SHANDONG
• 2 provincial government departments	• 10 provincial government departments
• 10 Industries	• 4 Industries
• 1 Industrial associations	• 1 Industrial associations
• 2 NGOs	• 6 NGOs
• 2 local government at the community level	• 3 local government at the community level
• 1 community representatives	• 6 community representatives
• 1 Banks	• 0 Banks

COMMUNITY REPRESENTATIVES

- 15 selected part-time graduate students of KUST, and 2 community (street) administrative officials.

With respect to the energy service needs and priorities in both provinces (Question 1 of the questionnaire), the highest priority was given to improving electricity supply for industry. Both in Yunnan and Shandong, stakeholders considered this service as important to very important (average score of 4.7), followed by energy efficiency improvement in industry (average score 4.2) and municipal solid waste management. Improved electricity supply for households was given medium priority and within this category a higher priority was given in both provinces to electricity for urban communities, although electricity for rural communities received a higher score in Yunnan than in Shandong (3.5 vs 3.2), which is not a surprise given that Yunnan has more rural communities. Heat for industry was also valued differently in both provinces. In Yunnan, this service was considered to be of medium importance whereas in the more industrialised region of Shandong, it received the average score of 4 (important). An overview of scores in both provinces is given in **Table 5-8**. It must be noted though that stakeholders considered all services listed in question 1 as of medium importance at least. Some stakeholders added some possible services under 'other services', but the scores given for these were low, so that these were considered to be of less importance than the ones already mentioned in the questionnaire.

Table 5-8. Energy technologies needs and priorities in Yunnan and Shandong (in descending order)

Yunnan		Shandong	
Energy Service	**Score**	**Energy Service**	**Score**
Electricity for industry	4.7	Electricity for industry	4.7
Energy efficiency in industry	4.3	Energy efficiency in industry	4.3
Municipal Solid Waste management	4.2	Municipal Solid Waste management	4.2
Heat for industry	4.1	Heat for industry	4.0
Electricity for service sectors	3.5	Electricity for agriculture	3.6
Electricity for households - urban	3.4	Electricity for households - urban	3.6
Electricity for households - rural	3.3	Energy for cooling	3.5
Electricty for agriculture	3.3	Heat for households	3.4
Energy for cooling	3.3	Electricity for service sectors	3.4
Heat for service sectors	3.2	Electricity for households - rural	3.0
Heat for households	3.1	Heat for service sectors	2.9

In the second question, stakeholders were asked to identify sustainable technologies which, in their view, would be appropriate and suitable for improving the energy services identified in Question 1 in both provinces. While question 1 did not reveal many large differences between stakeholders in Yunnan and Shandong – *e.g.* the top-4 priorities were exactly the same –, the ranking of technologies in question 2 showed more substantial differences between both provinces (although the differences in scores between the highly ranked technologies are small). In Yunnan, the highest scores (most suitable and appropriate technologies) were given to energy saving lamps, solar coolers, and clean-coal technologies for large-scale electricity production. In Shangdong, on average the highest score was given to clean-coal technologies, followed by large-scale hydropower through dams. Energy saving lamps came in third position. Finally, it was striking to see that stakeholders considered technologies mentioned in question 2 for applicability in municipal solid waste management as of medium suitability or lower, whereas the service itself had been considered important in question 1. A possible reason for this is that the technologies shown to stakeholders in question 2 for municipal solid waste management would not only capture the methane but also use it for electricity or heating purposes (through combustion or gasification of the waste itself or the methane captured). Apparently, these technologies are presently considered less suitable by stakeholders, although this could be partly explained by the limited familiarity of stakeholders with these technologies. **Table 5-9** compares the technology suitability according to stakeholders in Yunnan and Shandong.

Table 5-9. Suitability of technologies in Yunnan and Shandong (in descending order)

Yunnan		Shandong	
Technology	**Score**	**Technology**	**Score**
Energy saving lamps	4.2	Clean-coal for large-scale power supply	4.4
Solar coolers	4.2	Hydropower through dams	3.9
Clean-coal for large-scale power supply	4.1	Energy saving lamps	3.8
Cement industry energy conservation	4.1	Cement industry energy conservation	3.8
Hydropower through dams	3.9	Solar coolers	3.6
Supercritical power plants	3.8	Iron & steel industry energy conservation	3.4
Iron & steel industry energy conservation	3.8	Wind power for large-scale power supply	3.3
Coal-to-gas for large-scale power supply	3.8	Solar cookers (for households)	3.2
Chemical industry energy conservation	3.7	Combustion of municipal solid waste	3.1

When comparing the technology scores with the preferences for technology developments formulated by the Chinese Government (see for instance the above 11th Five-year Plan), then it can be concluded that there is consistency between both. Electricity security of supply for households and industry is a top priority according to stakeholders and mentioned as such in government strategies for the medium term. Also, the interest in wind and hydropower technologies are in accordance with the government's aim to increase the share of renewable energy-based power production in the Chinese energy mix. Efficiency improvement in industry has also been ranked highly by both the stakeholders and the government.

With respect to sustainable development contributions of technologies in China (Question 3 of the questionnaire), the following observations could be made. For both provinces, sustainable development has been assessed in terms of economic, environmental and social aspects for the technologies considered most appropriate and suitable in Question 2. For Yunnan, stakeholders expect very large economic benefits from energy saving lamps as well as large environmental and social benefits. Important economic aspects recognised by stakeholders is that energy demand can be reduced when using energy saving lamps, that energy bills can become lower, and that energy distribution systems become more stable when less energy is needed for lighting. Improved efficiency was recognised by stakeholders as an important contribution to environmental protection and to increase the comfort of lighting. However, it was noted that for these benefits to be realised, the lamps must be of a high quality so that they can indeed last as long as needed to reap the benefits of efficient lamps, and that the lamps give an almost immediate full light instead of a weak light first, which then extents to full light after a while. For solar coolers, economic and environmental benefits were considered as very large (5), whereas social benefits were expected to be medium.

Yunnan stakeholders found very high economic and environmental development benefits for clean-coal technologies applied in large-scale power supply, whereas social aspects are considered important benefits. In the cement industry, energy efficiency improvement technologies are mainly considered important from an environmental point of view, whereas economic and social aspects are though to be less important. The relatively low importance attached to economic benefits in the cement industry could be considered a surprise since the energy efficiency gains would reduce operational costs of the plants. Of the renewable energy technologies, hydropower has the highest scores with economic and environmental sustainable development aspects considered very important; social aspects for this technology have acquired a lower score, but are still considered important for supporting sustainable development.

Table 5-10 and **Table 5-11** shows the sustainable development scores for the priority technologies in Yunnan and Shandong, respectively (derived from Question 2 above). In general, it can be concluded that stakeholders in Yunnan expect most sustainable development to come from economic and environmental aspects, whereas social aspects (*e.g.* poverty alleviation, health care, education, empowerment) are thought to be less important for the technologies analysed.

Table 5-10. Sustainable development contributions of technologies, Yunnan stakeholders

	Economic aspects	Environmental aspects	Social aspects
Energy saving lamps	4.9	4.1	3.9
Solar coolers	5.0	5,0	2.3
Clean-coal for large-scale power supply	5.0	5.0	4.0
Cement industry energy conservation	3.6	4.4	3.2
Hydropower through dams	5.0	4.3	4.0
Supercritical power plants	4.0	4.3	3.6
Iron & steel industry energy conservation	4.0	4.5	3.6
Coal-to-gas for large-scale power supply	4.0	4.2	3.0
Chemical industry energy conservation	3.8	4.5	4.2

Table 5-11. Sustainable development contributions of technologies, Shandong stakeholders

	Economic aspects	**Environmental aspects**	**Social aspects**
Clean-coal for large-scale power supply	4.3	4.3	3.5
Hydropower through dams	4.8	4.8	3.8
Energy saving lamps	4.6	4.9	4.6
Cement industry energy conservation	4.4	4.6	3.9
Solar coolers	4.8	4.6	4.0
Iron&steel industry energy conservation	4.4	4.8	3.6
Wind power for large-scale power supply	4.3	4.3	3.5
Solar cookers (for households)	4.8	4.8	3.8
Combustion of municipal solid waste	?	?	?

Also in Shandong it could be observed that stakeholders generally found economic and environmental sustainability aspects more important than social aspects. Energy saving lamps was assessed best in terms of sustainable development contribution with high scores for all three types of aspects. While the first two categories of sustainable development aspects acquired scores of between 4 and 5 (important to very important), social aspects were scored between medium importance to important. Generally, though, the priority technologies received higher scores from stakeholders in Shandong than they did in Yunnan. One explanation for this difference could be differences in familiarity with and knowledge of sustainable development benefits between the groups of stakeholders.

5.4. Israel

5.4.1. Country context

Israel has a technologically advanced market economy with substantial government participation. It depends on imports of, among others, fossil fuels (crude oil, natural gas, and coal), grains, beef, and raw material. Despite its limited natural resources, Israel has intensively developed its agricultural and industrial sectors over the past 20 years so that it has become largely self-sufficient in agricultural products and has extensive facilities for oil refining, diamond polishing, and semiconductor fabrication. Israel receives large amounts of venture capture from other countries and has the highest ratio of venture capital per unit of GDP in the world.

Although the Government of Israel in principle favours privatisation of state-owned companies, the energy sector has remained largely nationalised and state-regulated, ostensibly for national security reasons. Israel is a world leader in solar technologies and relies heavily on solar energy for water heating. Until recently, when a significant offshore natural gas field was discovered, Israel had essentially no commercial fossil fuel resources of its own, and needed to import almost all (97%) of its energy. Therefore, the country has attempted to diversify its energy supply sources and to utilise renewable energy sources such as solar and wind energy.

Traditionally, Israel has relied on long-term oil purchase contracts with Mexico, Norway, and the UK and on coal contracts with Australia, South Africa, and Colombia. The country itself hardly produces oil, although it is expected that Israel has some oil reserves (5 billion barrels) underneath its gas reserves and possibly through its geological connection with the oil-rich Palaeozoic petroleum field stretching from Saudi Arabia through Iraq to Syria (possible Israeli reserve: 3.8 million barrels). Israel also hopes to increase the role of natural gas in its energy mix in coming years, in particular for electricity generation. This gas could be imported from Egypt's Nile Delta and offshore regions, but recently an offshore gas field on Israel's own territory has been discovered with a proven reserve of almost 42 billion m^3.

Israel meets approximately 30% of its energy demand requirements by burning coal (primarily for electric power generation), of which it imports 93%: in 2001, about 47% of these imports came from South Africa, with the rest coming from Colombia (21%), Australia (16%), and Indonesia (16%). In order to further diversify the import portfolio, Israel has also begun importing coal, or is planning to do so, from the USA, China, and Poland.

In 2001, the total energy requirement was 19.435 million tonnes of oil equivalent (MToe), of which 60.9% was supplied by oil, 36.2% by coal and the remaining part by renewables (mainly solar water heating). In 2004, 67.1% of the electricity produced by the IEC (Israel's Electricity Corporation) was generated by coal and fuel oil, 18.4% by natural gas turbines, and 14.5% by combined cycle plants. However, these percentages are changing in the direction of a larger share for natural gas and a smaller share for oil and diesel-fired generators. IEC plans to spend about 1 billion € over the next ten years to help reduce emissions from its power plants. New coal plants are to be equipped with flue gas desulphurisation and combustion systems, and most of IEC's existing gas turbines have been retrofitted with low nitrogen combustion systems. Most of the coal ash waste produced by IEC's three coal-fired power plants is sold to the cement industry.

Israel is a world leader in solar technology development and relies heavily on solar energy for water heating, which is required for most domestic users in the building standards. The present share of renewable energy in primary energy is approximately 3.1%.

As part of an effort to increase privatisation of the country's power sector, Israel's Ministry of Energy has directed IEC to purchase at least 900 MW of power from independent power producers by the year 2005 (of which possibly 150 MW are expected to come from solar and wind facilities, with the rest mainly natural gas-fuelled).

Israel is a non-Annex I country under the UNFCCC, which it ratified on 4 June 1996, and a Party to the Kyoto Protocol, which it ratified on 15 March 2004. The Ministry of the Environment was established by government decision on 25 December 1988 and is responsible for the national co-ordination of all environmental issues, including Climate Change. The Ministry of National Infrastructures supervises the energy sector, by the means of the 'Fuel Authority' for the oil sector and the 'Electricity Authority' for the electricity sector; the development of gas projects depends on the 'Natural Gas Projects Management'.

5.4.2. CDM profile

Israel's Designated National Authority for the CDM (DNA) was established in 2004 within the Ministry of Environment, with representatives of several governmental and public bodies: the Ministry of the Environment, Ministry of Transportation, Ministry of Industry and Trade, Ministry of National Infrastructures, Ministry of Finance, Ministry of Agriculture, the Manufacturers Association of Israel, IEC, and the environmental NGO Zalul. . The DNA has established procedures for the assessment of CDM project proposals and their alignment with national sustainable development criteria. It also serves as 'service platform' to assist project developers during the CDM project cycle.

The main function of the DNA is to determine whether a proposed CDM project complies with sustainable development criteria. For this purpose, the Israeli DNA has formulated sustainable development indicators, which will be used in the assessment process of the Project Design Document:

- *Economic and technological impacts*: development and transfer of technology, infrastructure, utilization of resources,
- *Social sustainability impacts*: improvement of employment, living standards, human and institutional capacity such as education and welfare services, and
- *Local, regional and global environmental impacts*: improvement of air quality by reduction of emissions of pollutants (such as radiation), and biodiversity increase.

Possible CDM project opportunities in Israel can be found in a wide array of categories:

- *Energy*: Use of renewable energy sources such as solar energy, geothermal energy, wind turbines, hydroelectric stations, utilisation of waste heat, biomass, *etc*.
- *Transportation*: Establishment of a mass transit system, switch to clean vehicles fuelled by cleaner fuels.
- *Waste*: Collection of methane gas from landfills and wastewater treatment plants, generation of energy from waste, treatment of livestock waste, *etc*.
- *Industrial and public buildings*: Installation of energy saving lighting, installation of solar collectors, *etc*.
- *Industry*: Increasing production efficiency and saving on fossil fuel combustion, transfer to dry production processes in the cement industry, *etc*.
- *Land-use changes*: primarily reforestation and afforestation projects.

Although these project categories offer a considerable CDM potential, two areas with a particularly large potential are highlighted below (information provided by ENTTRANS partner ICTAF):

- *Waste management*: Israel has made major strides in its waste management over the past decade by closing 77 large waste dumps and replacing them with state-of-the-art central landfills with systems for leachate collection and treatment, leakage prevention and collection of gas emissions. However, the methane captured from the waste decomposition is hardly used anywhere in Israel for heat and electricity generation. However, some 90% of the country's waste is still landfilled in a less controlled way; only a few of the sites extract and utilise methane. Consequently, this sector is a strong contributor to Israel's GHG emissions, also due to the high global warming potential of methane (21 times that of CO_2).
- *Energy*: The rate of growth of electricity consumption in Israel is among the highest in the world, reaching some 6% per annum in the last decade. Based on a 'business as usual' scenario, the IEC anticipates the production of 74 GWh in 2020, which would imply a CO_2 emissions level of nearly 60 $MtCO_2$ per year. Emissions from this sector may be reduced by two means: changes and improvements in the electricity production system and use of renewable energy.

Within the above overview of possible CDM categories, the following areas/market niches where renewable and new energy efficient services could be successfully launched, possibly through the CDM, can be identified:

- Large public buildings (such as universities),
- Isolated areas such as unrecognised Bedouin villages,
- Energy conservation in arid areas,
- Solar collectors for water heating for residences, hotels, and medical centres, and
- Solar collectors for water heating at high temperature for industrial use.

Up to October 2007, 21 CDM projects in Israel have entered the pipeline of projects that are either under validation, or have been registered, or are in a process of registration (see **Table 5-12**). All these projects have in the meantime been approval as eligible CDM projects by the Israeli DNA. Fourteen of these projects are at the stage of validating the project design document including the calculations of the expected GHG emission reductions. The other seven projects have been registered by the CDM EB as official CDM projects. In total, should these projects perform as planned in their design documents, it is expected that they will generate 10.6 million CERs by the year 2012, which can then be transferred to industrialised countries with quantified commitments. Moreover, most of the projects have a lifetime that goes beyond the year 2012 (the end of the Kyoto Protocol commitment period) and will continue generating emission reductions and thus CERs. Again assuming full performance, the projects will deliver 31.7 million CERs by 2030. However, as noted in Chapter 3, in actual practice CDM projects hardly perform according to plan with some project performing below and others even above expectations. In general, it is expected that projects deliver around 75% of planned CERs (see Chapter 3), which would imply for the current Israeli projects between 7 and 8 million CERs by 2012 and around 25 million credits by 2030 (Fenhann, 2007).

It is also interesting to note that the fossil-fuel switch projects mentioned in **Table 5-12** are all in the field of switching from oil or coal to natural gas (in a textile plant, a paper mill, and two new gas-fired stations/plants).

Table 5-12. CDM project pipeline for Israel, as per October 2007

	Registered	Requested review	At validation	Correction requested	Registration requested	
Agriculture			1			
Biogas			2			
Biomass energy	1		1			
EE industry	1					
Fossil fuel switch			4			
LGC	2		4			
N_20	2		2			
Wind	1					
Total	**7**	**0**	**14**	**0**	**0**	**21**

Source: UNEP Risø Centre, after Fenhann (2007)

5.4.3. Energy Needs Assessment

For the first part of the ESNA in Israel (assessment of priorities and needs, and suitability of technologies), key stakeholders in the energy and financial sectors were selected. Among them were investors, renewable energy company representatives, planners, energy service company representatives, and decision makers at the local and national level. Only representatives of domestic companies and organisations were invited to participate and they had to work for companies and organisations which had been involved in the Israeli energy market for at least two years. Eventually, 45 stakeholders from the following categories collaborated with the research team:

1. *Government*: DNA committee members, Government Delegates, Relevant Ministry Departments, NGOs representatives – these stakeholders are active in the field of CDM policy making in Israel and represent official and public units inside and outside the national government involved in assessing CDM issues;
2. *Major Industry & Business Associations*: Commercial sector, Industrial sector, Chamber of Commerce, Industrial Chamber – these public organisations represent key economic sectors such as industry, transport and the construction and are responsible for most of the national energy consumption;
3. *Enterprises, Technical Agencies and Other Organizations*: Energy Agencies, ESCOs, Utilities – these stakeholders represent the private sector and the potential entrepreneurs for CDM projects;
4. *Representations of major IFIs and donors*: IFIs, EIB, World Bank – this group includes potential donors for financing and investment in CDM projects.

ENTTRANS partner ICTAF organised a stakeholder-brainstorming workshop in January 2007 in order to identify promising clean energy technologies processes in Israel and to assess the potential for their implementation through the CDM. Stakeholders present at this workshop were interviewed in the margin of the meeting, whereas others were interviewed bilaterally afterwards (either through bilateral meetings or by telephone).

With respect to Question 1 on the energy service needs and priorities in Israel, there was a common understanding among the stakeholders interviewed that energy is essential for day-to-day life. Therefore, *electricity for households* was considered very important ('5'), since consumption of electricity by households is one of the main drivers for the annual increase in energy consumption in Israel. Despite that, some stakeholders assumed that this trend would be more moderate since most of the residential buildings in

Israel already use air conditioning systems, so that the electricity demand will become more stable. In general, the interviews did not show a clear distinction between rural and urban communities.

The interviewees also gave a very high importance to the service of *electricity for service sectors* ('5'), which was mainly based on the argument that recent national economic developments have shown a shift from agriculture and industry towards commercial and health service activities. There was a consensus among stakeholders interviewed that the need of electricity in this sector is high and will remain high in the short to medium term, while there have been no incentives to cut electricity usage in these sectors.

Energy efficiency in industry was also given a score of '5' (very important energy service for Israel) as improvement of energy consumption systems for more efficient energy use was considered critical for the industrial sector, both from an economic and environmental point of view. Most of the interviewees emphasised the importance of investing in provision of efficient energy technologies as the preferred solution to reduce energy costs and CO_2 emissions. Since the steps taken by the government and the private sector have thus far not been sufficient, additional measures in this direction are needed.

Electricity for industry received a score of 4.5, which was explained by stakeholders because of the high annual rate of industrial growth and consequently the growing need for electricity. This growth is largely accompanied by an increased use of automatic machines such as robots, in particular in high-tech industries. Many of the high-tech industries consume mainly electricity for the customer systems and for air conditioning and heating so that their energy needs profile is comparable to that of service sectors. According to some stakeholders, co-generation systems in industry would have good potential in Israeli industrial sectors.

The opinions on *heat for industry* differed in the sense that in some industries heat is much needed, whereas in other industries the need for heat is very low. Despite the trend of moving from traditional industries to high-tech and services, there is an essential need for efficient heat technologies in the heavy industries. Some stakeholder mentioned the potential for co-generation systems in industrial sectors, which would combine the need for heat with the need for electricity in industrial sectors. Nonetheless, this service was considered important by Israeli stakeholders ('4').

Energy service needs that were considered by stakeholder as either of medium importance, or important ('3.5' on average) were:

- *Electricity for agriculture*: On the one hand, the agriculture sector in Israel has been reduced annually, and plays a minor role today in the Israeli economy. On the other hand, the remaining agricultural branches use more electronic and other sophisticated equipment than before (for example, use of lightning and temperature control systems), so the consumption of electricity per capita is higher. Therefore, the interviewed stakeholders tended to give this energy technology need a medium ranking.
- *Energy for cooling purposes (e.g. medicines)*: Energy for cooling is needed mainly for space acclimatisation. Energy for other cooling purposes such as storage of food or medicines is also essential, but its overall impact on the use of energy technologies is minor.
- *Municipal solid waste management*: There was disagreement among the interviewees regarding the need for energy technologies for solid waste management. While some interviewees emphasised that Israel has developed advanced relevant technologies for this service, and that the country could largely improve waste management, others were more sceptical because of the limited sources of waste in a small country like Israel.

Finally, heat for households and for the service sectors was considered unimportant ('2') by stakeholder as these services are generally well covered in Israel through application of air-conditioning systems and radiators.

In Question 2, stakeholders assessed the suitability of clean energy technologies for fulfilling the services addressed in Question 1. Three categories of technologies were found very suitable with a score of '5': solar based technologies, energy efficiency improvement in residential dwellings, and coal-to-gas fuel switch technologies:

- *Solar*: solar photovoltaic (PV) and solar thermal for water heating were particularly mentioned, in particular due to the high potential for solar-based technologies in Israel. It was nonetheless mentioned that suitability of PV technologies might be somewhat threatened by the rather high costs associated with this technology. Solar thermal for water heating is already applied in Israel (see Section 5.4.1) and has thus been relatively well proven.
- *Efficiency improvement in buildings*: sustainable building design, improved air conditioning and energy-saving lamps were considered very suitable technologies for Israel ('5'), in particular with the objective to reduce energy demand in households, which was considered a very import priority in Question 1 (not the improvement of electricity delivery, but the reduction of electricity demand for the same services was meant in Question 1). Some stakeholders explained that sustainable building design would fit well in the new Israeli building standards which encourage energy use reduction in buildings. A similar reasoning was given by stakeholders for passive cooling technologies and solar cooling technologies (rated around '4.5' in terms of suitability within the Israeli context). Both technologies contribute to energy efficiency and have already been applied in construction of buildings in Israel. Although climate control in buildings (*e.g.* through cooling or air-conditioning) was not considered a energy service for which measures were recommended in Question 1, air-conditioning is one of the main sources of energy use and stakeholders recommend that more efficient systems would increase energy efficiency in households and thus reduce the pressure on electricity demand by households and institutions. The main support of air-conditioning improvement came from interviewees of ESCO companies. Finally, while lightning is regarded as one of the main energy areas that needs to be more efficient, there was a consensus about the potential of energy-saving lamps in Israel. Some of the interviewees remarked that the main obstacle for implementation of this technology is the high price of the lamps.
- *Coal to gas*: There was a consensus among the interviewees that the current process of switching from coal to gas in energy production in Israel will continue according to the energy plan of the government and IEC (see Section 5.4.1). Coal to gas technologies therefore suit well in this strategy.

Wind energy was ranked '4.6' in terms of suitability, although thus far only a small amount of wind energy capacity has been installed in Israel in specific high areas. Most of the interviewees were convinced that if Israel were able to overcome some technological and political obstacles (see Chapter 6), wind power can be a more important source of clean energy in Israel.

A similar suitability rank was given to *methane combustion technologies* ('4.5'), although municipal solid waste management as a service was ranked relatively low ('3.5'). Stakeholders acknowledged the high potential of this technology in terms of ecological and economic gains, in particular under the CDM, as it would also contribute to additional low-carbon energy production.

Solar lanterns were considered a suitable ('4') technology particularly for remote areas in the country that are not connected to the grid, but also for remote bus stations, agricultural infrastructures and selected motorways. Most of the survey interviewees were aware that the use of solar lanterns increases every year in Israel, mainly in arid areas in the south of the country, but they also mentioned that the impact of the technology is very much limited to specific areas and applications and that the impact on overall energy saving in Israel is modest.

Medium suitability ('3') was considered for *clean coal technologies*, *coal steam improvement*, *hydropower through dams*, *solar towers*, and *biogas for electricity generation.* Regarding clean coal technologies, the most significant characteristic of the answers was the lack of knowledge of the technologies and their potential implementation in Israel. In fact, even those experts who were familiar with clean-coal technologies agreed that the implementation potential is not high. The main use of these technologies is by the national electricity company IEC in support of its aim to reduce emissions of pollutants from its coal power plants. Although IEC considers clean coal technologies as one of the most promising energy technology types, the overall potential has thus far been expected as rather small. Regarding coal steam improvement most of the interviewees agreed that this technology fulfils mainly the needs of countries in which electricity generation is based on coal. In Israel, the technology could be applied in some of the coal fired plants, as well as in some textile industries.

Since there are almost no rivers with a topographic potential for production of hydro energy except for the north part of the Jordan River, the suitability of hydropower technologies is not high in Israel. However, this situation might change if a World Bank programme to explore construction of a canal between the Red Sea and the Dead Sea along the border between Israel and Jordan, will deliver favourable results. Implementation of that project would include the building of some hydropower installations.

The solar tower technology has been developed in Israel and theoretically has a large potential in the country. However, the technology has not yet been implemented in the country, except in a model at the Weizmann Institute for Science (information provided by ENTTRANS partner ICTAF). Recently, there has been an initiative for implementing the technology in Spain. Against this backdrop, stakeholders had a mixed attitude towards this technology: possibly a large potential, but there were doubts about its practical applicability.

On *biogas for electricity generation technology*, stakeholders mentioned a very high potential for this technology in solid waste and sewage systems, with the advantage mainly in environmental, rather than economic terms. This technology is considered more appropriate for the rural rather than the urban society of Israel.

Low suitability scores were given to *geothermal energy* (2.5), *combined heat and power production* (1.5), and *geothermal heat pumps* (1). The potential of geothermal energy production is a bit ambiguous. While the Israeli company *Ormat* is one of the world leaders in geothermal technology production, geothermal energy production in Israel is very limited. Some of the interviewees clearly expressed that this technology is not at all relevant for Israel; others were convinced that geothermal energy application could be possible if local physical conditions could be better dealt with. Regarding *geothermal heat pumps*, there was no significant belief in its applicability in Israel. Combined heat and power production or co-generation has been supported by the Government of Israel with two resolutions, which aimed at stimulating electricity production by private producers in general (in 1999), and through co-generation in particular (in 2002). However, the familiarity with the technologies among most interviewees was low and therefore the average suitability was ranked relatively low.

Above, in Section 5.4.1, it was explained that Israel has a rapidly growing energy need, which are mainly in the field of electricity security of supply for industrial and household sectors, including for heating and cooling purposes. Solar thermal systems are needed for water heating, LPG is needed for cooking needs and finally coal and natural gas are needed for electricity generation. In addition, there is a need for petrol for transportation. All other energy needs detailed in the stakeholder questionnaire are related to needs in rural (agricultural) communities.

The suitability and appropriateness of sustainable energy technologies in Israel is generally not limited by the level of knowledge and R&D activities in the areas of clean energy technologies in the country. Instead, the opportunities for implementation of most technologies are limited since they are not always suitable for the local geographic, climate, and socio-economic circumstances in Israel.

One interesting outcome of the survey is the lack of knowledge among most of the interviewees (60%) regarding the less well-known energy technologies. In general, the representatives of R&D organisations and the government experts were familiar with almost all technologies while NGOs and commercial organisation/consultancy representatives were not and mainly focused on their 'own' specific technology, *e.g.*, solar PV, bio-diesel or fuel cells. This aspect will be paid attention to in the market mapping exercise for Israel in Chapter 6, where improvement could be found by arranging awareness raising activities.

5.5. Kenya

5.5.1. Country context

Kenya lies in Eastern Africa bordering the Indian Ocean (see Figure 5-7). It became independent from the UK on 12 December 1963. Kenya's landscape varies from a low coastal plain to plateaus with altitudes of over 3 km in inland regions. The country has a region of fertile grasslands in the southwest region, and several forest areas (3% of the country is covered by forest) and mountains in the other regions. The southwest of Kenya is considered one of the most successful agricultural production regions in Africa (Library of Congress, 2007). Kenya's climate varies from tropical along the coast to arid in the interior, especially in the north and northeast. A main problem with the climate is that rainfall patterns cause some parts of the country to become very dry during dry seasons. Only the southwest region and the coastal area receive more or less reliable rainfall. Kenya has a rich agricultural land and a unique physiography and wildlife, which is attractive for tourists (Library of Congress, 2007). However, Kenya has not many mineral resources.

The environment in Kenya is generally threatened by problems such as deforestation (the country's forest coverage was reduced by half during the last three decades), soil erosion, desertification, water shortage and degraded water quality, poaching, and domestic and industrial pollution (Library of Congress, 2007). In particular, the availability of water is expected to become a problem in the future since water resources have been polluted by agricultural chemicals and urban and industrial wastes. Because of deforestation, erosion of land takes place, as well as silting of dams and flooding.

Although the economy of Kenya has recently been growing favourably (2.3% in 2004 and 6% in 2005-6), it is among the worst performing economies in Africa and particularly dependent on the production of the agricultural sector and performance of the tourist sector. It is therefore dependent on such factors as the weather and fluctuations in world prices for agricultural products. Agriculture is an important economic sector in Kenya, which employs 75% of the country's population. However, the service sector (largely built around tourism) produces 63% of Kenya's Gross Domestic Product (GDP). Due to rapid population growth, unemployment and poverty have increased. By 2000 57% of the people lived below poverty lines, with 23% living on less than USD 1 per day (Library of Congress, 2007). Another problem for the functioning of Kenya's economy is corruption. According to Transparency International, Kenya ranks among the six most corrupt countries in the world.[28] Recent economic performance improvement has been supported by a strong performance in tourism, an increase in telecommunication and good results in, among others, the tea sector.

Kenya has a modest industrial sector (responsible for 14% of gross domestic product), which is still larger than in the neighbouring countries in East Africa. Important blockages for industrial sector growth are the limited supply of hydroelectric power, high energy costs, insufficient transport structure, corruption and the relatively low prices of imported products which put pressure on the prices of domestically produced commodities. Nairobi, Mombasa and Kisumu are large urban centres where most of the industrial activities

[28] http://www.transparency.org/.

take place. The main activities within the industrial sectors are grain milling, beer production, sugarcane crushing, and the fabrication of consumer goods (Library of Congress, 2007).

Figure 5-7. Map of Kenya

Source: http://www.hmnet.com/africa/kenya/ke_tourist/kenyatmap.html

Most of Kenya's electricity supply comes from hydroelectric stations at dams along the upper Tana River, as well as the Turkwel Gorge Dam in the west. Other electricity supply sources are geothermal energy production (Kenya is located in a volcanic region, where water temperatures in aquifers in the earth crust are very high and suitable for electricity production through steam) and imported electricity from Uganda. The main electricity production company is the state-owned Kenya Electricity Generating Company (KenGen) while the Kenya Power and Lighting Company (KPLC) handles electricity transmission and distribution. A key problem with electricity supply in Kenya is the periodic outages due to drought and consequently less hydropower. Since Kenya does not have oil reserves (only recently coal was discovered, see Section 5.5.3), all required petroleum must be imported, which is about 20-25% of the value of Kenya's imports (Library of Congress, 2007). In Mombasa, a petroleum refinery is operational which supplies 60% of local petroleum products.

5.5.2. CDM profile

Up until the organisation of the second Conference of the Parties serving as the Meeting of Kyoto Protocol Parties in Nairobi in November 2006, Kenya was hardly active in the area of the CDM, despite the country's involvement in several capacity building efforts funded by UNIDO, Pembina Institute, CDM-SUSAC, UK Department for International Development (Wücke and Michaelowa, 2007). Kenya has been a Party to the UNFCCC since November 1994 and it ratified the Kyoto Protocol in February 2005. In June 2006, the Government of Kenya established it designated national authority for the CDM under the National Environment Management Authority (NEMA).

In order to be able to approve CDM projects proposed for implementation in Kenya, NEMA has established a set of indicators for projects' contribution to sustainable development. These indicators have been derived from a domestic assessment of Kenya's sustainability priorities.[29] Three categories of indicators have been defined: social development, environmental development and economic development.

With respect to contribution to social development in Kenya, projects are assessed on their effect on:

- Poverty alleviation: contribution to reduction of unemployment, creation of new activities and impact on local community.
- Gender Equity: employment for women and equitable distribution of wealth.

Environmental development indicators defined by the DNA are:

- Protection of the global environment: GHG emissions reduction.
- Protection of the local environment: improvement in quality of air, water, soil, *etc*.
- Efficient resource utilisation, including an assessment of impact on intra-generational equity.

Finally, economic development indicators for CDM projects in Kenya are:

- Macro-economic level: contribution to reducing foreign expenditures, contribution to national debt reduction, and facilitating positive long-term effects.
- Micro-economic level: cost-effectiveness of project investment.
- Energy-related indicators: contribution to energy source diversification, impact on energy security of supply, contribution to energy efficiency/saving.
- Technology transfer: state of the art technology transfer, effective transferability of technology.

According to the DNA, the backdrop for CDM projects in Kenya is that GHG emissions in the country, as well as in the region, are low and that the CDM would mainly contribute to avoiding GHG emissions in the future rather than reducing present emissions. The DNA recognises food security and secure energy supply are the two major problems in the country and important causes of environmental degradation and social concern (extreme poverty, extensive farming, increasing demographic pressure, resources overuse, water management difficulties are common problems in many areas) and expects the CDM to contribute to solving these problems.[30]

Table 5-13 shows the CDM pipeline for Kenya as per October 2007. The biomass energy project is based on using bagasse as a fuel source for a 35 MW co-generation plant. The hydropower project uses run-of-river technology and the geothermal power project is an extension of the existing Olkaria geothermal plant. The three projects are expected to generate 2.7 million CERs by the year 2012, which have been purchased by among others the World Bank Community Development Carbon Fund, the World Bank Biocarbon Fund (Wücke and Michaelowa, 2007), and Japan Carbon Finance (Fenhann, 2007). A striking aspect noted by Wücke and Michaelowa (2007) is that due to the limited CDM activities in the country, no specialised CDM consultancy has been established yet.

[29] http://www.nema.go.ke/downloads/Sustainable%20Development%20Criteria.pdf.
[30] NEMA, see footnote above.

Table 5-13. CDM project pipeline for Kenya, as per October 2007

	Registered	Requested review	At validation	Correction requested	Registration requested	
Biomass energy			1			
Hydro			1			
Geothermal			1			
Total			**3**			**3**

Source: UNEP Risø Centre, after Fenhann (2007)

5.5.3. Energy needs assessment

During September 2006 – March 2007, stakeholders in Kenya were consulted to explore what areas were considered to be the priority areas to address in terms of energy needs within their own country context and to try to assess which technologies they considered were most suitable to meet those needs. In addition, some indication of the perception of the sustainability benefits to be delivered by the selected technologies was assessed. Around 35 stakeholders were selected for bilateral interviews from different levels within a country, such as the international, national, regional, and local level (for a list, see the report on Kenya's ESNA annexed to this report). At this point it is worth noting that Kenya has only recently discovered coal reserves in the north of the country. This was not generally known by the respondents and only a few were interested in any of the coal or other fossil fuel technologies listed.

The results from averaging the scores or from the value formulae are the same and give a score for the preference of the respondents for the priority sectors as shown in Figure 5-8. The priority range of interest in the graph is from 3 (medium relevancy), 4 (high relevancy) to 5 (very high relevancy). The graph is in ascending order and it is clear that the range of scores is actually quite narrow with all the energy needs identified being more than medium relevancy.

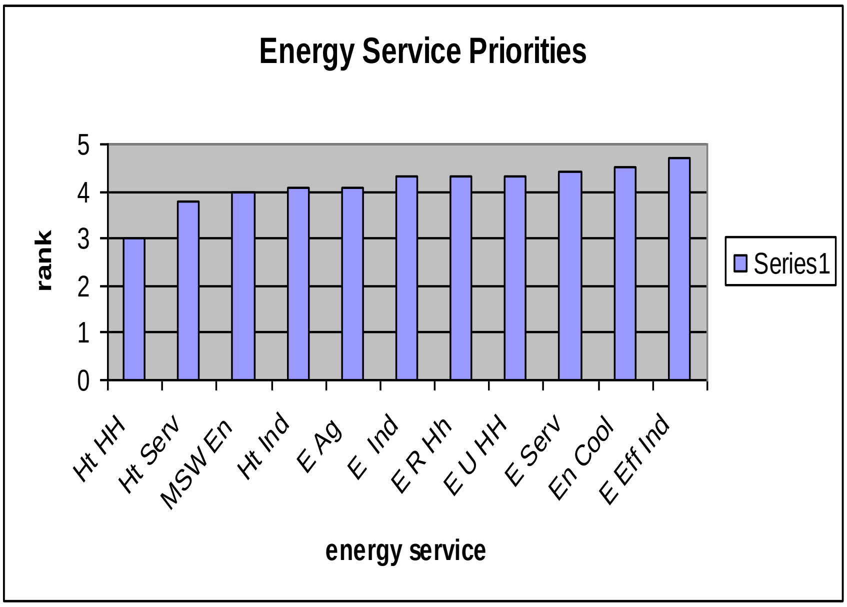

Figure 5-8. Priority area for energy services in Kenya

It shows that 8 out of 11 categories were averaging above 4 in value with Energy Efficiency for Industry the key priority. This was also the sector where there was most agreement in the scores given. Energy for cooling was perceived to relate to mainly health centres and was therefore also given a high priority and energy for the service sector reflects the importance of tourism in Kenya. Electricity for urban households had a slightly higher priority than for rural households because of the perception of the higher numbers involved in urban areas. Electricity for industry and agriculture are relatively less prioritised. The main reason for this was the low rating (2) given by the respondents in the Ministry of Energy whose perception seemed to be that that problem had been solved. This was out of tune with all other respondents who gave this area a high priority.

Heat applications were not seen as such high priority as Kenya has a very stable climate and heat is considered to be needed only in the mountains. In fact, heat for households, mainly as hot water was seen to be not a political issue and could be neglected in contrast to the priority given to electricity supply. The heat sectors had the greatest diversity of scores/views. In common with many areas there seemed to be little understanding about the way electricity is often used inappropriately for heating and that proper management of the heat sector would be beneficial for electricity as well as a Demand side management measures and for the general efficiency of the use of primary energy sources.

As there were four people from the ministry of energy in the sample analysed it was possible to see that although there was agreement between them on some issues they also maintained a range of views on most of the areas. There did not seem to be any bias from a 'ministry of energy' political line.

Additional priority areas of interest were:

- Transport,
- Water for irrigation,
- Food processing,
- Energy for schools.

Experience in Kenya showed that there are problems with the list of technologies as they stand. The technologies were listed according to the energy services they deliver. As a result, early respondents indicated that they would score the technology the same whether it was referring to heating or cooling and these could be amalgamated. Some technologies, coal-based CHP or micro (using gas) CHP, did not apply to Kenya, so this was changed to biomass-based CHP. Another problem was that many respondents were unfamiliar with some of the technologies listed, *e.g.*, clean coal, heat pumps, solar thermal for space heating and cooling and industrial (food applications), solar towers and solar thermal large for electricity, boiler upgrades, municipal solid waste management, and biogas technologies. This unfamiliarity affected stakeholders' perception and their ability to rank the technologies. The ratings on the technologies over all the final respondents (22) are given in Figure 5-9.

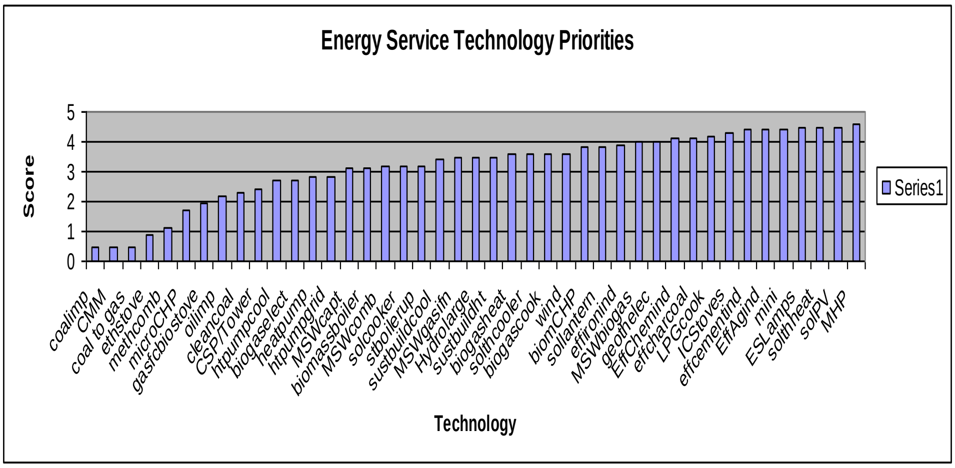

Figure 5-9. Technology priorities in Kenya.

The technology with the highest score was micro-hydro power. There are 13 technologies with an overall ranking above 4 (high) and these are given in red in **Table 5-14**. Solar thermal for heating is the only technology not in line with the energy service priorities perceived in Figure 5-9.

However, as was mentioned for the ESNAs carried out for the other case-study countries in this Chapter, respondents' individual priorities varied depending on their knowledge and experience and any particular interests and enthusiasms, *e.g.*, for solar. Therefore, the priority list of technologies should be taken in combination with further qualification.

Table 5-14. Technology Priorities in Kenya in ascending order of preference

Technology	Rating	Technology	Rating	Technology	Rating	Technology	Rating
Coal to gas	0.5	Heat pumps decentralised	2.8	Biogas for cooking	3.6	Efficient cement production	4.4
Coal steam improvement	0.5	Heat Pumps Grid	2.8	Solar thermal for cooling	3.6	Mini /micro systems	4.4
Coal-mine methane	0.5	Methane capture MSW	3.1	Wind	3.6	Efficient agricultural industry	4.4
Ethanol stove	0.9	Biomass boiler	3.1	Biomass CHP	3.8	Energy saving lamps	4.5
Methane combustion	1.1	MSW Combustion	3.2	Solar lantern	3.8	Solar thermal for heating	4.5
Micro CHP	1.7	Solar cooker	3.2	Efficient iron/ and steel industry	3.9	Solar PV	4.5
Gasification stove	1.94	Steam boiler upgrade	3.2	MSW biogas	4	Micro-hydro	4.6
Oil steam Improvement	2.2	Building design for cooling	3.4	Geothermal for electricity	4		
Clean coal	2.3	Municipal solid waste gasification	3.5	Efficient chemical industry	4.1		
Solar tower / CSP	2.4	Sustainable building design for heat	3.5	Efficient charcoal	4.1		
Geo thermal Cooling	2.7	Hydro Large scale	3.6	LPG for cooking	4.2		
Biogas for electricity	2.7	Biogas for heat	3.6	Improved cook stoves	4.3		

The questionnaire explored some of the economic, environmental and social benefits which might be expected to be delivered from the technologies provided they are implemented well. In addition, stakeholders were asked to rate how well the benefits would be expected to be delivered. Again, 5 is very high, 4 is high, 3 is medium and so on. The benefits under each of the headings (economic, environmental, social, see Chapter 4 for an explanation) were listed and numbered and the respondents chose which applied to their priority technologies. None of the respondents completing this section added any additional benefits though they did add some disbenefits.

In order to analyse this section of the results an average of the ratings of how well each of the categories of benefits would be delivered was made across the respondents for each technology. Then the range of benefits attributed to each technology was examined and the fraction of the total possible was calculated. The average rating for the category of benefit was then multiplied by the amount of benefit (fraction of total) for each benefit category and then summed over all the categories to give an overall performance for each technology. Figure 5-10 shows the overall results.

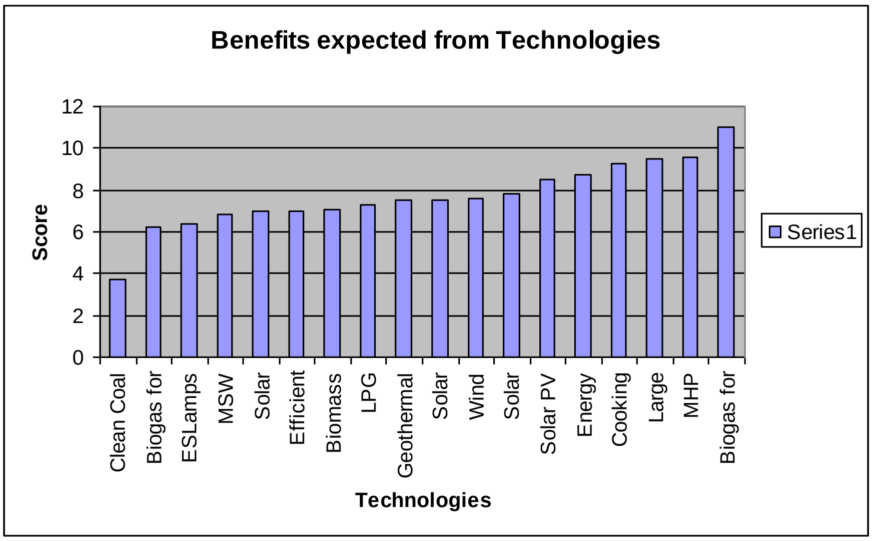

Figure 5-10. Expected sustainable development benefits from technologies in Kenya

Unexpectedly, the highest sustainable development benefits were expected from biogas for electricity, which was considered of medium importance in terms of fulfilling energy needs and priorities in Kenya. However, the number of respondents was low. Generally, across the technologies, not much consistency could be seen in this respect: some technologies which were considered important for energy needs scored relatively low in terms of sustainable development benefits, and vice versa. An explanation could be that stakeholders may consider only a few sustainable development criteria important, so that a technology may score, *e.g.*, high on these but low on the other criteria, and still be considered to deliver an important contribution to the country's needs and priority. It illustrates that a more detailed and comprehensive analysis is required as respondents had limited awareness of possible implications of the technologies. It depends on where projects are implemented what benefits or disbenefits may be delivered and it depends on HOW they implemented whether or not these benefits actually are delivered. Knowledge of possible benefits could affect the priority given to a technology. For a country strategy there will be many considerations that have to be taken into account in terms of reliability, security of supply and demand needs and the possible sustainability benefits should be part of that assessment.

5.6. Thailand

5.6.1. Country context

Thailand's economy and energy consumption have both been growing substantially over the past fifteen years. In 2002, Thai GDP had become 1.45 times larger than in 1992 and for the entire period 2003-2016, a growth of 184% is expected. The most important sectors in the Thai economy are Industry (44% of GDP) and services (47%), while agriculture contributes around 9% to GDP. Annual economic growth during the past years has amounted to 6.1% (2004), 4.5% (2005) and 4.9% (2006).

According to the report published from the Department of Alternative energy Development and Energy Efficiency (DEDE) in 2004, however, growth in energy consumption has been stronger than economic growth. For instance, in 2002, electricity consumption was twice as large as in 1992 and in 2016, 2.39 times as much electricity will be consumed in Thailand than in 2003. Consequently, at present, each percentage of GDP growth in Thailand results in a growth in electricity consumption of 1.4% (EGAT, 2004).

Of course, electricity consumption is only part of the overall energy consumption. In Thailand, the largest energy-consuming sector is transport (37%), followed by industry (36%), the residential and commercial sector (21%) and agriculture (6%).[31] In terms of electricity alone, the highest consumption takes place in industry (46%), followed by the business sector (36%), the residential sector (22%), and others (7% together). Particularly interesting with respect to electricity consumption is that, with an average annual growth of 5.2%, peak electricity demand is expected to double from the 2005 level (around 20,000 MW) around the year 2015.

Thailand's energy is produced for over 80% by conventional energy sources and in 2003 only 0.5% was produced with renewable energy sources. The remaining part was produced through traditional energy sources, such as traditional biomass. Figure 5-11 shows the composition of energy production in 2003 and the projected composition for the year 2011, according to the renewable energy policy plan of Thailand. The aim of the Government of Thailand is to reduce the share of traditional energy from 16.5% to 11% and that of conventional energy from 83% to 81%. This would imply a significant growth in the use of renewable energy sources.

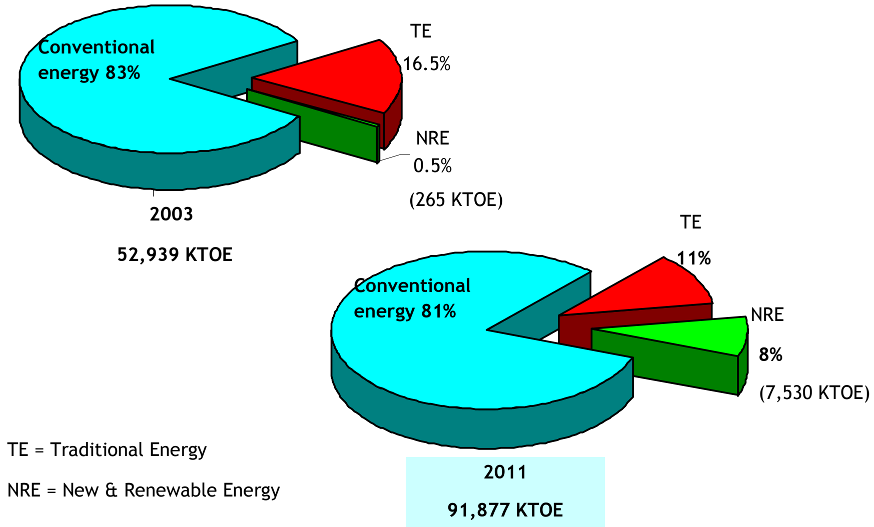

Figure 5-11. Renewable Energy Policy of Thailand

Source: Thai Ministry of Energy, 2003.

[31] Source: www.eppo.go.th.

Four main renewable energy sources will be used to reach this target. First, modern biomass-based power capacity is targeted at 1140 MW by the year 2011 from the presently installed 700 MW (including biogas 20 MW). Although Thailand's installed wind power capacity is approximately 0.7 MW, technological advances in turbine size and efficiency could improve this capacity. In the Government plan for 2011, wind power capacity is aimed at 100 MW. The country's installed grid connected mini and micro-hydropower capacity is approximately 139 MW, and this will be increased to 350 MW by 2011. Solar power capacity is targeted at 250 MW in the same year. However, these renewable energy targets in the Government plan for 2011 are still far below the country technical potential, which is shown in **Table 5-15**.

Table 5-15. Estimated Renewable energy potential in Thailand

Resource	Technical potential (MW)	Year 2011 Government targets (MW)
Biomass (includes biogas)	7,000	1140
Solar PV	>5,000	250
Wind	1,600	100
Micro- & Mini- hydro	700	350
Total	>14,000	1840

Source: Thai Ministry of Energy, 2003.

The acceleration of domestic energy resource development is part of Thailand's energy strategy which is focused on strengthening the national energy supply security and competitiveness and which consists of the following elements:

- **Efficient use of energy:** the objective is to reduce the elasticity of increased energy consumption after a 1% GDP increase from 1.4% (see above) to 1%.
- **Energy security of supply:** ensure sufficient and reliable energy supply for at least 30 years.
- **Renewable energy development: i**ncrease share of RE from 0.5% to 8% of total final energy by 2011 (see above).
- **Develop Thailand as the "Regional Energy Center":** enhance Thailand's capacity to become the Regional Energy Centre by restructuring relevant factors and shifting the role from being an energy buyer to an energy trader in the future.
- **Development of energy information technology** in order to become a modern energy centre in providing domestic and international energy information
- **Participation and environmental concern:** promote utilising of clean fuels *i.e.* ethanol, biodiesel, *etc.*

5.6.2. CDM profile

Thailand ratified the UNFCCC in December 1994 and the Kyoto Protocol in August 2002. The Ministry of Natural Resources and Environment (MNRE) was assigned by the Cabinet as the DNA for the CDM in July 2003. MNRE then appointed the Office of Natural Resources and Environmental Policy and Planning (ONEP) to be the National Focal Point on the UNFCCC and the Kyoto Protocol. ONEP is responsible for co-ordinating CDM implementation in Thailand. The Government of Thailand considers the CDM as an instrument to encourage the private sector in utilising renewable energy sources for their activities and thus to reduce their GHG emissions. The CDM is also seen as a tool to support the strategies of the Ministry of Energy which were mentioned above. Hence, the priority sectors and projects to be developed as the CDM projects in Thailand are as follows:

1. Energy generation and usage:

- Biomass power generation
- Renewable energy
- Energy efficiency
- Energy conservation
- Fuel switching

2. Environment related to energy:
   - Waste-to-energy, *e.g.*, using waste or wastewater to produce energy from.
3. Increased efficiency in transport.
4. Energy efficiency in industrial sectors.

Thailand's policy for implementing CDM projects is as follows:

- Upon application for approval of a CDM project, each project will be approved by the Cabinet Ministers on an individual basis.
- The projects will need to promote the country's overall goal of sustainable development.
- The projects should create technology transfer and capacity building.
- The projects should give top priority to benefiting local communities.
- The government will provide a framework for the trading of CERs.

The sustainable development criteria of the CDM projects in Thailand as developed by ONEP consists of 9 criteria and 18 indicators with an economic dimension, environmental dimension, and social dimension (see **Table 5-16**).

Table 5-16: CDM project approval criteria in Thailand

	Economic dimension
Local income and living standards	• Increase/generate local income or employment
National economy and security	• Reduce imported energy • Increase energy efficiency
Technology Transfer	• Increase of local technical skill on operation and maintenance of new technology • Promote local technology development
	Environmental dimension
Climate change and air quality	• Reduction of GHG emission • Reduction of air pollution (i.e. SO_2, NOx, PM 10 and aerosol) • Reduction of other hazardous/toxic air pollution substances
Water and waste	• Water consumption • Water quality indicators • Solid waste management plan
Land and Resources	• Manage risk/impact of ground water/ underground water system • Non-degradation of natural resources (i.e. water, land and forest)
Ecosystem	• Maintain generic species, its habitat and ecosystem biodiversity
	Social dimension
Capacity Building to local stakeholders and self sustainability	• Training of local staff • Encouragement on self-sustainability and poverty reduction
Equity and accessibility to services	• Access to energy service • Access to other public services

Source: http://www.onep.go.th/cdm/en/cdm_approv.html

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Formerly, Thailand's CDM project approval process was rather extensive and time consuming as a project had to be submitted first to ONEP, after which the project design document (PDD) was sent for comments to a 'concerned Ministry' (*e.g.* Energy, Transport, Industry) and for review to an Expert Group. After that, the project documentation including these comments and review was submitted to the so-called 'National UNFCCC Committee', which is chaired by the Minister of MNRE. The next step in the approval process was the 'National Environment Board' chaired by the Deputy Prime Minister. Finally, the Cabinet had to take a final decision on the project, after which the DNA could sign and issue a Letter of Approval. This procedure could take about 60 to 70 working days per project.

However, recognising that this long process might discourage potential CDM investors in Thailand, ONEP developed a simplified project approval procedure (see Figure 5-12) which is centred around the newly established (in August 2006) Thailand Greenhouse Gas Management Organization (TGO), which will: asses PDDs, serve as a CDM registration and information service centre for Thai stakeholders, market and promote Thai CDM project opportunities, monitor operational projects and provide training to potential CDM project developers in Thailand. As such, TGO will carry out the DNA tasks. In the new procedure, project approval takes place as follows:

- A PDD, together with an approved Environmental Impact Assessment report, if prescribed by Thai law, or an Initial Environmental Evaluation report, are submitted to TGO.
- Within 3 working days, the PDD shall be submitted to the concerned Ministries for comments which will be provided within 15 days.
- Then, the TGO Board will decide on project approval.

This new procedure should take approximately 30 working days.

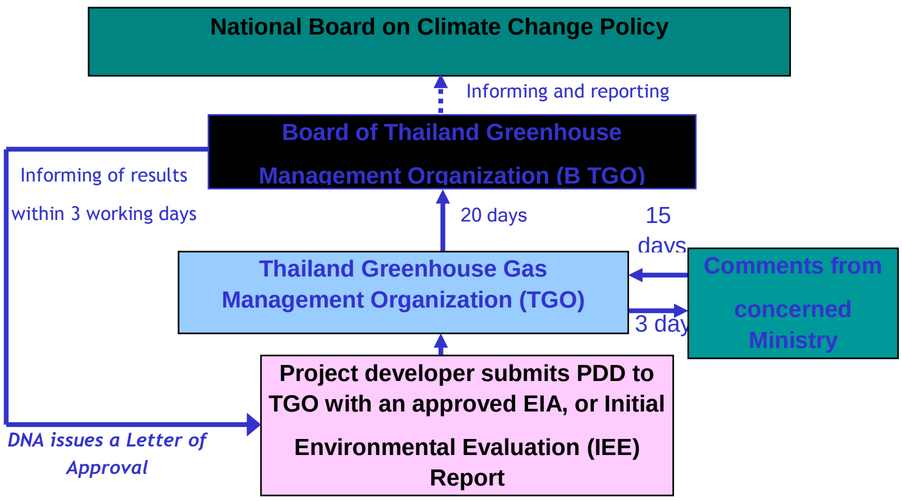

Figure 5-12. Tentative CDM draft approval procedure after establishment of TGO

Source: information provided by ENTTRANS partner AIT

Table 5-17 shows the present CDM project pipeline in Thailand. After the establishment of TGO and the completion of the new approval procedure, the first set of seven CDM projects could be approved on 30 January 2007. Five of these projects aim at producing energy from biomass and the two remaining ones are biogas power plants. The timing of this approval was extremely important since these projects had already been implemented since May 2003 (planned credit starting dates for the projects concerned varied from

May 2003 to January 2006). Officially, early implementation of projects was no problem as the Kyoto Protocol allows crediting of projects as of the year 2000.

However, the CDM EB had set a deadline for submission of the documents of these early projects by March 2007. In case a validated PDD with host country approval had not been submitted to the CDM EB by that date, that project's emission reductions achieved would not be eligible for certification anyway and thus loose their economic value (around USD 14 million) (JIN, 2007). Repeated postponement of the approval for these early projects in Thailand implied that the projects could not be officially submitted to the CDM EB for registration for a long time. Since March 2007, 28 more projects have been approved by the TGO which shows that project approval has become quicker now.

As can be seen in **Table 5-17** most Thai CDM projects are in the area of biogas production for power generation. The biogas will be produced at farms by applying anaerobic digestion technologies with animal waste and/or crop residues as feedstock, and by treatment of wastewater from, *e.g.*, palm oil and ethanol production plants.

Table 5-17. **CDM project pipeline for Thailand, as per October 2007**

	Registered	Requested review	At validation	Correction requested	Registration requested	
Biogas	1		25			
Biomass energy	4		4			
Energy efficiency own generation			3			
Landfill gas capture			2			
N_2O			1			
Total	**5**		**35**			**40**

Source: UNEP Risø Centre, after Fenhann (2007)

5.6.3. Energy Needs Assessment

For the assessment of priorities and needs in terms of energy services in Thailand, 26 stakeholders have been interviewed. Some of these stakeholders are involved in policy making in the areas of energy, environment and development, promotion and development of industry and international trade and regulation of relevant sectors (*e.g.* energy, agriculture, forestry), while others represented different economic sectors, such as finance and industry, or (environmental) NGOs (see **Table 5-18**). The names of these organisations are listed in the *Report on the Stakeholder Assessment in Thailand*, which is annexed to this study.

Table 5-18. Stakeholders interviewed according to the category

Stakeholder Category	Numbers
INGO	1
Universities	3
Industry Representatives	3
Ministry of Industry	2
Ministry of Energy	2
Energy Utilities	2
Consultant	3
International Organization	2
Project Developer	3
Government organization	3
Investor	2
Total	26

Also in the case of Thailand, it was experienced that stakeholders liked to talk more about their own experience with technology implementation than to focus on services and technologies that they were not or less familiar with. Consequently, not all stakeholders fully completed the questionnaire questions 1 and 2. Nonetheless, the information provided in addition to the ranking of services of technologies was very useful. For instance, from the Thai Military Bank, much information was received about the financing of sustainable energy technologies, while the representative from the DEDE provided information on the strategies of the government. The interpretation of the interviews has therefore been partly carried through a qualitative judgement.

With respect to the rating of energy service needs and priorities in Thailand, it could be observed that stakeholders attached a very high priority to Electricity provision for industry, Energy efficiency in industry and Electricity for agriculture. This is shown in Figure 5-13. Twenty stakeholders rated electricity for industry as (very) highly important, 17 stakeholders rated energy efficiency in industry as high and very high and 16 stakeholders rated electricity for agriculture as high and very high. The needs and priorities rated shortly below that are Municipal solid waste management and Heat for industry. Electricity for rural communities and Electricity for urban communities have been considered by stakeholders to have a medium priority. It could also be observed from the interviews that almost none of the stakeholders added other needs and priorities to the list given in the questionnaire. One of the stakeholders added Transportation by biofuel in the list.

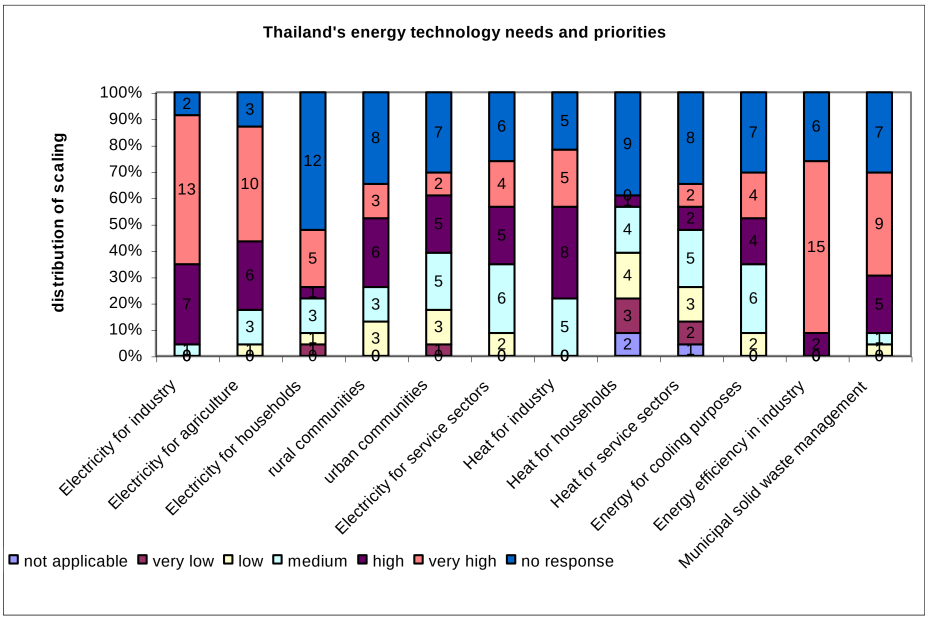

Figure 5-13. Energy Technology needs and priorities in Thailand

From the answers to question 1 of the questionnaire, it can be concluded that stakeholders focussed mainly on the industrial sector rather than on household sectors in Thailand when assessing needs and priorities. This has been explained by stakeholders, among others by the fact that Thailand has achieved a large degree of industrialisation and that this results in a large energy demand in industrial sectors. Partly, according to stakeholders, this demand can be managed by improving the energy efficiency in industrial plants through installation of modern equipment. Most of the households in Thailand have access to electricity, due intensive government programmes, so that according to stakeholders, transfers of technologies to this sector are less important than for industrial sectors.

After exploring the energy service needs and priorities, stakeholders focused on suitable technologies in Thailand. In the category of *electricity production technologies*, Biogas for a power generator and Biomass-based electricity production technologies were mentioned by 22 and 21 stakeholders, respectively, as (very) suitable for fulfilling Thailand's energy needs. Almost all stakeholders mentioned that there is a huge potential for biomass and biogas in Thailand (*e.g.* waste water treatment and animal waste treatment), which is also reflected by the large share of these technologies in the present CDM project pipeline in Thailand. In addition, stakeholders generally argued that steam boiler upgrading would also be suitable in Thailand as it could easily be implemented in any power plant. Around half of the stakeholder were of the opinion that methane combustion technology for electricity generation would be suitable to very suitable to fulfil the needs identified for Thailand in Question 1. The lowly ranked electricity generation technologies in the list are hydro (dams), wind and solar (PV). The main problem mentioned by most stakeholders for Solar (PV) is that it has a very high investment cost with relatively low efficiency. Nonetheless, five stakeholders considered Solar PV as very suitable for Thailand given the high technical potential. Wind energy potential in Thailand was considered low by almost all stakeholders due to the low wind speeds in the country. Stakeholders were of the opinion that most of the hydropower resources in Thailand have already been utilised so that scope for capacity extension is rather limited.

With respect to the suitability of heating technologies, although heating as such was not among the highest priority services in Question 1, stakeholders considered the suitability of biogas-based heating and solar thermal (for water and space heating) are very suitable for Thailand, as well as co-generation which could both fulfil electricity needs in households and industry and provide heat in both sectors. Their suitability is considered higher than that of sustainable building design, although the latter is thought to be very suitable for cooling purposes. Stakeholders mentioned, when answering this question, that due to the climate in Thailand, cooling is much more a need than heat, although cooling was rated by only eight stakeholders as important or very important in Question 1. The scope for geothermal energy (both heat and power) in Thailand is considered very small.

Lighting and cooking technologies were given relatively low ratings. Only compact fluorescent lamps (lighting) and use of biogas for cooking and lighting were considered suitable or very suitable by about half of the stakeholders. Improved cook stoves and solar cookers received low ratings.

Technologies for energy efficiency improvement were largely rated as 4 (suitable) and 5 (very suitable). 20 stakeholders ranked energy efficiency in the cement industry as high and very high. Next on the priority list is energy efficiency in iron and steel industry. These are followed by energy efficiency in agro and food industry and energy efficiency in chemical industry with a slightly lower number of high and very high ranks. Since there is a huge energy consumption in the industrial processes, almost all stakeholders argued that energy efficiency techniques should be implemented in every industrial processes so that the consumption may be minimized to certain extent. This suitability rating is in accordance with the priority ratings in Question 1.

Ratings for Municipal solid waste management technologies in Question 2 were a bit ambiguous in the sense that several stakeholders found these technologies suitable for Thailand, while at the same time about one-third of the stakeholders did not give any score at all, which can partly be described by lack of familiarity with the technologies. A similar pattern could be seen for municipal solid waste management in Question 1. Among the four different technologies, biogas production, waste gasification, and methane capture in landfills have almost similar pattern of rankings. The least suitable technology of these four is combustion of waste.

Figure 5-14 summarises the overall results of the ranking of the technologies by distinguishing the high priority and low priority technologies. It could be observed that, according to the stakeholders consulted, a very high priority technology in Thailand is Biogas for generator which is followed by the electricity production using biomass. These two technologies currently dominate the Thai CDM portfolio (see Section 5.6.2). Energy efficiency in different industries is also considered to have high priority. Biogas for heating purpose also finds the top position in the priority list. Next follows the co-generation based technologies and steam boiler upgrading. Methane capture in landfills acquires a somewhat lower ranking than the above-mentioned technologies but is still considered a technology with high potential. As mentioned above, according to stakeholders, geothermal heat pumps, wind, efficient charcoal production, solar cookers, improved cook stoves, solar (PV) and MSW combustion are the least suitable technologies for Thailand.

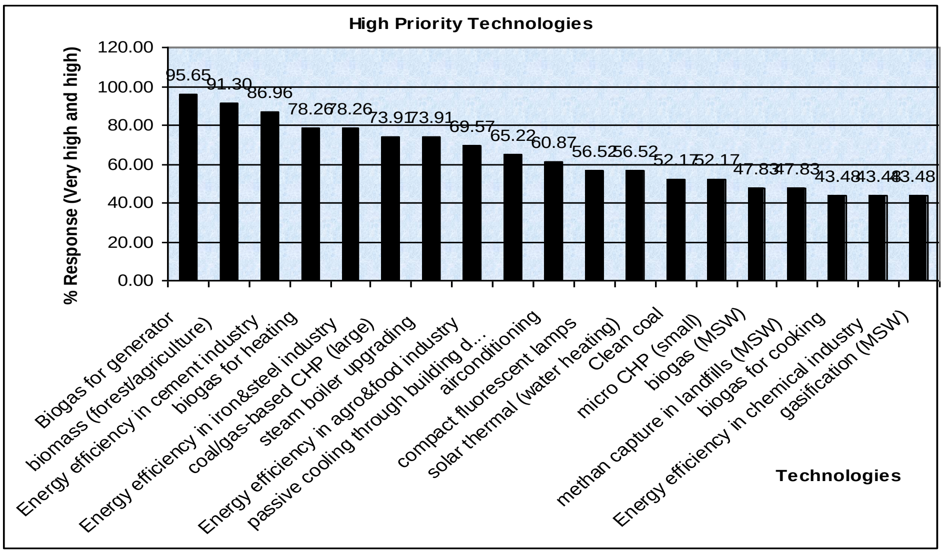

Figure 5-14. High priority technologies in Thailand

Sustainability benefit ratings could be obtained for only few very high-ranking technologies which include Biogas, Biomass, CHP, steam boiler upgrading and Energy efficiency technologies, due to time constraints during the interviews. However, stakeholders were willing to talk about the benefits from their own side rather than ranking the ones which are in the list. Hence, rating could be obtained for only a few highly suitable technologies, which was still considered useful in getting an overall idea of the benefits from these technologies.

The sustainability benefits ranked as high and very high are almost similar for the cases of biogas and biomass. For these technology types, the economic benefits such as energy supply diversification, replicability potential, lower dependency on imported fuel, and contribution to country's economic development are ranked high and very high by most of the stakeholders. Of the environmental aspects, the main benefits are resource saving and global CO_2 reduction. In the case of biogas, solid waste management is considered an important additional benefit. The picture in terms of social benefits was more ambiguous with health improvement being the most important aspect for application of biogas and biomass technologies.

For energy efficiency improvement technologies stakeholders noted the high replicability potential in Thailand once applied and demonstrated, as well as the support to the country's economic development, energy supply and transmission reliability, resource saving and contribution to CO_2 emission reduction.

From the application of co-generation on a small and large scale stakeholders expect benefits in terms of lower dependency on imported fuels, increased energy supply and transmission reliability, economic development of Thailand, local air improvement, global CO_2 emission reduction, and saving of energy resources.

Replicability potential, economic development potential, local air improvement, resource saving and waste management improvement were generally mentioned more frequently by stakeholders across the technologies.

5.7. Discussion and conclusions of a cross-country analysis

In this Chapter, the energy service needs assessment approach developed for ENTTRANS has been used for the case study countries Chile, China, Israel, Kenya and Thailand in co-operation with energy and environment stakeholders for these countries. This analysis has resulted in both an overview of prioritised energy service needs and the identification of energy technologies that are possibly suitable for fulfilling these needs. This section contains a discussion of these findings and an attempt to compare the results found for different countries in a cross-country analysis.

5.7.1. Energy service priorities

The priorities across all the case study countries for the energy service needs are listed in **Table 5-19** below.

Table 5-19. Cross-country comparison of prioritised energy service needs

Country	Priorities for Energy service needs (Scores of 4 and above)
China: Yunnan and Shandong	• Electricity for industry • Energy Efficiency in Industry • Municipal Solid Waste Management • Heat for industry
Israel	• Electricity for Households both rural and urban • Electricity for service sectors • Energy Efficiency in Industry • Electricity for Industry • Heat for Industry
Kenya	• Energy efficiency in Industry • Energy for Cooling • Energy for service sector • Electricity for Urban households • Municipal Solid waste management for Energy • Electricity for rural households • Electricity for Industry • Electricity for Agriculture
Thailand	• Electricity for Industry • Energy Efficiency in Industry • Electricity for Agriculture • Municipal Solid Waste management for energy
Chile	• Energy Efficiency in Industry • Electricity for rural households • Electricity for Industry

The energy service priorities listed in **Table 5-19** reflect the current country context for energy service supply. In all the case study countries energy efficiency in industry and electricity for industry are seen as high priority areas and perhaps reflect a need which has been growing over time due to lack of investment in this area and aging of current technologies. In Israel, Chile and Kenya electricity for households was also a priority while Thailand and China considered that this problem had been addressed already and was no longer an issue. Municipal solid waste management for energy was a priority for China, Thailand and Kenya but not for Chile or Israel. Energy services for the service sector were particularly important for Kenya and Israel. For Israel this was related to growth in this sector at the expense of industry and agriculture while for Kenya tourism is a major economic driver. Electricity for agriculture is seen as a priority in Kenya and Thailand due to the importance of this sector in the economy.

Overall, the emphasis in China was on energy services for industry in terms of efficiency, electricity and heat required to maintain their high economic growth rate. This was also a driver in all the other case study countries as mentioned earlier and in the case of Chile was also concerned with the security of supply of energy imports. Kenya had the broadest range of priorities including the need for cooling services for medicines and perhaps this reflects the broad range of investment required in the country.

5.7.2. Priority technologies to meet energy service requirements

The results from the set of interviews with the wide range of stakeholders in each country indicate that approaches for an improved match between GHG emission reduction demand and technology demand to meet host countries' needs and priorities have to pay due attention to the existing country energy context. This can be seen in the contrast between stakeholders in, *e.g.*, China and Kenya in terms of interest in different technologies (see **Table 5-20**). For China, the priority technologies are determined by the existing emphasis on coal power stations to meet energy needs, as well as energy efficiency requirements in industry. The concern on efficiency in industry is common to Kenya but in their case, priority technologies cover a much broader range and are also more concerned with poverty alleviation.

Municipal Solid Waste technologies for energy, though not necessarily the highest priority, were nevertheless rated highly in all the case study countries along with Compact fluorescent lights, and Solar thermal. Energy efficiency technologies for industries are also common to all case study countries except for Israel while wind power is highly rated for all countries except for Thailand because of their low wind resource. In China the emphasis is on large-scale electricity supply technologies while in Thailand, Israel, Kenya and Chile there was more emphasis on a range of smaller scale technologies for space and water heating, for cooking, lighting and distributed generation. China is the only advocate of large-scale hydro dams and clean coal technologies are also rated highly in common with Israel, Thailand and Chile. Biomass technologies were rated highly only in Kenya, Thailand and Chile for obvious reasons. Similarly, cooking technologies were given priority mainly in Kenya and in Shandong. Because of the appreciation within Chile and Israel of the need to limit demand in the domestic sector, energy efficiency technologies related to buildings are rated highly in those countries only. Surprisingly CHP is only mentioned as a priority technology in Kenya and Thailand. Solar PV is rated in Israel and Kenya while the costs are cited for low priority in other countries. Geothermal energy was given priority only in Chile. In Kenya, geothermal opportunities were considered to have been exploited already.

The country descriptions of the assessment for priority technologies illustrate that there was a problem in some bias in the assessment of the priority technologies due to a range of issues and these are discussed further in Section 5.11.

Table 5-20. Priorities for Energy technologies (Scores of 4 and above)

Chile	Israel
• Energy Saving lamps	• Solar PV
• Sustainable design of buildings	• Solar Thermal
• Passive cooling technologies	• Sustainable Building design
• Biomass for electricity	• Energy saving lamps
• Municipal solid waste Landfill methane capture	• Air conditioning
• Wind power	• Coal to gas for power
• Coal Mine Methane combustion for electricity	• Wind power
• Mini/micro hydro	• Municipal solid waste methane combustion
• Energy conservation in the cement, agro, chemical and iron and steel industries	• Solar lanterns
• Geothermal	
• Solar Thermal	
Kenya	**Thailand**
• Mini/micro Hydro	• Biogas for electricity
• Efficient cement production	• Biomass for electricity
• Solar thermal for heating	• Energy efficiency in cement industry
• Efficient agricultural industry	• Biogas for heating
• Energy saving lamps	• Energy efficiency in Iron and steel industry
• Solar Thermal for cooling	• Coal/gas based CHP
• Solar PV	• Steam boiler upgrades
• Efficient iron and Steel Industry	• Energy efficiency in agro industry
• Mini/micro systems	• Passive cooling by building design
• Improved cook stoves	• Air conditioning
• Efficient chemical industry	• CFLs
• Efficient charcoal production	• Solar thermal water heating
• LPG for cooking	• Clean coal
• Wind power	• Micro CHP
• Municipal solid waste gasification for energy	• Municipal solid waste Biogas
• Municipal solid waste biogas for energy	• Municipal solid waste Methane capture from landfill
• Biomass CHP	
China: Yunnan Province	**China: Shandong Province**
• Energy Saving lamps	• Clean-coal for large-scale power supply Hydropower through dams
• Solar Coolers	• Energy saving lamps
• Clean coal for electricity	• Cement industry energy conservation
• Energy efficiency in cement industry	• Solar coolers
• Large scale hydro	• Iron & steel industry energy conservation
• Supercritical boilers for power	• Wind power for large-scale power supply
• Energy efficiency in iron and steel industry	• Solar cookers (for households)
• Coal to gas for electricity	• Combustion of municipal solid waste
• Energy efficiency in chemical industry	

5.8. Exploration of different viewpoints in assessment of technological preferences

The stakeholders interviewed using the questionnaire were diverse ranging from academics and policymakers to industry and NGOs as discussed earlier and it was obvious that in some cases there was a tendency to prioritise technologies in which the respondent had a special interest. It is possible to analyse the results of the questionnaire to look at the different groups of stakeholders within each country but the numbers tend to be low so that the results and conclusions can only be indicative. An example is given of the results and approach used to explore the perspectives within Chile.

5.9. Overall comparison of ESNA with EGTT procedures

In this section, the results from the ESNA questionnaires for technology priorities are contrasted with the TNA procedure applied by the UNFCCC Expert Group on Technology Transfer (EGTT) for China in the following section. The priority results in each case were developed using different approaches as the EGTT required much more analysis and discussion but with the aim of refining down to a small set of priority technologies whereas this first part of ENTTRANS was based on a questionnaire and interviews with some discussion of the range of alternative technologies available.

The EGTT has carried out TNAs in 94 non Annex 1 countries. In contrast to ENTTRANS, their approach is to agree on criteria for the technologies on a participatory basis with internal and external experts. These criteria include environmental, economic, technology transfer and investment criteria including the cost effectiveness of GHG reductions. Bearing these criteria in mind the experts proposed a range of technologies based on their experience. This initial list of technologies is further refined to a few priority technologies whose barriers to development are identified and an action plan to overcome them formulated. It is unfortunate that of the possible Multi Criteria Analysis approaches which could have been used, the Analytical Hierarchy Process (AHP) was chosen as an evaluation tool. The AHP approach has several inherent faults which can lead to misleading results (DETR, 2000). A Multi Criteria Decision Analysis approach used with a trained facilitator is a better option which is well tried and grounded in decision theory.

Of the 94 countries where TNA exercises were undertaken there is already available information for Kenya, China and Chile. Compared to the ESNA approach of ENTTRANS there is no consideration of energy service needs and technologies to address those needs and the technologies were decided on the basis of experts' experience in both cases though a more strategic basis regarding the country context would need to be incorporated at a later stage. As part of the analysis, GHG impacts were assessed and cost effectiveness considered.

As an illustration, for China the technologies initially identified are listed in the **Table 5-21**.

Table 5-21. Comparison between EGTT and ENTTRANS for China

EGTT	ENTTRANS
Initial set	Set of 46 technologies
1. High efficiency boilers 2. Large thermal power generation (300-600 MW) 3. Cogeneration 4. High efficiency electric motors 5. Green lighting 6. Energy saving buildings 7. Coal-bed methane recovery and utilization 8. Biomass gasification 9. Wind energy 10. Solar thermal heat 11. Biogas 12. Waste heat and energy recovery 13. Village hybrid renewable energy (wind & PV) 14. High efficiency cook stoves 15. Alternative fuel transportation for urban regions 16. Small-scale hydropower 17. Combined cycle natural gas power generation 18. Central heating 19. Waste gas recovery	See **Table 4-5. Sustainable, low-carbon technologies selected for ENTTRANS study** (Chapter 4 of this report)
Final Set	**Priority technologies identified under ENTTRANS**
1. Circulating Fluidised Bed Combustion (CFBC) 2. High Efficiency Motor 3. Boiler (increasing efficiency) 4. Wind power 5. Coal Bed Methane power generation	**Yunnan** 1. Energy saving lamps 2. Solar coolers 3. Clean-coal for large-scale power supply 4. Cement industry energy conservation 5. Hydropower through dams 6. Supercritical power plants 7. Iron & steel industry energy conservation 8. Coal-to-gas for large-scale power supply 9. Chemical industry energy conservation **Shandong** 1. Clean-coal for large-scale power supply 2. Hydropower through dams 3. Energy saving lamps 4. Cement industry energy conservation 5. Solar coolers 6. Iron & steel industry energy conservation 7. Wind power for large-scale power supply 8. Solar cookers (for households) 9. Combustion of municipal solid waste

Conclusions

1. The EGTT approach starts from a wide range of technologies and deliberately focuses on a few high-priority options identified through a multi criteria assessment. It is noticeable that despite the range of initial technologies considered the final list under the EGTT focuses purely on large-scale electricity supply options. This may be due to the bias from GHG cost efficiency and economies of scale but energy savings lamps are essentially no-regrets options so that that is difficult to reconcile. It may point to an inherent bias in the range of experts consulted.

2. The ENTTRANS approach recognises the geographical differences in a large country such as China and though there are many technologies in common between Shandong and Yunnan there are also several differences reflecting their more local concerns and needs.
3. For China, only two technologies, wind power and high efficiency boilers, were common to both the ENTTRANS analysis and the EGTT analysis, though one could argue that CFBC or ICGCC are both advanced clean coal technologies and so the overlap is greater.
4. Nevertheless, we would agree that an overall assessment of the sustainability benefits from the technologies as conducted under the EGTT is useful but that in practice the methodological approach is not the strongest. Such an assessment needs to be related to the local site conditions and also depends on the weights which should be given to the criteria and then sensitivity analysis to determine robust options. The AHP technique is also not recommended.
5. The technologies must also be placed in the context of an overall strategy to deliver the energy service needs. Electricity is only one of those needs. The EGTT approach to identify priority technologies does not necessarily consider the overall context of energy service delivery.
6. The aims of the first part of ENTTRANS in using the questionnaire was to identify energy service needs and priority technologies to meet those needs and in the process explore the perceptions within different countries. The aims and approach of ENTTRANS are therefore different to EGTT and not surprisingly give a different result. This indicates that decisions based on TNAs have to be carefully considered and a wider set of participants allowed to contribute to the EGTT TNA may be helpful as well as consideration of a new approach to avoid anchoring in existing technologies which is proposed in Chapter 8 of this report.

5.10. Problems with assessment of preferred technologies

Given the range of technologies to meet the energy service needs presented to respondents it was obvious from the interviews that there were technologies with potential for application in the country which were being given a low score and therefore did not appear in the lists of preferred technologies. Consideration of the factors influencing these scores from the interviews showed that there are a range of factors influencing the assessments made.

1. Awareness

There were large gaps in people's awareness of a range of potentially useful technologies. There were two main aspects to this:

a) Some respondents had never heard of some technologies or did not know anything about specific technologies such as what it could deliver and whether it was available. This meant that they were not confident in making assessments so that potential technologies did not feature in the final lists. This can be seen in the country reporting of results from question 2 (see Annex 1) where a bias was identified when there were low scores due to lack of information on which to make an assessment. Discussions with respondents indicated that even if they knew something about the new technologies, they would need to see a project technology type actually up and running in the context of their own country before they could commit to considering it for future implementation (see the discussion on trialability in Chapter 6). This means that the technology lists for what is needed might be biased by what technologies have already been implemented in the country. Based on the stakeholder responses, people seemed to be locked in to established technologies in the country context and ways of doing things. For instance, stakeholders did not give high ranks to solar space heating and cooling to replace electrically driven air conditioners in hot countries, mainly due to lack of knowledge and experience with the technology.

b) Short term/long term – Some technologies are perceived to be available now while others are considered something for the future and therefore are rated lower because they are perceived as not so relevant in current planning considerations for the provision of energy services. Respondents did not seem to have sufficient information on the state of development and usage round the world of 'new' technologies.

In order to assess the impact of existing gaps in people's awareness of some potentially useful technologies, in the context of this Chapter a short illustrative analysis was carried out for Chile with a focus on the technologies Concentrating Solar Power and Compact Fluorescent Lamps. The aim of this exercise was to explore the impact of a substantial implementation of these technologies on meeting Chile's energy service needs. Chile was taken as an example since the ESNA results for the country in Section 5.2.3 showed a clear emphasis of stakeholders interviewed on existing technologies and a possibly increasing dependence on coal-based technologies. This analysis is shown in Appendix 5-A.

2. Perception of costs

There also seemed to be an automatic assumption for developing countries that technologies which had not been used in their context before, were more expensive than existing technologies and presented more risk and were therefore again not rated highly for that reason.

3. Historic experience

Another factor colouring the assessment of technologies was historic experience. If a new technology had been badly implemented for whatever reason, then this created an automatic bias against it for some respondents. Added to this is the fact that people tend to anchor in what they know and are familiar with, which implies that the adoption of new technologies has to overcome this resistance to change in the decision making process.

4. Power in the market and resistance to innovation

Another aspect is who is taking the decision on technology implementation and who is giving advice. Many existing systems tend to be grid electricity oriented and employ power engineers who are used to this system. As a result, ENTTRANS has found that the power engineers and those concerned in existing large energy supply companies are usually unwilling to consider decentralised energy production and may feel threatened by it. Conversely respondents in the solar industry tend to bias their replies towards solar. As pointed out by Winskel (2006) "Organisations operate in embedded socio-technical networks and tend to re-invest in established competences: disruptive technologies (*e.g.* renewable energy technologies) rarely make sense to incumbents so their development is left to outsider organsiations"

5. Cultural Aspects

Cultural aspects are also important in the success of technology transfer. For example, in Kenya it was found that a solar cooker pilot programme was not a success because people did not like to cook outside. They did not want others to see what they were cooking and there were problems of dust and dogs, *etc.* Also people usually eat in the evening, so the timing of the availability of solar cooking technology is not compatible with their lifestyles.

5.11. Conclusions and recommendations

1. The stakeholders consulted in each country were very skilled and had the objective of improving country performance. Their input was comprehensive and considered. The TNAs for each country vary in terms of potential adoption of low carbon technologies depending on the country conditions and resources and in terms of existing awareness of their options along with the other factors considered in Section 5.10 above. Few people are conversant with the state of play and potential of all the possible low carbon technologies. However, there is no doubt that opportunities are being missed (see Appendix 5-A on the opportunities in Chile for example) and this is explored further in the market mapping exercises in Chapter 6.
2. This lack of confidence in the practicality and affordability of low carbon technologies in the country context and in the necessary timescales presents a major barrier for a low carbon future.
3. From the assessment it has become clear that a TNA as currently applied by institutions will automatically be rooted in existing technologies and competences and existing powers in the market will resist perceived threats from 'disruptive' technologies. This is normal. Existing TNA exercises as currently formulated therefore cannot deliver the full range of technologies and the innovation needed to accelerate a move to a low carbon future as they ignore the influence of the factors above. This is in line with Innovation Systems theory as well as with studies carried out on innovation as described in the review in Chapter 6.
4. If innovation to low carbon technologies is to be accelerated then there has to be an approach which takes account of these problems in assessment while maintaining the level of participation that is required for buy in for any changes in direction made and to ensure that country priorities are met. This is discussed further in chapter 8.
5. In Kenya and in Chile coal has recently been discovered in the country and the large utilities are planning to move to coal technology and not necessarily clean-coal technology as costs will be a major factor in their investment decisions. There is therefore little time left before lock-in to a high carbon future for some developing countries.

Appendix 5-A

Exploration of Potential for New Technologies in Chile: the case for CSP and CFL

This analysis explores for Chile, the potential of Concentrating Solar Power and Compact Fluorescent Lamps to deliver key energy services for the country. Both technologies have a significant technical potential within Chile, but 'somehow' do not receive (sufficient) attention from relevant stakeholders, because of gaps either in stakeholders' awareness of the technology, or in domestic R&D and/or public/private investment. It should be noted that within ENTTRANS no detailed market maps for these technologies were generated within Chile though CSP and CFLs were discussed in Kenya and Thailand (see Chapter 6) and no specific actions or measures to counter several barriers and blockages can be fully formulated as such activities would require a highly detailed insight into specific sectors and the policy (rules and regulations) and industry environment (business behaviour on micro- and meso-level). Consequently, the analysis below is only a first preliminary attempt to establish a well-informed discussion on the feasibility and potential of certain sustainable energy technologies within a given country context. It gives an overview of the fundamental (macro-economic) forces within an economy and will identify some of the blockages and barriers that can be expected when introducing a new technology.

5-A.1. Concentrating Solar Power (CSP)

5-A.1.1. CSP within the country context of Chile

In the ENTTRANS stakeholder assessment in Chile, especially the solar technologies were considered to be of relatively little importance. Although solar thermal for households scored relatively well with 4.1 (on a 5-point scale), the other solar technologies, such as photovoltaics, solar lanterns, *etc.* scored 3.2 on average or lower. Solar technologies in Chile are generally hampered by the sometimes immature status of the technology and by country-specific economic circumstances, *e.g.*, fossil-fuel subsidies versus import tariffs on renewable energy hard ware.

OECD (2006) describes several issues that inhibit the deployment of solar thermal technologies. Although the paper does not address solar thermal technologies for electricity generation (*i.e.* CSP) most of the observations for solar thermal for heating technologies hold also for CSP in general. Besides the conventional technical barriers related to solar thermal energy that in most cases and under an assumed set of circumstances (*i.e.* solar irradiance) are minimised and/or manageable, the economic, institutional, legal and cultural/behavioural barriers have proven to be the most persistent for the deployment of solar thermal technologies. All the barriers and issues mentioned coincide with the general findings on barriers and blockages of the market mapping process executed by the ENTTRANS consortium during the country workshops (see Chapter 6). Although the range of barriers are well charted and the relevance of country specific circumstances emphasised, the paper does not address the country specifics. Based on the knowledge and data assembled within the ENTTRANS project a discussion on the deployment of CSP in Chile will be presented below.

In the North of Chile the Atacama Desert belongs to the world's driest deserts with a very strong solar irradiance of about 4,828 kcal/M2/day. The CSP technology as such is highly compatible with conventional thermal power generation (ENTTRANS, 2008). Using CSP as a hybrid option with conventional thermal power generation significantly reduces flexibility issues as opposed to stand-alone CSP units. However CSP is usually coupled to a thermal store when stand alone to give round the clock power. Given the fact that most of Chile's mining activities take place in the Northern Atacama region, where almost all power is generated via conventional (coal or natural gas fired) thermal units, the construction of CSP could potentially reduce the high level of energy import dependency of the country. In addition, there would be an increase in energy security of supply for mining companies and other power consumers in that region, since the reliance on the (currently) volatile natural gas supplies from Argentina (see Section 5.2.1) can be reduced (depending on contractual off-take agreements).

Several CSP initiatives and activities already take place in countries such as India, Morocco, Spain, Iran, South Africa, Jordan, Egypt, and the USA, mainly in and near desert regions where solar irradiance is generally high and the potential conflict with alternate land-usage is marginal. Given the size of the Atacama Desert and its high annual average solar radiation CSP is likely to have significant potential in the Northern part of Chile. However, as no concrete CSP initiatives take place in Chile this technology and its potential appears to be undervalued and/or overlooked.

5-A.1.2. CSP potential in Chile: A simulation

In Chile, the significant amount of excess installed capacity in the Northern grid (SING) could be a major barrier for the deployment of CSP. Nevertheless, as domestic power demand is likely to grow and as an interconnection with the SIC grid is under consideration, additional CSP-based thermal capacity surely has a near-term deployment potential. An interconnection between the SING and SIC grids could also provide an additional daily flexibility advantage of CSP (day[32]) in combination with (stored) hydropower (night). Moreover, by increasing installed capacity and by increasing the load factor of the already installed capacity within the SING grid, Chile could potentially become a net exporter of electricity within the region. With respect to the case of Chile there seem to be sufficient technical design options available for possible future CSP deployment.

Although given the fact that technology components of CSP plants are proven, large-scale deployment of the technology in its current business and political environment strongly depends on the specific economics, political will/ambition and finance. Despite the technical potential, there are specific elements that are currently not in place to allow for efficient and effective deployment of CSP. An integrated power grid interconnection design, aside from specific CSP plant design (either stand-alone or CSP-conventional thermal hybrids), is required to optimise the energetic, environmental and economic efficiency of new capacity additions, such as CSP. Increasing the load factor of installed capacity in the SING grid combined with measures to address immediate short-term supply fluctuations are strong factors that shape the economic environment for potential CSP deployment in the Atacama region. Several possible scenarios are possible in this respect. As natural gas supplies to the power plants connected to the SING grid remain volatile, domestic action to enhance security of supply could spur coal usage and/or in combination with CSP. This scenario would call for immediate and rapid action with regard to the development and deployment of CSP. The expected level and characteristics of idle capacity (mostly natural gas will stand idle) could function as an important barrier to economically viable development of CSP, especially when additional power demand centres (i.e. no interconnection with SIC grid) are not found. The current situation (2008), however, is that large-scale CSP deployment is likely to be uneconomical without additional incentives mainly due to the overcapacity within the SING grid though there are good arguments for the infrastructure link between the networks. The potential for distributed generation is also not clear.

In another plausible scenario, natural gas supplies are delivered on time and at contracted volumes. The appropriate policy and public action to such a scenario would provide some additional time for adequate design, development and deployment of CSP and other renewables and/or (additional) interconnections. Currently, it is expected however, that even if natural gas supplies are steady there still is a certain level of excess installed capacity available within the SING grid. In this case again creating (additional)

[32] Additional daily flexibility could be created via storage of excess heat produced during daytime for producing power at night via heat recovery, for example by underground storage of heat.

interconnections either national (SIC grid) or international (*i.e.* to Bolivia, Peru and/or Argentina) will prove to be an interesting course of action if one wants to deploy CSP.

The discussion above portrays some of the fundamental forces that determine the macro-economic environment for CSP technology implementation in the Atacama Desert. Although a CSP market chain does not exist within Chile, there are several market players currently active in the region (*i.e.* mining companies, power utilities, transmission system operators, industrial investors) that could perform various roles, either within the (future) CSP market chain and/or within the enabling environment. Furthermore, given the current concentrated nature of power demand and supply within the SING grid, co-ordination and co-operation on the development and deployment of CSP in this region should be relatively straightforward as most market players can perform multiple functions, as power supplier, power demand, and/or investor. Supply chains are not complex as this is a thermal power technology.

After having set up a CSP market chain, where also potential technology suppliers are involved, the discussion is likely to focus on factors such as, the dispatch regime, preferential grid access regime, guaranteed off-take and/or long-term supply contracts, exemptions and appropriate incentives (fiscal, rules and regulations, international emissions trading via CDM, *etc.*).

At the micro-level (*i.e.* individual project), there are several of issues to be resolved before a large investment in a (new) technology is made. After the technology assessment (*i.e.* which technology is suitable?), the project design often focuses on technical and financial aspects (*i.e.* project lay-out, technical features, return on investment, CAPEX and expected OPEX, *etc.*). In most cases, such micro-economic issues are up to the scrutiny of the project developer and potential investor as it often involves commercially sensitive information. One aspect of project design that often is still lacking in the micro-economic environment is a project specific GHG-reduction potential calculation (see below for a project simulation).

CSP could also be used to displace part of the combustion of coal at a thermal power plant as coal plant has a higher baseline emission level compared to a CSP plant. For this simulation, a stand-alone CSP plant is considered where the solar-based power generated mainly displaces natural gas and coal fired thermal power (grid emission factor) when supplying to the SING-grid. In order to illustrate the GHG reduction potential of a CSP plant in the Atacama desert it is estimated that the SING grid has a baseline emission factor of a factor 1.5 of that of the SIC grid (596 tonnes of CO_2-eq. per GWh/y [=EFsic] x 1.5 = 894). Since no recent estimate from a PDD or recent documentation could be retrieved, this estimate is solely provided for illustration purposes. Nevertheless, given the fact that the SIC grid produces electricity based on about 50% hydropower and 50% conventional thermal power (mainly natural gas) and that the conventional thermal capacity in the SING grid (100% thermal) has a large coal base, this estimated emission factor is fairly conservative.

Considering a stand alone CSP plant with a 64 MW capacity (similar to the proposed Nevada Solar One Plant[33]), which is contracted to supply 129 GWh annually a rough estimate can be made of the GHG emission reductions that can be realised with this technology in Chile. If 129 GWh of power produced from the SING grid is replaced by CSP generated power the estimated GHG emission reduction per annum (given the estimated emission factor) would amount up to 115 ktonnes of CO_2-eq. per annum (i.e. about 2.3 Mton of CO_2-eq. for a period of 20 years).

The data chosen for this project simulation do not exactly reflect the conditions in Chile where the solar irradiance, load factor, OPEX and CAPEX could be different and the total potential could be much higher. Nevertheless, this CSP plant example gives an idea of its GHG emission reduction potential. Assuming a

[33] http://www.renewable-energy-world.com/display_article/294300/121/ARCHI/none/none/1/CSP-lifts-off:-Nevada-Solar-One-comes-to-life/

linearly increasing project performance directly proportional to an increase in scale a 640MW CSP plant is estimated to reduce up to about 1,15 Mt CO_2-eq. per annum.[34]

The potential power from CSP plant is very high as they can be modular, do not need much land and desert conditions give high insolation levels. For example, for the TRANS CSP project[35] they expect that "Starting between 2020 and 2025 with a transfer of 60 TWh/y, solar electricity imports could subsequently be extended to 700 TWh/y in 2050. High solar irradiance in MENA and low transmission losses of 10-15 % will yield a competitive import solar electricity cost of around 0.05 €/kWh." In this fashion, CSP presents an opportunity for development in the south and for south-south technology transfer and trade.

5-A.2. Compact Fluorescent Lights (CFL)

Compared to CSP technologies, CFL were ranked relatively highly in terms of priority technologies and contribution to sustainable development (4.5 average) by the stakeholders interviewed in Chile though not so highly for the other case study countries. However, the concept of energy efficiency and efficient light bulbs is widely known probably more so than with other energy technologies and that CFLs are a direct substitute for incandescent light bulbs. Although the technology and its potential have been widely acknowledged up to date, there has been no large-scale and/or programmatic deployment of CFLs in Chile (and other countries) thus far, despite its almost obvious benefits.

Rigid behavioural consumer patterns and a lack of clear incentives to reduce energy consumption are often key issues that need to be addressed when one wants to deploy CFLs (but other small-scale energy efficiency options in general as well) on a large scale.

5-A.2.1. CFL in the country context of Chile

An Integrated Environmental Strategies (IES) study published by the Catholic University of Chile in December (O'Ryan and Febré Ingenieros Consultores, 2006), explores the GHG emission reduction and other effects (ambient air pollutants and health benefits) from an assumed climate change policy for Chile in relation to a business-as-usual scenario. In addition, it also simulated these effects for a number of technology options, including CFL in Chile. Based on data on the Santiago area, and an assumed baseline based on the dispatch regime of two local power plants, the application of CFL (for which a certain penetration rate was chosen) appeared to have significant benefits in terms of CO_2, CO, SO_2, NO_x, NMHC, PM and $PM_{2.5}$ in the order of magnitude of 80% given the assumed baseline, mainly due to electricity savings. Indirect public health (*i.e.* predominantly due to air quality improvement) benefits were derived from these results. The study also showed that an IES policy approach enables policy makers (from different ministries) to identify the trade-offs of certain policies more easily, and one of the main conclusions was that there is much to be gained in this area in terms of policy integration.

Within Chile's *Programa Pais de Eficiencia Energetica* (Mellado, 2007) two efficient lighting projects have been proposed, the first is on the replacement of inefficient incandescent light bulbs in households (*Proyecto de recambio de ampolletas*) and the second project involves the replacement of inefficient public lighting (*Proyecto de recambio luminaries publicas*). In 2007, it became clear that the Government of Chile (*Ministerio de Economia*[36]) was considering the implementation of these projects as a programme of activities under the CDM based on the distribution of CFL within the country. The basic idea of the project is to distribute two CFLs each

[34] Increasing the size of a project could create several scale advantages in terms of construction costs, etc. which generally improves project economics.
[35] TRANS-CSP, 2006, http://www.dlr.de/tt/desktopdefault.aspx/tabid-2885/4422_read-6588/
[36] http://www.economia.cl/aws00/servlet/aawsconver?1,archivo,503520.

to 40% of the lower-income households free of charge. The programme will be developed together with the Inter-American Development Bank (IADB).

The programme's contribution to energy savings is estimated to be around 97 GWh per annum and 388 GWh in total during the four-year project duration. The climatic benefits of this programme have not been calculated yet and depend on the specific project design. Assuming a countrywide applicable power grid emission factor of 596 tonnes of CO_2-eq. per GWh/y (assumed country-wide grid emission factor equal to SIC-grid factor) the estimated GHG emission reduction mounts up to 57,8 ktonnes CO_2-eq./y (231,25 ktonnes CO_2-eq. in assumed four year period).

In order to get a clearer view of what the project design could look like and what kind of impact such a programmatic initiative would generate, a simulation will be presented below on the potential of large-scale CFL deployment in Chile in CDM emissions trading, energy and environmental (only GHG emissions) terms. Within the CDM framework, a number of CFL projects have already been developed.

5-A.2.2. CFL potential in Chile: A simulation

The proposed CDM-CFL projects, which promote energy efficiency, involve a large amount of CFLs to be distributed to domestic end-users. For instance, the Visakhapatnam CFL project (Visakhapatnam CDM project, 2007) in India involves the distribution of about 870 000 CFLs to approximately 580 000 households, while claiming a GHG emission reduction of 49 ktonnes of CO_2-eq. annual average during a ten-year crediting period. The project participants aim to distribute 45.000 CFLs in Ghana (Ghana efficient lighting retrofit project, 2006) with an annual average estimated GHG emission reduction of 1.1 ktonnes of CO_2-eq. during a ten-year crediting period. Both projects mentioned calculate their estimated GHG emission reduction based on the applicable grid emission factor. One positive feature of the specific CFLs used in the Ghana project is that they are able to withstand substantial voltage fluctuations, so that they have a significant longer life span than the average conventional incandescent light bulb.

No CFL project at such a scale has been considered in Latin America, although government programmes and several papers indicate the desirable characteristics of widespread use of CFLs in countries like Chile. In order to make an adequate technology simulation for the impact of the above-mentioned CDM-CFL project in Chile it is essential to acquire data and information on the power grid and its emission factor(s).

As Chile has four largely independent power grids (with specific emission factors), it is relatively straightforward to identify where a CFL project will generate the most emission reductions. In the Northern part of the country the grid emission factor is favourable for CFL application, since still a significant share of coal fired power in that area. Together with natural gas the Northern grid, SING (Sistema Interconectado del Norte Grande) is predominantly fossil fuel-based. The central and largest power grid SIC (Sistema Interconectado Central) has a large share of hydropower generation supplemented with natural gas and some diesel and coal. Given the seasonal and annual variability of hydropower generation the grid's emission factor can vary significantly, which is a factor that should be taken into account when establishing the baseline emission factor.

The other two Chilean independent power grids are much smaller and are located in significantly less densely populated areas. When considering a countrywide distribution of CFLs this could decrease project economics somewhat in terms of distribution costs and monitoring. However there are a number of possible additional sustainable development benefits of CFL application, such as ambient air quality improvement (and indoor air quality, especially in cases where liquid or gaseous fuel for lighting in domestic use is replaced by CFLs). Another benefit, mainly for smaller and/or unstable grids that frequently experience significant voltage fluctuations CFL application could also be favourable as CFLs are better able to cope with this issue and thus have a relatively long lifetime.

For the purpose of this analysis, we only look at the SING and SIC power grids as they represent about 93% of the total power produced in Chile. Both grids are by far the largest of the country and are located in the most densely populated area of Chile, particularly in the Santiago area. The relevant grid emission factor can be derived from various CDM projects in Chile that take the SIC as the relevant grid. From the documentation of the Hornitos hydropower plant, the combined margin (weighted composite of the build margin and operating margin emission factors) emission factor is taken, which amounts up to 596 tonnes of CO_2-eq. per GWh/y. As currently no CFL project via the CDM is proposed within Chile we can assume a specific number of CFLs being deployed for instance in the Santiago area.

Assuming a programme of activities in CFL distribution in the Santiago area amongst all income groups, we can derive a crude absolute number of CFLs. As Santiago has about 5 million inhabitants, and assuming an average of 2 people per household and while assuming an average of 3 CFLs per household the theoretical maximum potential for CFL deployment in this geographical area is about 7.5 million CFLs.

Additionally, if 20% of this population acquires access to the CFL distribution programme (according to project criteria) an estimated number of 1.5 million CFLs. The baseline assumption here is that solely conventional incandescent light bulbs are replaced. With an estimated average number of operating hours of four hours per day and a subsequent project lifetime of ten years the estimated reduction in power consumption in the area is estimated to be about 97.5 GWh per annum (about 65 Watt reduced consumption per CFL per annum[37]) resulting in an annual GHG emission reduction of approximately (97.5 GWh x 596 tonnes CO_2-eq./GWh) 58 ktonnes CO_2-eq. per annum. During an assumed 10-year crediting period this would yield a total power saving of 975 GWh and 0.58 Mt CO_2.

The size (*i.e.* number of CFLs, energy savings) and scope (lower-income households) of this project simulation – in terms of estimated GHG-emission reductions – is comparable to the CDM-CFL project that is currently being develop by the IADB. This would imply that the future CDM-CFL project should involve the distribution of about 1.5 million CFLs in Chile.

These savings are significant and could be rolled out across the country and not just in Santiago so that the potential in avoidance of coal-fired power generation and the environmental implications including GHG reductions would be significant. The development of a market for CFLs could be stimulated by the proposed CDM project.

[37] 65 W per CFL per annum is taken from relevant PDDs as a default factor for energy savings.

Part III

Technology Transfer Aspects

6. Technology Transfer Aspects: Mapping markets for technologies

6.1. Introduction to Technology transfer

As explained in Chapter 4, the purpose of technology transfer under the UNFCCC Article 4.5 is to "…promote, facilitate, and finance as appropriate the transfer of, or access to, environmentally sound technologies and know how to other Parties particularly Developing Country parties to enable them to implement the provisions of the Convention".

The key challenge in this respect is that low-carbon sustainable technologies need to be adopted both by developed as well as developing countries, which requires that developing countries avoid past unsustainable practices and being locked into old, less sustainable technologies. Instead, technology transfer should allow them to move quickly to environmentally sound and sustainable practices, institutions and technologies. The transfer or innovation process must be fast enough to reduce global vulnerability to climate change. In this process the CDM could play a key role as it is focussed on low(er) carbon technology transfers to developing countries.

The process of technology transfer is informed by a range of literature on technology transfer, innovation, development, behavioural change and economic development. This Section therefore draws on some of this literature and highlights aspects of special relevance to this study. In particular, the market mapping exercise discussed below extends the studies in this area in examining the networks for different technologies and sizes of technologies in a range of country contexts and in exploring the role of CDM in that process.

6.1.1. What is technology transfer and what is really transferred?

The IPCC report on Methodological and Technological Issues in Technology Transfer (IPCC, 2000) contains a broad definition of technology transfer. They define technology transfer in terms of a set of processes "covering the flows of know-how, experience and equipment, for mitigating and adapting to climate change amongst different stakeholders such as governments, private sector entities, financial institutions, NGOs and research/education institutions". Transfer includes diffusion of technologies and technological co-operation across and within countries. The term is usually applied to transfers from North to South, but as Brewer (2007) points out, it neglects the fact that some developing countries have climate friendly technologies which could be transferred from South to North and also from South to South.

According to the IPCC (2000), technology transfer involves the process of "learning to understand, utilise and replicate the technology including the ability to decide which technology to transfer and adapt it to local conditions and integrate it with indigenous technologies".

The term technology transfer refers to both the transfer of knowledge and of the hardware. Knowledge can be comprised of explicit technical scientific knowledge about the principles of how a technology might work. Such transfers also need to involve knowledge about the practicality of the technology to make it work under a range of circumstances. Then, when a technology is being transferred through an organisation, such as a manufacturer, there is tacit knowledge associated with the procedures associated with the organisation. For the host developing country, there are similar knowledge requirements with additional need for people who can interface with the host country organisations and people who can understand and have knowledge about the systems into which the technology is being transferred with its supply and support chains.

Of course, knowledge is not enough for a complete transfer of the technology. There also needs to be consideration of the host country social capital for the skills and expertise needed and host country technology base in terms of manufacturing capacity, supply chain capacity, end-of-life/waste disposal, institutional capacity and sustainability of the whole process and the social networks between them. For the technology innovation to deliver benefits to the communities within the host developing country, it is also imperative that local organisations buy themselves in the investment and that communities are involved in the technology implementation process.

IPCC (2000) considers only North-South transfers and breaks down some of the elements of the processes involved. It recognises a diversity of stakeholders in the process and identifies the following key actors:

- Project developers,
- Technology owners,
- Technology suppliers,
- Product buyers,
- Recipients,
- Users of the technology,
- Financiers and donors,
- Governments,
- International organisations,
- NGOs, and
- Community Groups

They do not mention research organisations, trade organisations and educational institutions, though these are also important in supporting the transfer process.

IPCC (2000) points out that technology transfer can take place in a number of ways and lists the following:

- Directly between government agencies,
- Within vertically integrated firms, and
- Partnerships across a network of information service providers, business consultants and financial firms.

In bringing in the idea of key actors and networks, they are extending the technology transfer system and this is explicitly addressed in the market mapping approach which has been used in this study and is described in Section 6.2 (see also Chapter 4).

The IPCC (2000) report also recognises that the pathways for transfer will depend on the country context, sector and type of technology and this is also recognised in the current study within the market mapping exercise in Section 6.2. However, they explicitly mention pathways for interaction, such as:

- Government assistance programmes,
- Direct purchases,
- Licensing,
- Foreign direct investment,
- Joint ventures,
- Co-operative research arrangements,
- Co production agreements,
- Education and training, and
- Government direct investment.

Moreover, in addition to the ways in which technology transfer can take place and the pathways for transfers, the IPCC report also identifies stages within the processes involved in technology transfer:

- Identification of needs,
- Choice of technology,
- Assessment of conditions of transfer,
- Agreement,
- Implementation,
- Evaluation,
- Adjustment to local conditions, and
- Replication

It is emphasised that the processes are complex and not necessarily sequential. The final stages, from agreement to replication, represent the transfer to the local energy market and this is the focus of the market mapping exercise performed by ENTTRANS; the first stages, identification of needs and choice of technology, are comparable to the ESNA exercise in Chapter 5 of this study.

Barriers to technology transfer have been identified by many workers (Ellis and Kamel, 2007; IPCC, 2000) and these are discussed in detail in Sections 6.2 and 6.3. However, looking at the transfer processes as a system, particular to the type of technology, scale of the technology and country context, means that barriers are more related to blockages in the flows through the system or a lack of supporting and enabling institutions. This will be discussed in the coming sections.

The IPCC quite rightly emphasises that there is no fixed prescription for enabling technology transfer and that activities have to be grounded in the stakeholder and country context, as well as the technology scale and type. However, they focus on three main activities which are considered to make a significant contribution to overcoming barriers:

- Capacity building,
- Enabling environment, and
- Mechanisms for transfer.

First, it is worth looking at technology transfer in more detail from a conceptual view. In the following sections, some of the developments of the theories in this area and the implications of this review for technology transfer and the approach and results from this study are traced.

6.1.2. Technology Transfer and Innovation

The technology transfer process for a sustainable energy technology involves a process of innovation into an existing energy system. In many studies (Lundvall *et al.*, 2002), *innovation*, whether social or technical, 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 country, which may be more or less well developed. The innovation chain involves both the processes of research and development and the commercialisation of the technology, including its social acceptance and adoption.

Innovation theory

The importance of social capital for successful innovation, in terms of the multiple stakeholder collaborative learning and knowledge transfer activities, has been pointed out by the national systems of innovation (NSIs) approach developed by Lundvall *et al.* (2002). Other important aspects of such national innovation systems can be found at regional, technological and sectoral levels within a country. As Lundvall *et al.* (2002) point out, innovation system ideas are rooted in development theories (Hirschmann, 1958) and so it is appropriate to make a connection between technology transfer aspects to developing countries and development theories.

When analysing economic change in developing countries, development theories used to emphasise the role of institutions, whereas in developed countries markets were assumed to dominate. In developing the theory further, it became evident that the development of new technology was an interaction between the user sectors and the producer sectors within a country. However, in the context of technology transfers from industrialised to developing countries, such as with the CDM, one possible model is that less developed countries are the user sectors and industrialised countries the producer sectors. Other possibilities, of course, are that less developed countries are both producers and users of technologies, such as in unilateral CDM and in South-South transfers (*e.g.* technologies produced China and implemented in CDM projects in other countries in Southeast Asia).

Further studies on NSIs showed that success in innovation relate to long-term and close interaction with external agents (Rothwell, 1977). It was also realised that trust, loyalty and power relationships of the players in the market are important (Lundvall, 1985) which led to the focus on 'interactive learning' and which is the basis for the current focus on networks and mechanisms for innovation. It also supports the above-mentioned IPCC emphasis on the influence of differences in country contexts on technology transfer. For example, how firms and organisations from different countries interact depends on the differences between countries in terms of languages and mores, trust and transfer of tacit knowledge. In this respect, institutional aspects such as norms, habits and rules play an important role, as has been emphasised by Johnson (1992), who stated that institutions play a key role in the process of relationship building and building of trust and that the regulatory and legal environment round an existing market, such as property rights, contract laws corporate law arbitration, and labour market institutions will have an effect on this.

Innovation systems have two main dimensions: the structure of the system and the institutional set up. The structure of the system is concerned about what is produced and what are the competences developed by the system, while the institutional aspect is concerned with how the production innovation and learning actually occurs within the system.

Lundvall (1985) specifically recommends the NSI approach for less developed countries as innovations are based on everyday activities in firms and abilities of ordinary people. However, he emphasises that the rate of change based on short-term financial criteria in markets has serious consequences for maintaining the social capital upon which the development of intellectual capital depends. In his view, the short-term financial focus ignores the value of longer-term ecological implications and this has a negative impact on the innovation system.

Innovation according to Schumpeter (1939) would involve firstly the demonstration of a technology and then the diffusion of the technology in space and over time. Thus, a new 'technology' is adopted by the market and is disseminated throughout that market. As we have seen, the process of adoption is complex and also involves some behavioural change on the part of the receiver. This means that people must make an effort to actively seek out and adopt the technology and adapt to its requirements. The efficiency of this adoption process will depend on people's experience, values and perceptions, but also on the economic, social and political environment.

Rogers and Shoemaker (1971) and Ostland (1973-4) developed a sociological/psychological theory of diffusion of innovations which has been widely applied to innovation of new technologies. Rogers (1983) defines diffusion as: "the process by which an innovation is communicated through certain channels over time among the members of a social system." He derives three concepts from the theory: diffusion, adoption and innovativeness. Adoption refers to the famous S-shaped curve where the innovation, *e.g.*, technology is adopted by more and more of the social system until it saturates the system. The rate of diffusion of the technology is the time taken to move from low numbers of adoption to the saturated level as also described by Gruebler (1997). Innovativeness is related to the personal characteristics of the individual who may be willing to change. Five stages of 'innovativeness' for individuals are identified and these stages correspond to the S-shaped diffusion curve (Rogers 1983). These stages are as follows:

1. Innovators (first to adopt),
2. Early adopters,
3. Early majority,
4. Late majority, and
5. Laggards (last to adopt).

A review of the application of diffusion theory is provided by Rogers (1983, 1995, 2003). Key factors in the adoption process, which will affect the outcome, are identified. These factors include personality traits, attitudes, and socio-demographic factors, the nature of the social system, and their perception of the attributes of the innovation. These in turn require consideration of the communication system between the social actors and also the constraints of the social system. Social psychology is concerned with the links between the individual and society. Rogers (1983), like Lundvall, emphasises the social processes involved in diffusion and the nature of the social system. He proposes that system norms which reflect cultural patterns of behaviour have an important role in determining responses to innovation. *Thus studying local practices and the barriers that these produce as well as incentives for adoption of an innovation can provide a foundation for progress in innovation acceptability and acceleration compared to the normal top down approach.*

Rogers and shoemaker (1971) also introduced five types of perceptions which they identified from their study of innovations. These perceptions will have an affect on the decision to adopt the innovation and will thus affect the overall rate of adoption. The perception of the innovation is affected by the following psychological characteristics:

- **Relative Advantage**: the perception of how much better the innovation is relative to the status quo,
- **Compatibility**: the perception of how well the innovation fulfils the person's needs, values and past experience,
- **Complexity**: How easy it is to understand and use,
- **Trialability**: The possibility of being able to try out the innovation on a limited basis before adoption, and
- **Observability**: How clearly can the results of the innovation be seen?

The work of Bauer (1960) and Ostland (1973-4) has added to this list the characteristic of *risk*: the expected probability of economic personal or social problems resulting from adoption (see also Guagnano *et al*, 1986). This can be modified to *perceived risk*: which is the perception of the social, physical and functional risks of the innovation (Shama and Wisenbilt, 1984).

Rogers and Shoemaker in 1971 also found that the relative importance of relative advantage, compatibility, trialability and observability were higher compared to perceived risks and complexity for adopters. Demographic factors were also found to be important with age and income being key. Young and highly educated professionals on high incomes tended to be adopters.

Observability and trialability have been the subject of contention as some studies failed to find these aspects important. However, this is technology dependent and further work understanding the role of demonstration programmes was conducted by Shama and Wisenbilt (1984) and Leonard-Barton (1981). This is important in terms of accelerating innovation and the findings within the country studies described in chapters 5 and 6 on the expressed need to see technologies in action within the country context.

Developments from Rogers' original work linked diffusion theory with social network theory (Darley and Beninger, 1981) to account for the social intractions which also affect the decision to adopt and innovate.

This links to the work of Lundvall on national systems of innovation. In addition, the six factors identified above (including risk) can be disaggregated into subfactors which can explore the complexity of the decisions being made. Trialability however was distinct in this respect.

Shama and Wisenbilt (1984) postulated a refinement of the factors based on a review of the literature and the studies carried out. These are:
1. Economic feasibility,
2. Reliability, maintenance and safety,
3. Legal and regulatory issues, and
4. Regional aspects.

One of his insights was that financial barriers may not be a good indicator as such as what is important is the relative advantage over the status quo which he pointed out will only be manifest over time. Using life cycle costing with energy savings and payback times is problematic as it involves consideration of system efficiency, location, energy prices, income level and uncertainties in future prices for energy services.

Hobday (1997) points out that successful developing countries are good at linking into the national systems of innovation in developed countries. The NSI approach with its focus on norms, habits and rules within a country is particularly useful where there is a need to take account of local and traditional knowledge. In many developing countries, such knowledge is largely not documented and lodged solely in local competences (Ernst and Lundvall, 1997). Lundvall *et al.* (2002) stress that the approach has been applied mainly to industrialised countries and it will be important to consider the effect of globalisation on the possibilities to build innovation systems in developing countries.

An aspect that has been identified as currently lacking in the NSI approach, is that it does not handle the potential for power struggles and conflicts over income within the innovation interactive learning focus. Such problems could offset the co-operation and communication aspect of innovation development, or as Gu and Lundvall (2006) state: "interactive learning possibilities can be blocked and competences destroyed for political reasons" and "counteractive policies are needed as is stability in the financial and macroeconomic fiscal and monetary policies". To further improve innovation systems, there is a need for long-term competence building in firms and society. Gu and Lundvall (2006) recommend a cross-policy strategy with elements from social, employment, education, science, energy and environmental industrial, energy and environmental policies. Banks and financial ministries, he suggests, are not the best people to do this.

Gu and Lundvall (2006) propose that production capital and intellectual capital are easily reproduced, but that natural and social capital are not. Therefore, focussing only on production and intellectual capital and neglecting natural and social capital is not sustainable.

The above has shown that innovation systems theory has developed from analysis of existing systems in the industrialised countries to a focus on the role of social capital in the form of multi stakeholder networks for collaboration, interactive learning and transfer. However, it should not be applied directly to developing countries without taking account of their particular context.

Gu and Lundvall (2006) suggested that the main requirements for innovation within a country are:
- Formal rules in market regulations and planning,
- Informal norms rules and values that shape collaboration ways or compete,
- Strong and diversified systems,
- Well developed structural and institutional support eg 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.

Conflict can arise because something is replaced and power and income can be lost from one set of people and transferred to innovators. There can be deliberate moves to block the innovation process for this reason. Policies to minimise these opportunities are needed, in particular in developing countries which may be more vulnerable to this. In addition, in international co-operation aspects, issues of knowledge transfer can emerge, such as in the case of monopolistic electricity utilities blocking market entry for renewable technologies.

With respect to the role of energy technologies in innovation, studies have shown that energy systems are subject to inertia and lock-in effects (Unruh, 2000, 2002) and that introduction of renewable energy technologies involves informal organisational and behavioural norms (Karnoe, 1996). Winskel *et al.* (2006) show that "Organisations operate in embedded socio-technical networks and tend to re-invest in established competences: disruptive technologies [*e.g.* renewable energy technologies] rarely make sense to incumbents so their development tends to be left to small outsider organisations." This is an important observation which is reflected in the results of ENTTRANS where stakeholders interviewed in the case-study countries have given low priority to technologies that they were not familiar with. This in turn has implications on how technology transfer processes should proceed.

Therefore, it has been argued that policy interventions are needed to make firms consider alternative energy technologies (Rip and Kemp, 1998). According to Reijnders (2002), there is a need for policy to support a technology push and feed-in market pull for effective system building. Therefore, widespread support for renewables at the preparatory stage is an essential precursor for policy intervention to facilitate industrial growth.

Studies of other energy systems also indicate that developing a new technology requires a long period of learning and network building in the experimental phase with sustained policy support to maintain a range of different designs and to avoid lock-in round unsuccessful designs. According to Bergek and Jacobsson (2002), creating and maintaining this 'Design Variety' requires an inclusive style of system building. Social acceptance plays an increasing role in the market development of an innovation. Wustenhagen *et al.* (2007) postulated that there are three main elements of social acceptance: a broad general public acceptance in principle for renewable energy technologies, effective policies for new investors, and collaborative decision making on spatial planning.

6.1.3. Technology transfer and economic growth

Gruebler (1997) examined the process of technology transfer in terms of the patterns of diffusion of innovation at a macro level. He found that, for a range of technological innovations, they all followed the three stages of invention, diffusion and saturation, as identified earlier by Schumpeter (1939). He also uses the well-known S-shape diffusion curve (Hobshawn and Rude, 1968) for social or technological change to show that the time between the initial invention/demonstration to adoption varies with how radical the change is in terms of the sociological and organisational and institutional system changes involved. In addition, these innovations were accompanied by other critical innovations. For example, the development of road systems goes in parallel with the development of oil pipelines for supplying the fuel for the cars. Gruebler (1997) also showed that diffusion is also a spatial phenomenon with areas that adopt an innovation later, do so faster, but with less penetration.

Gruebler (1997) points out that the cycle of invention, diffusion and saturation followed by a new invention which substitutes for the original 'technology' tends to go through a period of crisis in transitional periods when the old system is saturating and the new is still at the early stages of innovation. Saturation leads to a decline in the rate of technical and social change leading to a slowdown in economic growth. This transitional period lasts for some time before a period of accelerating rates of change occurs. These economic growth periods seem to correlate with the emergence of a cluster of interrelated innovations leading to new products, markets, industries and infrastructures supported by social and organisational processes.

6.1.4. Summary of insights from the literature

The review has provided many insights for technology transfer to developing countries. Energy systems in most developing countries, even in least developed countries, tend to have large-scale infrastructure and institutional inertia, similar to those in industrialised countries. Changing investments in energy infrastructure to low-carbon alternatives and more decentralised energy generation and making industry more efficient could be hampered by ingrained habits and training, as well as pressures from industrialised countries to buy their older technologies.

If there is a possibility of leapfrogging, then concerted efforts would need to be made to overcome the lag times built into changing long-term infrastructure systems or of circumventing them. Currently available high-carbon or older technologies tend to be cheaper and more affordable for developing countries and play to the existing experience and know how.

The role of social capital in terms of the multi-stakeholder networks in innovation systems needs to be recognised and explicitly fostered. Lundvall *et al.* (2002) warn that short-term financial criteria can undermine this resource and that natural and social capital cannot easily be renewed.

Power and lack of trust in markets can block change as can be seen in the behaviour of monopolistic electricity utilities (whether overtly privatised or not) towards distributed energy and new sources and the use of intellection property and other methods for blocking innovation. Gruebler (1997) showed that economic losses from innovations will affect some existing market players who will therefore resist innovation. As Winskel *et al.* (2006) point out "Organisations operate in embedded socio-technical networks and tend to re-invest in established competences: disruptive technologies *e.g.* renewable energy technologies rarely make sense to incumbents so their development tends to be left to small outsider organisations."

The need for the country and technology context has been shown in the NSI approach to be grounded in the institutional settings within the country relating to cultural norms and rules and firm-to-firm interactions.

Rogers' work on the key factors affecting perceptions for decisions to adopt an innovation showed that these included relative advantage, compatibility, complexity, observability, trialability and risk. Early adopters tended to be young, highly educated professionals. The findings within the country studies described in Chapters 5 and 6 on the expressed need to see technologies in action within the country context indicate that in the technology transfer context that this may be an important factor in terms of accelerating innovation.

These key perceptions of new technologies therefore need to be addressed, and in addition awareness of the existence of the new options. In the short term, small-scale new technologies may have more opportunity to enter these markets.

Presently, the CDM concentrates on single projects, mostly in isolation of the host country's national and technology context, and does not address technology transfer on any scale. It currently does not foster the supporting systems needed to enhance adoption of a new technology, and it can therefore only address part of the process. The isolated installation of projects is useful for only the very early stage of demonstration of an invention, but the real technology transfer processes will require much more effort. This study provides insights into how the CDM could be adapted to deliver more technology transfer through improvement of the country system for adoption of low-carbon technologies.

In this analysis it is suggested that for real technology transfer a more programmatic approach to the CDM needs to be invoked so that a portfolio of projects can be introduced which is designed to explore the range of circumstances and applications in the host country, supported by complementary programmes to foster the knowledge transfer systems and knowledge transfer networks needed for success.

The following sections discuss the ENTTRANS approach to explore the country systems for adoption of technologies by the market and present the results of the research done in the five case-study countries.

6.2. Market mapping

Where the ICCEPT study on 'Innovation in long term renewables options in the UK' (Foxon *et al.,* 2003) identifies five stages of transfer of a technology into the market (basic and applied R&D; demonstration; pre-commercial; supported commercial and commercial), the CDM as a project mechanism can only really contribute to the demonstration and pre-commercial phase unless other supporting activities can be included under a programmatic CDM. In order to examine what these supporting activities might be, a new approach, 'market mapping', was used to explore the country and/or sector systems into which the technology would be diffusing.

Mapping the market is a relatively new approach which was devised by Albu and Griffith (2005) in the context of extending a sustainable livelihoods framework for small-scale poor farmers in developing countries (see also Chapter 4). They considered that, although the sustainable livelihoods approach was powerful in considering some of the key constraints, objectives, and drivers for communities, it did not address the issues of developing markets for the local sustainable livelihood activities. The technique has since then successfully been applied to a number of developing country situations (Griffith and Edwards, 2006) with the main aim of creating networks to support the development of the markets for improved co-ordination and innovation. Independently the International Potato Centre in Peru developed a similar participatory market-chain approach (PMCA) (Bernet *et al.*, 2005). These two ideas have subsequently been amalgamated in the work of Albu and Griffith (Almond and Hainsworth, 2005).

The relevance to ENTTRANS study is therefore clear in terms of exploring what needs to be done to move a technology into the diffusion stage in a developing country. The application of the market mapping approach to technology transfer activities is novel and was used in this study to explore the system into which the technology would be transferred in the developing country.

6.2.1. The Market Mapping Technique

Albu and Griffiths (2005) describe the process of technology diffusion by dividing the market map into three elements: the business enabling environment; the market chain; and the market supporting services. These elements are illustrated in Figure 6-1.

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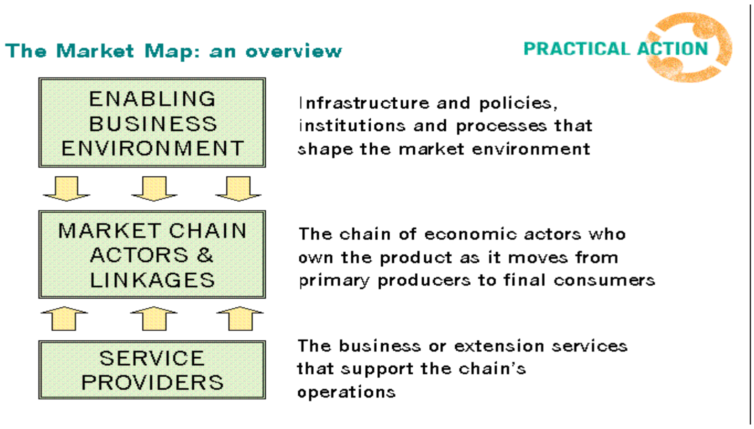

Figure 6-1. The market map method.

Source: Albu and Griffith, 2005.

The market chain

For the market chain which is the main representation of the market system, the question being asked is: Who are the economic actors in the market chain? This question should elicit responses which may include: Primary producer, Importer, Traders, Processors, Input suppliers, Energy Company, Wholesalers, Retailers and Customers.

Business enabling environment

The business enabling environment should include the critical factors and trends shaping the market and the operating conditions such as infrastructure, policies, and institutions. The purpose is to identify the trends affecting the business environment and to identify who has the power in the market and who is driving change. This can then provide information on whom to lobby and help determine opportunities for action. According to Albu and Griffith (2005), the enabling environment encompasses the following:

- Relating to market demand,
- Consumption trends,
- Tax/ subsidies and tariff regimes,
- Relating to transformation activities ie 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,
- Business licences and regulation, and
- Standards quality control and enforcement.

Supporting Services

Supporting services are the business and extension service providers supporting the market chain. The linkages to the market chain are shown in Figure 6-1 to complete the market map. The purpose is to identify the needs for services and who the users are. This gives insights on what can be done in terms of supporting services to make the market more efficient. Such services are myriad but can include financial services, quality control, technical expertise and market information services, *etc.*

The shape of a final map is shown in Figure 6-2.

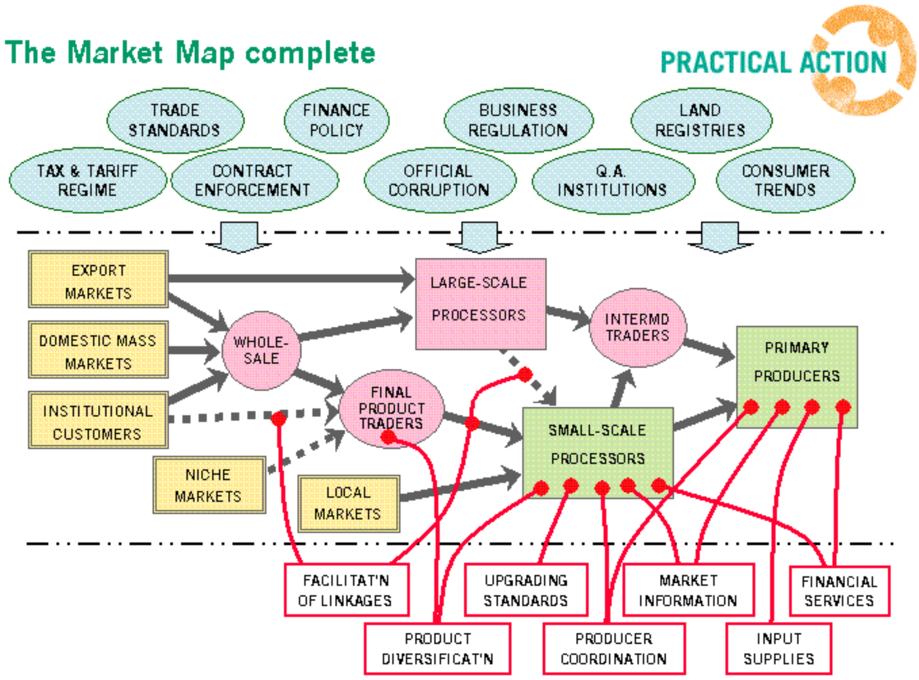

Figure 6-2. An example market map

Source: Albu and Griffith, 2005.

6.2.2. The market mapping process

The market mapping exercise takes place in a three-stage process involving:

a. The creation of a preliminary map using existing knowledge by the research team members. This may or may not be necessary. If there is a shortage of time, this can be helpful as the basis for discussions. On the other hand, it may act to anchor the participants in a particular model which is not the same as their perceptions of the system. In ENTTRANS, this was used in some cases where time was very short.

b. A participatory process to engage the market players:
   (i) to identify incentives for engagement in the exercise;
   (ii) to form market opportunity groups of representatives through whom a large number of small producers or other market actors can be represented; and

(iii) to conduct a participatory market chain analysis (PCMA) to create a market map while also building trust and negotiating and networking.

In the ENTTRANS exercise, due to time and budget limitations the focus has been mainly on (iii), though there was some element of (i) in the preparation of the invitations to the workshops held in the case-study countries. For small-scale technologies, depending on the numbers of existing players step (ii) might be required.

c. An action phase resulting from the formation of a functioning network of market actors based on the relationships formed and the trust engendered. By necessity, this last phase has to be taken up by the country stakeholders as an ongoing activity beyond the contractual scope of the ENTTRANS study.

Thus, market mapping involves a process of identification of market stakeholders, identification of incentives for engagement by these stakeholders in the technology diffusion process and then a series of meetings with stakeholders to generate a detailed map of the system in which they operate to identify opportunities to increase the efficiency of the operation of the market and opportunities for development and co-operation. The outcome of the overall process is the creation of a network of market actors able to carry this forward into the future and deal with new problems and make changes as required. The main aim is to create a network that is able to explore the system and identify and meet the system's challenges.

The insights into the system gained in the process are the basis for future development and can give some indication of the directions for supporting activities for technology transfer.

Finally, it must be noted that in carrying out the workshops in the ENTTRANS case-study countries for the PCMA, it became obvious that markets for technology transfer could be very different, as there could be a market for large-scale energy technologies, and one for small-scale energy technologies. Both types of markets are explored further in the results from the Workshops described in the next Section.

6.3. Workshop results

6.3.1. Market mapping in co-operation with stakeholders

In this section the workshops organised in the case-study countries during June-October 2007 are reported on and the market maps obtained are summarised and discussed. The details of the workshops have already been reported in the final reports of the workshop, which are available on the ENTTRANS website[38] and in the Annex to the *ENTTRANS Periodic Activity Report 2007*. The importance of the country context for technology transfer can be seen in the particular historic energy environments and geographical considerations as well as cultural aspects for each country.

The main aims of the workshops, to which the same stakeholders were invited who participated in the questionnaires as well as other interested stakeholders, were:

- To feedback the results from the questionnaire on energy needs and technology priorities (see Chapter 5).
- To explore the existing market system into which a new low-carbon technology would be introduced through the CDM by using the 'market mapping' approach.
- To explore how the CDM affected this process at the international and national levels and also how it could facilitate market adoption of technologies.

In the next sections, the results of the market mapping are discussed. The specific country approaches to the workshop with the technologies considered are introduced first of all and this is followed by discussion

[38] http://www.enttrans.org.

and comparison of the different elements of the country maps followed by the opportunities identified and then the blockages or barriers in the system preventing progress on the efficient operation of the market. Comparisons are made across countries for small and large-scale technologies. The barriers are also compared across countries and discussed relative to the questionnaire, the IPCC special report on technology transfer, EGTT, and other sources.

Kenya

For the workshop in Kenya, no preliminary map was prepared but the initial workshop aim was for the participants to do this without an initial template prepared by the team as this may influence the outcome. It was felt that there was sufficient time in the workshop to allow people to generate a map.

The participants were split into two groups:

1. Group 1 constructed the market map for a large-scale project involving **Concentrated Solar Power (CSP) for grid or mini grids electricity** (see Figure 6.3).
2. Group 2 constructed the market map for a small-scale project involving **a biomass gasification stove for cooking in households or institutions** (see Figure 6.4).

The three elements of the market map were discussed in the groups and the links between them elicited.

China

For China, the participants were a mixture from Shandong province and from Yunnan province (see Section 5.3.3). Though a preliminary map had been prepared, it was not used as in order to avoid anchoring the participants and because there was sufficient time for discussions. The participants were split into three groups and they considered the following transfers:

1. Group 1 constructed the map for **large-scale imported electricity supply technologies** (*e.g.* wind turbine power, see Figure 6-5)

2. Group 2 constructed the map for **large-scale imported energy efficiency technologies** (*e.g.* in cement industry, steel industry, *etc.*, see Figure 6-6).

3. Group 3 constructed the map for **small-scale new technologies** (*e.g.* solar heating and cooling, see Figure 6-7).

Thailand

In Thailand, the participants considered the following two sets of technologies based on an initial market map prepared by country partners:

1. Group 1 constructed the market map for **large-scale technologies such as biomass and biogas based generation** (see **Figure 6-8**).
~~2.~~1. Group 2 constructed the market map for **small-scale CFLs and solar thermal heating** (see Figure 6-9)**.**

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Unfortunately, the market mapping exercise was restricted in time and mainly the large-scale technology map was discussed and developed. Though the small-scale technologies were not fully discussed, they are included for completeness.

Israel

The study partner from Israel adopted a different format and hosted a large meeting to discuss the potential of clean energy technologies, the technological perspective of renewable energies and the commercial and environmental regulation in the Israeli energy market (see Figure 6-11). The focus was on solar energy technologies for electricity and how the CDM could help support the diffusion of these. One observation from the workshop was that to replace fossil fuel use in Israel, 2 TWh per year of solar energy technology would have to be installed. Biofuels, clean coal and solar PV were also discussed followed by a discussion on the CDM and emissions trading. The key conclusions were as follows:

- ~~1.~~ The solar thermal technologies are mature technologies. They can provide electricity, heating and cooling in many places in Israel and around the globe.
- ~~2.~~ The achievement reached until now in harnessing solar energy are impressive and cover the many applications.
- ~~3.~~ To assure reduction of pollutant emissions (CO_2 and others) derived from using fossil fuels, additional systems using solar PV and solar thermal must be introduced.
- ~~5.~~ The present costs of electricity, as well as the costs of heating and cooling, neither contain the hidden costs of the emitted pollutants, nor the environmental burden of using conventional fuels. Those values ought to be taken into account when comparing the real cost of solar thermal energy to other means of providing energy. Bearing this in mind, the solar and some biofuel technologies must still be supported by local authorities, either through an appropriate legislation or through direct financial subsidies.
- ~~6.~~ CDM and other financial tools might be efficient tools to promote implementation of some technologies especially when the incentives of the Israeli government do not exist.

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Chile

The ENTTRANS partner from Chile adopted a different format and addressed some different questions. A discussion was held on the feasibility of the use of low-carbon technologies in Chile. The result was that it was agreed that such alternative technologies could not meet the demand for electricity. It was not clear if the different energy services had been discussed separately or if decentralised generation rather than centralised grid production had been discussed. The difficulties and insecurity of supply for natural gas and the soaring oil price were cited as reasons for concentrating on coal for power in the future especially as new coal reserves had been found in the south.

The focus of future technologies would be in clean coal technologies such as coal gasification especially as these can be retrofitted to existing plant at relatively low cost.

Due to time limitations at the workshop, stakeholders did not explore market mapping for new technologies, as in the other case-study countries, but concentrated on looking at the barriers to penetration of renewable energies in Chile. The discussion was based on existing experience from case studies in Chile involving biomass for co-generation, run-of-river hydro and a wind power project. The barriers identified are discussed in Section 6.3.3.

Figure 6-3. Group 1 Kenya - market map for large-scale

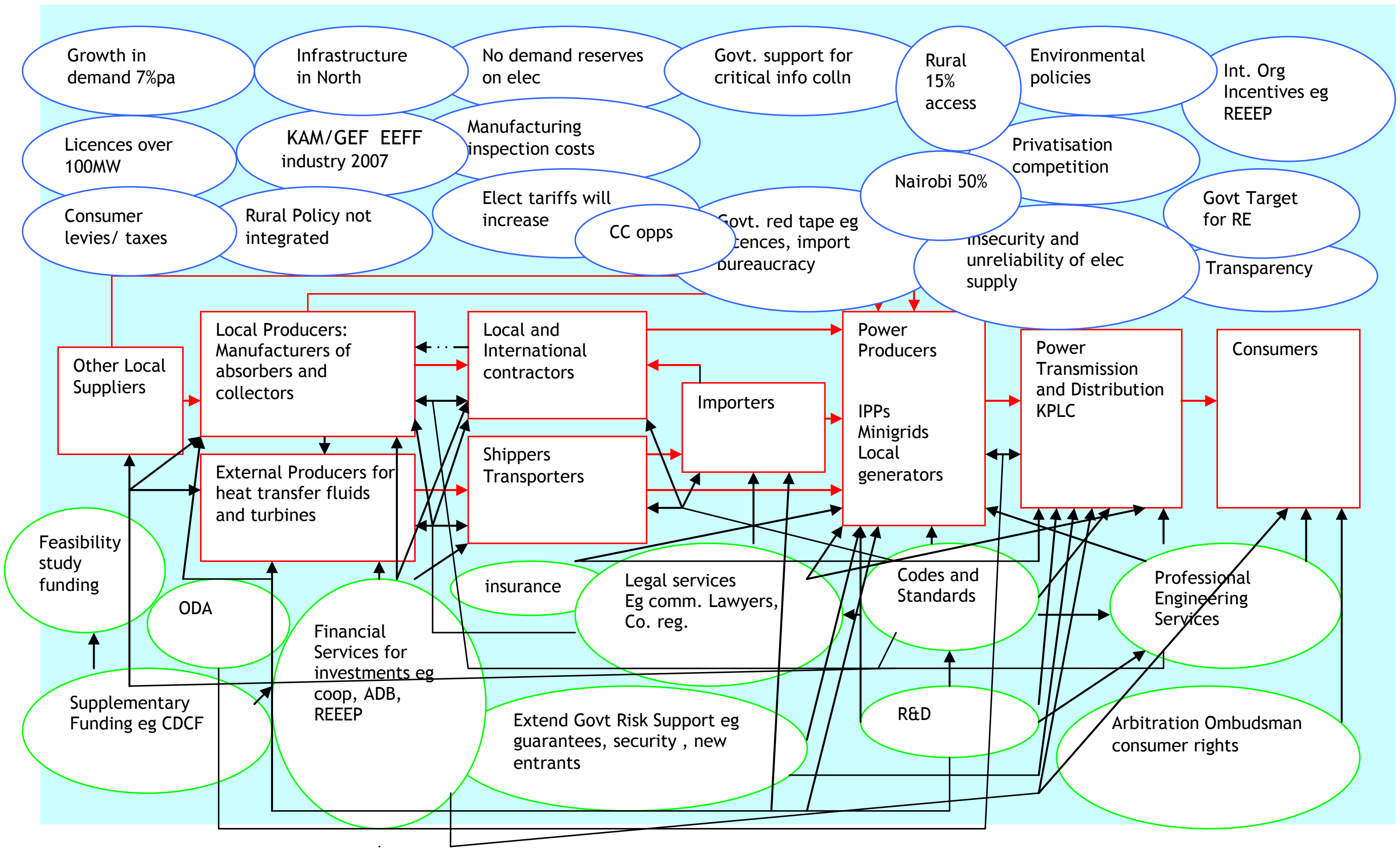


Figure 6-4 . **Group 2 Kenya - market map for small-scale biomass gasification stoves CSP**

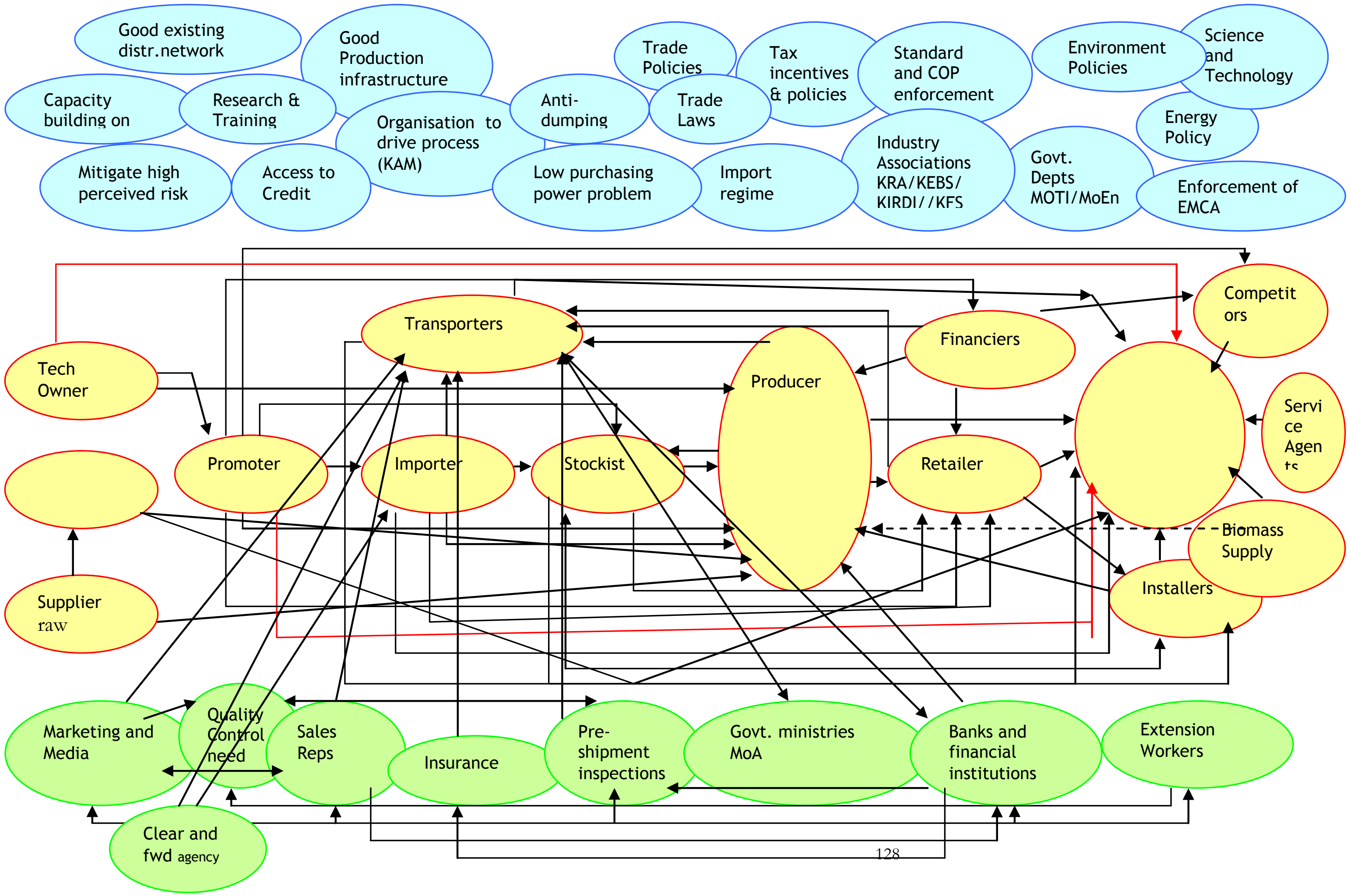


Figure 6-5. CHINA: Group1 Market map for large-scale wind turbines

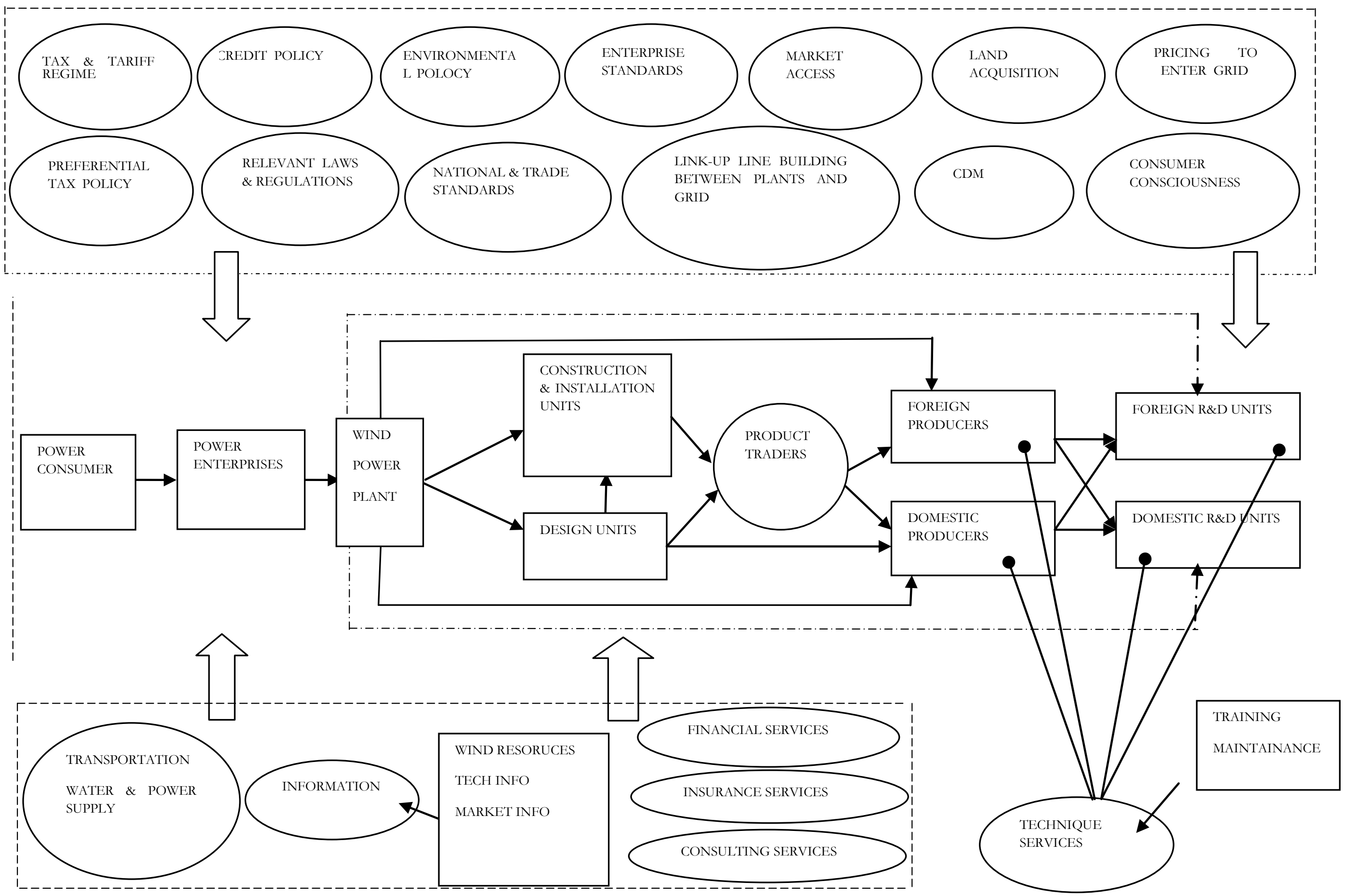


Figure 6-6. CHINA: Group 2 Large scale Energy Efficiency technology for the cement industry

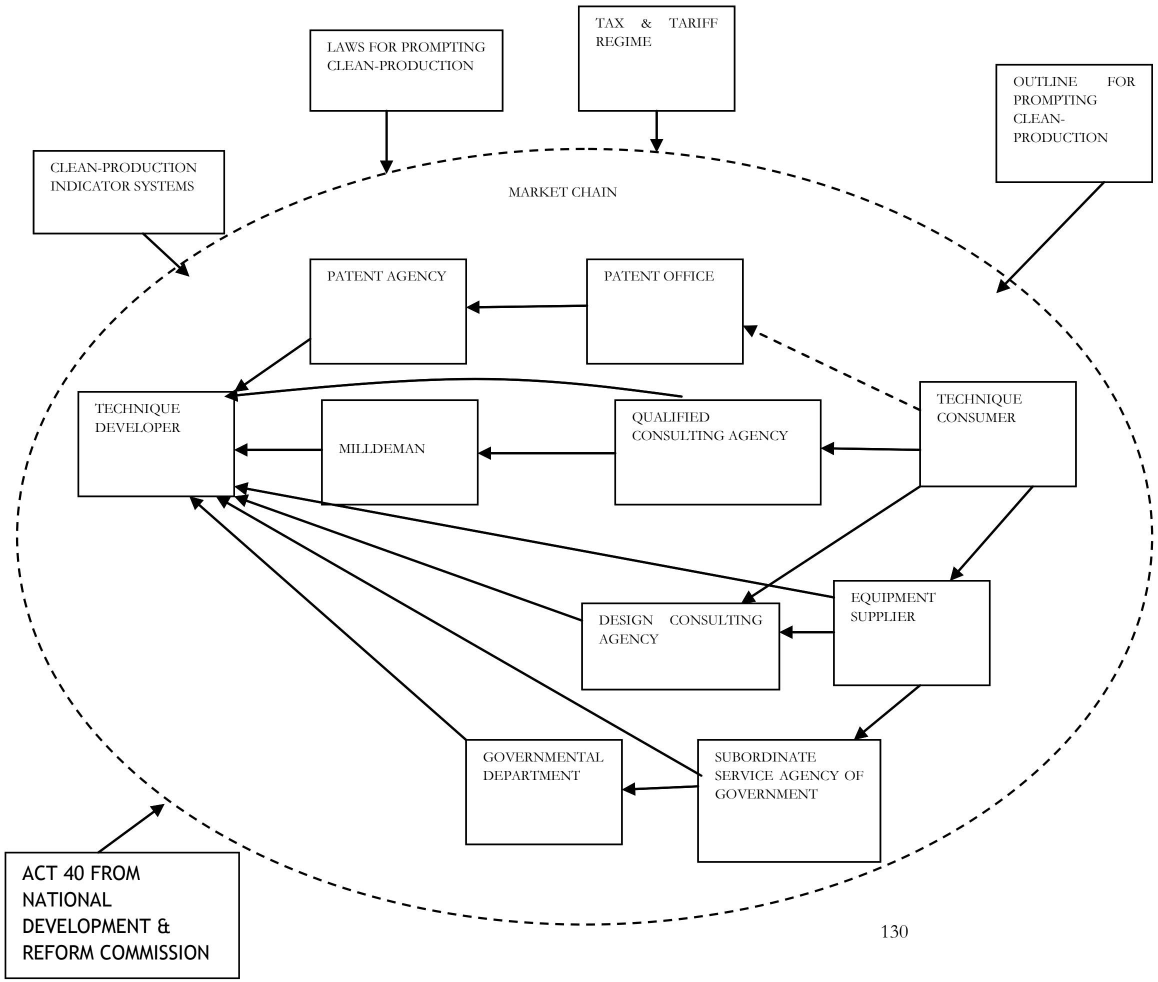


Figure 6-7. China: Group 3: Market map for small scale solar heating and cooling

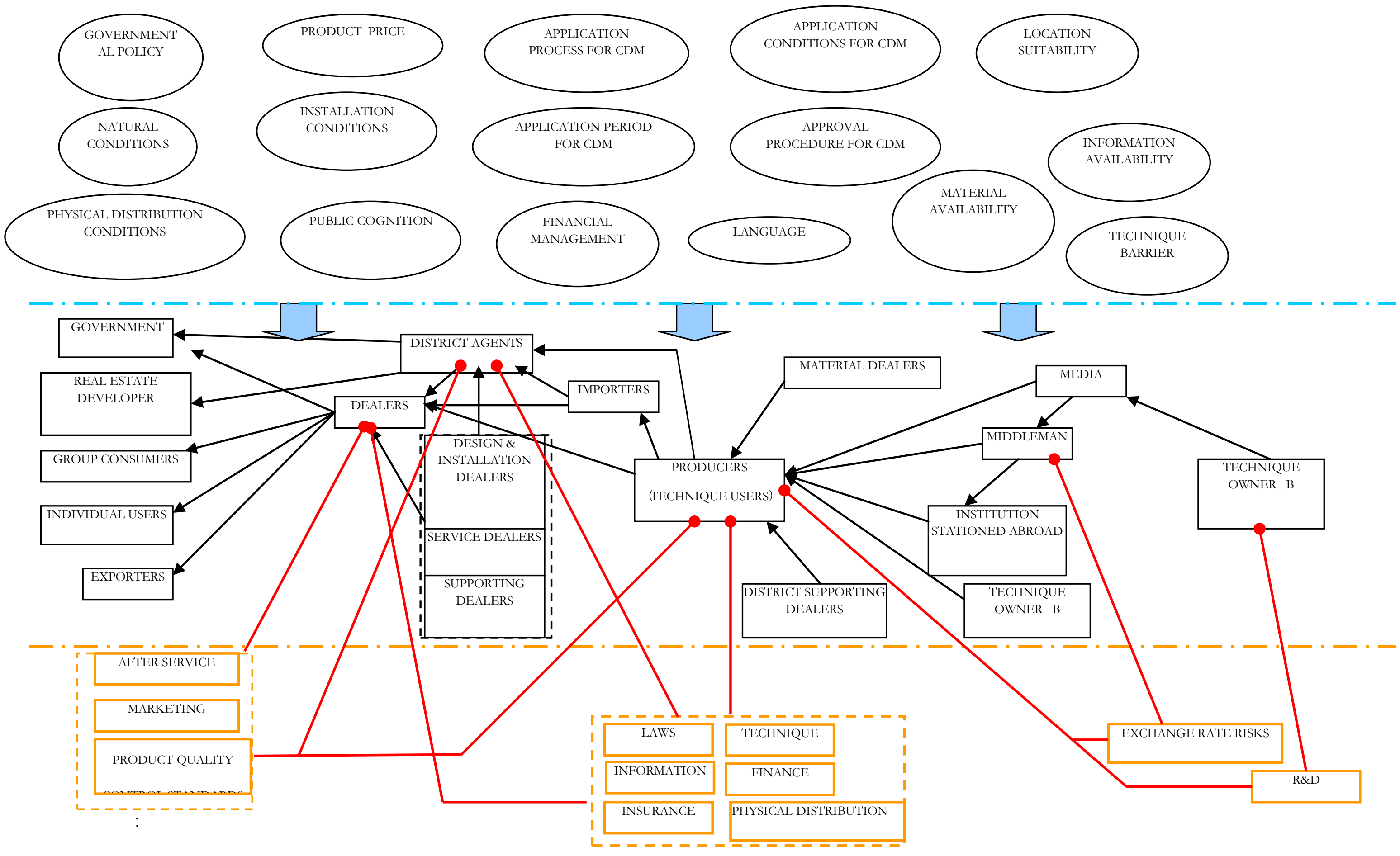


Figure 6-8: Thailand: Group 1 Market Map for Biomass based large scale Technology for electricity production.

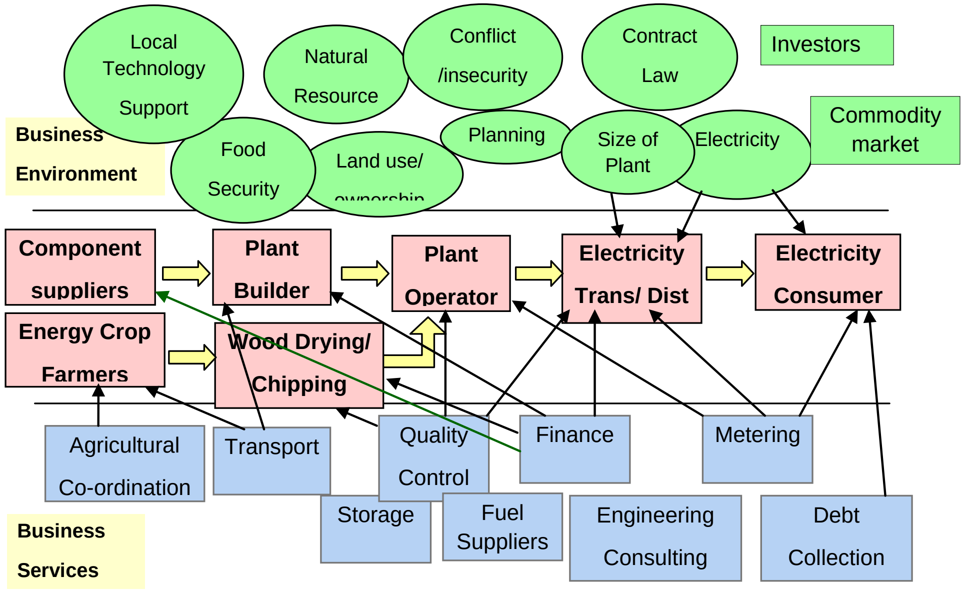


Figure 6-9. Thailand: Group 2 - Market map for Compact Fluorescent lamp

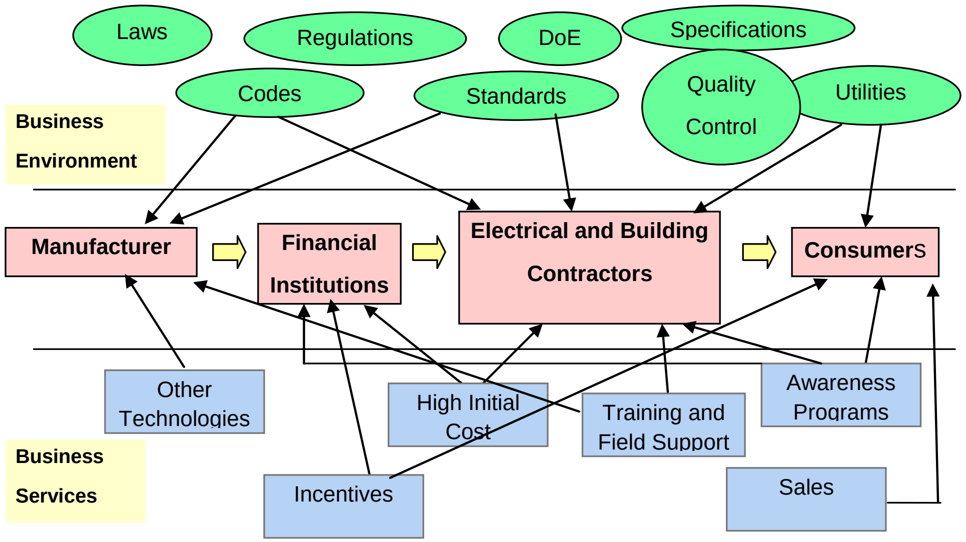


Figure 6-10. Thailand: PROPOSED Market map for small-scale solar thermal heating and cooling.

(This map was the proposed map subject to discussion but time limited input for more specific information)

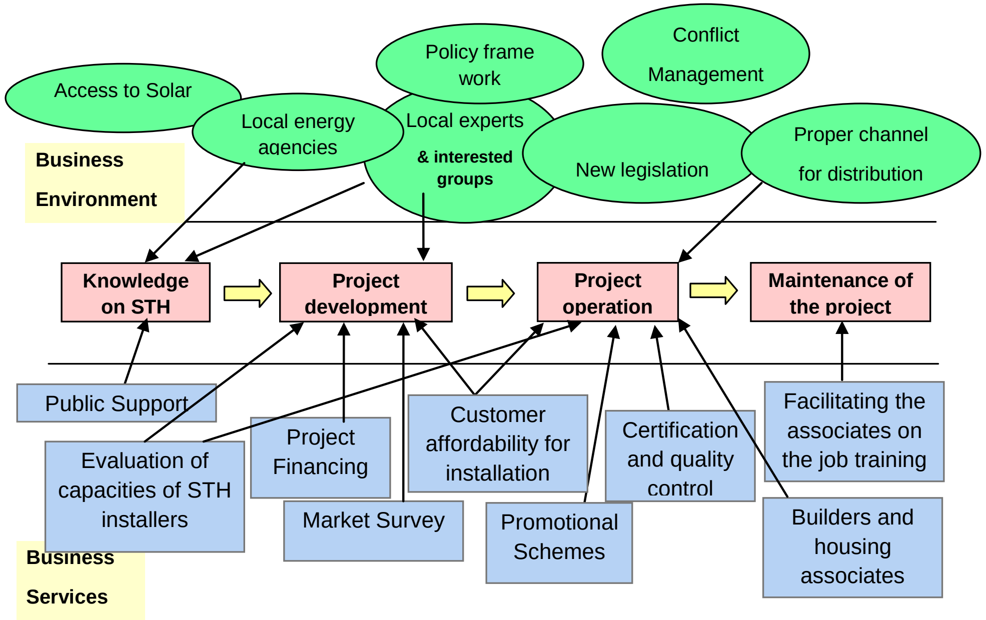
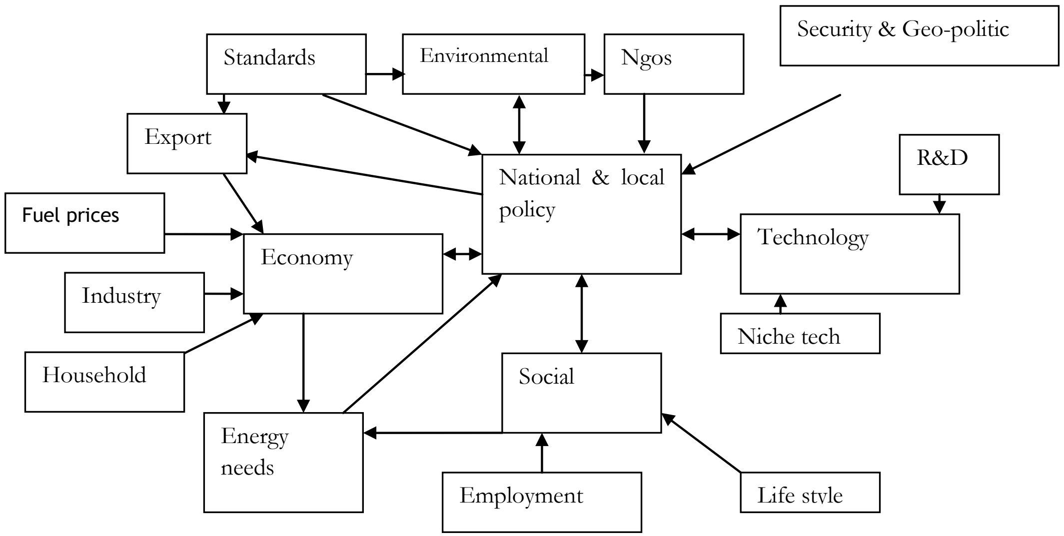


Figure 6-11. Energy market map in Israel



Comparison of market maps for large and small technologies in case study countries

The Market Mapping exercise was undertaken to explore an area which is not usually considered in terms of technology transfer, but which is crucial for successful transfer: the nature of the market within which the technology must compete. If markets are inefficient or resistant to change or lack trust then overcoming the barriers being identified will not provide a successful transfer on their own. The exercise is designed to allow the market players to interact and examine their market system in a way which normally does not occur. The aim is to generate the impetus for a market network actively looking to maximise the efficiency and equity in the market.

In practice, differentiating between the enabling environment and the supporting services (see **Figure 6-1** and Figure 6-2) was not always clear-cut and different countries/groups viewed these differently and so there is overlap between these. The exercise undertaken in the countries could only be a first step in this process of generation of knowledge and stakeholder contact and trust. Nevertheless, it can provide interesting insights into the process needed for technology transfer.

The technologies chosen and agreed with the group were designed to challenge the *status quo* where possible. The results are given in the market maps and summarised in the tables below.

It is clear that there are large differences between countries in both implementing the new market mapping technique and also in the country responses to the exercise.

Small vs large-scale market chain across countries

For Kenya and China, the market maps for the small-scale technologies were different in terms of complexity to the large-scale technologies. In Thailand the maps for small-scale were not fully completed and developed due to restricted time.

Comparing the market chain elements of the map, it is clear that in Kenya and China there is a greater range of stakeholders involved in the chain for small-scale technologies. In Kenya, the main differences compared to large-scale were in the need for retailers, sales agents, promoters, installers, service agents and wholesalers. Similarly for China, the small-scale technology focus seems to be on the need for the district dealers, district agents, design and installation dealers, service dealers and real estate developers. 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. In addition, the importance of quality control and regulation was recognised in including this aspect as an integral component.

For large-scale technology, the chain ends with the utilities and distribution companies who already have their distribution network and who are not changing what they sell. For imported technologies, there are additional areas such as shipping, but in both cases the technology may be imported and so both need this aspect which is recognised under importers. 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 the larger-scale technology.

It therefore seems clear that for adoption of the small-scale technology by the market there is a need either for an interface to an existing network for reaching customers, or the creation of such a network and interface to it. Programmes of small-scale projects intended for transfer have to ensure that this aspect is built into the programme design.

Enabling business environment across countries

The enabling business environment should include the critical factors and trends shaping the market and operating conditions such as infrastructure, policies, and institutions, fiscal aspects, financial incentives, infrastructure for distribution and production. In general, the main factors included in the mapping were as follows:

- Government department co-ordination and red tape,
- Regulation, fiscal and legal,
- Trade and research institutions,
- Transparency and Trade Laws, especially regarding Independent Power Producers (IPP),
- Small scale: local expertise, research, training, financing, risk offsetting,
- Large scale: tariffs, privatisation and int. incentives,
- Policy environment, and
- Public awareness and information.

Commonly noted aspects for implementation chains for large and small-scale technologies for Kenya, China and Thailand were: government departments (red tape), trade and research institutions, standards, price, regulation and legislation, and policies.

For small-scale technologies in Kenya the accent was on research and training and accessing financial resources, quality control and the high risk of small-scale technologies, while the large-scale technology enabling environment for CSP was dominated by privatisation, tariffs, and international incentives. For Kenya, government policy on licences seems to be good. Quality control and standards for Kenya and Thailand again seem to be a concern for small-scale technologies as was availability of local expertise.

In Thailand, a specific concern not seen in Kenya or China was over conflict and security, food security, and land use/ownership and this is related to the nature of the fuel as this was associated with biomass generation. Debt collection was also a concern.

Transparency and Trade laws (*e.g.* intellectual property rights, patent office) were mentioned in Kenya and China as part of the enabling business environment. Public awareness and information availability was also a key concern in China for the enabling environment and mirrored in the inclusion of media in the market chain for small-scale solar thermal.

The enabling business environment depends on the country context and the technology though there are many general aspects that countries and technologies have in common. There are some differences across large and small-scale technologies related to quality control and risk and access to finance for small-scale projects.

Support Services across countries

As mentioned above there is some overlap between the support services and enabling environment. Therefore, if a topic is mentioned the enabling environment it is not repeated here under support services:

- Financial services,
- Legal services,
- Professional engineering services, and
- Government planning and support, including R&D and Codes and standards.

For large-scale CSP in Kenya the support services were grouped under financial services, legal services and regulations, professional engineering services and government planning and support (*e.g.* R&D). These general headings apply to Kenya, China and Thailand and also apply to small-scale projects, except for professional engineering services which tend to be more relevant for large scale technology projects.

Thailand had the addition of Debt collection and metering as a concern though finance for investment was not perceived as a problem in Thailand.

Links between support services and market chain across countries

The links between the support services and the market chain can show where some key services are needed or where blockages might occur. For the large-scale CSP in Kenya key roles are seen in financial services, government support including R&D, legal services and codes and standards. These also applied to the small-scale biomass gasification stoves along with quality control and marketing. In China for large-scale wind turbines similar support services apply but with emphasis on technique services for training and maintenance. Small-scale solar thermal in China also covered the same concerns but identified exchange rate risks in addition. In Thailand, as mentioned earlier, the same links are given but with debt collection as an extra service supporting the market. Small scale followed a similar pattern though there are less data on these.

Technology and country specific aspects

The Chinese stakeholders identified natural conditions and physical distribution conditions as important concerns for the enabling environment for small-scale projects though they will also affect large-scale projects. Material availability and location suitability were also highlighted. These general concerns are manifest in the following examples from the maps for Kenya and Thailand.

With respect to biomass-based technologies in Thailand there were concerns about the security of the fuel supply and food security, whereas also legal and contractual conditions needed to be strengthened.

For large-scale CSP technology application in Kenya there were concerns with infrastructure for arid and semi arid land, wayleaves and water**.**

Summary

Taken together the insights from the market chains in the five case-study countries shows that the enabling business environment and the support services along with the links can provide an initial picture of the complexity of the system and also of the areas where blockages can occur and which need to be examined and corrected where possible in order to enable the full technology transfer opportunities. It is also clear that the maps have elements in common for the market chain, enabling business environment and support services but alos that country conditions are important and the type of technology and its size.

These insights are a first step in elaborating the complexity and key activities for successful transfer. The creation of a market network is needed to explore the system further for the country and technology specific opportunities and blockages.

In the following sub-sections, the groups identified an initial set of opportunities and blockages.

6.3.2. Opportunities identified from market mapping

As a next step, the stakeholders were asked to identify opportunities arising from the market mapping analysis. These have been listed in **Table 6-1** below for each country and for the different technology scales.

In Kenya in both large and small-scale technology interventions, the participants were able to identify many opportunities and sustainability benefits emerging from adoption of the technologies. In the workshop a genuine enthusiasm was generated for the technologies which had not been considered before then. At the country level, stakeholders identified benefits in terms of economic development, such as improved skills and creation of jobs, and in terms of increased energy security of supply and improved balancing of power supplies. At the local level, identified benefits from the technologies were: poverty alleviation, in particular when introducing CSP in the north east part of Kenya, which is a poor area, and small scale local benefits; improved quality of life, *e.g.*, because of the improved access to modern types of energy; and improvement of health, because of the avoidance of in-house smoke caused by burning traditional biomass for cooking purposes.

With respect to opportunities at the international level, stakeholders mentioned that a technology, once it is adapted to developing country conditions, could be further exported to other developing countries. In addition, the contribution of introducing low-carbon technologies in the country to addressing the issue of global warming was recognised.

Additional funding leverage and hybridisation with other renewable technology opportunities were also valued.

The emphasis in Thailand was on the opportunity to have superior technology with the associated knowledge and skills training benefits and development of services from local suppliers as well as the opportunity to adapt to new technology. One example of a technical aspect of the market map mentioned at the workshop was the fact that compact fluorescent lamps are preferred over incandescent bulbs, because they are tolerant of voltage swings in the power grid. Incandescent bulbs, instead, more easily break because of voltage swings. The stakeholders in Thailand also mentioned that by mapping the market for a new technology, policies and incentive schemes in the country could be refined and directed towards investments in new technologies. It would also provide an opportunity for local suppliers to learn to develop technology programmes instead of relying mainly on foreign investors to complete project development and implementation. Usually, the latter route is preferred in Thailand because it offers a stronger financial position, but with the CDM revenues, the first route could become increasingly feasible. Finally, it was recommended that local consultants were used, where possible, for technology implementation projects (under the CDM) in order to reduce transaction and monitoring costs and make sure that the project is fully in accordance with the local preferences.

China is different to many countries in that the main companies who would buy large-scale technology are government-owned and therefore the main market actors are governed by government policy and regulations rather than market pressures. This does not apply to some industries for large-scale energy efficiency. Nevertheless, some provinces offer subsidies to encourage manufacturers to change to technologies that are more efficient. For example, in Shandong province a technology fair being held in October 2007 offered 50% subsidies to manufacturers to adopt new technologies. In China, the main driver for large-scale projects would be government policy and regulation rather than market forces. For energy efficiency in industry, the central government or the provinces can offer incentives for change. However, for small scale projects there would be an opportunity to develop a market.

In Chile, government-led regulatory changes requiring electricity from renewables can provide the driver for change and the opportunity to develop a market. A new law, *the Short Law II* requires 5% of demand from small clients be met by renewable sources. Another new law is under consideration which would require all generators larger than 200 MW to dispatch at least 8% of their energy from renewables. Stakeholders expected access to CDM finance to improve the internal rate of return of technology implementation projects.

Israeli stakeholders recognised opportunities in the solar market for power generation and for small-scale technologies as delivering benefits for energy security to the country. According to stakeholders, Israel has built up experience with a range of technologies and has a good potential for a range of applications. An important driver for implementation of new technologies is the need for low carbon and energy security of supply. Stakeholders mentioned though that only by including external effects from conventional fossil fuel combustion in the cost calculations (*e.g.* energy prices) would justify the additional initial financial risk related to introducing and implementing new technologies.

Summary

The key opportunities seen by the participants in utilising the 'new' technologies discussed for the market maps included the following Trade and Sustainability Benefits:

- Trade opportunities,
- Economic development and superior technology,
- Electricity load balancing and security of supply,
- Poverty alleviation,
- Increased funding and new policy directions, and
- Improved skills.

Table 6-1 summarises for each country the opportunities identified in technology implementation chains.

Table 6-1. Opportunities identified in technology implementation chains

	Kenya
*Opportunities for **small scale biomass gasification***	• Categorisation of technology implementation as programmatic CDM • Opportunities for technology and innovation • Opportunities for technology adaptation • Opportunities for locals to participate • Opportunities for local capacity building • Opportunities for financial savings at household and national level • Opportunities for job creation and poverty alleviation • Opportunities for waste management utilisation • Opportunities for international trade • Opportunities for scaling up • Opportunities for reduced IAP for health • Opportunities for reduced time and frequency of firewood collection
*Opportunities for large scale **CSP***	• More producers • More economic development • More security of supply • More jobs • More low carbon sustainability • Balance power supplies and national power matrix as CSP is located in north east of country and CSP power would be available at times when Hydro would be unavailable. • Development of capacity and skills • Additional funding leverage • Poverty alleviation with increased electricity access as located in poor areas • Quality of life improvements such as education for local communities • The technology would help achieve Millennium Development Goals (MDGs) • Desalination, geothermal, thermal storage possible with hybridisation

Table 6.1. cont.	**Thailand**
Opportunities for ***small scale CFLs and solar thermal***	• Access to CDM finance • CFLs are tolerant of voltage swings in power grid compared to incandescent bulbs
Opportunities for ***large scale biomass/biogas for power***	• The basic market chain is already in operation in Thailand • Foreign turnkey integrated technology solutions (foreign direct investment, FDI, route) usually superior technology • Foreign investors for complete project development, training and knowledge transfer; FDI route has strong financial position • Ongoing refinement of policy and incentive options: policies and incentives for investing in new technologies being developed by the government • Opportunity for local suppliers to learn to develop to provide full integrated new systems • Upstream suppliers outside the country may need to be targeted *e.g.* Taiwan • CDM can enable international finance for projects • Need for trade associations to carry out lobbying to facilitate technology transfer especially short pay back times • Adaptive research to reduce language barrier and unwillingness to use new technology; with facilitate training and demonstration of performance in local context • Use of local consultants where possible to reduce transaction and monitoring costs
	China
Opportunities for ***small-scale solar thermal for heating and cooling*** *&* ***large scale wind for power and energy efficiency technologies***	China is different to many countries in that the main companies who would buy large-scale technology are government owned and therefore the main market actors are governed by government policy and regulations rather than market pressures. This does not apply to some industries for large-scale energy efficiency. Nevertheless, some provinces offer subsidies to encourage manufacturers to change to more efficient technologies. For example in Shandong province a technology fair being held in October 2007 offered 50% subsidies to manufacturers to adopt new technologies.
	Chile
Opportunities for ***renewables***	• A new law, the Short Law II requires 5% of demand from small clients be met by renewable sources • A new law is under consideration which would require all generators larger than 200MW to dispatch at least 8% of their energy from renewables • Access to CDM finance to improve the internal rate of return of projects
	Israel
Opportunities for ***renewables***	• Current experience with a range of technologies and good potential for a range of applications • Driver is need for low carbon energy mix and energy security of supply • Costs taking account of externalities can justify the additional initial financial risk • Environmental and health advantages • Export opportunities of technologies • Solar thermal technologies: mature technologies, able to provide electricity and water heating • Contribution for development of new local industry (*e.g.* solel)
Opportunities for ***energy efficiency technologies***	• Contribution for better environment • Increased security of energy supply • Improving living standards • Does not need large investments • Increase of public awareness

6.3.3. Comparison of Barriers/Blockages

From the market maps and the discussions, participants were asked to summarise where they considered the main blockages in the system to be. In the following tables the results of this exercise are given. In the report of the **Chile** workshop, many points were made relating to small-scale technologies and these are included. In Thailand, there was insufficient time to discuss the blockages for the small-scale technologies. The overview of blockages identified at workshops is given in **Table 6-2**.

The picture emerging from **Kenya** was of weak supporting and enabling structures for the market from government incentives, standards and procedures (*e.g.* import) and lack of integration across policies to infrastructure, R&D and lack of local capacity and expertise. In addition, there needed to be easier links to external producers for capacity building and awareness for large-scale technologies and government support to offset the risks of introducing a new technology. Development of investment capital funding sources were also required and activities to overcome language and cultural barriers and local business practice conditions.

In addition to these aspects, **Thailand** identified the lack of a technology transfer network and central focus point as barriers. The supply chain for biomass was also an issue as discussed earlier. The local embedded country technology network being risk averse and slow to change was mentioned as a problem. This was linked to the small size of firms limiting their potential for engagement and change. A general point was the need to incentivise first movers by offsetting risks of new technology.

China was also concerned with the barriers discussed above but aware of exchange rate risks and also that change in China is government-led, and if the government sets targets, they will be met.

Chilean stakeholders showed concerns with all the barriers mentioned above, as well as costs of new technologies in line with all the countries and the problem of the lack of externalities in current costing methods. The biggest barriers seem to be the availability of coal as a cheaper but less sustainable energy source and the monopoly for electricity supply which is resistant to change.

Israel considered blockages in both renewables and energy efficiency technologies and in common with other countries was concerned with the apparently higher costs, lack of regulations, standards and enforcement, lack of incentives to adopt energy efficient measures, lack of awareness, lack of competition and interestingly the lack of co-operation between industry and R&D. This latter reflects part of the role of a functioning market network.

Table 6-2. Blockages identified in technology implementation chains

	Kenya
Blockages for ***small scale biomass gasification***	• Financial • Clearance of goods: The goods come through the customs bonded warehouses and one normally needs an accredited company or firm to help process and handle paperwork with the revenue and custom officials before goods are released. This process is called clearance of goods. • Infrastructure poor: communication system • Weak policies/legal framework for enforcement of laws and regulations • Poor extension services • Lack of awareness among stakeholders • Social/cultural barriers • Lack of enforcement of standards and quality control • Lack of capacity for Operation and Maintenance of technology • Lack of spare parts • Lack of media interest in promoting technology • Gender participation and integration • Turnover tax in 2007/8 finance bill and this will affect small and medium-sized enterprises disproportionately • R&D needs to be reviewed • Monitoring and evaluation
Blockages for ***large scale CSP***	• Access to external producers: linkages and contacts are needed. For example Database, New technologies, capacity building to train manpower and manufacturers • Risk of newer technologies: financing of studies and for developing the project • Import procedures (New Act will give a tax holiday for renewables) • Direct funding from donors (individual projects for private sector) • Linkage of R&D and developer of project • Tariffs, feed-in tariffs (market rewards), Government incentives and net metering • Venture Capital scarce • Kenyan Revenue Authority taxes • Standards are a key factor supporting markets and affect some technologies *e.g.* CFLs

Table 6.2. cont.	**Thailand**
*Blockages for **Small Scale CFL and solar thermal***	• Not fully discussed • High transaction costs • Government Incentives and subsidies are not enough nor is Board of Investment privilege • Monitoring small scale projects such as CFL is difficult and costly
*Blockages for **large-scale biomass/ biogas***	• Lack of country specific operational deployment experience of technology, local business practice and local market intelligence/data/information especially for FDI route; • Lack of properly functioning technology transfer network • Lack of central focus/focal point with relevant branch specific information • Lack of security of the supply and constant quality of the feedstock and lack of transparency in the fuel supply systems • Legal infrastructure and general contracting culture: Feedstock security is coupled to a problem with the local contract culture and the legal infrastructure which means that suppliers though contracted will go where the price is highest at the time. • The unavailability of specific local expertise in case of directly imported biomass/ biogas based technologies • Barriers in terms of market potential, country specific operational and business practice conditions for the foreign technology suppliers who offer integrated installations in Thailand, mostly also due to cultural and language barriers • Local embedded country route has not got strong financial position and preferences for solid proven technology so is slow to change • Lack of investment finance for new technologies *e.g.* national private, national public, international: local preference for financing projects with short payback times of 4 years • Conflicts and insecurity in terms of financing schemes of the projects New technology seen as too risky • Insufficient policy tools and incentive schemes for the deployment of cleaner technologies. Government Incentives and subsidies are not enough nor is Board of Investment privilege • Local suppliers usually not able to provide complete integrated systems • Relatively small size of local companies limits their ability to absorb new techniques and information in order to change • Existing infrastructure and supply chains lock in • Lack of profitability of projects • Risk and uncertainty round price for carbon • Lack of TT network • Lack of knowledge • Lack of data and information • Country institutional and incentive structures • Language and culture • Reluctance of first movers to incur lobbying costs to remove barriers • Government regulations on waste water can affect Biogas plant and bio-ethanol projects • LFG projects need to partner municipalities to avoid pollution and other problems

Table 6.1. cont.	**China**
*Blockages for **small scale solar thermal for heating and cooling***	• Exchange rate risks • Technique barrier • Language • Application process for CDM • Approval process for CDM
*Blockages for **large scale wind for power and energy efficiency technologies***	• China is different to many countries in that the main companies who would buy large-scale technology are government owned and therefore the main market actors are governed by government policy and regulations rather than market pressures. This does not apply to some industries for large-scale energy efficiency.
	Chile
*Blockages for **renewables***	• High costs • Lack of an adequate investment atmosphere for this type of undertaking. • Lack of pertinent lines of financing for this type of technologies in consideration of risks involved • Lack of suitable legal and institutional structure • Lack of knowledge on the new technologies • Limited availability of spare parts and experience in maintenance, and • Existence and availability of cheaper technological alternatives no matter their worth for a sustainable development • Chile has a quasi monopoly for electricity generation which effectively prevents new market entrants • Environmental costs are ignored when establishing generations costs and tariffs • A new law, the *Short Law 1*, which allows exemptions for renewables from toll payment is restricted to renewables under 9 MW thus preserving the status quo for the grid.
	Israel
*Blockages for **renewables***	• High costs • Lack of regulations and standards to support technology development • Economic obstacles for clean energy technologies such as solar PV • Lack of competition in the energy sector • Limited social awareness
*Blockages for **Energy Efficiency***	• Insufficient cooperation between industries and R&D • Insufficient incentives for investment in energy efficiency technologies • Existing standards to support technology development are not obligatory

6.3.4. Summary of common blockages

This comparison is carried out mainly from the data for Kenya, Chile and Thailand. There are many **common blockages** which are independent of size or technology. These are presented below in terms of the different aspects of the market map (see again the basic format in **Figure 6-1**):

- **Market Chain aspects:**
  - Lack of technology transfer network,
  - Lack of awareness of stakeholders and for large projects particularly linkages and contacts to external producers,
  - Cost of new technologies and no accounting for externalities,
  - Availability of cheaper high carbon alternatives,
  - Need to demonstrate unfamiliar and adapt to local conditions, and

    - Lack of competition especially in electricity supply.
- **Enabling Environment aspects:**
    - Weak policies,
    - Lack of regulations, standards and enforcement,
    - Complex procedures,
    - Import procedures need to be simplified and incentivised for these new technologies,
    - Lack of integration across government, *e.g.*, fiscal policies and particularly tax regimes need to be aligned to encourage their adoption,
    - Poor infrastructure, and
    - Lack of incentives.
- **Support Services aspects:**
    - Lack of R&D support,
    - Lack of market information,
    - Lack of good quality control,
    - Local capacity building to bridge expertise gaps,
    - Language and cultural support, and
    - Finance availability for new technologies and small-scale technologies and measures to offset the additional risks associated with these new technologies.

6.3.5. Some differences for small compared to large-scale projects

The differences between small and large-scale projects are probably more a matter of degree rather than the result of complete absence of the key factors in the case of large-scale technologies and will also be dependent on the technology type as well as the implementation context. However, it is interesting to note that for large-scale technologies nearly all the blockages referred to are on the 'enabling business environment' side while for the small scale, though the enabling business environment is important, there is also emphasis on the support services and market chain. Some points are listed as follows:

Market chain:

- As indicated above 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:

- Poor infrastructure especially for communication for small scale project support,
- Weak policies and legal framework and enforcement applies to all sizes,
- For large-scale electricity supply concern is over tariffs and feed in tariffs, government incentives and net metering.

Support services 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.

6.3.6. Comparison of blockages for technology transfer from a range of sources

Although we discuss barriers to technology transfer and this terminology is in constant use, it may be better to consider the transfer of technology in terms of the market mapping, as an integrated whole system, and to view barriers as blockages or inefficiencies in that system. In **Table 6-3** we list from the literature and from this study what are commonly called barriers to technology transfer. The market mapping approach results have shown clearly that what we have is a mixture of market chain, enabling business environment and supporting service requirement inefficiencies in the systems in different countries with many common factors but also with factors which will be specific to the country context, the technology context and whether it is a large-scale or small-scale technology. This therefore can only be a start to elucidate what can be done to support technology transfer. In the following Table the various factors have been identified. In agreement with the IPCC (2001), barriers arise at every stage of the transfer process are country context dependent and will also vary with the specific sector /technology/project.

Table 6-3. Blockages to technology transfer in ENTTRANS, IPCC, EGTT, OECD/IEA

Source	Blockages
ENTTRANS	
Enabling Environment	• Import procedures need to be simplified and incentivised for these new technologies • Lack of integration across government; for instance, fiscal policies such as tax regimes also need to be aligned to encourage adoption of low carbon technologies • Standards and enforcement are key • Poor infrastructure especially for communication for small scale project support • Weak policies and legal framework and enforcement • For large scale electricity supply concern is over tariffs and feed in tariffs, government incentives and net metering • Lack of incentives
Market	• Lack of technology transfer network • Lack of awareness of stakeholders and for large projects particularly linkages and contacts to external producers • Cost of new technologies and no accounting for externalities • Availability of cheaper high-carbon alternatives • Need to demonstrate unfamiliar and adapt to local conditions • Lack of competition especially in electricity supply
Support Services	• Lack of spare parts • Poor extension services • Social and Cultural Barriers • Lack of media interest • Monitoring and evaluation • Capacity Building for training manpower and manufacturing • R&D support needs to be reviewed • Finance availability for new technologies and small scale technologies and measures to offset the additional risks associated with these new technologies • Gender participation and integration/equity

Table 6.3 cont.	
IPCC	
Enabling Environment	• Political • Economic - high transaction costs • Trade • Policy • Insufficient legal protection • Inadequate environmental codes and standards
Market	• Lack of information • Lack of full cost pricing
Support Services	• Insufficient human capacity • Lack of investment capital and risk aversion • Lack of understanding of local needs
Expert Group on Technology Transfer (EGTT)	
Enabling Environment	• Fair trade policies • Removal of technical, legal and administrative barriers to technology transfer • Sound economic policy • Strengthen environmental regulatory frameworks • Transparency • National Institutions for technology innovation • Involvement of social and managing technologies in a macroeconomic policy framework • National legal institutions that introduce codes and standards, reduce risk and protect intellectual property rights • Utilising tax preferences • Improving access to publicly funded technologies and other programmes, in order to expand commercial and public technology transfer to developing countries • Transparent and efficient approval procedures for technology transfer projects
Market	• Underpinnings of sustainable markets for EST
Support Services	• Research and technology development; • Means for addressing equity issues

Table 6.3 cont.

Solar Thermal latest state of the art systems: Review of barriers for OECD/IEA

Enabling Environment	• World energy prices; low mitigate against new technology • Demonstration and awareness raising outreach programmes required • Local legal requirements for permits, *etc* • Good contract law and performance guarantee schemes • Financial support policies for technology • Incentives for the technology needed such as green and white certificates and use of cooperative procurement • Reduce import tariffs • Building Regulations and legal barriers
Market	• Historically disappointing performance through need for householder to modify behaviour. Immature technology and poor installation has led to historical aversion. State of the art systems are now reliable and have overcome previous problems. • Availability of lower cost alternatives *e.g.* gas • Use of payback time criterion limits consideration of overall economic lifetime benefits • Up front costs tend to be high except in China and vary according to latitude and systems are best when combined heating and cooling and applied to new build • Existing subsidies for fossil fuel technologies and lack of internalisation of externalities in their costs • Property Developers and rental market have no incentive to invest • Problems with collective market in apartment buildings mean new build or complete renovation min options • Incapacity of washing machines, *etc.*, to work with hot water fill
Support Services	• Major problem is Lack of competence in installers and planning engineers as need careful installation with new skills not just central heating • Solar heat for domestic needs fundamental R&D on storage materials and concepts For cooling and air conditioning systems for commercial buildings the system level needs to worked out for these larger systems More R&D for small scale cooling at Household level and for industry applications is also required. Current spending on R&D are extremely low. • Lack of awareness • Perception of complexity • Need for certification and quality control

6.3.7. Conclusions and Recommendations

1. Although there are common barriers affecting the different parts of the market map there is nevertheless a need to recognise that the country context, the technology and the specific conditions relating to that combination need to be taken into account when considering activities to improve technology transfer. This is in line with IPCC findings (IPCC, 2000).
2. Although market mapping was only used in ENTTRANS, it is clear that the 'barriers' can be categorised in terms of enabling environment, market chain and support services. This categorisation allows easier comparison between the studies.
3. The EGTT barriers focus mainly on the enabling environment. They define 'Enabling environment' as "government policies that focus on creating and maintaining an overall macroeconomic environment that brings together suppliers and consumers in an inter-firm co-operation manner (UNCTAD, 1998a.

TD/B/COM.2/33)" (EGTT, 2008). The focus corresponds with the enabling business environment part of the Market Map used in this study. In practice some of the items on the list of barriers in EGTT (2008) can be assigned to the market chain and to the support activities for the market as shown in the table. The EGTT also identifies specific areas to enhance the enabling environment for technology transfer and these are included in the list provided.

4. Though the market chain and support service issues are apparently not so well addressed in terms of barriers or enabling activities by the EGTT approach, the sector level activities for technology information dissemination undertaken as part of the technical information theme under the EGTT activities will encourage market networks. For the EGTT the market chain barrier identified was 'the underpinnings of sustainable markets for EST' so that the market mapping with the formation of a market network as in ENTTRANS would be in line with this general aim. As observed earlier, the small-scale projects tend to have a bigger market chain and more support service requirements so that this observation may imply an emphasis on mainly large-scale electricity supply energy technologies.
5. The difference between large and small scale project maps in terms of the enabling environment, market chain and support services appears to be supported by the solar thermal study results which are very similar to the ENTTRANS study for small-scale projects and interestingly advocated 'demonstration and awareness raising outreach programmes' which was also an outcome of this study (see Section 6.3.3).
6. The results from ENTRANNS are also in line with the general IPCC barriers though give much more detail and structure to them.

6.3.8. Future steps

In the workshops carried out in Kenya and China the participants were asked at the end of the workshop what they considered should be the next steps. The key outcome from the meeting in Nairobi was that participants decided that it was important that they follow up the workshop and organise themselves into a ***network*** to hold meetings to follow up on the issues raised on the operation of the market and technology transfer with the objective of progressing CDM project proposals. KIRDI, the Kenyan Industry Research and Development Institute, which is funded by the government, offered to organise the meetings which they thought should be monthly. The meeting therefore catalysed the formation of a new energy market network.

Participants at the workshop in Kunming (China) agreed that there was a need for additional action in China and that the following initiatives would be beneficial:

- Strengthen local governmental co-ordination in different regions of the country and establish specific local governmental organization to co-ordinate CDM projects (already in progress).
- Promote public participation by introducing effective forms, *e.g.*, CDM game field.
- Every province should issue the provincial plan in responding to climate change, based on the national plan that had been already issued (National Development and Reform Commission People's Republic of China, 2007).

6.4. Workshop results for the CDM

The workshop was structured to investigate the following questions designed to elicit insights into the key questions on the CDM. The technique used in the Kenya and China workshops was an H-diagram approach which is fully described in the reports (annexed to the ENTTRANS Periodic Activity Report 2007). From the approach the positive and negative aspects of the CDM are identified and then an action plan of what could be done to improve the CDM is generated. In other country workshops, a discussion approach was taken and the results of these discussions are also included in roughly the same format.

The following two questions were asked:

1. The first question was: **How effectively does the CDM support Technology Transfer of suitable technologies?**
2. The second main question was broken down into two areas which were dealt with separately by some discussion groups and conflated in others. This question focuses on improving the CDM at the international and national level for facilitating technology transfer: **'How can we improve the CDM to ensure CDM projects are in line with energy services considered most needed and avoid ad-hoc CDM projects, and improve the efficiency of CDM host country operation to fast track CDM projects?'**

The approach was to consider how well the CDM is performing on these issues and then what could be done about it and by whom. The results from the workshops are reflected in the conclusions and recommendations in Chapter 8 and are listed in the Tables in to the ENTTRANS Periodic Activity Report 2007 and summarised in the section below.

6.5. Conclusions and Recommendations

All countries developed recommended actions based on the discussion of the questions above by exploring the positive and negative aspects of the performance of the CDM on technology transfer, as well as recommended action needed to improve this performance. The country recommendations have been amalgamated and summarised here under three main activity headings: technology transfer enhancement, host country facilitation of the CDM, and CDM procedural change at the international level.

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Technology transfer enhancement:

- There is a need for development of local CDM knowledge suppliers and consultancies over time to replace any import needs in the project planning, including the preparation of CDM project design documents. Several stakeholders mentioned that presently there is not enough local participation in the preparation of PDDs. Local knowledge suppliers are likely to have a better knowledge of local needs and priorities and may see CDM opportunities around technologies that are suitable for fulfilling these.
- Governments need to provide local standards and better enforcement, as well as enabling policies, integrated regulations, and legal and financial supporting structures for technology transfer. Alignment of existing policies and removing policy inconsistencies (some policies stimulating and other policies hampering low-carbon technology transfer) would also be productive.
- It is recommended that several CDM projects with the same technology, but carried out in different locations in a host country and at different scales should be grouped (*e.g.* under a programme), to iron out problems that individual projects may encounter and adapt the projects to host country conditions.
- Intellectual property right problems need to be addressed within PDDs and the project contracts (possibly emission reduction purchase agreement or ERPA), especially patents and cost of patents.
- Participants mentioned the advantage of having an effective mechanism for technology transfer under the CDM within a country, which could, among others, check the technical and financial feasibility of a CDM project idea before entering the stage of preparing a PDD and the subsequent

validation procedures. Such a mechanism could facilitate discussions with industry and research and development institutes within the country at the planning stage.

- It is important that within developing countries CDM new technology projects are linked to national strategies on energy planning to promote national focus, co-ordination, and resource allocation.
- Enhanced capacity building associated with the technology transfer to meet local requirements should be part of the CDM project

Host country facilitation of the CDM:

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- Improve cross-departmental government co-ordination to spread awareness and understanding of CDM. In several developing countries, national climate change co-ordinating committees already exist, which could be used for this co-ordination, although their resources are generally scarce.
- Participants underlined that more action within developing countries on R&D and innovation could stimulate change and make more technologies technically suitable for the country. The CDM could support these technologies' step towards commercialisation.
- As Internet access is not easy for everybody in developing countries, much information on implementation aspects of low-carbon technologies (including sustainable development benefits) is presently unknown to a large group of people. Host country action on infrastructure improvement, especially improved Internet access, would help increase people's awareness of technology benefits and disbenefits.
- The DNA could make CDM information and advice more accessible to stakeholders in the country and affordable locally. This could take the shape of specific training programmes in *e.g.* industrial sectors or local government departments and it would increase people's familiarity of a range of new technologies.
- Promotion of CDM projects by the DNA of the host country must work two ways. On the one hand, DNA should promote domestic CDM projects to international investors in CERs, but, on the other hand, the DNA should help local institutes explore domestic technology transfer opportunities for the CDM. This would require at least a one-stop-shop set-up of the DNA so that people can easily contact the government with CDM project ideas and the DNA should have a well-functioning feedback mechanism. A strong focus on the Internet for such a feedback mechanism is at present not realistic. This more active role for the DNA requires that it is adequately resourced, which may also apply at the international level to ensure that funds are available.
- With respect to the latter point, stakeholders have argued that the focus for the CDM should in the first phase not be on projects alone, but on sectors which are considered promising for technology transfer through the CDM. A developing country's CDM strategy would then be centred around priority sectors within which projects are identified, preferably by local knowledge providers.
- CDM projects involving Biomass need to ensure fuel supply security.
- For China it was suggested that a plan for energy saving and emission reductions should be prepared for each province. This initiative could apply to all countries.

CDM procedural changes at the international level:

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- It was underscored at several workshops organised in the context of ENTTRANS that the CDM architecture and its application at the level of investor and host country governments should strive for a combined maximum of CO_2 emission reduction and contribution to sustainable development in the host country ('max CO_2-SD'). Consequently, single focus on technologies with large CER potential but little sustainable development gains, or the other way round, were considered lower priority CDM technologies.

- Generally, one of the key conclusions of the stakeholder assessment is that programmatic CDM will become an important tool to both bundle small-scale projects and organise similar (not necessarily small-scale) projects carried out at different locations and scales. Procedures for programmatic CDM should however not be overly complex, especially not if all activities within a programme still need to individually show additionality, *etc.*
- Technology transfer should become explicit in guidelines for the CDM at the level of the CDM EB and should explicitly ban dumping of technologies that are rather outdated in industrialised countries but still result in emission reduction when implemented in developing countries and when replacing very old technologies.
- A very concrete suggestion to increase people's familiarity with new low-carbon technologies and enhance their acceptance of such technologies, so that locking-in into old high-carbon technologies can be prevented, was to develop a CDM technology demonstration in a project or programmatic mode. A programme would have the advantage of showing a technology at different locations within a country (for small-scale technologies such as for cooking programmes are inevitable, but also for energy efficiency improvement technologies programmes could be more useful). From such demonstration programmes, spin-offs could be created later on in the course of the programme or new activities to implement the technology could be added to the programme during its lifetime (a programme has a maximum duration 28 years and new activities can be added after its starting date).
- It is recommended that high (and sometimes prohibitive) up-front transaction costs (project identification and PDD) should be avoided through: a) new financing approaches such as the use of CERs to pay for these costs or enable a compensation for project investors for the transaction costs after the CERs have been sold, or b) lower consultancy fee expenses by using local experts for project identification and maintenance, or c) host government and international authorities to subsidise high cost of CDM application in case these projects clearly aim at transferring low-carbon technologies to countries that are presently underrepresented in the CDM pipeline or at supporting low-carbon technologies that are presently not largely applied in CDM projects (*e.g.* cooking, tidal wave energy, *etc.*). It is also recommended that projects from least-developed countries should be exempted from payment of registration fees and CDM share of proceed contributions.
- Innovations are needed in financing projects, *e.g.*, in criteria.
- The idea of guaranteed purchase of CERs was generally supported. Within the market, such guaranteed purchase is taking place with commercial brokers buying CERs through forward-market contracts (*i.e.* before realisation of the emission reductions) and thereby taking risk of non-delivery. Also, the World Bank has followed a strategy that it guarantees the purchase of all CERs from projects that it is involved in during the first commitment period of the Kyoto Protocol and of 30% of the emission reduction credits after 2012.

- Additionality of CDM projects should be reviewed and simplified as it is felt that the present tool for proving additionality will not stimulate changes in the energy investment patterns of developing countries. For some developing countries there are no other projects which would be undertaken in the absence of the project and the country circumstances should be recognised when assessing additionality of emission reductions. It would be better to have a more positive approach to additionality in the sense that a project is additional when it requires capacity building actions such as setting up ongoing training schemes for local employees. Also, a simplified additionality tool could be proposed which would allow project developers to choose those steps that are most appropriate within the country or project context (*e.g.* when a technology is implemented for the first time, this could be sufficient proof of additionality). Finally, a positive list could be established with technologies which implementation would be exempted from an additionality test (because of their contribution to sustainable development in low-income developing countries).
- Host countries may benefit from a more regional co-operation in terms of knowledge exchange, capacity building, and technology transfer strategies. The EU research-based and facility programmes, for instance, could support such regional co-operation and CDM playing field enhancement.
- Finally, it has become clear that several industrialised countries have CDM capacity building programmes managed by governmental agencies for development co-operation (*e.g.* DGIS in the Netherlands, DANIDA in Denmark, GTZ in Gemany, *etc.*) which focus mostly on helping developing countries to streamline their DNA procedures (including Internet sites in English and local language). It has been recommended that the work of these agencies be also focussed on helping CDM host countries to identify their energy service needs and priorities and suitable low-carbon technologies. For this it would be better if the activities of these development co-operation agencies are co-ordinated with the CER acquisition ministries/agencies in the same countries. Such inter-ministerial co-operation on the CDM could target CER money more towards technologies that could achieve the above-mentioned 'Max CO_2-SD' objective of the CDM.

Finally, in Israel, CDM issues were discussed in an earlier smaller meeting in February 2007 the main points related to the CDM were as follows:

- The households sector has a significant potential for energy saving. However, its scattered nature makes it difficult to establish a relevant CDM project.
- In the short term, the municipal solid waste sector has the largest potential for CDM projects in Israel.
- New Israeli CDM projects should take into consideration the possibility of Israel joining OECD in the short term. This might limit the opportunities for launching Israeli CDM projects after the second period of Kyoto protocol in 2012, should this also imply quantified emission reduction/limitation targets.
- While economy plays a basic role in the CDM process, there is a need to focus on two main energy areas: electricity and heat.
- The potential projects for CDM in Israel should be able to be sustainable also after the completion of the CDM contribution.

The main technological fields for implementation in Israel are:

- Solar (thermal and PV),
- Biomass,
- Energy saving technologies (including passive cooling &sustainable design):
    - Israel is an export country for energy technologies (*e.g.* geothermal, biofuels),
    - Insufficient awareness,
    - Israeli small market preventing large CDM investments in many attractive technologies,

- There is a need for specific legislations, obligatory standards and supportive economic policies (*e.g.* subsidies), and
- Solar and selected biofuel technologies must be supported by local authorities, either through an appropriate legislation or through direct financial subsidies.

7. Experience with Diffusion of Sustainable Energy Technologies within the EU

7.1. EU programmes and policies to develop sustainable energy technologies

In the course of the past decades, the EU policy agenda has increasingly reflected an increased awareness of the need to let economic growth coincide with reduced pressure on the environment and natural resources. Key aspects of this overall sustainable development objective are GHG emission reduction and enhancement of energy security of supply. In order to support this objective, the EU has become an important partner in international research programmes on developing sustainable energy technologies. The EU itself has established such programmes as: JOULE, THERMIE, APAS, FAIR, INCO-DC, ALTENER, of DG-TREN and DG-Research. In addition, the European Commission and several EU entities participate in research programmes of the International Energy Agency (PVPS, the Greenhouse Gas R&D programme, the Bio-energy Agreement, *etc.*), UNIDO, UNEP, OECD, GEF, WEC, IPCC, WWF and FAO.

A key theme across these programmes is the need to develop sustainable energy technologies such as renewable energy technologies in power generation and technologies to increase the efficiency of energy use in households, services, industry and transport (UNEP and IEA, 2007). For instance, in March 2007, the EU Heads of States and Government adopted a binding target that by 2020 20% of the EU energy production shall be based on renewable energy sources.[39] In addition, progress has been made in terms of removing subsidies that encourage the wasteful use of energy, and introducing economic incentives for low-carbon technologies. Particular energy-related measures planned by the EU are explained below:

- *End-use efficiency and Energy Services*: It has been estimated for the EU that energy efficiency can be increased by 20% above present standards in a cost-effective manner (*e.g.* through so-called 'no-regret' measures) (Nilsson, *et al.* 2007). In order to support this, the European Commission has formulated a Directive on the promotion of end-use efficiency and energy services which contains targets, mechanisms, incentives and institutional, financial and legal frameworks to remove existing market barriers and imperfections. According to the Directive, Member States shall adopt overall national indicative energy savings targets of 9% for the ninth year of application of the Directive (*i.e.* 2015).[40] Member States shall take cost-effective, practicable and reasonable measures designed to contribute towards achieving this target (European Commission, 2007).

- *Energy Efficiency in Buildings*: The buildings sector accounts for 40% of the EU's energy requirement. Research has shown that more than one-fifth of the present energy consumption in buildings, which corresponds to 30-45 Mt CO_2 per year, could be saved by 2010 by applying more ambitious standards to new buildings and through refurbishment of existing buildings. The aim of improved energy efficiency in buildings has been set out in a series of legal documents: *e.g.* the Boiler Directive (92/42/EEC), the Construction Products Directive (89/106/EEC), and the buildings provisions in the SAVE Directive (93/76/EEC). The Directive on the Energy Performance of Buildings (2002/91/EC of 16.12.2002) came into force on 4 January 2003 and aims at a substantial increase in investments in energy efficiency measures within public, commercial and private buildings in all EU Member States.

[39] EU Council Decision of 8 March 2007.

[40] Directive 2006/32/EC of the European Parliament and of the Council of 5 April 2006 on energy end-use efficiency and energy services and repealing Council Directive 93/76/EEC.

With respect to energy efficiency in buildings it is also important to consider the potential for renewable energy technologies for heating and cooling of buildings. Almost 50% of the final energy consumption in Europe is used for heating needs in buildings, industrial processes, and for domestic hot water production. Renewable heating technologies (solar thermal, geothermal, biomass) have a huge potential for growth as emphasised by objective which was recently formulated by the European solar thermal industry: 1 m^2 of solar collector area for every European by 2020, which would amount to 320 GW_{th} of installed capacity (ESTIF, 2007).

- *Combined Heat and Power (co-generation)*: The use of combined heat and power (CHP) is considered a priority area for many EU Member States. The simultaneous production of heat and power offers energy savings and avoided CO_2 emissions when compared with separate production of heat and power. In addition to that, GHG emission reductions can be achieved by using cleaner fuels for CHP. Nearly 40% of the electricity generated through cogeneration is produced for public supply purposes, often in connection with district heating networks. The remaining 60% is generated by auto-producers, mainly for industrial processes.[41]

In December 1997, the European Council endorsed a strategy for co-generation with an overall indicative target of doubling the share of electricity production in the EU from co-generation from 9 in 1994 to 18% by 2010 (for the EU-15 states).[42] Projections show that meeting this target could avoid emissions of over 65 Mt CO_2/year by 2010. In 2001, the share of electricity produced by co-generation processes in the EU had risen to 10%, although Member States' performance in terms of installed CHP capacity varied from 2% to 60% of the electricity production. Hence, a new EU Directive focuses on providing a framework for the promotion of CHP by: overcoming still existing barriers, advancing its penetration in the liberalised energy markets, and mobilising un-used potentials. The Directive does not include targets, but urges Member States to carry out analyses of their potential for high efficiency co-generation.

- *Renewable Energy Sources*: Promotion of renewable energy use is an important aspect of the EU's policies to address the growing dependence on energy imports in Europe and to tackle climate change. Since 1997, the Union has been working towards an ambitious target of a 12% share of renewable energy in gross inland energy consumption by 2010. In 1997, the share of renewable energy was 5.4%; by 2001 it had reached 6%.

With the enlargement of the EU in 2004, the new Member States have been requested to adopt the RES-E Directive by 1 May 2004. In the accession treaty, national indicative targets are set which has resulted in an overall renewable electricity target for the enlarged EU of 21% of gross electricity consumption by 2010 (Commission Staff Working Document, 2004). This target has been formulated in the Directive 2001/77/EC1[43] on the promotion of electricity produced from renewable energy sources in the internal electricity market, which has also set differentiated targets for each Member State. The Directive further stipulates that Member States have to provide better grid access for renewable energy generators, streamline and facilitate authorisation procedures and to establish a system of guarantees of origin. Under the Directive, Member States have set up individual RES-E (electricity from renewable energy source) targets. They are free to choose their preferred support mechanism in order to achieve the targets and/or are allowed to continue to do so for a transitional period of at least seven years after a new EU-wide regulatory framework would be adopted.

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[41] Directive of the European Parliament and of the Council on the promotion of cogeneration based on a useful heat demand in the internal energy market, COM (2002)415 final – 2002/0185 (COD).
[42] European Commission Communication on CHP (COM (97)514 final).
[43] Directive 2001/77/EC of 27 September 2001 on the promotion of electricity produced from renewable energies sources in the internal electricity market (OJ L 283, 27.10.2001, p. 33). The date for the implementation of this Directive was October 2003 and for the new Member States, 1 May 2004.

Between 1990 and 2006, the turnover in the area of renewable energy sources in the EU grew from €1.5 billion to €20 billion. This, however, is only considered the beginning of a continuing strong growth (European Renewable Energy Council (EREC), 2007). The European Renewable Energy Council (EREC) and Greenpeace have recently published "*The Energy [R]evolution*" scenario which provides a practical blueprint on how to half global CO_2 emissions, while stabilising the energy demand at about today's level and at the same time guaranteeing sufficient economic growth up to 2050 and beyond. Under this scenario, half of the primary energy demand would be covered by renewable energy sources by 2050. Reaching the 20% binding renewable energy target agreed on by EU leaders is crucial to tap this huge potential.

In order to fully utilise the potential for renewable energy sources, it is important that existing technologies are further diversified so that their applicability can be enhanced. For instance, although hydropower is a mature technology in comparison with other renewable energy sources, its potential could still be enhanced if new applications such as pumped storage plants and multipurpose plants (electricity production combined with drinking water supplies, waste treatment plants, irrigation channels) are utilised. In addition, the efficiency of existing hydropower plants may be increased. Another quickly developing renewable energy source is ocean energy which development has grown exponentially over the last five years. At present, several large-scale installations are either being tested in real sea conditions, or are under development. By 2010, at least several MW of installed capacity will be available to deliver electricity to the grid, which is also expected to lead to an employment generation of 10-20 jobs in coastal regions for each MW added.

Past experience has shown that research and development activities in the field of renewable energy in combination with application of renewable energy technologies has led to considerable cost reductions. Over the past two decades, 40% of the reduction in the cost of wind energy can be directly attributed to research and development. The 40% average market growth achieved since the year 2000 in the EU solar photovoltaic electricity sector has been due to progressive cost reductions achieved by a combination of research and technology development efforts and achievement of economies of scale in production and application of the technologies.

- *Other promising technologies*, which are presently under development within the EU and which have a large potential to contribute to the EU energy policy goals for 2050 are: energy storage, second generation biofuels and hydrogen vehicles, hydrogen as energy carrier, energy efficiency in transport and in buildings as well as photovoltaics, concentrated solar power, polygeneration, and nuclear fusion.

7.2. Barriers to technology implementation experienced in the EU

As explained in Chapter 6, the success of implementation of sustainable energy technologies in a market depends on the efficiency of the implementation circumstances in that market, *i.e.* the chain of implementation steps from entering the market, through legislation to the end users. Market development of sustainable energy technologies is often hampered by a combination of mainly non-technical constraints which are country- or region-specific (Beck and Martinot, 2004). Generally, some typical problems related to the implementation of sustainable energy technologies, which have also been discussed in Chapter 6, are:

- Many potential users of sustainable energy technologies have no or little experience with their application and the assistance provided in the development of such technologies is insufficient. Moreover, dissemination of EU experience sustainable energy technology implementation to other countries in the world has been limited;
- It is difficult to get information on the success and failure of existing projects, which requires an stronger dissemination of information and experience;
- There is a difficulty of firm dispatch in utility grid operations: power from renewable energy sources

such as solar and wind may not provide the same levels of firm dispatch to which a utility is accustomed and this may require changes to a utility's dispatch procedures;

- In most cases, environmental concerns and environmental costs of conventional power plants are not included in the assessment of the energy potential at the planning stage;
- In several countries, the renewable energy market faces opposition from existing interest groups, in particular from those groups that benefit from the actual reliance on conventional energy sources and who have an interest in delaying renewable energy technology development;
- In several countries introduction of sustainable energy technologies is hampered by a significant administrative bureaucracy, an absence of official policies and strategies for the promotion of these technologies, and a lacking institutional/legal framework. Examples of such barriers are the following:
  - *Too many authorities involved*: Sustainable energy generating technology implementation is often hindered by the fact that too many authorities are involved in technology implementation while co-ordination among them is limited. Each layer of competence for the authorisation of energy generating units (*e.g.* national, regional and municipal) may impose their own conditions for technology implementation, which delays investments and increases investment uncertainty. Where different levels of government administrations are involved, countries could establish one-stop authorisation agencies (with standard forms and requirements), which are responsible for the co-ordination of several administrative procedures. The German *Federal Office for Shipping and Hydrography* which serves as a one-stop counter for off-shore wind power in Germany, could serve as an example.
  - *Long lead times needed for obtaining necessary permits*: For onshore wind projects authorisation procedures may take two to seven years,[44] while the authorisation procedures for offshore wind projects mostly take even longer. Until recently, no clear procedures were established for the division of responsibilities among the different government authorities concerned. Improvements could be sought in clear guidelines for authorisation procedures and obligatory response periods for the authorities involved. The setting of approval rates[45] is an excellent tool for checking the streamlining of authorisations.
  - In several countries and regions, the future development of *renewable energy projects is not taken into account in spatial plans*. Where different levels of authorities are involved, a possible solution to this problem could be the process of preplanning as carried out in Denmark and Germany. In this process municipalities are required to assign locations that are available to project developers for a targeted level of renewable electricity generating capacity. In these pre-planned areas, the permit requirements are reduced and permits issued more quickly. In Sweden, these areas are called 'areas of national interest for wind'.

    The planning and permitting process is also affected by the easiness of relating the different forms of European environmental legislation. For instance, the European Commission is working on linking the Water Framework Directive and the Directive on electricity from renewable energies as far as hydropower is concerned. Such combined approaches could provide transparency on when a hydropower project is acceptable and not in conflict with other EU legislation related to water management.

[44] This period applies in the Netherlands and Scotland.
[45] The British Wind Energy Association publishes yearly approval rates: the last year, 2004, had a 80% approval rate.

7.3. Technology diffusion mechanisms

In order to help overcome the barriers to technology transfer and implementation mentioned above, several approaches and mechanisms can be used. These are described below.

- *National Systems of Innovation:* In the literature it has been suggested that technology innovation and diffusion would take place more efficiently through so-called National Systems of Innovation (NSIs) which create an enabling environment for sustainable technology transfers by integrating capacity building and access to information (see also Chapter 6, Masinda, 2005). Subsystems and the quality of interconnections within them can successfully influence technology transfer. The concept of NSIs can be enhanced through partnerships with international consortia. Partnerships would be system oriented, encompass all stages of the transfer process, and ensure the participation of private and public stakeholders, including business, legal, financial and other service providers from developed and developing countries.

- *Official Development Assistance (ODA)* is an important mechanism for technology transfer to developing countries, and it could also assist in improving policy frameworks and capacity building. There is increasing recognition that ODA can best be focused on mobilizing and multiplying additional financial resources (IPCC, 2000).

- The *Global Environment Facility (GEF)* is the Financial Mechanism of the UNFCCC (managed by the World Bank and UNDP) and is a key multilateral institution for transfer sustainable energy technologies transfer. The GEF currently targets incremental, one-time investments in mitigation projects that test and demonstrate a variety of financing and institutional models for promoting technology diffusion, thus contributing to a host country's ability to understand, absorb and diffuse technologies.

- *Multilateral Development Banks (MDB)* could, thereby requested by governments: take increased account of the environmental consequences of the programmes that they support, develop programmatic approaches to lending that remove institutional barriers and create enabling environments for private technology transfers, and establish partnerships in NSIs.

- The *UNFCCC* addresses technology transfers from industrialised to developing countries in its Article 4.5 (see Section 4.1). In addition, the CDM under the Kyoto Protocol is also considered an important mechanism for technology transfer to developing countries (see Chapter 3, IPCC, 2000).

- *Research, development and demonstration (RD&D) policies* aim at alleviating technical barriers and reducing costs by improving materials, components, system design and tools for installers and users. During the past 15 years, only 7.7% of RD&D budgets in IEA member countries was devoted to renewable energy technologies. Solar heating and cooling represents only 0.55% against 2.68% for solar PV. Wind power, geothermal energy and concentrated solar power receive even less money, which suggests that public R&D funding is somehow inversely proportional to the energy potential (IEA, 2006a).

In addition to these concepts and mechanism, governments can support market deployment of sustainable energy technologies through a wide array of policies, from outreach and raising awareness to training to certification of components and systems at national or international levels, to various financial incentives to reducing import tariffs. Outreach programmes are necessary to raise awareness of potential customers of the possibilities of sustainable energy technologies, *e.g.*, through successful demonstration projects. Training, especially of engineers and installers, is also a key component of comprehensive support programmes to market deployment. For instance, lack of knowledge of solar-based technologies of most professionals in energy service companies, architects, building developers and other energy experts and key actors is an important barrier to diffusion of these technologies. This training should not focus only on the technical aspects, but also involve sales and marketing experts, and would enable a broadening of assessing a technology from a sole focus on 'pay back time' to a broader set of product evaluation criteria.

Governments, industry associations and regional authorities can furthermore develop certification systems for sustainable energy technology equipment. Another way to make customers, especially large installations, more confident about a technology is through guaranteed-result schemes. Finally, purchase of technologies in collaboration with other installations could reduce time and costs of the procurement, as well as reduce the risks for manufacturers. Ultimately, co-operative technology procurement could accelerate technology innovation. Westling (1997) provides several examples of energy end-use projects where the utilisation of the technology procurement method in Sweden led to energy reductions of 30-50%.

Energy service companies may also offer third party financing to overcome the 'split incentives' barrier, which relates to situations in which funding for investment and funding for running costs are not compatible at the decision maker's level.

Most industrialised country governments have put in place policies to financially support the dissemination of renewable energy technologies. This support is generally justified by focussing on the ancillary benefits from implementing such technologies, such as increased security of supply and reduced pollution of local air. In addition, government support to such technologies could contribute to creating economies of scale so that costs could be reduced. It could also reduce the distortions that may arise when cost structures of different technologies differ (IEA, 2003).

Tax credits and grants usually constitute the core of the public policies to support the dissemination of sustainable energy technologies, alongside qualification of materials guaranteeing performances. These could take the forms of feed-in tariffs or (possibly tradable) obligations for installations to increase the share of renewable energy sources in their energy mixes (*e.g.* through green certificates). Some EU countries have developed energy saving certificates or 'white certificates' systems, which require producers, suppliers or distributors of electricity, gas and oil to undertake energy efficiency measures for the final users that are consistent with a pre-defined percentage of their annual energy deliverance. White certificates can be tradable.

7.4. Examples of technology innovation and implementation programmes

After having assessed barriers to technology implementation and possible ways and programmes to help overcome these barriers, this section describes examples or success stories in this respect in both the EU and in developing countries.

7.4.1. Success stories in the EU

The Netherlands: tax deduction for investments in energy-saving equipment and renewable energy - Energy Investment Allowance (EIA)

The Netherlands aims to reduce its dependence on fossil fuels and to create an economy that is both efficient and sustainable in terms of its energy use. One of the ways to reach that goal is to stimulate investments in energy saving assets and renewable energy sources. Through this programme, implemented jointly by SenterNovem and the Dutch Tax authorities, Dutch companies investing in energy efficient equipment and renewable energy sources can receive a compensation of 44% of the investment costs by deducting these costs from their fiscal profits (SenterNovem, 2007). The maximum amount that can be received from the tax authorities is €108 million per year. In order to be eligible for tax deduction, the equipment applied must be on the 'Energy List' and the investment should be reported to the Dutch Investment Schemes and Arbitrary Depreciation Office (located in Breda) within three months after the purchase.

Greece - Guaranteed Solar Results (GSR) Concept

In Greece, solar energy applications are almost exclusively used for water heating and with 300 ha (2005 figures) the country is the second solar collector market in the EU (after Germany). The Greek domestic market has continuously been growing at a rate of 11 ha per year (Karagiorgas, M. and T. Botzios, 1999). 95% of the installed solar thermal systems in Greece consist of glazed collectors used in individual or public water heating applications. The GSR concept implies that a solar system is expected to supply a minimum quantity of energy each year for a given hot water consumption. If the energy supplied is less than the energy guaranteed, the technical pool that has signed the contract should compensate their client. The GSR contract offers four essential advantages:

- **No financial risks** – The client or energy user is guaranteed a certain annual energy supply, which also guarantees the investment payback time.
- **Easy bank loans** – The absence of financial risks makes it easier to borrow the money needed for the investment.
- **No breakdown worries** – The working order of the system is permanently monitored in order to signal any anomaly in the working order. In the case of a system failure, repairs are carried out quickly by the technical pool in order to avoid compensating the client.
- **Preferential funding** – Subventions for collective solar installations are generally linked to guaranteed performance.

The GSR concept applied in Greece has the form of 'third party financing': besides the user and the manufacturer of the solar system, a third party is introduced which, in practice, is an 'Energy Service Company' or ESCO, whose role is to:

- Finance the solar system;
- Supply the technical expertise;
- Monitor the working order and results of the solar system; and
- Ensure system maintenance.

The user pays the ESCO an amount that is directly related to the amount of energy supplied by the solar system. Once the financial investment of the ESCO has been returned, the user becomes the sole owner of the installation. In this way, the energy user can exploit a solar system without an initial investment or risk and the ESCO has the incentive to maintain the equipment until the return on the capital investment (with interest) has been achieved.

Denmark, wind energy

In Denmark, quantitative targets, usually in the form of an agreement between the government and the two biggest utilities, have played a role in the diffusion of wind electricity in the country. The first target is found in *Energy 21* (the plan of the Danish Government for sustainable development of energy in Denmark): 60,000 windmills to supply 10% of Denmark's electricity by the year 2000 (Agnolucci, 2007). Interestingly, this production share target was achieved about two years before the target date, while the number of turbines was still below 5,000. This aspect of an increased average size of turbines had not been foreseen by the Danish Government when adopting *Energy 21*. Another programme was introduced in 1990 with the aim to build 100 MW of wind power capacity (Grohnheit, 2002), which was followed up in 1996 when the government and the utilities signed an agreement for the installation of 200 MW of wind power capacity. In 1998, utilities signed another agreement to install 750 MW of offshore wind turbines before 2008. According to the government's forecast, these turbines would generate 10% of the electricity consumption. The agreement is considered the first phase of a programme to reach 4,000 MW before 2030 (Danish Energy Agency (DEA), 2002).

Investment incentives have been important in Denmark, both to promote research on the next vintage of technologies and to increase the adoption of the current vintage. In the case of wind energy, since 1979 citizens who installed wind turbines were reimbursed 30% of the investment. However, during the 1980s the incentive was diminished to 10% and eventually abolished in 1989 after about € 37.6 million (€-equivalent) had been granted (Meyer, 2004). Research in the wind sector has been funded by the *Danish Energy Research Programme*. In 2001, about € 1.6 million was spent on research on new turbines (Lorenzen, 2001). New design of wind turbines was also supported in the 1998 round of the *Development and Diffusion Programme for Renewable Energy* in Denmark. As new turbines were considered a demonstration project, investors were compensated for about 20 to 40% of the costs. Funding was also provided to test stations and to dissemination of knowledge, information and advice (OPET, 2001). Privately owned offshore wind turbines were funded under the *Development of New Renewable Energy Technologies*, which was established in 1997.

The basic support mechanism for wind energy in Denmark is a fixed price system with an environmental premium per kWh op top of the market electricity price. Currently, new wind turbines are paid €0.058/kWh for the first 12,000 full load hours. For offshore wind turbines, the tariff is €0.061/kWh for 25,000 full load hours. A number of transitional schemes are in operation for older wind turbines.

Germany, solar photovoltaics (PV)

The total PV capacity in Germany increased from 70 MW in 1999 to 115 MW in 2000, an expansion of almost 65% in one year (in 2001, around 20,000 solar installations were installed in Germany). Growth continued reaching an installed capacity of 258 MW and a generation potential of about 190 GWh in 2002 and about 260 GWh in 2003. Nowadays, Germany has the largest share of installed PV in the EU. In general, renewable energy technologies play an important role in the German energy policy, both at national and regional levels. Most German regions have energy policies, targets and support mechanisms designed to encourage the development of renewable energy (*e.g.* Berlin's energy policy). Especially, PV has benefited from support from regional governments. Incentives for renewable energy are provided by the 'Electricity Feed in Law' of 1991 and it successor (in April 2000) the 'Renewable Energy Law - feed-in tariff'. For PV systems built before the end of 2001 a feed-in tariff of € 0.59/kWh will be paid, which will be gradually reduced over time by 5% per year.

7.4.2. Success stories in developing countries

Morocco – Solar Heaters

Only in a few developing countries, notably Morocco and Tunisia, international support through the GEF has been provided for solar thermal technologies. The number of solar water heaters in Morocco has strongly increased from about 20,700 in 1998 to about 111,300 in 2004. This growth can partially be attributed to a GEF project implemented by UNDP (GEF, 2005). Since an analysis of the existing market showed that the growth of solar water heater use was hindered by the low quality and reliability of previous solar water heaters, the project has been designed to focus on improving product quality and reliability. Part of the project focuses on training governmental agencies and private firms to promote, evaluate, and install solar hot water systems. This helps the country to develop norms, standards, and testing procedures to ensure that all solar water heaters sold and installed in the country are built to meet the highest international standards. Moreover, the project shows improved technology standards to assemblers and manufacturers, how to apply these standards and procedures to training architects and engineers, and how to develop codes of practices for constructors, installers, and plumbers (GEF, 2005).

Chile – Hydro Energy

The Chile Quilleco Hydroelectric CDM Project consists of a 70 MW run-of-river hydropower plant, located on the Laja River, 8 km downstream of the existing Rucue hydropower plant. The project will generate on average about 422 GWh of electricity per year, with a firm power capacity of approximately 47 MW. The project will feed into the Central Interconnected System through a 0.5 km 220 kV transmission line connected to the Central Interconnected System (see also Section 5.2.1). The Netherlands Clean Development Mechanism Facility will purchase 100 $ktCO_{2e}$ of CERs each year between 2008-2012, and additional CERs produced by the project will be retained by the firm Tractebel.

China – Wind Energy

In 2000, the GEF approved a USD 12 million grant to China to help develop wind power generation and reduce GHG emissions. The grant is only one component of a USD 98 million investment project that is designed to help China diversify its energy resources and reduce its dependence on coal (see also Section 5.3.1). The project is estimated to add 78 MW of electricity generation from three new wind farms in Dabancheng, Fujin and Xiwaizi. The present installed capacity of wind power generation in China is 265 MW, which is about 1% of the country's known wind energy potential (American Wind Energy Association, 2001). This amount could increase due to the *'Key Points of the Program for Development of New Energy and Renewable Energy Industry in the 2000-2015 Period'*, which aims at a renewable energy production of 43 million toe by 2015 (by then, 2% of the country's aggregate energy demand') (European Renewable Energy Council (EREC), 2007).

Kenya – Hydro Energy

The Tungu-Kabiri community micro hydropower project in the rural area around Mount Kenya demonstrates how the use of micro hydropower can bring development to rural areas in Africa. About 96% of the rural population in Kenya still lacks access to grid-based electricity (see Section 5.5.1). A pilot project initiated by *Practical Action* in Kenya has shown the potential for decentralised micro hydro schemes to provide access to electricity. In Tungu-Kabiri, rural Kenya, almost 200 households have formed a commercial enterprise to own and operate the micro hydropower plant, which they constructed and continue to maintain themselves. The micro hydro plant now supplies electricity to a number of local enterprises and households, thereby contributing to improving the quality of life in the area. This project has shown that micro hydropower can effectively meet the energy needs of poor off-grid communities. It has also demonstrated that communities are willing to invest time and money for improved energy services, and can organise themselves to build and operate a micro hydropower plant (Muriithi, 2006).

Thailand – Biomass Energy

In Thailand, as has been shown in Section 5.6.1, biomass represents a significant energy generating potential, in particular in co-generation (CHP). As of January 2003, the total installed CHP-based electric generating capacity in Thailand was 3.6 GWe, which accounted for 7.8% of the total installed power capacity in the country. 15% of installed CHP-based electric generating capacity was based on biomass (Bhattacharya and Abdul Salam, 2006).

In 1992, the Thai Government announced a policy to stimulate private sector participation in the electricity generation industry, especially via small power plants. As of today, the 1992 SPP program has resulted in 246 biomass-based SPP projects which supply electricity to the national grid (Therdyothin, *et al.*, 1992).

Through the EC-ASEAN COGEN Programme, the *Asian Institute of Technology* promoted the implementation of biomass power and CHP projects in Southeast Asia between 1992 and 2004. Under the Programme, more than 20 biomass projects were implemented in the sugar, palm oil, rice and wood industries with capacities ranging from 500 kWe to 41MWe.

AIT is also working to promote the sugar sector in Thailand through a project financed by the European Commission under the EU-Thailand Economic Co-operation Small Projects Facility. The project consists of technical assistance to sugar mills in Thailand for technology transfer and training in several areas, such as advanced process and equipment for producing sugar, clean and efficient use of energy in sugar manufacturing, and effective use of sugarcane residues (*e.g.* bagasse for generating power and/or heat required at the site and export of excess power to the grid).

7.5. Financial support systems and support programmes

This Chapter has shown several examples how government policies and programmes in combination with involvement of the private sector can be effective in sustainable energy technology transfer and implementation. The private sector has the capacity to mobilise the funds required to address pressing energy needs, but incentives to do so, as well as legislation to create a stable investment climate, need to be provided by governments. As has been shown in Chapter 6, this is particularly important in developing countries where the perceived risks of technology investments are generally higher and investments are more difficult to attract (UNEP and IEA, 2007). This section summarises a number of policy measures that governments can take to provide incentives for investments in sustainable energy technologies. These measures have already been developed and applied in the EU and the experience thus gained could be fed into technology support programmes in developing countries, possibly in combination with the CDM (see Chapter 8). It must be noted that the below categorisation into four groups is a fairly simple presentation of the real energy incentive policy landscape in Europe, which also contains several mixed systems with elements from each of the categories (the description of tax incentives shows an example of such combinations).

Feed-in tariffs exist in most of the Member States

Under feed-in tariff systems domestic producers of 'green' electricity receive a market price for the electricity that they produce and on top of that, in order to be able to achieve an acceptable internal rate of return (*i.e.* to compensate for the non-profitable part of green electricity production), they are paid a specific price per kWh produced as a subsidy. The latter component is called the feed-in tariff and is usually set for a number of years. Generally, the green power producers receive the full price per kWh from electricity companies, usually distributors, who are subsequently compensated for that by the government. These schemes have the advantages of investment security and the possibility of fine-tuning,[46] so that it could promote mid- and long-term technologies. On the other hand, they are difficult to be harmonised at the EU and there is a risk of over-compensation if the tariff remains the same while electricity production costs of a particular technology reduce because of learning effects. A variant of a feed-in tariff scheme is the fixed-premium mechanism, which is currently implemented in Denmark and Spain, which offers a fixed premium or environmental bonus on top of normal or spot prices for electricity generated by renewable energy technologies (European Commission, 2005).

Under the green certificate system

Currently, in Sweden, the UK, Italy, Belgium and Poland, a green certificate system is operational which also has the aim to compensate green electricity producer for the difference between the costs of production and the market price for electricity (the non-profitable part). Unlike feed-in tariff, under a green certificate system the compensation takes place in the form of certificates that end users (or power

[46] Fine-tuning in this context refers to flexibility within the system to allow for adjustments (fine-tuning, but not wholesale changes or elimination of polices) a regular predetermined time schedule if circumstances change.

producers using fossil-fuel-based technologies) must purchase from green electricity producers. Green certificate systems could have different forms. For instance, a scheme could require utilities to submit a pre-determined amount of green certificates to the government (or a designated authority) by the end of the year as a token of its contribution to green electricity production during that year. Utilities could generate these certificates by switching from fossil fuels to renewable energy sources in their own electricity production, but they could also buy such certificates from green electricity producers. In another form, end-users can be asked to submit green certificates by the end of the year, showing that they have purchased the required amount of green electricity during that year.

In case, a utility or end user is not able to submit the required amount of certificates by the end of year (required means according the quota of certificates determined before the year), a penalty must be paid for non-compliance. These penalty revenues are generally either used for research and development of renewable technologies, or transferred the general government budget. Since utilities/end users wish to buy these certificates as cheaply as possible, a secondary market of certificates has developed where green electricity producers compete with each other to sell green certificates. Therefore, green certificate schemes have developed into market-based instruments. These systems could work well in the Internal EU market and, at least in theory, the risk of over-compensation is lower than in the case of feed-in tariffs. However, green certificates may pose a higher risk for investors because their price is determined by the market and may thus fluctuate. Consequently, technologies with a long-term sustainable energy potential, but which require higher initial costs, are not easily developed under such schemes. Also the administrative burden of green certificates is larger than with feed-in tariffs.

Pure tendering procedures

Under a tendering procedure, the government places a series of tenders for the supply of green electricity which is then supplied on a contract basis at the price resulting from the tender. The price that the producers receive, again, is based on the market price for electricity (which end users pay) with on top of that a compensation for the non-profitable part (which the government pays as part of the tender contract). While tendering systems theoretically make optimum use of market forces, their stop-and-go nature does not contribute to stable investment conditions. There is also a risk that low bids may result in projects not being implemented. Within the EU, tenders for green electricity mainly take place in France and Ireland. France has recently changed its system to a feed-in tariff scheme combined with a tendering programme in some cases. Ireland has recently announced a similar move.

Systems based only on tax incentives

Within the EU, green electricity support systems based purely on tax incentives are only applied in Malta and Finland. In most other cases (*e.g.* Cyprus, UK, and the Czech Republic), tax incentives are used as an additional policy tool.

Part IV

Role of CDM in Promoting Sustainable Energy Technologies in Developing Countries

8. Insights and Implications for Technology Transfer and the CDM

8.1. Summary of findings in ENTTRANS

8.1.1. CDM state of play

Given the twin objectives of the CDM a typical CDM project would bring together industrialised countries' demand for certified emission reductions (CERs) and developing countries' demand for sustainable (energy) technologies and other means to achieve development goals. The resulting technology transfer would be a low-carbon technology that supports the host country's national needs and priorities. Actual CDM practice, however, has shown that projects are largely initiated by the demand for relatively low-cost CERs and this has resulted in a skewed distribution of projects toward a small group of developing host countries (China, India, Brazil, Mexico and South Korea). Asia and Latin America together have a share in the global CDM project pipeline of almost 95%. Sub-Sahara Africa only has a few projects and most of these are in South Africa. For CDM project investors the general investment climate in host countries is decisive when taking into account performance related risks.

Reasons often quoted for this unbalanced geographic distribution of projects are:

- Difference in quality of the Designated National Authorities for the CDM (DNA) in the host countries (number of staff, skills, task envisaged, and funding). As a consequence, DNA activities could differ from carrying out the formal tasks required by the CDM EB to actively promoting CDM project opportunities based on what the host country needs.
- Scale of the CDM projects; large-scale projects are more popular as the CDM transaction costs related to the CER accounting can be spread across more credits; several small-scale projects are too small in terms of CER revenues to be able to pay for the transaction costs.
- Investment climate in the host countries, which does not support technology transfer under the CDM.

The first of these issues has been addressed by some DNA support programmes (such as *Capacity Building for the CDM* or CD4CDM Netherlands, DANIDA Denmark, GTZ Germany). Yet, much work remains to be done as there are still many differences in how DNAs operate. Although many developing countries have now announced the establishment of a DNA to the CDM EB, there are large difference between countries in terms of these DNA offices are equipped (number of staff, their training background and professionalism) with most Asian and Latin American DNAs being relatively efficient, although some of them have in the meantime had to reform and streamline their procedures, whereas several African DNAs are operated by a limited number of staff who are also responsible for other environmental issues and therefore do not have time to fully focus on the CDM.

In some cases, DNAs approve projects as supportive to the country's sustainable development without an *ex-post* verification of this contribution. Some other countries also verify the latter (see Chapter 3). The risk of a DNA functioning at the minimally required level (*i.e.* required by the *Marrakech Accords*) is that CDM projects in their country become *ad-hoc* activities without necessarily being in line with the country's development strategies or leading to adoption of the technology.

DNAs can also extend their required tasks (establishing sustainable development criteria for projects and carrying out project approval procedures) to promotional tasks. This, however, could lead to conflicts of interest because the aim to attract more CDM projects could lead to a less robust project proposal check and approval decision-making. Involving more governmental departments could help prevent such conflicts of interest, but this could make the procedure less efficient.

The CDM EB has recently started to address the second issue by the decision on the eligibility of so-called Programmes of Activities. Such programmes, which can have a lifetime of 28 years, provide a larger scope for very small-scale activities under the CDM, such as technologies for cooling, lighting and cooking, as they enable spreading of transaction costs across a larger range of emission reduction activities. In addition, such programmes may also provide for grouping of a range of similar larger-scale project investments on different locations in the host country. Remaining issues are: who is the programme owner, how will the revenues be spread across the participants?, *etc.* Nevertheless, as has been argued in Chapter 3, such programmes could provide ample opportunities to incorporate the CDM in a host country's national development strategies.

With respect to the third issue it has long been assumed that technology transfer could be facilitated by the CDM because a project offers CER revenues (in hard foreign currency) and possibly additional training programmes for operation and maintenance to local employees. However, Chapter 3, in combination with the stakeholder assessment in Chapter 5, has shown that for many technologies these benefits are not enough for implementation of these technologies through CDM projects. In particular, low carbon technologies that countries are unaware of or have no experience of or that are relatively new to a country and/or that may conflict with existing systems in a country were not considered for meeting energy service needs. In order to explore how transfer of low carbon technologies could be supported and how the CDM could support this process, a further assessment of the market implementation chain of a technology in the country in terms of finding blockages and incentives for low-carbon technologies has been carried out. The conclusions of this assessment are discussed in Section 8.2 below.

8.1.1 Technology transfer and innovation insights

A review of the literature in technology transfer and innovation processes in Chapter 6 has provided some insights into the process of adoption of low carbon technologies and the role of the CDM which has been examined in this study. The review concluded that changing investments in energy infrastructure to low-carbon alternatives and more decentralised energy generation and making industry more efficient could be hampered by ingrained habits and training, the existing lack of enabling business environment and supporting services as well as pressures from industrialised countries to buy their older technologies. As Winskel *et al.* (2006) pointed out "*Organisations operate in embedded socio-technical networks and tend to re-invest in established competences: disruptive technologies [e.g. renewable energy technologies] rarely make sense to incumbents so their development tends to be left to small outsider organisations*."

Therefore, technology transfer processes as they are currently arranged including the CDM will not provide for technology transfer and the innovation processes that they require due to anchoring in existing systems and know-how.

If there is a possibility of leapfrogging, then concerted efforts would need to be made to overcome resistance to change, especially as currently available high-carbon or older less efficient technologies may be cheaper and more affordable for developing countries and play to the existing experience and competences. Lack of awareness and experience with new technologies in the country context and uninformed perceptions of reliability, market readiness and costs need to be overcome.

One key factor in promoting innovation is the role of multi-stakeholder networks in national systems of innovation (NSI). The importance of these networks needs to be recognised and explicitly fostered within the host countries. Lundvall *et al.* (2002) warned that short-term financial criteria can undermine this resource and that natural and social capital cannot easily be renewed. Thus the exploration of the market implementation chains for small and large-scale technologies using market mapping, as described in Chapter 6, could form the basis for fostering the development of market networks for low carbon energy technologies.

The need for the country and technology context for any technology transfer has been shown in the NSI approach to be grounded in the institutional settings within the country relating to cultural norms and rules and firm-to-firm interactions.

There are two main market areas for innovation of low-carbon technologies. One is the area of large-scale technologies suitable for existing centralised distribution systems, and the other area is the community or domestic small-scale technologies markets for distributed energy systems. The market for large-scale technologies tends to be dominated by a few utilities and surrounded by legislation so that there tends to be a very restricted form of market. Large-scale technologies tend to be sourced at the global level and adoption by this 'market' tends to be justified under energy strategies based on well-tried technologies.

For small-scale energy technologies, the market is much more open usually with an existing embedded market with many stakeholders which forms a commercial competitive environment under which adoption must take place. In this embedded market, players cannot afford to take risks and solid proven technology specific to the country context can be preferred unless the risks are reduced by supportive actions. In most of the case study countries in ENTTRANS, from the market mapping exercises in Chapter 6, there seemed to be more vibrancy and opportunity for small scale technology markets compared to the inertia of the large scale systems and institutions.

Power and lack of trust in markets can block change as can be seen in the behaviour of monopolistic electricity utilities (whether overtly privatised or not) towards distributed energy and new sources and the use of intellection property and other methods for blocking innovation. The reason for this behaviour has been explained by Gruebler (1997) who showed that economic losses from innovations will affect some existing market players who will therefore resist innovation as they perceive it as a threat rather than an opportunity.

Rogers' (1983) work on key factors affecting perceptions for decisions leading to adoption of an innovation identified relative advantage, compatibility, complexity, observability, trialability, and later risk. These factors have been developed and used in a range of studies. In this study all these factors are relevant for adoption and are mentioned in some form as barriers in the exploration of the markets in the market mapping exercises. In particular, in the country studies an expressed need was to see the new technologies demonstrated and adapted to country context conditions. This reflects the trialability factor. This in turn reflects the need to be confident that low carbon technologies will deliver the energy services needed especially where decisions are going to have large and long-term impacts as in a future energy strategy.

Therefore, it is recommended that for innovation for energy systems in a country (industrialised or developing) it is necessary to first of all ensure that all the stakeholders are familiar with, understand and have seen demonstration plants in their country context for alternative technologies not currently under consideration but which have a known potential to contribute to a low carbon future and are reliable and practical.

It was also clear from the analysis of the questionnaires in Chapter 5 that, though there seemed to be little disagreement on what energy service needs were required, there was disagreement between different types of stakeholders as well as within the types of stakeholders on what the priority technologies should be. In every case it was important to take account of the existing country context and business environment and the technology priorities reflected these country conditions as well as the existing competences and attitudes.

8.1.2 Technology transfer and the role of the CDM

At present, as mentioned above, the CDM concentrates on single projects, mostly in isolation of the host country's national and technology context, and does not address technology transfer on any scale. It currently does not foster the supporting systems needed to enhance adoption of a new technology, and it therefore only address part of the process related to the early stages of demonstration and pre-commercialisation in the developing country market.

The isolated installation of projects is useful for only the very early stage of demonstration of an invention, but the real technology transfer processes will require much more effort. This study provides insights into how the CDM could be adapted to deliver more technology transfer through improvement of the country system for adoption of low-carbon technologies.

In this analysis it is suggested that for real technology transfer a more programmatic approach to the CDM needs to be invoked so that a portfolio of projects can be introduced which is designed to explore the range of circumstances and applications in the host country, supported by complementary programmes to foster the knowledge transfer systems and knowledge transfer networks needed for success.

8.1.3 Low carbon Technologies

As part of this study, descriptions of low-carbon technologies were prepared which were designed to provide information on what the technology provided in terms of energy services, how it worked, and what the environmental economic and social impacts may be from the technology. Examples of successful implementation were also provided along with assessments of potential, sources of investment, costs, market readiness and future developments. These are collated in a combined Deliverable 5&6.

There are many low-carbon technologies which could benefit either from further development to make them fully market ready or adapted to local country conditions or for which insufficient awareness and knowledge is available in order for people to be able to make measured judgements. **Some of these technologies are listed below and they by no means detract from existing potentials for wind, PV, micro hydro and other low-carbon technologies that tend to be much more familiar.** The list is not comprehensive but indicates technologies with real potential where very little further investment would ensure that they take their place alongside wind and solar.

The technologies for further development and investment for market readiness and/or awareness raising are:

- Solar thermal for space heating and cooling and hot water,
- Concentrating solar power both large and small scale for electricity generation and waste heat usage,
- Solar ponds especially in conjunction with desalination plant for electricity, heat and use of concentrated brine,
- 'Heat' pumps for heating and cooling and other geothermal technologies,
- Run of river hydro for electricity supply,
- Marine technologies such as wave power, tidal power, offshore wind for electricity supply,
- Biomass gasification for: a) cooking stoves, b) community gas supplies, c) electricity generation (CHP),
- Combined heat and power large and small-scale, *e.g.*, recent trials on fuel cell CHP units using natural gas or use of biomass,
- Municipal solid waste landfill gas capture, gasification, and biogas,
- Biogas for cooking, lighting, space heating/ cooling (especially for solving the animal slurry waste problem),
- Sustainable building design for passive heating and cooling and high efficiency,
- Efficient industrial processes, *e.g.*, for cement, iron and steel, *etc.,*
- LEDs for lighting rather than CFLs,
- Clean coal, and
- Carbon Capture and Storage.

In addition an overview analysis has been carried out on one country, Chile, in order to explore the potentials for GHG emission reductions by moving away from the currently proposed path of exploiting the new coal reserves in the south of the country (Appendix 5-A to Chapter 5). Specifically, the analysis explores the use of CSP in the Atacama desert and the use of CFLs for lighting in Chile. Given that this would require investment in a connection between the north-south grids which would have its own advantages, the potential for CSP with thermal storage would be very high and the GHG emission reductions for even just one plant of modest size are explored. This analysis, by its nature, was only an indication of what could be explored in country energy service strategies and indicates one direction in which engagement of country stakeholders could be obtained to be able to consider alternative low carbon futures.

8.1.4 Country market mapping for technology transfers

The market mapping exercise described in Chapter 6 allowed the initial formation of a network of market actors to form to discuss the technology transfer of low carbon technologies. This was only a first step but it indicated that in all the countries there was potential to take it further. The mapping identified the actors in the market chain and the enabling business environment surrounding the markets as well as the supporting services for the market. This enabled the identification of opportunities and of blockages in the market.

In Chapter 6 there were many opportunities identified by the groups for the low-carbon technologies considered. Spatial and temporal aspects are important such as balancing load over the year and where the benefits arise in terms of local poverty alleviation. The blockages identified by the groups were analysed using the market, enabling business environment and the support services as a typology. Small-scale projects tended to have larger market chains and a distribution of blockages in all areas whereas large-scale technologies mainly were hindered by the enabling business environment such as the policies, codes and standards, and fiscal and legal environments.

There were blockages common to all the case-study countries and some very specific to the country. For example, in Kenya one of the blockages was the lack of investment sources, while in Thailand this was not considered to be a problem.

In addition, the role of the CDM was explored on three levels. The market level was considered and how the CDM could support this and then the international level and the national level. In each case the performance of the current CDM configuration was assessed to determine what it was and was not delivering and then what activities would improve the main problems identified.

The identification of blockages and activities to improve technology transfer for low-carbon technologies and for the CDM as well as the results discussed in the sections above have formed the basis for the following recommendations on activities to improve technology transfer and to improve the ability of the CDM to deliver technology transfer benefits.

8.2. Recommendations for accelerating technology transfers and the CDM

As has been pointed out by the IPCC (2000) the key lessons are that networking among stakeholders is essential and the best transfers occur where there are multiple benefits. The recommended presented in the following sub-sections are therefore grounded in the studies on technology transfer and innovation and on the insights from the surveys and market mapping exercises performed in this study.

8.2.1. Need for demonstration of reliability and practicality of technology

To provide for innovation of low carbon systems, existing but less well-known low-carbon technologies need to be introduced and accepted by policymakers and industry through demonstration of reliability and practicality at the country level with a view to specific assessment for inclusion in a) country energy strategies and plans, and b) introduction to the country technology market.

8.2.2. Energy Service Needs Assessment and familiarisation programme combined with TNA

The study has shown that the usually recommended approach for assessing technology needs in a (developing) country inadvertently anchors a TNA in existing technologies and will always look to the past and be limited by existing infrastructures and experiences. ENTTRANS has shown that the technology needs assessments interviews rated many low-carbon technologies on the low side or not at all so that they showed up as being not preferred. Therefore, it is recommended that an energy service needs assessment (ESNA) combined with a programme of technology familiarisation should be conducted with the developing country stakeholders. After that, the technologies to meet those needs could be assessed only after full discussion and awareness raising of all the possibilities for large-scale and small-scale low-carbon technologies. This process of identifying for developing countries energy service needs and priority technologies to meet those needs, while exploring the perceptions within different countries, has been detailed in **Figure 8-1**.

Energy services are proposed as not all energy services need to be met by the supply of electricity and this provides a basis for greater diversity and resilience in the energy supply system. This process would allow policymakers and industry players to become familiar with these new short, medium and long-term technology possibilities for innovation of low-carbon systems.

Awareness raising could take the form of information dissemination coupled to programmes of visits to existing demonstrations of technologies and also specific in-country **demonstration programmes** of reliability and practicality coupled to any adaptation of the technology required. Therefore, there should be a link to R&D.

Once this process of introduction and acceptance by policymakers and industry has been carried out, it can be followed by the **assessment of the technologies** to meet the energy service needs for inclusion of low carbon technologies in a) country energy strategies and plans, and b) introduction to the country technology market. This process has to **engage stakeholders at all levels** from government to local communities to ensure that choices deliver the required sustainability benefits.

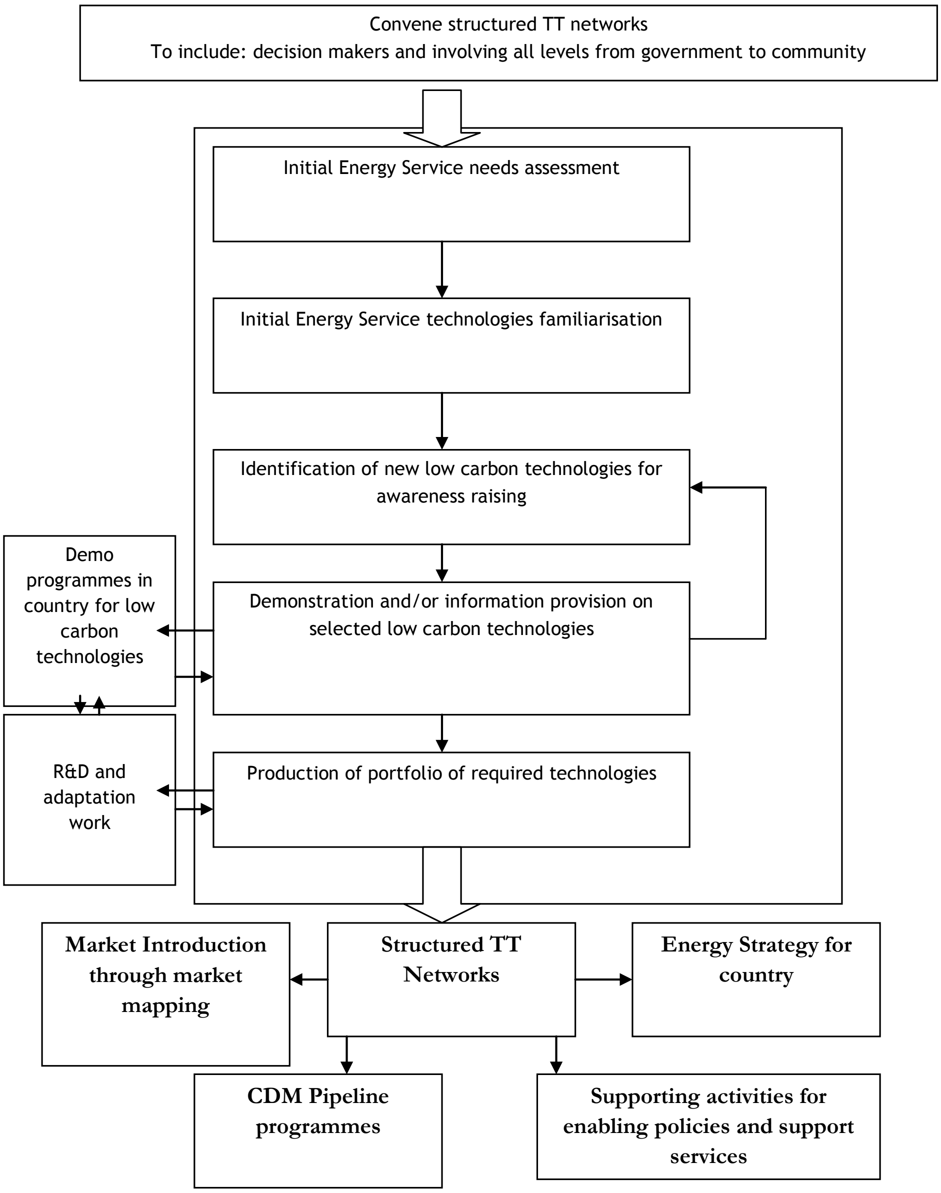
The ESNA and familiarisation and assessment exercise should result in an **agreed portfolio of low carbon technologies within existing systems**. Networks can then be set up to produce **national energy strategies**, market mapping for introduction of the technologies and input to CDM programmes. In addition, the strategy and market networks can generate the integrated package of measures needed to support the transfers through identification of the blockages and opportunities. These supporting measures on the enabling business environment and the market support services would then also have to be undertaken for successful transfers and examples are given in the next section.

It is important to point out that both the ENTTRANS process and the supporting activities on the enabling business environment and market support services are ALL required as far as possible to ensure successful adoption and transfer. This process is not a 'one-off-quick-fix' but should be seen as catalysing a new direction for a longer-term programme requiring a commitment to continuing support.

This is in line with Philibert (2006) who, in addressing the problems of solar thermal energy in his report to the UNFCCC, pointed out that all of the activities to remove barriers are needed if successful transfer is to occur.

The process envisaged would involve the following steps (see **Figure 8-1**), some of which are iterative.

Figure 8-1. ENTTRANS Process Sustainable Technology Transfer for a Low-Carbon Future.



8.2.3. Supporting Actions for successful technology transfer

This section presents recommendations which have been derived from this study, particularly on the barriers to transfer and deals in more detail with **supporting actions for technology transfer which need to be identified for each country context and implemented as an integral part of the transfer process**.

Fostering the creation of networks of market actors to facilitate technology transfer activities through characterisation of the market for the technology

- **Market Networks** – The shaping of a market with its actors and supply chains depends on the technology being transferred and the country context. The formation of networks of market actors through the process of conducting ***Market-Mapping*** exercises would be needed to first identify the economic actors and then identify, together with these local actors, the possible technology supply chains and their enabling business environment and supporting services. The formation of market networks strengthens the operation of the market and contributes to examination of the existing market chain, e.g. through highlighting blockages and inefficiencies at all levels within the market including at government and regulatory level. Further action can then be generated to address these problems. This is the first part of the SUSTT diagram above.

Stimulating Market Demand

- **Market information systems and Raising awareness** – Creation of demand and incentives for change is a major element in enabling the market to develop and so it is important to make information available and raise awareness. This would imply a two-pronged approach with awareness raising exercises on a large scale via the media coupled to good market information on reliability and quality of suppliers and systems. Once people say 'What can I do?' Industry should be ready with the answers. A source of good market information, *e.g.*, products available from whom and also guarantees that suppliers are accredited and checked from manufacturer to installer, etc., (such as with the CORGI system in the UK) are required. Also clear price signals for energy technology and CO_2 emission reductions are needed.

Investment facilitation

- **Risk minimisation** – The risk to the investor (both national or international investors) associated with introduction of a new technology needs to be minimised. **There are several activities to do this such as by introduction of the technology in an institutional or industry sector context to create a demand and /or through either government/FDI sponsored programmes of demonstration of low carbon technologies or through bundling/ programmatic basis under the CDM.** This would provide a ready-made market which generates confidence and awareness. If the technology is properly implemented and is shown to be reliable and useful then this can assist in a wider dissemination and development. Further participatory consultations with investors in the countries would characterise risk mitigation strategies more fully as a first step. Small-scale businesses are particularly vulnerable. This would also help overcome the problem of first movers taking all the risks while others free ride. Issues such as energy and feed-in tariffs are important. It also supports the development of the supply chains needed in the market.
- **Multiple funding sources** – Limited availability of sources of investor funding are a major problem in many countries. Therefore, multiple funding sources and ease of application and information availability would help this development.

- **Investment Criteria –** Technology choices also have to avoid the trap of least financial cost solutions and take account of the externalities. There are implicit subsidies for existing technologies and so policies to level the playing field for new market entrants are needed. New approaches to funding demonstration and small-scale projects are also essential with reappraisal of the suitability of other investment criteria such as payback time and other criteria as appropriate. The recent UNFCCC contribution on this subject (e.g. compliance fund, share of CER proceeds) needs to be implemented more widely.

Supporting the operation of the market.

- **Transparency control** – Good transparency control especially avoiding corruption on the enforcement side is extremely important for proper development of a market and for maintaining good reputation and customer relations. Too often, for instance with compact fluorescent lamp, there seems to be poor quality control leading to growing resistance to change to CFLs after bad experiences and wasted resources.
- **R&D** – Adaptive research and development for low carbon technologies to ensure suitability for local conditions is needed and to encourage development of new technologies and to build **technical capacity**.
- **Training** – Appropriate installer, operation, maintenance and servicing, and management skills training would be needed to support the technology transfer and delivery of local benefits. Programmes of training support could be provided alongside the main technology projects or CDM projects. This sort of capacity building is an important component in successful transfer.
- **Support promising technologies and increase their availability –** In some cases, really good technologies with huge potential (see list above in section 8.1.2) such as solar thermal for cooling in developing countries are not being used and the fine detail and availability of these systems are not entirely clear. An off-the-shelf solar thermal space cooling option is not really available, *e.g.* for householders or hoteliers, *etc.*, but a much more focussed development in the country contexts involving manufacturers and suppliers, as well as skills development for installation and design is vital. This could possibly involve the IEA task forces. Integration with architectural practice would also be very good. Targeted investment in the short term to make the technologies fully available would yield large GHG benefits. The same applies to concentrating solar power and to hybrid combinations of renewables to provide integrated solutions. This activity combined with risk minimisation would provide good initial support.
- **Access of industrial sector to technological knowledge** – Support for exhibitions of new technologies and possible discounts and incentives to take part in programmes of projects may be a useful way forward here to encourage manufacturers to change and provide captive short term markets to facilitate investments. At the ENTTRANS workshop in China, the partners learned about such exhibitions in China. This could also be done through joint industrialised country/EU/ host country initiatives. In addition, more external links would improve access to technological information. These external links need to be actively fostered.

Support for host government.

- **Host country policy framework** - Facilitating countries' ability to formulate a policy framework, legislative and fiscal incentives and other measures to address countries' technological needs and gaps. At the Annual Meeting of the World Business Council for Sustainable Development, the EU Development Days in Lisbon, and the World Energy Conference it was recommended by participants, and in particular by industry representatives that government leadership is needed to establish transparent, long-term and stable policy targets and strategies. This also involves an integration of climate change issues in international development co-operation. Consideration also needs to be given to appropriate policies to offset any blocking tactics from monopolies in the market.

- **Streamlining of countries technology transfer processes** – The host government departments involved need to be streamlining and aligning policies, incentives and procedures with regard to their role in and impact on the transfer process so that, *e.g.*, import/export barriers are not counterproductive for low-carbon technology transfers**.**
- **Support for capacity building** – The host government capacity to make the suggested changes and support for technology transfer will require funding and training
- **Interface between decentralised systems and the grid –** For electricity supply projects the interface between decentralised systems and the grid is an area of concern which could also be assisted by a programme of TT activities which could address issues such as feed-in tariffs and charges for grid connections and the creation of 'virtual' power stations and smart metering. Decentralised energy supply technologies and systems can play an important role in the energy security of supply, also in developing countries, because its role is complementary to centralised energy provision (even based on local renewable energy resources).

8.2.4. Role of the CDM and Technology Transfer

The following recommendations are made against the backdrop that the key parties involved in the CDM (CDM EB, developing countries, and industrialised countries) have a joint responsibility in stimulating low-carbon, sustainable energy technologies to developing countries through CDM projects. The EU could play an important role in supporting each of these responsibilities.

CDM Host Country Issues

- **Strengthening the role of the CDM in low-carbon sustainable technology transfers.**

1. **Promotion/marketing of Designated National Authorities (DNAs) as one-stop-shops** for CDM activities. This involves streamlining the process for foreign investors, as well as initiatives to build capacity within DNA and within sectors for project participants for all aspects of the CDM, including bundling of CDM projects and programmatic CDM. It is suggested that DNAs are assisted in achieving these tasks and build capacity (*e.g.* DGIS in the Netherlands, DANIDA in Denmark, GTZ in Gemany, *etc.*). It is also important that DNAs do not operate in isolation from other policies and decision makers at the government level (ministries of finance, development planning, energy, agriculture, trade, *etc.*) and there are integration structures in place.
2. Support is also needed for the formulation of **low-carbon CDM strategies by the host country** based on national needs and priorities and suitable technologies for which technology implementation chains have been clearly mapped and streamlined along the lines explained in the ENTTRANS process in **Figure 8-1**. As explained above it is important that these strategies are based on participatory processes and information collection and analysis with good two-way communications. Such strategies also involve awareness creation especially for industry and project proponents with trade associations to be involved. Technology choices also have to avoid the trap of least financial cost solutions and take account of the externalities. These low-carbon CDM strategies thus formulated should lead to a **domestic CDM project pipeline** in line with priorities identified as well as to market introductions.
3. **CDM in its programmatic form could also support programmes of demonstration projects** covering a range of sizes, sectors, locations, implementation models and scales of country conditions to prove and adapt the technologies using a participatory process. One off projects can be useful but a portfolio or programme approach to projects should be preferred where possible.

4. Although formulating CDM strategies is a country-specific exercise depending on the different country contexts, it is also recommended that countries collaborate through **regional co-operation in order to share experience and to establish South-South dialogues**. For instance, the ENTTRANS analysis in the five case study countries could thus be expanded towards a regional scope: Chile – Latin America; China – Asia (*e.g.* India); Kenya – Sub-Sahara Africa; Israel – MEDA countries; Thailand – Southeast Asia (*e.g.* Lao PDR, Vietnam, Nepal, Cambodia). Countries could use the ENTTRANS/SUSTT methodology for energy service and technology assessments with market mapping and supporting activities promoting low carbon technology transfers through CDM projects.
5. **Assistance to project developers** for the preparation of project design documents to reduce transaction costs taking account of language barriers could improve uptake of CDM opportunities. Accessible and simple information for people to undertake a project design document would be a first step. Accessibility is an issue in countries where internet connections are not reliable. Equally important to reduce costs and stimulate local interest will be **support for programmes to develop local accredited validation and verification entities** to reduce CDM project cycle costs. **Guarantees for the purchase of CERs** in this commitment period and post Kyoto such as those by the World Bank would also contribute to minimising risks and costs.
6. **CDM projects to be linked with development initiatives where appropriate**. Although CDM projects should not use Official Development Assistance (ODA) funds for the investment and acquisition of CERs, the expertise in development projects would be a valuable input for the CDM projects as suggested at COP-MOP-2 held in Nairobi (Kenya, November 2007). Such deliberate links between CER acquisition and development assistance experts would ensure maximisation of local development benefits under the CDM.

CDM at the international level

Streamlining CDM procedures to make the mechanism more accessible for investments in *e.g.* small-scale projects or energy efficiency activities across a range of installations in an industrial sector is the main aim of the following recommendations:

1. **Explicit guidance on Technology Transfer** and avoidance of dumping needs to be incorporated into the modalities of the CDM
2. **Review the additionality concept;** for some developing countries there are no other projects which would be undertaken in the absence of the project and the country circumstances should be recognised when assessing additionality of emission reductions. It would be therefore be better to have a more positive approach to additionality in the sense that a project is additional because it is required a) to adopt a participatory approach to the project design and development and b) to establish capacity building actions such as setting up on going training schemes to maximise the transfer and local benefits. This would at the same time stimulate the involvement of local stakeholders in project identification and preparation and would thus enhance participatory process in the preparation of projects.
3. In order to make the CDM fit for technology transfer and for sustainable development it could be used mainly in the **programmatic mode**.
    - Programmatic CDM can be used to demonstrate new technologies under a range of different circumstances in the country and this has to be supported by the specific activities detailed under Technology Transfer issues and CDM host country issues (both detailed above) otherwise it will not support technology transfer. These specific supporting actions could themselves become a programmatic CDM project.
    - Programmatic CDM is very suitable for energy efficiency improvement projects in households (*e.g.* cooking, lighting) and industry (*e.g.* one technology applied within an industrial sector at

different locations but under similar circumstances), but its applicability needs to be improved by:

- Streamlined programme approval and registration procedures (presently around 400 days),
- Allowing more than one methodology for baselines and monitoring for calculating the emission reductions of activities within the programme (*e.g.* methodologies for insulation and fuel switch within a built environment retrofit programme), which is presently limited to one methodology only.

- Programmatic CDM requires monitoring modalities: case-by-case monitoring of activities' performance when activities within the programme are large-scale; sample monitoring when activities are small-scale.

4. **Enable the development of new methodologies for GHG accounting procedures** (including baselines) of CDM projects by experts (as a result of research) to be given to developers and the EB rather than the developers bearing the costs of preparing new methodologies by themselves, as is current practice**.**
5. Devise alternative schemes to **minimise the up front loading of costs of PDD**, for example by using CERs to pay the costs either by paying later or by borrowing or by using an increase in the levy to assist in offsetting the costs as well as by support for increased accreditation of local entities.

8.3. Final Recommendation at International Level

It is suggested that **a new initiative be introduced under the UNFCCC to accelerate innovation.** This would focus on the ENTTRANS integrated process (**Figure 8-1**) from technology transfer network formation and ESNA assessment to technology demonstrations, technology needs assessment and final market innovation and supporting activities for the enabling business environment and market services as described above. The market network structures would be designed to link to energy strategies and markets as well as the CDM and would be facilitated by supporting actions for the enabling business environment and market support services. This would assist in accelerating the transfer process for less well known but potentially useful low carbon technologies. Additional measures to ensure delivery of sustainability benefits and monitoring would have to be built in to such a system.

It would be separate from and in addition to the CDM improvements suggested above though it could inform a proposed CDM country portfolio.

Such a participatory process to develop low-carbon futures and accelerate the transfer of low-carbon technologies in line with the *Bali Roadmap* agreement of December 2007 would provide a roadmap for all Parties to move forward and would provide substance to 'meaningful participation' of developing and developed countries.

Possible targets for the amount of low-carbon technologies in the energy service mix over time would provide intermediate goals for eventual decarbonisation of the energy service systems in both developed and developing countries.

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Annex 1 – Questionnaire

Question 1. Energy service needs and priorities

What are, in your view, the main energy technology needs and priorities within **<name country>** for the medium (up to 2012) to long term (post-Kyoto; 2012-2020)? Please indicate the relevancy using the following ranking scale:

5 - very high, 4 - high, 3 - medium, 2 - low, 1 – very low, 0 - not relevant for **<name country>**

Table 1. Energy service needs and priorities	**Ranking (0-5)**[47]
1.1 Electricity for industry	
1.2 Electricity for agriculture	
Electricity for households	
~~o~~1.3 rural communities	
~~o~~1.4 urban communities	
1.5 Electricity for service sectors	
1.6 Heat for industry	
1.7 Heat for households	
1.8 Heat for service sectors	
1.9 Energy for cooling for all sectors including medicines and food industry	
1.10 Energy efficiency in industry	
1.11 Municipal solid waste management	
1.12 Other needs and priorities:	

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[47] Criteria for the ranking are:
o need for increased access to energy
o need for reliable energy supply
o larger need for affordable energy supply

Question 2. Technology appropriateness and suitability

a) Which of the technologies from the table below do you think would be appropriate and suitable to meet the needs and priorities ranked as 5 and 4 or 3 in Question 1? Please, use the following ranking scale:

5 - very high, 4 - high, 3 - medium, 2 - low, 1 – very low, 0 - not relevant for **<name country>,** n.a. – no opinion

Note for interviewer: It is recommended that the interview result in at least 4 technologies (preferably more). The technologies have been grouped according to energy source (for instance, there are several solar energy applications for e.g. heat, electricity, cooking).

b) Based on your experience, are there any technologies relevant to **<name country>** or locality within **<name country>** that are missing from the list of technologies? Please add as indicated in the table below.

c) Please indicate in the 'comments' column which of the chosen technologies are in line with country strategies and development plans.

Technology and service **I suggest making it very explicit**	**Ranking (0-5)[48]**	**Comment on the reasons for the ranking given**
1 clean coal for large scale electricity supply		
2 steam boiler upgrading for large scale electricity supply		
3 coal-to-gas for large scale electricity supply		
4 oil steam improvement for large scale electricity supply		
5 coal steam improvement for large scale electricity supply		
6 natural gas from coal seams or oil for large scale electricity supply		
7 a. hydro (dams) for large scale electricity supply		
b. Run of River hydro for large scale electricity supply		
8 geothermal for large scale electricity supply		
9 wind for large scale electricity supply and for community or small scale electricity supply		
10 mini/micro hydro (rivers) for community and household scale electricity supply		
11 biomass (forest/agriculture) boiler (for large scale electricity supply)		
12 a. Biogas for generator (for large scale electricity supply)		
b. biogas (heat for community, industry or households)		
c. biogas (cooking for institutions and households)		
d. biogas (anaerobic digestion from Municipal Solid Waste for large scale electricity or local heat or both)		
13 a. solar towers (for large scale electricity supply)		
b. Solar (pv) (for large and small scale electricity supply)		
c. Solar thermal (for large scale electricity supply eg in deserts)		
c. Solar thermal (water and space heating at institution/ household level)		
d. Solar coolers (cooling at institution/ households level)		
e. Solar lanterns (lighting at households level)		
f. Solar cookers (cooking for households)		
g. Solar Pods for electricity supply and heat		
14 CMM for generator (for large scale electricity supply)		
15 a. sustainable design buildings (for heat and light through orientation, design, insulation)		
b. passive cooling through building design (shading, chilled beams, natural ventilation)		

[48] Criteria for the ranking are:

- domestic availability of energy source: water, wind, coal, gas, oil, etc.
- level of reliability of the technology
- national provenience
- dependence on foreign assistance
- operation and maintenance (know-how, adequate experience with technologies or capacity building opportunities, operational 'culture' for complex technologies)

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16 a Air Water or ground source heat pumps on-grid (community heat and cooling or for industry)		
b. Air Water or ground source heat pumps off-grid (heat and cooling for households or industry)		
17 a. CHP coal/gas-based large-scale electricity and heat supply		
b. Micro CHP small-scale for electricity and heat for households / commercial level		
c. Biomass CHP at community or household level for electricity and heat		
18 energy saving lamps (lighting end use in buildings)		
19 efficient charcoal production (for households /commercial cooking)		
20 improved cook stoves (for households /commercial cooking)		
21 LPG and LNG (for households /commercial cooking)		
22 cement industry energy efficiency/saving measures		
23 iron & steel industry energy efficiency /saving measures		
24 chemical industry energy efficiency /saving measures		
25 agro & food industry (e.g. sugar) energy efficiency /saving measures		
26 methane capture in landfills (MSW) for large scale electricity or local heat or both		
27 Combustion of Municipal Solid Waste (MSW) for district heat or electricity		
28 Gasification of Municipal solid Waste for large scale electricity or heat or both		
29 Wave power for large and small scale electricity supply		
30 Tidal power for large scale electricity supply		
31 Ethanol Stove (from sugar production) for efficient cooking for HH/institutions		
32. Biogasification stove (wood or husks, *etc.*) for efficient cooking at institution/ households level (25l water boiled for 1 kg wood)		
ADDITIONAL MISSING TECHNOLOGIES		

Question 3. Sustainability benefits from the selected technologies

What sustainability benefits would you expect from the technologies which you have ranked as 4 and 5 in Question 2? Please indicate how well implementation of these technologies would be expected to deliver the relevant sustainable development benefits, using the following ranking scale:

5 – very high, 4 – high, 3 – medium, 2 – low, 1 – very low, 0 – not relevant for the country; n.a. – no opinion

Note for interviewer: this question would cover at least 4 technologies. In case too many technologies have been identified in Question 2 as suitable to cover in this interview, the interviewee can select about 4 technologies.

Economic Benefits/ Impacts	Rank (0-5)	Environmental Benefits	Rank (0-5)	Social Benefits	Rank (0-5)
○ Energy-supply diversification ○ Replicability potential in the country ○ Lower dependency on imported fuels ○ Energy-supply/transmission reliability incl. grid security ○ Energy price stability ○ Contribution to the country's economic development ○ Employment		○ Local clean Air ○ Global CO_2 emission reduction ○ Resource saving ○ Land protection ○ Water management (quantity and quality) ○ Solid waste management ○ Naturel conservation ○ Reduction of environmental risks		○ Socio-economic welfare especially poverty alleviation ○ Health care ○ Education ○ Communication and transport ○ Public governance ○ Empowerment e.g. through participation in decision making or training.	○
○ Total		○ Total		○ Total	○
negative aspects:		~~o~~negative aspects:		~~o~~negative aspects: ○	

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Survey/Respondent Identification

[It is recommended that the interviewer briefly summarises the ability of the interviewed person to cover the subject, time to pass complete interview, identity of interviewee *etc*.]

Country:	
Date of Survey:	
Respondents profile	
Name (optional):	
Affiliation:	
○ Government/public administration (level: national/regional/ municipality	
○ Industry (manufacturing, other)	
○ Services	
○ Consultant/advisor (area)	
○ NGO (area)	
○ Other	
Function (management, official, expert, other):	
○ Stakeholder's status/interest (as appropriate):	
○ Energy producer (grid/off-grid)	
○ Energy consumer	
○ Other	
Knowledge/experiences of energy technologies:	
○ Level (between 1-5; 5 is highest)	
○ Type/area of experience	
○ Practical (specify)	
○ Theoretical (specify)	
Knowledge of/experiences with the CDM:	
○ Practical (ranking 1-5; specify: e.g. CDM project	
○ Theoretical (ranking 1-5, specify: e.g. negotiation, strategic studies, capacity building)	
○ Knowledge of national strategic plans (ranking 1-5)	