Making Global Technology Markets Work for Combating Climate Change and Contributing to MDG's[1]

Report 1. Background

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1. Introduction

A key element of climate change mitigation and adaptation is the transfer of more effective and efficient low-carbon technologies between developed and developing countries. Although several policy mechanisms for technology transfer are in place most observers agree that these have not been very effective in accelerating the rate of diffusion of energy efficient and renewable based technologies. There is a need for market-oriented approaches in order to diffuse efficient technologies more rapidly and to reduce high transaction costs which is a major factor explaining low effectiveness of existing mechanisms. At the 2007 G8 Summit in Heiligendamm it was recognized that an "expanded approach to collaboratively accelerate the widespread adoption of clean energy and climate friendly technology" is needed[2]. while in recent climate change negotiations such as the Bali Action Plan the need for scaling up technology transfer also features prominently. The problem is how to gear global markets towards rapid delivery of a range of technologies that have proved to be efficient and affordable for several uses but yet have limited market shares. A further key element of the transfer process is the build up of capacity in the recipient countries such as the knowledge, skills and organization necessary for effective implementation of those technologies and the emergence of domestic production. The cases identified here from a range of sectors including energy-efficient lighting, solar panels, high-efficiency electric motors, energy-efficient cement production and micro-finance. These cases are chosen because the uses they represent take up a significant share of global energy use and because these technologies have limited penetration until now, whereas micro-finance is chosen as it can act as a vehicle for adoption of more energy-efficient application and solar panels in

[1] This paper was commissioned by the Dutch Development Cooperation Office to gain further insight into potential mechanisms for technology transfer of environmental sound technologies in the light of the climate change challenge.
[2] G8 Summit Declaration, Heiligendamm 2007, par. 54.

developing countries. Effective technology transfer mechanisms need to take into account the specific nature of the selected technologies, the various forms of distribution and delivery relevant for their diffusion, and the local context for successful adoption and implementation of these technologies by users. This paper reviews existing mechanisms and develops ideas for more effective technology transfer mechanisms for these selected technologies. Key elements of such mechanisms need to take into account effective global access to environmentally sound and energy-efficient technologies while also ensuring that appropriate technological capabilities are developed at the local level.

2. Technology transfer mechanisms: current status, key concepts and potential mechanisms

The role of technology transfer has been part of the UNFCC and its negotiations since the UNFCC was signed in 1992. For developing countries the transfer of environmentally sound technologies from 'North to South' has been an important component for their commitment to climate agreements. Although currently a number of mechanisms are in place, most notably the clean development mechanism (CDM) and the global environment facility (GEF), it is generally agreed that much more TT is needed for climate change mitigation and adaptation. At the recent COP in Bali (December 2007) it was decided "to elaborate a strategic programme to scale up the level of investment for technology transfer to help developing countries address their needs for environmentally sound technologies, specifically considering how such a strategic programme might be implemented along with its relationship to existing and emerging activities and initiatives regarding technology transfer and to report on its findings to the twenty-eighth session of the Subsidiary Body for Implementation for consideration by Parties (Decision 4/CP.13)." (GEF, 2008). Developing countries take the position that any commitment to specific GHG reduction goals can only happen if accompanied by very significant expansion of technology transfer and support facilities. Consequently, in September 2008 China and the G77 put forward a proposal for a technology mechanism to accelerate the "development, deployment, adoption, diffusion and transfer of environmentally sound technologies among all Parties, particularly from Annex II parties to non-annex I Parties, in order to avoid the lock-in effects of non-environmentally sound technologies on developing country Parties, and to promote their shift to sustainable development paths"[3].

Existing mechanisms are often said to lack effectiveness as they are unable to mobilize the investment potential of the private sector and widespread adoption beyond the initial projects selected for support (Egenhofer et al, 2007; Forsyth, 2007). Some key reasons for this are:

- high transaction costs;
- too generic, whereas technology specific approaches are needed;
- a specific project focus whereas broader market transformation is needed to ensure widespread adoption of the environmentally sound technologies.

[3] Information on UNFCC website, accessed 27 October 2008: http://unfccc.int/files/meetings/ad_hoc_working_groups/lca/application/pdf/technology_proposal_g77_8.pdf

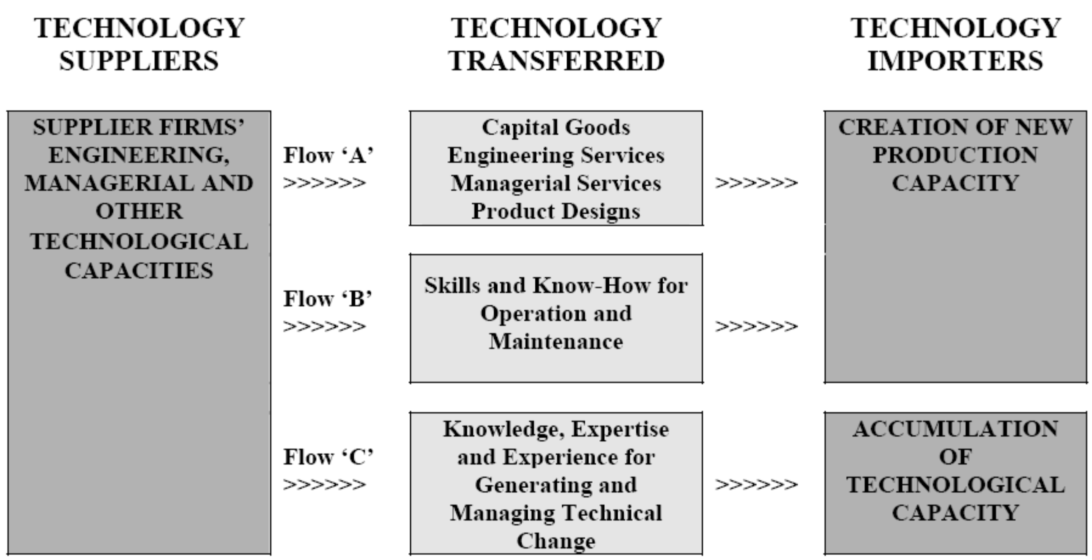
- energy-efficient end-use applications are hardly represented due to complexity and number of end-users; projects often involve single-site project activities in the case of CDM;
- large-scale project activities are dominant in CDM relative to small-scale projects, as the bureaucratic and procedural burden is easier to incorporate into large-scale projects;
- concentration of for example CDM projects particularly in larger developing countries with more developed institutions for CDM project activity such as India and China, while for example African countries are heavily underrepresented.

In the light of the apparent weaknesses of existing mechanisms for technology transfer, recent COPs have focused more specifically on the potential of sectoral and technology-oriented approaches. Sector-specific approaches are now being considered as part of the post-2012 negotiations under both the UNFCCC and the Kyoto Protocol, and in other government-led processes, such as the Major Economies Meeting on Energy Security and Climate Change (MEM), the Asia-Pacific Partnership for Clean Development (APP), the East Asia Summit, the Group of Eight (G8) and the Asia-Pacific Economic Cooperation (APEC) forum (Baron & Barnsley, 2008). These types of mechanisms have also been proposed by a range of industry associations, private sector organisations and think tanks. Some sectoral agreements are already operational in practice. Examples of voluntary, industry-led SA include those of the International Aluminium Institute (IAI), the International Iron and Steel Institute (IISI) and the Cement Sustainability Initiative (CSI) of the World Business Council for Sustainable Development.

Elements of more effective technology transfer

IPCC defines technology transfer as "a broad 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. It comprises the process of learning to understand, utilize and replicate the technology, including the capacity to choose and adapt to local conditions and integrate it with indigenous technologies" (IPCC, 2001). Transfer can take many forms but one of the most dominant forms has been through foreign direct investment (FDI). The importance of FDI in the successful development strategies of Asian newly industrializing countries is often stressed. Key elements of this success were the strategy and ability to imitate and replicate technology indigenously and the parallel development of local skills and knowledge. Others forms are transfer through the provision of products incorporating the technology, e.g. energy-efficient lighting or photovoltaic panels for off-grid electrical supply, or licensing the capability to produce such products, perhaps to an indigenous firm, through co-development of domestic and foreign firms or through a joint venture (Barton, 2007). A further form is the support of national capability to research and produce the products independent of a foreign company. A final form is technology transfer through official development assistance (ODA). Especially for low-income developing countries this is the dominant form of technology transfer while technology transfer to low-income developing countries through FDI is rather limited.

Experiences with technology transfer have led to understanding the concept of technology transfer as a process that includes a flow of knowledge as well as goods which has to be paralleled by processes for learning and capacity building in developing countries. This is illustrated in the subsequent figure. It is therefore necessary to see technology transfer as part of a broader process of sustained, low carbon technology capacity development in recipient countries (Ockwell et al, 2008). Others have in similar vein stressed the importance of adequate absorptive capacity and technological capabilities in recipient countries (Mytelka, 2007). Key constraints for effective technology transfer of low-carbon technologies to developing countries are therefore often related to the lack of transfer of capital goods, equipment, and knowledge in combination with lack of an appropriate host environment for technology transfer. Especially an understanding of the influence of the characteristics of the host environment on technology transfer is lacking, as was also stressed in the recent Chatham House conference on Technology: A platform for Development?[4] Local culture and social structure, the legal and regulatory framework, the political environment and the domestic market in developing countries have been identified as critical factors (Barnett, 2005, Morsink, 2008). Our lack of knowledge about the influence of these factors is caused by an overweighted focus on the characteristics of technologies and the difficulty of studying these factors as they are context specific and thus interdependent of each other. An important conclusion from the Chatham House conference was that a focus on identifying best practices and on measurement and evaluation of current projects might significantly increase our understanding of these often critical factors.



Source: Bell (1990)

[4] Technology: A Platform for Development? Thursday 30 October 2008 to Friday 31 October 2008 http://www.chathamhouse.org.uk/events/conferences/view/-/id/127/

3. Mechanisms for accelerating technology: case studies of five technologies

3.1. Overview and characterization of case studies

We have selected five technologies for further analysis of technology transfer through global technology markets. Widespread uptake of these technologies would lead to significant reduction in global carbon emissions as the end-uses and industrial uses they represent take up a significant share of global energy and electricity use.

3.2. Lighting

3.2.1 Introduction

Lighting is an important element in the daily life of the majority of the world population. It is also a major contributor to the climate change problem as it represents around 19% of the world's electricity consumption and emits 1900 Mt of CO_2 on an annual basis which is equivalent to around 8% of world emissions (IEA, 2006: 25). The dominant technology is the traditional incandescent light bulb, of which around 15 billion are installed globally. In the past decades energy-efficient lighting has become available with energy savings of between 70 and 80% relative to incandescent lamps, most notably compact fluorescent lighting (CFL) which is now commercially available, while light emitting diode (LED) technologies are at a pre-commercial stage and are expected to deliver light even more efficient than CFL . Global annual sales of incandescent light bulbs were around 13 billion units in 2003, while the number of CFL lamps sold annually is estimated at just over 1 billion (IEA, 2006). Incandescent light bulbs are mainly sold in the residential sector where are responsible for around half of the light production, they take up a much smaller share of around 5% of light production in the commercial sector (offices) and an almost negligent share in the industrial sector and for outdoor lighting (Lefevre et al, 2006).

Substituting conventional light bulbs with CFL lighting could contribute significantly to climate change mitigation and several programmes have been set in motion to support this transition. Apart from the substitution of candescent lighting by energy saving lamps there is also significant energy saving potential by replacing fuel-based lighting markets (often kerosene based lamps) by energy-efficient electric lighting. This could also have a positive effect on health conditions in poor rural households in developing countries, thereby also helping to meet Millennium Development Goals on health. Especially in poor rural areas in Africa and Asia the use of energy-saving lamps could also reduce the amount of electricity of stand-alone electricity systems such as small-scale electricity generation by diesel generators. Globally, it is estimated that around 1.6 billion people live without access to electric light (IEA, 2006) and increasing access through provision of energy-efficient lighting can improve social and economic conditions in poor areas in developing countries while minimizing the impact on greenhouse gas emissions.

3.2.2 Characteristics of technology, production, distribution and use.

The global market in lighting has long been dominated by three leading multinational lamp manufacturers: Philips (based in the Netherlands), Osram (Germany) and General Electric (USA). These three companies have presence in almost all global markets and have a significant share in global trade in lighting products, facilitated by a high degree of standardisation between international lighting markets (IEA, 2006: 251). However, their strength in specific regions varies, while also some major national markets are dominated by local manufacturers. For example in Japan companies such as Matsushita, Toshiba, Hitachi and Mitsubishi have a very strong national presence and OSRAM is the only one of the "Big Three" to have a significant market share (IEA, 2006). "Traditionally, China has also been self-sufficient in lamp manufacture; however, in recent years there has been a significant reform of Chinese industry, which has led China to become the world's major lamp manufacturing centre in market volume terms. In the past, China had literally thousands of small local lamp producers, but over the last 15 years many of these businesses have been consolidated, markets have been opened up to foreign direct investment and a great many joint ventures with international producers have been established. The result has not only been a startling and continuing transformation of lamp manufacturing capability, but has led to a huge transfer of technology and growth in domestic lighting product quality. The "Big Three" all have manufacturing facilities in China, but they account for only a small proportion of the Chinese market" (IEA, 2006: 251).

Energy-efficient lighting has been slowly penetrating the residential lighting market that is still dominated by the traditional incandescent light bulbs. In OECD countries key elements of this process have been (IEA, 2006; Figueres & Bosi, 2006):

- Increasing availability of energy-saving lamps in retail outlets;
- Information campaigns to increase awareness to users;
- The use of labels, rating and certification schemes to inform users about the energy use, costs and environmental implications of the lighting product they buy;
- Subsidies for energy-saving lighting to reduce the price gap with traditional bulbs. This is often done in the form of incentives such as a rebate or tax deduction, to motivate consumers to purchase energy-efficient lighting equipment;
- Minimum energy performance standards (MEPS) that determine (voluntary or mandatory) minimum efficiency levels for lighting products sold in a particular country or region;
- Programs to assist households and organizations with energy-saving, often done by energy service companies that then share part of the realized cost savings with the customers;
- Initiatives by a range of stakeholders, such as energy companies offering energy saving lamps at discounted rates for (new) clients, and NGO's actively promoting substitution of traditional lighting by energy-efficient lamps.

In terms of the technology involved, energy-efficient lighting is more than substituting traditional light bulbs for CFL's. "Lighting energy can be saved in many ways, including (i) improving the efficiency of the light source; (ii) improving the efficiency of the specific component of lighting system, typically the ballast; (iii) improving the efficiency of the luminaries; (iv) improving the efficiency of the control gear deployed; and (v) making better use of daylight inside built environment" (Figueres and Bosi, 2006: 2). In terms of the process of technology transfer this implies that effective TT involves also the built-up of knowledge and skills to facilitate the appropriate use and implementation of energy-efficient lighting within the specific local user contexts.

3.2.3 Evidence of TT and barriers to TT

A number of developing countries have implemented relatively successful energy-efficient lighting programmes. Major and successful CFL substitution programmes have been implemented in Brazil, Mexico, Peru, South Africa, Guadeloupe and Martinique. China has implemented an ambitious 'Green Lights Programme' and has become the world's largest CFL market. The Green Lights program was originally initiated by the Chinese government in 1996, yet its successor (2001-2005), in which UNEP and the GEF have an active role as supervisors and funding partners, is significantly more far reaching and ambitious. The project has as its main objective to "reduce lighting energy use in China in 2010 by 10% relative to a constant efficiency scenario" and as a secondary goal "to increase exports of efficient quality lighting products, aiding the Chinese economy and helping to reduce energy use and GHG emissions worldwide" (UNDP, 2000 in Lefevre et al, 2006). According to IEA (2006) "these experiences show that running successful efficient-lighting initiatives is more a matter of political priority and organisation than access to innate developed-economy advantages". Key factors for successful programmes have been:

- The price differential of CFLs compared to incandescent lamps has been minimised by direct subsidy or soft-financing.
- There has been a proactive promotional campaign.
- The quality of CFLs has been ensured.
- There has been pressure on the energy system, such as a power crisis.

Especially with regard to the quality of CFL there is a need for participation of the private sector to ensure that good quality is guaranteed. According to a recent study "analysis shows that one out of two compact florescent light-bulbs (CFLs) available in many areas of the world is of shoddy quality. Unless this issue is addressed in the near term, we will fall far short of energy saving goals, turning consumers against CFLs in the process"[5]. A key component in China's relatively successful CFL program has been the set up of a national standardization organization that is responsible for the quality of the CFL products and for which all producers are obliged to test their products against a number of minimum quality standards developed by the organization.

Regardless of existing programmes there are still huge opportunities in developing countries by focusing on energy efficiency and lighting particularly that could also reduce the stress on and expenditure of electricity generation and networks. This also involves reducing barriers for trade in energy-efficient lighting as the IEA study found that import duties for energy-efficient fluorescent lighting are often higher than those for

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[5] USAID. Confidence in Quality: Harmonization of CFLs to Help Asia Address Climate Change. USAID Regional Development Mission for Asia. Bangkok. October 2007.

incandescent lighting in developing countries which creates a perverse incentive to consume more electricity (IEA, 2006: 495).

An overview of barriers to further spread of energy-efficient lighting in developing countries is given by Figueres and Bosi (2006: 3). They report the following barriers:
Policy Barriers:

- Lack of institutional capacity, particularly at national level, to implement EE programs in the end-use sector
- Energy efficient technologies, including lighting, is not given due consideration at the fiscal policy level
- Lax, if any, Minimum Energy Performance for most end-use equipment.
- Pricing of electricity below costs and poor recovery of electricity bills.

Finance Barriers:

- Price sensitivity of the lighting market
- No financial incentive for manufacturers to invest in energy efficiency
- Lack of financial incentives and mechanisms to promote EE products in the market
- Financial misalignment or split incentives: those who make the decision on EE investments are often not the final users who pay the energy bill

Business and Management Barriers

- Lack of distribution channels for energy-efficient lighting
- Manufacturers uncertainty about market demand of high efficiency models
- Lack of resources amongst small-scale manufacturers for developing and marketing energy efficient products

Information Barriers

- Lack of awareness about residential sector energy end-use, and therefore the energy efficiency potential, amongst consumers as well as the policy makers
- Lack of information about the precise energy saving potential from energy efficient lighting
- Lack of information about state-of-the-art energy efficient design and manufacturing of energy efficient lighting system.

Technology Barriers

- Limited access to the state of the art energy efficiency technology among manufacturers
- Lack of EE driven applied R&D by the manufacturers as well as the government labs and research institutes
- Lack of adequately equipped and staffed independent test labs for energy efficiency testing of lighting system
- Limited experience of energy efficiency testing amongst engineers

Common Practice Barrier

- Lack of trust of new equipment
- Local customs and inertial behavior working to maintain the status quo in the design, selection and operation of energy-using equipment.

3.2.4 Mechanisms to enhance TT

The Global Environment Facility (GEF) is now leading the efforts to support a global phase out of incandescent light bulbs and develop a lighting market transformation strategy benefiting all economies, including the developing world. This initiative has been triggered by an increasing number of countries announcing their intention to phase out incandescent lighting. One of the first countries was Cuba which has banned the sale of incandescent lighting and started a programme of replacing traditional light bulbs with CFL, a process which is said to be finalized in 2008, making Cuba effectively the first country where incandescent lighting is phased out. Since early 2007 almost all OECD governments have begun to develop policies aimed at phasing out inefficient incandescent lighting. Australia was among the first to pronounce a time schedule and regulations for phasing out incandescent lighting by 2012, other OECD countries (EU, USA, Japan) have followed with similar time paths. Also industries have expressed their willingness and readiness to phase out incandescent lighting, Philips being the first in December 2006, followed by other firms. The EU has started legislative processes for phase out, while various EU countries are developing national measures for phasing out incandescent lighting ahead of the EU time schedule. For OECD countries it seems the process of phasing out has been set in motion and is likely to be finalized around 2012. A number of developing countries have already started a process of phasing out, China being the most well-known example, but for example also in Ghana a draft policy has been proposed by the government to ban imports of incandescent light bulbs and other high energy consumption lamps. Approval is anticipated in 2008. The key challenge now is to make phasing out of incandescent lighting a global process, with effective technology transfer of energy-efficient lighting to developing countries, with programmes to ensure that technological capabilities are built up to implement energy-efficient lighting properly, with standards and testing facilities to ensure that the quality of (domestic) energy-efficient lighting is up to scale, and with measures to prevent incandescent lighting to resurface.

The global lighting initiative is planning to do all these things. The project is to be jointly led by the United Nations Environment Program (UNEP) and the United Nations Development Program (UNDP). It will propose a global platform to harmonize energy efficiency lighting efforts in close partnership with global industry players. It will provide technical, policy and financial assistance to individual countries or group of countries. The initiative develops phase-out schedules for individual countries depending upon their specific situation, will allow low-cost access to product testing and design, and will prevent dumping of inefficient technologies in the least developed countries (Vallee & Lebot, 2007).

Key components of successful transfer of energy-efficient lighting are the following:

- Involvement of the private sector and connecting to initiatives of the European Lamp Companies Federation.
- Agreement accompanied by government regulation (phasing out inefficient lighting)
- Stakeholder collaboration (global, national, regional)

- Built up of domestic technological capabilities & regional networks (suppliers, maintenance, installers)
- Effective supply chain organization & distribution channels (retailers, ESCOs, utilities, etc)
- Discern different target groups & assessment of lighting needs. The Lighting Africa program (GEF-funded) is doing market research on key segments in Africa, namely rural and urban micro-enterprises and households, to assess lighting needs and potential for various energy-efficient lighting products, either on- or off-grid (IFC, 2008).
- Incorporating both horizontal and vertical technology transfer & dealing with IPR. This is for example relevant for the emerging LED technology, that is likely to deliver the next generation of energy-efficient lighting for multiple purposes. In their assessment of LED technology transfer to India, Ockwell et al (2006) find four key barriers to TT. Financial: manufacturing of LED chips is capital intensive and requires large investments beyond the scale of the relatively small Indian manufacturers; 2) IPR: LED technology is highly protected with patents and Indian companies have been unable to obtain licenses and instead have chosen to import LED chips; 3) Market barriers: Large lighting and LED manufacturers have not invested in India due to the small domestic market, and no joint-ventures are established; 4) Human capital: Although India has highly skilled engineers, expertise (and academic education) in LED technology is scarce. (Ockwell et al, 2006).

3.3. Solar panels

3.3.1 Introduction

A crucial component in mitigating climate change is a transition to a more renewable-based electricity system. Solar energy, captured through photovoltaic (PV) panels and/or thin film solar technologies is expected to be a key component of such a transition. While the installed base of solar PV is dominantly in the industrialized world, particularly Germany and Japan, solar panels form a clean and renewable source of energy that can contribute to improving energy access and health conditions in low-income areas of developing countries. This is particularly the case for rural areas in developing countries that are not connected to electricity grids and rely upon fossil-based sources for local system electricity provision. In urban parts of the developing countries solar panels could make a contribution to the renewable base of grid-connected electricity generation, in the same vein as the one-million rooftops programmes in Japan and Germany. The built-up of local technological capabilities and acceleration of technology transfer for solar technologies seem especially relevant since it is expected that electricity from PV will become competitive for household electricity consumption in the coming decade (EC, 2005; Sinke, 2005). Until now, domestic production capacity for solar power is virtually lacking in developing countries, with the exception of several Asian countries and China in particular. Almost all of the technological hardware for solar home systems in rural areas of developing countries is imported from OECD countries or China. Are there potential mechanisms to scale up diffusion of solar power to developing countries for off-

grid and grid-connected applications and to increase domestic capabilities for solar panel production and balance-of-system engineering? It may be that these two have to go hand in hand for the acceleration of solar panel uptake we would like to aim for.
To realize this actions have to be taken at different levels and from various key stakeholders. Global solar panel producers need to consider FDI in for example foreign countries and the possibility of setting up joint-ventures. More widespread distribution channels for solar home systems need to be developed, and this also demands vocational training of engineers for installing solar panels so as to reduce the balance-of-system cost. Moreover, domestic organization of electricity with the often dominant role of utilities who are fixated on large-scale centralized electricity generation needs to be addressed (Hofman, 2005). Off-grid solar home systems and grid-connected solar panels require much more decentralized organization and coordination of electricity systems, and skills and expertise for these needs to be developed within those utilities and within other electricity firms and energy service providers (Hofman, 2006).

3.3.2 Characteristics of technology, production, distribution and use.
Production of solar panels is concentrated in a limited number of countries and dominated by a select number of multinational companies. The production of PV panels is expensive and requires large-scale precision manufacturing capability. It is a moderately concentrated industry; the four leading firms produce about 45 percent of the market (Barton, 2007). Another study, also using 2005 data, lists five firms, Sharp, Kyocera, Shell Solar, BP Solar and Schott Solar, as holding 60 percent of the market. Today's firms are concentrated in the developed world, but there are five firms in the developing world, each producing at least 10 MWp (Barton, 2007). There are also a number of manufacturers of PV manufacturing equipment mainly concentrated in OECD countries. In China, the industry has been promoted by the government, through support for research into all forms of PV cells and through encouragement of the import or design of PV production equipment. The import of certain parts of the fabrication technologies was accomplished in part by a programme with the US Department of Energy in the early 1980s. According to a 2003 study, most of the actual production line equipment (or at least the key equipment) was imported from the United States or Canada, but one firm, GoFly Green Energy Co., built its own production equipment, while inverters and controllers were made locally (Barton, 2007). India's leading firm is a joint venture between BP Solar (51 percent) and Tata (49 percent). The joint venture has a solar manufacturing plant in Bangalore (Barton, 2007). According to Barton (2007), developing nations are facing an oligopoly structure in the solar industry but there is enough scope for new entrants to enter the PV market.

From a value chain perspective the number of companies involved becomes lower when travelling higher up the PV value chain. The upper hand of the value chain involves the production of silicon, the main resource for the solar cell, and this requires substantial know-how and investment, as does the production of wafers (EPIA/Greenpeace, 2008). Wit regard to the intermediate level of cell and module producers, knowhow and investment needs are smaller than for silicon and wafer production, and the number of firms in the market is higher. With regard to the installation of solar panels, at the end of the value chain, these installers are often found to be small, locally-based businesses (EPIA/Greenpeace, 2008).

3.3.3 Evidence of TT and barriers to TT

Nieuwenhout et al (2001) review experience with solar home systems in developing countries and report that by 2000 around 1.3 million solar home systems were installed. They reported organizational, financial and technical problems that create difficulty for effective implementation while also market transparency is limited, leading to lack of knowledge and information for potential users about cost-effective systems. More recently IFC (2008) has evaluated various solar energy projects in developing countries. “While IFC programs have been responsible for the installation of over 84,000 solar home systems , these programs have been less successful from a financial standpoint, IFC having been unable to significantly transform markets and create sustainable businesses as originally anticipated. The rural unelectrified market in developing countries is large. To reach it, proper segmentation along income lines, needs, and lifestyle are necessary. Experience has shown that the definition of affordability varies among market segments (relative income levels, market applications, etc.), and it remains a challenge for pv companies to identify the niche market segments where solar pv is the least-cost energy alternative for the consumer” (IFC, 2008: 6). Although it is generally recognized that costs of solar panels still form a barrier, there also indications that with the help of proper domestic incentives it is possible to move forward the PV market. Van der Vleuten (2007) reports that “where a sufficiently strong commercial supply chain network (‘market infrastructure’ with sufficient coverage and quality) has been developed, dissemination of SHS has been highly successful, reaching millions of households around the world. Examples of very successful commercial markets for SHS can be found inter alia in Kenya, Morocco, Sri Lanka, on the Tibetan plateau in Western China, and in Zimbabwe. Estimates underbuild that commercial markets in these locations have reached penetration of up to several MW of installed peak power per country or up to approximately 5% of the rural population” (Van de Vleuten et al, 2007: 1439). Similarly Otieno (2003) reports positive results in Kenya: “On a per capita basis, Kenya has the largest and most dynamic solar energy market among developing countries. Every year more than 20,000 new families buy a solar panel, and at present the number of rural Kenyans who get their electricity from the sun is more than twice as large as the number who are connected to the national electricity grid. Solar Energy Network, a Kenya-based NGO has proved to be an effective vehicle and tool to convey needed information about solar energy systems to the rural East Africans. Solarnet is well equipped with an extensive network of solar businesses including both Nairobi based distribution companies and town based retail shops), freelance technicians, rural schools, and other institutions active in the solar market. Based on Solarnet’s experience with solar energy markets in East Africa, they strongly feel that educational solar energy information can play an important role in raising awareness about solar energy and in improving the operation and maintenance practices of people in rural areas who depend on the sun to generate electricity in their homes, schools, health clinics, and small businesses. Solar electricity is also used by rural health clinics for vaccine refrigeration, by community water projects for irrigation pumping, by small businesses for income generation, and by over 150,000 rural families for lights, television, radio, and cellular telephone charging" (Otieno, 2003: 40-41). Also EPIA/Greenpeace (2008) in their overview of solar energy achievements reports the benefits of rural solar power. "Solar power can be easily installed in remote and rural areas, places that may not be targeted for grid connection for many years. Decentralised (off-grid) rural electrification based on the installation of stand-alone systems in rural households or the setting up of minigrids - where PV can be combined with other renewable energy technologies or with LPG/diesel - enables the provision of key services such as lighting, refrigeration, education, communication and health. This increases economic productivity, and creates new income generation opportunities. Furthermore, the technologies which are used to power off-grid applications (stand-alone PV systems, PV water pumping systems and hybrids) are often both affordable and environmentally sound. Due to their robustness, ease of installation and flexibility, PV systems are able to adapt to almost any rural energy demand in any part of the world. The load demand expected from small PV systems is usually focused on serving household (lighting, TV/radio, small home appliances) and social needs (health and community centres, schools, water extraction and supply), bringing both quality of life and economic improvements. During 2007, around 100 MW of PV solar energy was installed in rural areas in developing countries, enabling access to electricity for approximately 1,000,000 families" (EPIA/Greenpeace, 2008).

Moreover some countries have been able to develop a domestic industry for solar panel production. In China and India several domestic PV firms have been successful in establishing a production base and the possibility of entry is demonstrated by Tata-BP Solar, an Indian firm, based on a joint venture, and Suntech, a Chinese firm, based on a combination of its own technologies and of purchases of developed world firms.

3.3.4 Mechanisms to enhance TT

Shum and Watanabe (2008) present key elements that need to be taken into account for effective technology transfer of solar panels. The figure illustrates how the production and application of solar panels involves on the one hand the production of the photovoltaic module and on the other hand the installation and integration of these solar panels into local electricity systems, which are the Balance of System (BOS) costs of either grid-connected or off-grid applications. While the global value chain of the production of the modules (involving silicon production, wafer production and solar cell manufacturing) is rather concentrated, high-tech, and dominated by Western firms, the BOS subsystem involves interaction among local market players (engineering firms, utilities, energy service companies, and a range of users). Much can be gained here by establishing effective platforms for interaction, by facilitating standardization through appropriate organizations, and by increasing awareness and lowering access to information by building regional or local knowledge centers.

Because developing countries play rather different roles in the current solar panel value chains strategies need to be differentiated depending on their respective roles. For some of the more advanced Asian countries that have gained access to the solar panel production of the value chain the focus can be on facilitating access to technology in the form of co-development programs (such as for multi-crystalline panels but also for the emerging thin-film technologies) and sharing IPR. The focus can also be on expanding global silicon production as this is currently one of the main supply constraints for PV (silicon of course is a major input for several industries such as semiconductors and metallic alloys) with participation of developing countries. Another type of approach should focus on supporting the build-up of regional platforms for interaction of key stakeholders, knowledge centers that apply lessons learned from the many solar home systems that have been installed in relatively poor rural areas in developing countries and that act as catalyst for standardization processes.

Comparison and contrast of learning characteristics of major subsystems (Wene, 2000) in a solar photovoltaic system

	Module subsystem	BOS subsystem (system integration)
Locale of learning	Upstream in factory	Downstream along rest of value chain and involving other market players and users
Spillover of learning	Global but incomplete	Local and applications
Economics of learning	Mass production and R&D: dynamic economy of scale	Mass customization; knowledge reuse among projects; dynamic economy of scope
Partners of learning	Module suppliers driven Learning by doing	Among intermediary systems integrators, utilities and users Learning by interacting
Governance of learning	Firm-specific production, knowledge management routines	Local institutions such as design standards, regulations, systems integrators community, developers forum, etc.

(Source: Shum & Watanabe, 2008).

3.4. Energy efficiency in the cement industry

3.4.1 Introduction
The cement industry holds a key position in contemporary society as it holds together bridges, buildings, dams and other infrastructure. But the cement industry is also a major contributor to the climate change problem as cement production is roughly responsible for 3-5% of global GHG emissions (Batelle, 2002; Price & Worrell, 2006). Cement production occurs all over the globe, but production is now dominantly located in developing countries with 78% of world production (Roy, 2008). Production has expanded rapidly by 60% in past decade and particularly in developing countries with China responsible for 44% of world production in 2004 (Roy, 2008; Price & Worrell, 2006).

3.4.2 Characteristics of technology, production, distribution and use.
With regard to greenhouse gas emission mitigation according to Roy (2008) cement is among the industries with largest mitigation potential together with steel, and pulp and paper industries. With 1930 Mt CO2 the cement industry emits 4.6% of global anthropogenic GHG emissions (Watson et al, 2005). The production of clinker accounts for around 90% of cement emissions. Around 50% of cement emissions arise from the chemical process of converting limestone to lime to produce clinker. The emissions generated from creating the energy for this account for 40% of emissions due to 90% of the energy deriving from fossil fuels, in particular coal. Offsite electricity and transport emissions account for the remaining 10% of emissions. Developing countries account for 70% of global cement emissions. This figure is set to rise as developing countries continue to have higher demand for their construction and infrastructure sectors. China is by far the largest producer of cement with its production more than the next 20 largest countries combined (see also table beneath). Western Europe is the second largest producer at 11% followed by South and East Asia at 8%. The industry has undergone significant consolidation over the past decade to the point where the five largest companies represent 42% of global capacity and the ten largest 55%. However, in the cement sector is also composed of a vast number of small firms. For example, estimates for the total number of firms in China are from 5 000 to 8 300 and the top five cement producers in Russia account for only 10% of production capacity (Watson et al, 2005). Cement is primarily consumed close to where it is produced for two key reasons. The first is that raw materials for cement production are widely available. The second is that cement is a costly product to transport relative to its value, particularly over land. Only 5.8% of production is traded, with 40% of this traded between regions. The largest exporters are Western Europe, Japan and India while the USA is the largest net importer of cement, importing 8% of its consumption (Watson et al, 2005).

Table 1-1. Major Sources of Cement Production

Ten Largest Producing Countries	Production* in year 2000, million tonnes/yr	Primary Companies Funding Study	Sales in year 2000, million tonnes/yr
China *(estimated)*	576	Holcim (Switzerland)	82
India	108	Lafarge (France)	73
United States *(estimated)*	90	Cemex (Mexico)	51
Japan	86	Heidelberger (Germany)	47
South Korea	52	Italcementi (Italy)	39
Brazil	40	Taiheiyo (Japan)	30
Italy	39	RMC (UK) *	20
Turkey	39	Votorantim (Brazil)	17
Spain	38	Cimpor (Portugal)	16
Germany	35	Siam (Thailand) **	14
*Production including exported clinker.		*capacity rather than sales ***source* : Goldman Sachs	

Source: Batelle, 2002.

3.4.3 Evidence of TT and barriers to TT

The set up of an agreement in the cement industry will be a challenge because production is spread among many plants and companies across the globe while the level of international trade is rather low. Furthermore, a process of increased consolidation of the traditionally fragmented cement industry is under way through mergers and acquisitions, and through growth of large national players in emerging economies such as China and India. This increasing consolidation process may be accompanied by the establishment of a global cement industry institution, and thus better enable the cement industry to become a strong partner in sectoral agreements (Watson et al, 2005). According to Watson et al (2005) an emissions intensity agreement could be a way to move forward for the cement industry. This is because the variation in emissions intensities suggests reasonable room for improvement. “Estimates of the potential to reduce emissions using current methods suggest emissions could be reduced by an average of 33%. An agreement could serve to provide incentives to countries to adopt these more efficient technologies and practices. An agreement whereby all regions were required to reach Japan’s level of efficiency in 2020 would result in emissions being 16% lower than they would otherwise be” (Watson et al, 2005).

3.4.4 Mechanisms to enhance TT

The cement sector has reasonably good conditions for international cooperation as portions of the cement industry have also organized themselves under the World Business Council for Sustainable Development’s Cement Sustainability Initiative (CSI). The key challenge will be how to involve China as the CSI includes 16 companies representing about 50 percent of global cement production outside of China. Key components of the initiative are on ‘climate protection and CO2 management’, where monitoring and reporting of CO2 emission has been mainstreamed under members by setting up a common approach and monitoring and reporting protocol. The initiative also aims at developing public policy and market mechanisms for reducing CO2 emissions, but this has not been specified yet. Bradley et al (2008) conclude that “given uncertainties in future emissions and cement’s importance for the infrastructures of rapidly growing developing countries, fixed emission targets are unlikely to be attractive to either industry or governments”. A more likely approach is a focus on technology and financial assistance toward developing countries such as China and other countries where significant growth is expected. “If appropriate intensity metrics can be developed, this could be done in part through a crediting mechanism such as the CDM” (Bradley et al, 2008). De Coninck et al (2008) also indicate the potential for a cement agreement and develop an outline. Components of the cement agreement would be (De Coninck et al, 2008):

- Three large-scale demonstration plants with CCS in Annex-I countries (Japan, US and EU) before 2020;
- Technology mandates (state-of-the-art kiln) for new large-scale plants (e.g. >0.1 Mt cement/yr) in all participating countries;
- Technology transfer and financial assistance, e.g. from Japan to China and from US/EU to India, to achieve these targets;
- Targets for low-clinker cements (i.e. blended cement), e.g. 75% clinker content average across 8 years for Annex-I and 85% for non-Annex-I;
- Option for emissions trading: non-Annex-I countries exceeding their target can sell credits to Annex-I countries that are short of their target;

Key elements for cement agreements need to focus particularly on the options available to increase the amount of blended cement, and on diffusing best practices with regard to energy management, which also can involve developing low-carbon energy provision for this rather energy-intensive industry. Also pilots for carbon capture and storage could be well connected to the energy requirements of the cement industry.

3.5. Energy efficient electric motors and drives

3.5.1 Introduction

Electric motor systems are estimated to be responsible for up to 40% of industrial electricity demand worldwide (Brunner, 2007) and thus a major source of greenhouse gas emissions. “Diverging standards for electrical motor system components and the lack of correct information hamper the uptake of the most energy efficient equipment, because market stimulation efforts require widely accepted testing procedures, energy efficiency standards and energy labels” (Seeem, 2006). It is estimated that uptake of high-efficiency motors (HEM) could improve efficiency of motor system with 25 to 30% on average. Motor system components are widely-traded commodity goods that are currently subject to different testing standards and performance and labeling requirements. As a result, there are large variations in the market penetration of high-efficiency motors and motor systems around the globe. Countries that have implemented minimum energy performance standards at relatively high efficiency levels have market shares for high-efficiency motors of over 70%, whereas the market share in countries without them hovers below 10%, despite voluntary programs (SEEEM, 2006). The International

Energy Agency estimates that up to 7% of global electricity demand could be saved by more energy-efficient motors and motor systems. At present, both markets and policy makers tend to focus exclusively on individual system components, such as motors or pumps, with an improvement potential of 2%–5% instead of optimizing systems (McKane et al, 2008). What are then the reasons why industries do not implement HEM and optimize their systems for energy efficiency? According to McKane et al (2008) the barriers are foremost institutional and behavioral, rather than technical. The fundamental problems are lack of awareness of the energy efficiency opportunities by firms, suppliers and consultants; there is lack of understanding on how to implement energy efficiency improvements, and their is lack of a consistent organization structure for energy management within most industrial facilities. Energy use is rarely measured at the system level, so there is little available data. Without performance indicators that relate energy consumption to production output, it is difficult to document improvements in system efficiency (McKane et al, 2008).

The aim of energy efficiency policy instruments implemented at EU level among others for HEM is to achieve a market transformation, i.e. to foster the supply and use of more efficient products and systems and thus reduce energy use, while preserving the internal market. These policies measures include:

- information tools;
- minimum efficiency standards through Directives;
- negotiated voluntary agreement (Motor Challenge);
- energy classification/labelling and/or quality mark;
- energy services (ESCOs) and energy audits;
- white certificates;

Harmonization would not limit the freedom of individual nations or the EU with respect to policies and measures such as adoption of minimum energy performance standards (MEPS), setting dates for compliance and introducing sanctions for non-compliance, or designing effective incentive schemes for higher efficiency levels. The existing discrepancies in testing methodologies and the precise definition of efficiency levels are crucial in a globalized market where a large percentage of motor system equipment is imported and exported all over the world. In many countries electric motors are imported from regions of the world with different testing standards, making very difficult to implement energy efficiency and market transformation programmes. Electric motors are repaired an average two to three times during their lifetime. In many cases the efficiency is further degraded when the motor is repaired. This problem is particularly serious in developing countries due to the general lack of technical expertise to carry out proper motor repair. Harmonized testing procedures have to be practical enough to convince both industrial manufacturers and industrial users to apply the new, more precise methods easily and rapidly. No single country can take the lead in this effort: All countries have to join, participate and dedicate their engineering skills and experience to this international effort of convergence and harmonization. Energy efficiency in motors and drives is generally considered to be cost-effective, i.e. the more efficient motors and systems pay the additional cost (more material in steel and copper, additional power electronic components, additional labour for design and engineering, testing, etc.) within less than 2 years. Especially in new equipment there is no reason whatsoever not to buy and install optimally designed and highly energy efficient motors and electronic adjustable speed drives where feasible (SEEEM, 2006).

3.5.2 Characteristics of technology, production, distribution and use

There is a wide variety of electric motor producers with some of the largest players from the OECD, while also China has a significant number of large producers.
Motors are sold from the manufacturer to three different channels:
- large industrial end-users,
- distributors who sell them to small end-users and
- OEM (original equipment manufacturer) that put them into complete systems.

In only the first channel a direct link between initial cost and quality and energy savings will result. In all three channels efficient motor systems are at stake.

3.5.3 Evidence of TT and barriers to TT

A number of national and international activities to promote energy efficient motors and to provide standards are going on (SEEEM, 2006):

- IEC, ICEEE and other standard organizations have provided standards for testing the energy efficiency of electric motors. CEMEP in Europe, NEMA in the USA and many other organizations have launched labelling schemes and voluntary standards for high efficiency motors. Mandatory minimal energy performance standards have been enacted in the USA, Canada, Australia, New Zealand, Brazil, China and Mexico.
- The Motor Challenge campaign has increased awareness, competence and acceptance of efficient electrical motors in the USA and Europe. Similar campaigns have been (or will be) started in Australia, China, etc. An elaborate database for energy efficient motors is provided by EuroDEEM.
- The Collaborative Labeling and Appliance Standards Program CLASP has worked internationally to harmonize standards and labels. APEC-ESIS has worked on harmonized an effective energy efficiency standards in Asian countries.

3.5.4 Mechanisms to enhance TT

SEEEM is an international multi-stakeholder initiative to harmonize standards for energy efficient motor systems and to coordinate and speed up the energy efficiency impact. The ultimate goal of the SEEEM initiative is to promote rapid market diffusion of high-efficiency motor component technologies and systems worldwide, in order to reduce industrial and building electricity demand and greenhouse gas emissions from electric power generation.
To achieve this objective, the multi-stakeholder SEEEM initiative will facilitate (SEEEM, 2006):

• Greater alignment of international testing procedures, performance requirements and labeling schemes and
• Collaboration on the design and enforcement of effective policies and incentives.

3.6. Micro finance and micro insurance

3.6.1 Introduction

As already evident in the previous sections, a common barrier to adoption of technologies is the lack of financial capital of a large part of the target population in developing countries, which is especially relevant for the adoption of energy efficient lighting and solar panels. This lack of financial capital does not only refer to the disposable income which a household has available at a certain point in time but also to the reliability of an inflow of income sources over time. So next to access to financial capital there is also a need for mechanisms which increase the reliability of the income sources. To achieve both access and reliability of financial capital, micro finance and micro insurance have come up as soft technologies which provide access and increased reliability of financial capital and therefore can facilitate the adoption of other technologies. Micro finance allows households to get access to financial resources to adopt new technologies while micro insurance protects households to potential shocks which may strain income sources thus making income flows more stable.

In the light of reducing climate change and eradicating poverty these mechanisms can thus increase the likelihood of adoption of new technologies but in itself micro insurance can also function as a mechanism to adapt to climate change when it provides a way of coping with trends and shocks caused by climate change for which households are vulnerable, such as an insurance against floods.

In 2007, the microfinance market served more than 113 million borrowers[6]. However, approximately 80% of the potential market has not yet been reached[7]. For micro insurance it is estimated that only eighty million out of the world's 2.5 billion poor are now covered by some form of micro insurance. Most remain without access to this critical financial service. In India and China the percentage of poor that are insured is estimated below 3%. In Africa this figure is much lower – just 0.3% of the continent’s poor are insured. According to recent data, in 23 of the poorest 100 countries in the world, there is currently no identified micro insurance activity, representing an unserved population of 370 million[8].

3.6.2 Characteristics of technology, production, distribution and use.

Several definitions for microfinance exist but the term generally refers to small loans (usually less than US$200) made available to low income households, including the self-employed. Microfinance activities usually involves offering small loans, informal appraisal of borrowers and investments, possibilities for repeating loans and getting access to larger loans based on debt capacity and repayment performance, streamlined loan disbursement and monitoring and secure savings products[9]. Microfinance clients are mostly urban and rural, self-employed, tiny and small, low-income entrepreneurs. These entrepreneurs are often street vendors, service providers (beauty parlours, hairdressers),

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[6] http://www.microcreditsummit.org/pubs/reports/socr/2006/SOCR06.pdf on 2 November 2008
[7] http://mfi.unitus.com/ on 3 November 2008
[8] http://www.microinsuranceagency.com/about-micro.html on 28 October 2008
[9] http://www.rbapmabs.org/ on 28 October 2008

restaurant owners, artisans, blacksmiths, fisherman and other tiny and small scale entrepreneurs. The largest part of the microfinance market is served by conventional banks contributing to more than 21 million clients, followed by NGOs serving more than 15 million clients[10].

Micro insurance can be defined as:

> "*The protection of low-income people against specific perils in exchange for premium payments proportionate to the likelihood and cost of the risk involved*" (Churchill, 2006: 12).

Micro insurance is a subset of insurance that provides protection to low income households in a way that reflects their cash constraints and coverage requirements. Its clientele is different from the market served by existing formal insurance companies. Micro insurance clients are poorer and depend on income flows that can fluctuate considerably throughout the year. While the shocks the poor experience maybe the same, they are more vulnerable to them because they have fewer reserves to draw upon. Once their reserves are gone, repeated shocks force them into a reactive mode, always responding after a crisis (Cohen and Sebstad, 2005: 397, 411).

Micro-insurance can be brought to the low-income population in different forms. To date, four institutional approaches towards micro-insurance have developed. The first approach is the partner-agent model in which an established insurance company serves low-income clients through a distribution channel such as a micro-finance institution. The insurance company maintains the reserves, sets premiums, supervises claims and manages compliance with regulatory requirements. The agent institution facilitates the rational transfer of risk, resources and expertise between formal and informal sectors.
Under the second approach we find credit unions and cooperative/mutual insurers. These types of organizations offer loan protection insurance to ensure that the depth is not inherited by the family after the death of a debtor. Generally speaking these services are added to credit or savings services.
A third model is the direct sales model in which insurance companies serve low-income policyholders directly through individual agents which get paid on a salary or commission. Finally there is the community based model. This model is non-profit and has a voluntary membership. Policyholders prepay premiums into a fund and are entitled to specified benefits. The community plays and important role in the design and running of the program. A network support organization provides technical assistance (Churchill, Reinhard and Qureshi, 2005).

Micro insurance does not refer to the scope of the risk as perceived by the person who has micro insurance, as the risks which are covered are often substantial to the household. Micro insurance could cover a variety of different risks such as illness, death and property loss but demand research across many countries has repeatedly identified illness and death risk as the primary concern of low income households (Cohen and Sebstad, 2006: 25). This can help us understand why funeral and life insurance and health insurance are the most prevalent forms of micro-insurance.

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[10] http://www.mixmarket.org/en/scriptlets/heat_map.asp on 4 November 2008

3.6.3 Evidence of TT and barriers to TT

The success of microfinance has been stressed by the activities of the Grameen Bank for which prof. Muhammed Yunus, the initiator, received the Nobel Peace Prize 2006. Currently the Grameen bank has 7.56 million out of which 97 per cent are women. The concept of the Grameen Bank has been extensively copied and is now operating in Africa, South-America and even in the Lofoten in Norway. Other successful programs are led by Bank Rakyat Indonesia with more than 3,5 million borrowers and Amhara Credit Savings Institution in Africa with more than 500 000 borrowers.

Micro insurance is a more recent product but successful micro insurance programs include Delta Life Insurance Company in Bangladesh with more than 860 000 clients and Dhan Foundation in India with more than 35 000 clients.

Activities by several NGOs and MFIs also show that micro finance and micro insurance can make a contribution to creating an environment which fosters technology adoption. The SEWA bank, an Indian based bank focusing on the self-employed, has developed a scheme to promote the uptake of solar lighting through providing an energy loan which also includes battery replacement to ensure long term usage of the solar lighting equipment (Morris, 2006).

Kenya Women Finance Trust, an Kenyan MFI, has started collaborating with Shell through the Shell Foundation Breathing Space Fund for Kenya through focusing on cleaner domestic energy technologies. The overall purpose of the Fund is to improve the health and socioeconomic status of poor households by increasing access to, and use of, the improved domestic energy products and services that reduce indoor air pollution. These include LPG or cooking gas, biogas digesters, solar lighting and heating systems, improved cook stoves, solar cookers, fireless cookers and other renewable and efficient energy products.

The Fund seeks to create an innovative and commercially viable model for provision of finance by banks and micro finance institutions to small energy enterprises and consumers in Kenya. A bank will co-finance and act as the custodian for the Breathing Space Fund. KWFT will access the facility and on-lend funds to its membership for implementation of domestic energy schemes. This will comprise loans to members to purchase and install cleaner energy technologies. The Breathing Space Fund is being coordinated by IT Power Ltd, a leading international consultancy firm in renewable energy and climate change[11].

SEEDS, a Sri Lankan MFI offers loan products that focus on the provision of environmentally-friendly, clean energy technologies. To increase operational efficiency, SEEDS out-sources services such as sales, marketing, installation and maintenance through strategic partnerships with solar technology suppliers and itself focuses only on financing. Much like automobile sales packages, partner solar energy companies market

[11] http://www.kwft.org/news.asp?ID=5 on 29 October 2008

their products coupled with SEEDS financing packages. The MFI offers after-sales maintenance and service by being highly selective in their choice of partners[12].

The Global Village Energy Partnership (GVEP) was launched at the UN World Summit on Sustainable Development in 2002. It forges partnerships between developing and industrialized country governments, public and private sector institutions, and multilateral organizations in an effort to ensure energy access to modern energy services by the poor. The Partnership covers renewable energy, energy efficiency, modern biomass, liquefied petroleum gas (LPG) and cleaner fossil fuels[13].

Several barriers to TT of microfinance and micro insurance have been identified. The first barrier is that financial transactions with the poor are risky and expensive. The poor are more vulnerable and therefore more likely to be unable to repay. In addition, small loans and insurance carry high transaction costs which makes each dealing with a client less profitable. A solid system, with supporting infrastructure, for performing these financial transactions has to be developed. The creation of such a system is complicated because a geographical distribution network of organizations and communication infrastructure are required. A supporting legal and regulatory framework which supports financial transactions but also allows for action to be taken in case of faulty financial enterprises is also a barrier.

For potential clients it is difficult to evaluate merits of microfinance and micro insurance, especially in rural areas, as they are often unknown to the concepts or have been confronted with organizations which have mistreated them. Fear of loans and insurance are therefore motivations to refrain from adoption, especially for the lowest income households as the required repayment of loans of payment of premiums for micro insurance are often a substantial part of their disposable income.

3.6.4 Mechanisms to enhance TT

Numerous studies have been done which have identified key success factors for increasing micro finance and micro insurance outreach. Among the most important are:

1. An enabling policy framework through government programs and national coordination and a supportive legal and regulatory framework. This also includes donor support, consultation and collaboration.
2. Multi stakeholder participation, stakeholder consultation and collaboration, and clear communication with stakeholders.
3. Infrastructure for delivery and ICT supporting communication infrastructure.
4.. Being innovative in choosing collaterals so as to ensure that the credit is still interesting for lower class community but also can function as compensation in case the clients fail to repay their credit and thus ensuring the sustainability of the MFI.
5. Provision of training about microfinance and micro insurance concepts, and offering business support for enterprise development.

[12] http://www.uncdf.org/english/microfinance/pubs/newsletter/pages/2005_10/news_mobilize.php on 4 november 2008

[13] http://www.uncdf.org/english/microfinance/pubs/newsletter/pages/2005_10/news_mobilize.php on 4 november 2008

4. Initial conclusions

4.1 Outcomes of case studies

The five cases suggest that significant reduction of GHG emission can be realized by a more rapid diffusion of energy-efficient and renewable-based technologies. However the path to more rapid acceleration of these technologies is not straightforward. First of all the diversity of the technologies calls for approaches tailored to the specific characteristics of the technologies, users and the global value chains they represent. Those technologies fulfilling needs of households such as micro finance/insurance, solar panels and lighting require a different set-up of mechanisms relative to those oriented at large industries such as cement and high-efficiency motors. Moreover energy-use patterns within developing countries differ widely between the poor and middle classes and mechanisms will need to exploit various delivery models to reach those different groups effectively. The technologies differ with respect to the type and nature of investments they require and their complexity and this has to be reflected in the proposed mechanisms. Also the nature of global value chains and the integration of developing countries into those value chains differ. Whereas several Asian countries have been able to gain access to some of the value chains for the identified technologies, the role of other developing countries in global value chains is much more limited. The technologies identified also either have high levels of concentration (lighting, solar panels) and/or involve relatively complex and high-tech requirements which are often not available.

Secondly, adequate technological capabilities and absorptive capacity or in other words an enabling host environment is a key requirement for successful spread of the studied technologies. “Technology flows can be embodied in foreign direct investment (FDI), intermediate goods, capital equipment, or licensing, but may have little or no effect on development or growth without absorptive capacity” (Narula, 2003). The case studies have made clear the host environments differ widely across developing countries. The East-Asian newly industrializing countries (South-Korea, Taiwan, Singapore and Hong Kong) have developed enabling environments and effective absorptive capacity for the acquisition and exploitation of a range of technologies, including high-tech manufactures. They have built relatively effective ‘national systems of innovation’ and play an increasing role in strategy technology alliances, partnerships and agreements between countries and firms from the North and South (Archibugi & Pietrobelli, 2003). China is also making significant progress in this respect[14] and has become a major recipient of FDI, while for the cases analysed here Chinese firms take up an increasing share in domestic and international production of energy-efficient lighting, solar panels, high-efficiency motors and cement production (also by acquiring an increasing number of technology licenses). Nevertheless, barriers to access to environmentally sound technologies and to access for financing are still cited as the major constraints for further upgrading and delivery of technologies for mitigation and adaptation. The recent proposal of the G77 and China proposes the set-up of a technology mechanism under the UNFCCC that particularly aims at increasing access to and financing of environmentally

[14] For example the level of R&D as a percentage of GDP has risen from 0.7 to 1.1% from 1997 to 2002 while in most African countries declining trends can be observed with starting levels of R&D spending already well below 0.5% of GDP (UNIDO, 2005).

sound technologies, for example through co-development of technologies and intellectual property rights sharing (G77 & China, 2008).

A number of conclusions can also be drawn more specifically for the selected technologies. *Energy-efficient lighting* is the most straightforward case because it represents a not too complex form of substitution of existing products by a new generation of better products. There is also broad political and industrial support for the phase-out of incandescent lighting which offers a route to a global agreement on energy-efficient lighting and the phase-out of incandescent lighting. Apart from global partners (OECD countries, developing countries, lighting industry) such an agreement needs to be accompanied by stakeholder collaboration at national and regional levels. At national levels it is key to develop strategies and regulations to prevent inefficient lighting to resurface and it is crucial to safeguard the quality of energy-efficient lighting by setting up standardization and testing organizations. Programs such as Lighting Africa also can act as vehicles for diffusion, while taking into account the specific needs of various user groups such as poor households and micro-businesses.
For *solar panels* it is important to distinguish between the group of countries that is actively involved in solar panel production and the group that is mainly involved in application of solar panels in local electricity systems. For some of the more advanced Asian countries that have gained access to the solar panel production of the value chain the focus can be on facilitating access to technology in the form of co-development programs (such as for multi-crystalline panels but also for the emerging thin-film technologies) and sharing IPR. The focus can also be on expanding global silicon production as this is currently one of the main supply constraints for PV (silicon of course is a major input for several industries such as semiconductors and metallic alloys) with participation of developing countries. Another type of approach should focus on supporting the build-up of regional platforms for interaction of key stakeholders, knowledge centers that apply lessons learned from the many solar home systems that have been installed in relatively poor rural areas in developing countries and that act as catalyst for standardization processes.
With regard to *cement production* key elements of technology agreements need to focus particularly on the options available to increase the amount of blended cement, and on diffusing best practices with regard to energy management, which also can involve developing low-carbon energy provision for this rather energy-intensive industry. This requires the build-up of energy management expertise and of effective channels to bring this support to the many smaller cement companies in developing countries. For the large cement industry also pilots for carbon capture and storage could be well connected to their energy requirements.
High-efficiency motors include a range of technologies and applications across all industries. Mechanisms need to focus on two key aspects. In the first place there is still much to be gained by replacing less efficient motors by high-efficiency electric motors. Key components are awareness building and information campaigns and incentives to lower the higher costs of these high-efficiency motors relative to the less efficient ones. In the second place there is a need for energy management expertise and for improving energy management across the board of industries.

For most of the discussed technologies access to finance remains a key barrier for their further diffusion. A focus on further diffusion of *micro finance and micro insurance* could lower the risks associated with investments in these technologies. Setting up stakeholder platforms for micro-finance and micro insurance and connecting them to the potential mechanisms identified for the other technologies is a way to move forward. These platforms could also act as a vehicle to increase involvement and commitment of the private sector into these mechanisms, as lack of private sector involvement is seen as one of the key factors for slow diffusion of environmentally sound technologies. Needs assessment should be part of the mechanisms.

4.2 Harnessing Global Technology Markets towards more effective technology transfer

As was already mentioned in the introduction, an important element for effective technology transfer is the creation of an enabling environment in the developing country. This implies that country-specific social and institutional contexts need to be taken into account. For many cases of failure of technology transfer the lack of fine-tuning to the specific sociocultural and institutional context has been a contributing factor. Incorporation of a needs assessment and active national and local stakeholder involvement and contribution is one way to prevent this, while such a multi-stakeholder approach also holds promise for the build-up of local technological capabilities that are deemed crucial for any effective technology transfer.

Especially when analyzing environmentally sound technology transfer with the purpose of coming up with ideas for their improvement, a large part of the spectrum of cases for technology transfer is left out as the transfer of EST technologies has often not been very successful, hence this report. During the Chatham house conference it became evident that success stories for technology transfer do exist, initiated by, for example, Microsoft and Nokia. Although these cases concern different technologies, the importance of identifying best practices which deal with the social and institutional context were considered most important . Enabling factors such as infrastructure and a supportive political, legal and regulatory framework were deemed relevant but most critical seem to be partnerships with multiple stakeholders from the private and public sector and from civil society because these will bring in local knowledge, leverage and human and infrastructural resources. With these capabilities a multi stakeholder partnership can influence the creation of an enabling environment for technology transfer.

A further overall conclusion is that effective technology transfer to developing countries is hampered by limited access to knowledge and the proprietary nature of technologies (IPRs). The development of a much more open innovation structure could facilitate participation from developing countries. One part of such a strategy could be the creation of a global ‘Knowledge Fund’, an idea developed by Lynn Mytelka (2007) “as a “repository of patents dealing with technologies that are critical to the fundamental needs for food, drugs and environmentally sound technologies in developing countries” (Mytelka, 2007). Financial resources should also be put into the fund to ensure that appropriate local capabilities are developed in enterprises, knowledge institutes and the public sector in developing countries to make sure that when patents are being utilized also the tacit knowledge required to work these patents in a local context is transferred (Mytelka, 2007). While the ‘Knowledge Fund’ is basically designed as a global organization, national and regional knowledge centers could play a key role in facilitating the further application and diffusion of the knowledge, skills, engineering practices and technologies to local entrepreneurs, firms and other relevant stakeholders.

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