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**Transfer of Low-Carbon Technology under the United  
Nations Framework Convention on Climate Change:  
The Case of the Global Environment Facility and its  
Market Transformation Approach in India**

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A thesis submitted in March 2010 in partial fulfilment of the requirements  
for the degree of

*Doctor of Philosophy*

**SPRU - Science and Technology Policy Research**

**University of Sussex**

I hereby declare that this thesis has not been, and will not be, submitted in whole or in part to another University for the award of any other degree.

**Signature:** .....  
Rüdiger Haum

**Title:**

Transfer of Low-Carbon Technology under the United Nations Framework Convention on Climate Change: The Case of the Global Environment Facility and its Market Transformation Approach in India

**Summary:**

The transfer of low-carbon technology to developing countries is one of the key means to reduce greenhouse gas emissions in developing countries and therefore a key aspect of the United Nations Framework Convention on Climate Change (UNFCCC). This thesis aims to contribute to the understanding of international low-carbon technology transfer and how it might do justice to the interest of developed and developing countries. The empirical example is the technology transfer approach and its implementation by the Global Environmental Facility, which acts as the financial mechanism of the UNFCCC.

My theoretical framework includes two sets of theories. The first includes theories of international technology transfer. This set explains how international technology transfer may lead to economic benefits on the side of the technology recipient. This theory, however, does not explain how international technology transfer will lead to significant environmental benefits. I therefore included a second set of theories in my theoretical framework. Theories of diffusion of environmental technologies explain how technology might achieve environmental benefits such as the reduction of greenhouse gas emissions in developing countries.

A case study was chosen as method. In order to do justice to the research question, the empirical enquiry takes place on three interconnected levels. On the first level, the positions of developed and developing countries on the subject of technology transfer under UNFCCC were established. These serve as additional yardsticks for the discussion of the GEF approach and its outcomes. On the second level, the technology transfer approach of the GEF and the relationship to GEF and UNFCCC on the subject on technology transfer was established. On the third level, the GEF project Photovoltaic Market Transformation Initiative (PVMTI) in India, which follows the GEF approach to technology transfer, was investigated.

The thesis concludes, in relation to the research question, that the current GEF approach to technology transfer is unlikely to achieve the goals of both developed and developing countries. It is able to achieve the goals of developed countries as it tends to prioritise the environmental goals through selected demand side measures that are effective in achieving emission reductions. It is less effective in achieving development goals as international technology transfer is left to the private actor.

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Rüdiger Haum  
Brighton, March 2010

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## *List of Abbreviations*

AIJ	Activities Implemented Jointly
AOSIS	Alliance of Small Island States
a-Si	Amorphous Silicon
BHEL	Bhahrat Heavy Electrical Limited
BOS	Balance of Systems
C	Carbon
CBD	Convention of Biological Diversity
CDM	Clean Development Mechanism
CdTe	Cadmium Telluride
CEL	Central Electronics Limited
CIS or CIGS	Copper Indium (Gallium) Selenide
CO <sub>2</sub>	Carbon Dioxide
COP	Conference of the Parties
EGTT	Expert Group on Technology Transfer
EITs	Economies in Transition
EST	Environmentally Sound Technology
EU	European Union
FDI	Foreign Direct Investment
GEF	Global Environment Facility
GHG	Greenhouse Gases
IA	Implementing Agency
IFC	International Finance Corporation
IMF	International Monetary Fund
INC	Intergovernmental Negotiating Committee
IPCC	Intergovernmental Panel on Climate Change
IPR	Intellectual Property Rights
JI	Joint Implementation
KREDL	Karnataka Renewable Energy Limited
kW	Kilowatt
kWP	Kilowatt Peak
MEA	Multilateral Environmental Agreement
MNES	Ministry of Non-conventional Energy Sources
MoU	Memorandum of Understanding
MT	Market Transformation
MW	Megawatt
NEDCAP	Non-Conventional Energy Development Corporation of Andrah Pradesh
NGO	Non-Governmental Organisation
OECD	Organisation for Economic Cooperation and Development
OP	Operational Programs

OPS	Overall Performance Study
OS	Operational Strategy
PV	Photovoltaic
PVMTI	Photovoltaic Market Transformation Initiative
R&D	Research and Development
RE	Renewable Energy
REEEP	Renewable Energy and Energy Efficiency Partnership
SBI	Subsidiary Body for Implementation
SBSTA	Subsidiary Body for Scientific and Technological Advice
SHS	Solar Home Systems
SPP	Solar Photovoltaic Programme
STAP	Science and Technology Advisory Panel
TA	Technical assistance
TAB	Technology Assessment Panel
TT	Technology Transfer
TTF	Technology Transfer Framework
UK	United Kingdom
UNCBD	United Nations Convention on Biological Diversity
UNCCD	United Nations Convention to Combat Desertification
UNCTC	United Nations Centre on Transnational Corporations
UNDP	United Nations Development Program
UNEP	United Nations Environment Program
UNFCCC	United Nations Framework Convention on Climate Change
US	United States of America
W	Watt
WB	World Bank
WEBREDA	West Bengal Renewable Energy Development Agency
Wp	Watt Peak
WTO	World Trade Organisation



# 1 Introduction

The Global Environment Facility (GEF) is the financial mechanism of the United Nations Framework Convention on Climate Change (UNFCCC) and supports international technology transfer. The aim of this thesis is to better understand how far the GEF activities, with regard to international technology transfer, fulfil the interests of developed and developing countries' governments as expressed under the UNFCCC.

As I will explain in more detail in chapter 2, developed and developing countries' governments pursue differing goals with regard to international technology transfer under the UNFCCC: developed countries primarily aim to achieve green house gas emission reductions while developing countries primarily aim for economic benefits through access to technology.

The following introduction is organised in three parts to introduce the reader in more detail to the specific context of my research interest and to develop my research question. It will, firstly, situate the thesis within the context of international environmental policy and international technology transfer. Secondly, more information will be given on the United Nations Framework Convention on Climate Change and the Global Environment Facility. Thirdly, the research question as well as the structure of the thesis will be explained.

## 1.1 International Environmental Policy and Technology

The development of new and the diffusion of existing technologies are widely considered to partly alleviate the environmental problem of climate change through their potential to reduce the emission of greenhouse gases (GHG). The international transfer of relevant technologies to industrialising and developing countries is an important part of this endeavour, as their GHG emissions already constitute a significant part of current emissions, which are also expected to grow (IEA 2008). Technologies reducing GHG emissions have been labelled as 'climate-friendly' or 'low-carbon' technologies (in those cases in which they aim at the reduction or substitution of carbon dioxide (CO<sub>2</sub>) emissions) (German Advisory Council on Global Change 2009; Ockwell, Watson, McKerron et al. 2008).

The importance of international technology transfer in solving climate change is reflected in the integration of a number of articles stipulating technology transfer within the United Nations Framework Convention on Climate Change (UNFCCC) and has been underlined in various policy and academic texts. Despite the importance of the subject to climate negotiations to the solution of the climate problem, and a number of decisions under the UNFCCC, the negotiations have been protracted and have not led to a substantial transfer of low-carbon

technologies under the UNFCCC in practice (Verolme 2006; Murphy, Ham, and Drexhage 2005; Pachauri 2000; Ravindranath and Sathaye 2002).

One reason for the impasse in UNFCCC negotiations is that there are considerable differences in perspective concerning how to implement technology transfer activity. Developed and developing countries disagree about ways through which technology transfer can be best implemented (Wagner 2007). While negotiations on the UNFCCC level on the subject of technology transfer are proceeding, the Global Environment Facility (GEF) is transferring climate-friendly technology in its role as the financial mechanism of the UNFCCC (Dixon 2008).

## **1.2 Developed and developing country perspectives on development and environment**

The historical controversies between developed and developing countries concerning international technology transfer inform current debates on the subject of international environmental negotiations. Therefore, a brief historical overview is useful in order to contextualise contemporary debates under the UNFCCC.

In the aftermath of World War II and the 1960 and 1970s, developing countries felt unfairly excluded from the existing technology stock due to what they considered as the purely profit-maximising and monopolistic behaviour of the technology owners these being mostly multinational corporations. They considered technology to belong to humankind and negotiated within various international conferences for conditions under which they could have access to more technology at non-market prices. Technology should be transferred rapidly in mechanisms other than market-mediated transactions.

During 1970s, developing countries asked developed countries through the United Nations Conference on Trade and Development for the establishment of a new international economic order to replace the existing Bretton Woods system, as well as a revision of the practised rules of trade, which they considered inefficient in promoting their economic and development goals. Increased and altered conditions for international technology transfer were part of developing countries' demands. They were expressed in part with the aim of establishing an international code of conduct on the transfer of technology.

Developed countries considered technology to be a commodity, costly to develop and privately owned, and markets to be the optimal mechanism to determine the supply and demand of technology (Fan 1985; Tauber 1974). Although developed countries, in principle, did not question the need of developing countries to develop further and improve their economic conditions, their ideas concerning how to achieve development differed considerably. The

different perspectives on how to achieve development can be summarised in four groups: no re-design of existing institutions, even stronger promotion of existing rules of free trade (US and UK), modest re-design of institutions (EU), and significant re-design of institutions (developing nations) (Missbach 1999).<sup>1</sup>

Negotiations to improve the institutional conditions for international technology transfer were, however, generally fruitless. The issue of a new international economic order completely disappeared from the North-South agenda with the beginning of a severe economic and debt crisis of developing countries in the early 1980s (Patel, Roffe, and Yusef 2000; Missbach 1999).

### **1.2.1 Environment**

The issue of the environment was also on the developed/developing country agenda during the 1970s, although it was more in the form of developed countries pressing developing countries to solve their environmental problems. Developed countries, however, rejected any cooperation on the grounds that they needed to grow economically. It was not until the late 1980s, the publication of the Brundtland report and the establishment of the World Commission on Environment and Development, that the issue of economic development in developing countries re-emerged in relation to transboundary environmental problems (Glasbergen and Blowers 1995). The Brundtland report stated in moderate terms that the existing economic order kept developing countries in poverty, which contributed to their environmental problems. Limited international economic regulation was considered one reason for preventing poor countries from developing, and therefore from cleaning up their environmental problems. The report mentioned trade, transnational companies, development aid, and international technology transfer in particular. Although the old claims brought forward during the discussions around a new international economic order were only vaguely reflected in the Brundtland report, developing countries were open to discussing the associated term of sustainable development. From then on, developing countries integrated their economic concerns into negotiations about the environment (Missbach 1999; Porter and Brown 1991).

Although developing countries have not necessarily acted collectively with regard to global environmental problems, the literature on international environmental policy has identified a number of common positions that have re-emerged over the past 20 years during climate change

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<sup>1</sup> As an example, at a 1979 a world conference on science, technology and development held in Vienna, developing countries demanded that science and technology be considered part of the common cultural heritage of humankind in order to declare them as a legal basis for a more just regulation of access to both. To increase the technological capacities of the South, developing countries proposed a sectoral financial system that should undertake technology transfer on a continuing basis independent of donor decisions financed by developed nations. The negotiations resulted in the foundation of three institutions which remained insignificant. The South abandoned its initial demands over time, and negotiations stagnated and ultimately stopped in 1985.



negotiations. They can be summarised as follows: 1) developed countries are the cause of international environmental problems, 2) solving environmental problems shall not interfere with developmental goals of developing countries, 3) technology transfer at non-commercial terms is a condition for the application of clean technologies in developing countries, 4) more development aid is necessary to implement environmental protection measures (Missbach 1999; Najam, Huq, and Sokona 2003; Linner and Jacob 2005).

### **1.3 The United Nations Framework Convention on Climate Change, international technology transfer and the Global Environment Facility.**

The UNFCCC came into force in 1994. The main goal of the Convention is the reduction of greenhouse gas (GHG) emissions (UNFCCC 2002). The Convention stipulates that the reduction of greenhouse gas emissions in developing countries depends on support by developed countries, which may include the prior transfer of adequate financial means and technology.<sup>2</sup> The prospective access to technology was one incentive to make developing countries participate in the UNFCCC as the problem of climate change has been historically predominantly caused by industrialised countries (Grubb, Vrolijk, and Brack 2001; Ravindranath and Sathaye 2002; Gupta 1997). Developing countries' interests include the acquisition of proven, environmentally-sound technologies to confront the causes and the effects of climate change. Developed countries do acknowledge the need for such transfers, but they are reluctant to actually fund them (Ravindranath and Sathaye 2002).<sup>3</sup> In a more slightly radical framing, Roberts and Parks claim that developing countries have seen North-South cooperation in the field of environment as a means to liberate themselves from their perceived technological dependency on developed countries by means of technology transfer (Roberts and Parks 2007).

The Global Environment Facility was founded in 1991 with its role to financially support environmental protection efforts taking place in developing countries in the fields of climate change, biodiversity, pollution of international waters, and ozone depletion (Jordan 1994: 265). The GEF was assigned the role of financial mechanism to the UNFCCC in 1994, firstly on an interim basis, by Article 21 of the UNFCCC. In 1998, the Conference of the Parties (COP) to the UNFCCC decided to make the GEF the permanent financial mechanism to the convention. Supporting the international transfer of technology is part of the GEF duties to the convention.

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<sup>2</sup> For a discussion of the relevant paragraphs see chapter 4.1.2

<sup>3</sup> A number of commentators have pointed out that interests between states vary considerably and one cannot speak of unified developed and developing country positions within the more general climate change negotiations. At best, there are smaller actor groups sharing common goals (Depledge 2006). Missbach, however, claims that the issue of technology transfer is an exception (Missbach 1999: 266).

While negotiations on the UNFCCC level on the subject of technology transfer are proceeding without substantial agreements on the implementation of international technology transfer, the Global Environment Facility (GEF) is transferring climate-friendly technology in its role as the financial mechanism of the UNFCCC (Dixon 2008).

## **1.4 Research Question**

The research question is located in the context presented above. Considering the historical controversies over technology that seem to be perpetuated beneath the UNFCCC, it becomes not only fascinating but also urgent to better understand how far the GEF might do justice to the goals of both developed and developing countries with regard to international technology transfer.

The GEF's support of transfer of technology is unsurprising. Even before it was assigned the role of financial mechanism to UNFCCC, the GEF hosted a large, mostly technology-based climate change project program portfolio. It is rather surprising, however, that the GEF claims to transfer technology in its function as the financial mechanism to the climate convention because the parties to the convention have never reached an agreement on how to transfer technology that was also put into practice.

If the GEF claims to support the transfer of technology by the UNFCCC, a number of interesting questions arise. Firstly, how does the GEF conceptualise and implement technology transfer? Secondly, what are the outcomes of GEF technology transfer activity? And thirdly, how do these results relate to the goals of negotiating parties and any international technology transfer policy developed under the UNFCCC? Although parties to the UNFCCC have not agreed on the implementation of international technology transfer, a substantial body of UNFCCC documents and decisions relate to the question of international technology transfer.

In order to answer these questions, this thesis seeks to answer the following overarching research question:

To what extent does the Global Environment Facility approach to international technology transfer support the goals of developed and developing countries regarding international technology transfer under the UNFCCC?

This question is strongly evaluative and comparative in nature. It requires an understanding of the GEF approach to international technology transfer and its comparison to positions and policy under the UNFCCC. It also requires evaluating in how far the GEF approach matches positions and policy under the UNFCCC. The question furthermore requires explaining why the GEF approach supports or does not support the goals of developed and developing countries.

The focus is therefore on the design and the outcome of the GEF international technology transfer approach, its implementation and a discussion of how far both match requirements of technology transfer as articulated under the UNFCCC. The thesis does not primarily explain why the GEF operates in a certain way. It also does not, in detail, seek to explain how and why UNFCCC and GEF international technology transfer policy agendas emerged.<sup>4</sup>

This thesis is organised as follows:

*Chapter two* includes a literature review of the subject of international technology transfer under the UNFCCC and develops a theoretical framework to discuss, evaluate and compare international technology transfer policy and its implementation by the UNFCCC and the GEF.

As the literature review will show, very little research to date exists that investigates the positions of developed and developing countries on international technology transfer under the UNFCCC in detail. Therefore, a brief empirical analysis of country positions was conducted. It shows that the primary goal of governments of developed countries is to achieve environmental benefits in form of the reduction of greenhouse gas emissions. It also shows that the primary goal of governments of developing countries is to achieve economic benefits through access to technology. This is a very important step, as it qualifies the goals of developing and developed countries in more detail. The clear qualification of goals is an important condition of the discussion and evaluation of UNFCCC policy as well as the GEF approach to international technology transfer.

I then develop a theoretical framework based on theories that explain how international technology transfer may achieve environmental and economic benefits. This framework allows me to single out key elements in achieving economic and environmental benefits through international technology transfer. Having identified these key elements, I will be able to draw conclusions on how international technology transfer policy should be designed to achieve environmental and economic benefits. It will be used to discuss technology transfer policy under the UNFCCC, the GEF approach to technology transfer as well as the results of GEF project in India (chapters 4, 5, and 6). The theoretical framework will allow me to draw conclusion about how suitable the GEF approach to international technology is to achieve the goals of developed (environmental benefits) and developing countries' governments (economic benefits) in relation to international technology transfer under the UNFCCC. The theoretical framework will also allow me by differentiating between international technology for environmental and economic benefits to distinguish between differing notions of international technology transfer amongst different actor groups.

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<sup>4</sup> Only some understanding of the history of the GEF approach and the role of UNFCCC guidance is necessary as background information.

*Chapter three* introduces the chosen method to ‘operationalise’ the theoretical framework to answer the research questions and further explains the design of the case study conducted in chapters four, five and six. This step is important for answering the research question because it establishes

*Chapter four* analyses UNFCCC documents to establish what kind of decisions have been taken and what policies have been developed with regard to international technology transfer on the UNFCCC level. This step will allow understanding whether and how country positions have been translated into some form of UNFCCC policy. This step is important for answering the research question for two reasons. Firstly, it will allow me to understand whether any policy exists that may guide the GEF on international technology transfer. Secondly, it will allow understanding in how far any UNFCCC policy that might give guidance to the GEF is suitable to achieve environmental and economic benefits through international technology transfer in the first place.

*Chapter five* investigates the GEF approach to international technology transfer for low-carbon technologies and the role of the UNFCCC in its development and implementation. This step will be important in answering the research question as it provides an understanding of the GEF approach to international technology transfer and what role the UNFCCC played in its development. The theoretical discussion will allow me to formulate some assumption about the suitability of the GEF approach to international technology transfer to achieve environmental and economic benefits.

*Chapter six* investigates the Photovoltaic Market Transformation Initiative (PVMTI) as an example of a project that is designed and implemented according to the GEF approach. In order to gain a deeper understanding of the PVMTI projects and their results in relation to technology transfer, I compare it to an Indian government program, which pursued similar goals, and place it in the context of the Indian Photovoltaic Industry and its technology transfer activities. Chapters four to six are all in the context of my theoretical framework. The empirical investigation will allow me to empirically support and refine the assumptions about the GEF approach to international technology transfer and its suitability to achieve developed and developing countries’ government goals.

*Chapter seven* answers the research question, abstracts the theoretical and methodological lessons from the cases, provides a summary of the contributions of the dissertation, discusses the main conclusions, and provides recommendations for further research.

## **2 Theories of technology transfer and diffusion**

As seen in the introduction, developed and developing countries often have potentially incompatible goals in relation to international environmental policy. While developed countries predominantly use multilateral environmental agreements to pursue solutions to environmental problems, developing countries additionally pursue economic development goals.

In the following, firstly further investigate the positions of developed and developing countries' governments on international technology transfer under the UNFCCC. As the existing literature did not provide any detailed information, I conducted a UNFCCC document analysis. The document analysis underlined that developed countries' governments aim to achieve primarily environmental benefits through international technology transfer while developing countries' governments aim to achieve economic benefits. Building on this results, I will outline and compare two sets of theories that explain how both goals might be achieved in relation to technology transfer and climate change. Finally, I will develop a theoretical framework that includes the core elements of international technology transfer for economic and environmental benefits. This framework will allow me to map differences in policy with regard to international technology transfer on the UNFCCC and GEF levels, and to formulate assumptions whether and how a certain policy might be able either or both goals. It will also allow me to draw some conclusions on how international technology transfer should be designed in order to achieve both goals. The framework will serve as a backdrop for the discussion of UNFCCC decisions as well as GEF policy and the implementation of GEF policy in the empirical chapters 4, 5, and 6.

Technology and its proper social embedding hold the potential to support economic development and to mitigate climate change in developing countries. The first goal might be achieved through international technology transfer. It may contribute to the economic development of a developing country by expanding the country's industrial base. Development economists therefore interpret successful international technology transfer as the economically productive application of imported technology (Amsden 2002).

Technology and its proper social embedding might also achieve GHG emission reductions. However, emissions are not reduced through the productive application of technologies but rather through the diffusion of an environmentally benign technology within a country. The overall amount of emissions reduced is a function of the level of the operating effectiveness of a

specific installation of technology and the number of applications relative to emissions from the alternative not-used technology (Kemp 1997).<sup>5</sup>

As the two references above already indicate, different processes seem to achieve each goal. If that is the case, the next question is the extent to which these processes have similarities and differences. Understanding the essence of both processes – their commonalities, and their tensions – is vital for designing policy aiming to achieve both goals.

In the following chapter, I will discuss both processes separately and then compare their differences and similarities. I have three interrelated reasons for doing so. Firstly, despite possible similarities, a number of elements of the processes might differ. Secondly, if some aspects of technology transfer and diffusion differ, the desired outcomes of both processes might be achieved through different rather than identical policy interventions. In other words, policy interventions like GEF technology transfer programs might need differing designs depending on which goal they want to achieve – or an integrated design in the case that they want to achieve both.

Thirdly, in the case that only limited resources are available, some ‘trade-offs’ may have to be made. Differing goals need differing support, and thus different policies. Any policy intervention to support or facilitate should take into consideration the differences in the two processes underlying these goals and design policy instruments accordingly.

Rendering two sets of very complex and interdisciplinary bodies of theoretical work has to be undertaken with broad strokes and by comparing the main features of both processes. Naturally, a comparative perspective within the limited scope of a strongly empirical doctoral dissertation comes at the price of neglecting some of the details and fine ramifications of both theories. Understanding the main elements of both theories, however, is the basic condition to critically investigate the political discussions on the subject of technology transfer.

The remainder of the chapter is organised accordingly: I will begin by discussing the process of international technology transfer. Next, I will discuss the process of diffusion of low-carbon technology. Finally, I will compare both processes and discuss their implications for my research.

## **2.1 An alternative theoretical approach: Ecological Modernisation**

Choosing technology transfer and technology diffusion as a theoretical framework might seem unusual as my empirical research subjects are institutions of environmental policy and an

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<sup>5</sup> Effectiveness in this context relates to the technical efficiency of a technology (e.g. the efficiency of a photovoltaic cell) and the way it is operated (e.g. properly maintained etc.).

instance of its application: the UNFCCC as an environmental regime is in charge of policy formulation, the GEF as a hybrid of environmental administration and finance mechanisms, and finally the PVMTI project as the implementation of policy. Drawing on an environmental policy-related framework seems to suggest itself. Especially suitable are theories of ecological modernisation. Ecological modernisation theory aims to describe processes which not only alleviate the antagonism between economic production and environmental destruction, but also create synergies and economic benefits from environmental protection (Huber 2008). The key to achieve this integration is innovation (Mol 1995; Huber 2000; Jänicke 1997). One particular strand of ecological modernisation theory is explicitly concerned with the design of environmental policy leading to the integration of economic and environmental benefits through innovation (Jänicke 2008). The case of technology transfer under the UNFCCC would be a likely case to discuss in relation to ecological modernisation as its aims and means correspond to the theory's main subjects: achieving environmental (GHG emission reductions) and economic (development in developing countries) goals through innovation (technology transfer). Ecological modernisation, however, was not considered as it does not include a theory of technological change (Murphy and Gouldson 2000) and is therefore is not able to draw attention to the differences between transfer and diffusion.

## **2.2 Literature review on technology transfer under the UNFCCC**

The literature on technology transfer in relation to the UNFCCC can be divided into three sets. The first set provides overviews of specific measures and modes of technology transfer that could be used to transfer technology under the UNFCCC (Newell 2008; Ott, Curtius, and Maroulis 2008). The second set of studies defines criteria for successful technology transfer of climate technology based on non-UNFCCC-related transfer of environmentally-friendly technologies. They bear relevance to a discussion of international technology transfer but, as they are very limited in depth and scope, they cannot replace a comprehensive and more general discussion of the terms (Ramanathan 2002; Kathuria 2002; Ott, Curtius, and Maroulis 2008). The third set of studies investigates whether and how a specific mechanism might contribute to the international transfer of climate technology (Forsyth 2007; Forsyth 2005). The third set includes a growing set of evaluation studies in relation to technology transfer and the clean development mechanism (CDM). All three sets are of some relevance for my purposes but contribute only very little in explaining the processes of technology transfer and technology diffusion.

There is also a large set of literature attempting to understand the difficulties in and the requirements for transferring climate-friendly technologies in general (Martinot, Sinton, and

Haddad 1997; UNEP 2003). This particular set of literature comprises a large number of project evaluations, case studies, case study compilations, and attempts to synthesize the case study literature. This set of studies has a strong focus on project evaluation and tends to focus on deriving practical development policy recommendations and lessons for project design. The relevant parts of this set will be included in the chapter on the GEF and its market transformation approach.

### **2.2.1 The positions of the parties to the convention**

Although few academic studies exist, a large number of NGO publications as well as publications from the grey literature state that the largest differences on the subject of technology transfer exist between developed and developing countries (Bazilian et al. 2008).

More than 120 countries send representatives to UNFCCC negotiations, and one should be careful in identifying common interests among their governments especially within the very diverse groups of developed and developing countries. By speaking about developed or developing countries' common interests, I do acknowledge that those might be common only at the highest, most aggregate level. Nevertheless, I still think that it is justified to make general assumptions about developed and developing countries' interests on technology transfer within climate change.<sup>6</sup>

*De facto*, one can observe several main actors, some of them groups of states, trying to build common positions on various subjects including technology transfer and leading negotiations (Depledge 2006). At the same time, several authors have underlined that the notion of "developing countries" as a coalition seeking to advance shared norms and interests might be misleading in a number of fields of international relations, but that it has an empirically justified relevance in the case of international environmental politics (Williams 2005). Further empirical evidence that would support the assumption that developing countries act as a group is given by Kasa et al. through their empirical analysis of the negotiation practice of the G77<sup>7</sup> at UNFCCC negotiations. Although Kasa et al. note in increasing economic heterogeneity among G77 members, especially through the economic advances of China, India, and Brazil, and increasing bilateral negotiations of these countries on climate issues, they do not observe deviations from G77 positions within UNFCCC negotiations. The authors explain their observations mainly

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<sup>6</sup> A good example is the view of developing countries on the Expert Group on Technology Transfer introduced later in the text. Different views are exchanged about the effectiveness of the group and in what form it should continue. But even those countries satisfied with the group are in accord with the others that provisions for technology transfer in general, and administered through the group are still inadequate (FCCC/SBSTA/2006/MISC.10/Add.1; FCCC/SBSTA/2006/MISC.10).

<sup>7</sup> The Group of 77 (G77) is the largest intergovernmental organisation of developing countries under the UN. It was established in 1964 and aims to promote the collective economic interests of the group members (<http://www.g77.org>).



with the usefulness for maintaining G77 positions to avoid emission reduction commitments (Kasa, Gullberg, and Heggelund 2008).

Industrialised and developing country governments have both similar as well as diverging positions within and between their respective country groups. However, it is my argument that despite any differences between individual country positions, there are overarching, common positions within the group of industrialised countries that are not found within the group of developing countries, and vice versa.

In the following, I will briefly summarise the differing positions of parties regarding technology transfer as presented in the secondary literature for the negotiations leading to the UNFCCC. Since no academic literature on the positions of parties after the implementation of the UNFCCC exists, I will conduct an analysis myself.

The topic of technology transfer is addressed briefly in various studies on the UNFCCC, and has been characterised as being controversial between developed and developing countries from the beginning of climate negotiations onwards. According to the existing literature, the developing countries' interest is to receive proven, environmentally-sound technologies to confront the causes and the effects of climate change, and to support sustainable economic development within their respective country. The prospective access to technology was one incentive to make developing countries participate in the UNFCCC (Gupta 1997: 88, Ravindranath/ and Sathaye 2002: 253, Grubb et al 2001).<sup>8</sup> Developed countries do acknowledge the need for such transfers, but they are reluctant to actually fund the transfer of low-carbon technologies in any possible form. According to Ravindranath and Sathaye, this reluctance is based on the fear that transfer on non-commercial terms could threaten the industries (situated in developed countries) owning such technology (Ravindranath and Sathaye 2002: 6).

According to a number of authors, negotiations regarding technology transfer within the UNFCCC mirror older conflicts on how to best transfer technology from North to South from discussions concerning the re-establishment of the international economic system during the 1970s. Industrialised countries emphasized in that time the establishment of markets and commercial transactions, developing countries aimed for interventionist regulatory mechanisms to address economic inequality through re-distribution (Missbach 1999; Roberts and Parks 2007).

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<sup>8</sup> This is certainly not the case for participating small island states because they are immediately threatened by rising sea levels. Developing countries do not always act as a single group during negotiations, but have different interests. Including provisions for technology transfer as incentives to ratify and comply to multilateral environmental agreements is a noticeable trend within international environmental policy (Neumayer 2002).

### **2.2.2 Country positions in pre-UNFCCC negotiations**

The literature on the pre-convention negotiations mentions the question of technology transfer as one of the main contentious subjects between negotiating parties, but does not go much into the details and evolution of the conflict.

Oberthür identifies two, and Breitmeier three main conflicts between negotiating parties.

According to Oberthür, the main conflicts related to the limitations of CO<sub>2</sub> emissions and the transfer of resources from North to South to support developing countries confronting climate change and fulfilling the obligations deriving from signing the convention (GHG inventories and communications to UNFCCC) (Oberthür 1993). Breitmeier names the differing valuation of existing knowledge about the causes and consequences of climate change, the reduction of GHG, and the funding of technology transfer to developing countries as the main conflicts between negotiating parties (Breitmeier 1996). Forsyth claims that technology transfer was the “most long-standing and deep seated” conflict in the negotiations (Forsyth 1998). According to Gupta, the perspective of developing countries on technology transfer did not gain adequate prominence during the negotiations leading to the UNFCCC or soon afterwards (Gupta 1997: 144).

During pre-UNFCCC negotiations, the United States of America was generally opposed to additional financial resources for developing countries but supported the idea of technology transfer to facilitate research and the education of scientific staff. Germany circulated the notion that industrial countries should grant developing countries adequate and additional resources to meet the obligations deriving from the ratification of the convention. All industrialised countries agreed that the provision of any financial means should take place within an existing mechanism (Breitmeier 1996: 200). Oberthür points out that the USA also held the position that any transfer of technology should be on purely commercial, market-based terms. Developing countries demanded support from industrialised countries to address the causes and consequences of climate change already before the negotiations. During pre-UNFCCC negotiations, the Alliance of Small Island States (AOSIS) were pledged new, additional and appropriate financial resources as well as transfer of technology to “fair and most favourable terms” meaning that cost should be borne by developed countries. China and India held similar positions and favoured the “non-commercial” transfer of technologies. The position of the EU can be summarised as arguing for the appropriate transfer of technologies and the financial means to support developing countries. No position of the USSR or Arabic OPEC members is mentioned. Towards the end of the negotiations the G77 took a position that emphasised the importance of additional finance and technology transfer even more (Breitmeier 1996, Oberthür 1993: 38-45). No systematic literature on the development of the positions on technology transfer since the adoption of the UNFCCC exists to my knowledge.

### 2.2.3 UNFCCC document analysis

Official UNFCCC documents give insight into country positions. In order to establish the positions of different countries and country groups, submissions on the topic of technology transfer were analysed at two periods in time. Periods rather than fixed dates for submissions were chosen as country submissions are somewhat irregular, and not all of them, concerning technology transfer, take place at the same time. The first period, 1998 – 2000, is before and after COP4 when the Buenos Aires Action Plan was adopted, in which technology transfer featured prominently. The second period is between 2006 and 2008, before and after the adoption of the Bali Action Plan, which again very prominently featured the issue of technology transfer. From a methodological perspective it has to be underlined that not all parties to the UNFCCC have made submissions on the subject. Hence, what is summarised are positions of developed and developing countries as expressed under the UNFCCC.

The analysis of the country submissions asked two questions: (1) What goals of technology transfer are stated within submissions? (2) What mechanisms are suggested to achieve stated goals? To answer the questions, statements within country submissions directly related to technology transfer were considered.

Not all submissions were considered. Those left out made no reference to the questions despite addressing technology transfer more generally. Sometimes the statements were so general that a position on the controversial issues could not be discerned. An example for this is the statement of Georgia, which states: “Along with the transfer of ecologically-sound technologies and know-how from developed countries to developing countries, a possibility is to be provided for the implementation of advanced and competitive technologies and know-how elaborated in developing countries themselves.” (FCCC/CP/1998/MISC.5: 8).

As submissions from the first period were generally shorter and less complex, I have discussed them in summary. Relevant quotes on which the discussion is based are found in the appendix. For the second period, I have put country positions in a table. The quotes on which the table is based are also found in the appendix.

#### 2.2.3.1 First period: 1998 to 2000

*Positions of Annex II countries (developed countries obliged to support developing countries under the UNFCCC)*

During the first period, statements regarding technology transfer were short and the positions of developed countries were extremely similar. The private sector was considered as the main agent to support technology transfer and the role of the government was confined to facilitate private investment. The means that should be employed to facilitate investment are similar in all

submissions: the set-up of legal and policy frameworks that support private investments. Some states speak of enabling environments, but leave open whether the term has the same meaning as under the UNFCCC. All submissions assign a similar hierarchy to private and public actors. Private investors are most important to transfer technology, while public actors are most important in giving incentives to private actors' technology transfer activity. Means suggested are: building legal, institutional and policy frameworks (Australia), establishing enabling environments (Canada), developing "an appropriate mix of instruments that will accelerate the process and encourage the industry to initiate its own improvement programs" (Norway), removing market barriers and building human capacity, enabling environments (USA), and establishing legal and policy frameworks (Norway on behalf of the EU). No submission mentions any goals associated with technology transfer (relevant quotes and references to country submissions are found in appendix A).

*Positions of Non-Annex I countries (developing countries)*

Developing countries do not dismiss the role of private and other actors, but consider governments to be the main actors in transferring technology. Technology transfer in their view should not take place at market rates, but should be supported financially by developed country governments, and be a direct result of government activity. Some countries also stress that specific country needs should be established and considered.

As means, they mention grants and concessions (China), full funding (Lebanon). As goals they mention appreciable impact both in environmental and socio-economic terms, development (Columbia), technology should be integrated into the recipient nation's economy, local technology base (South Africa), capacity building available in recipient countries to absorb the technology in the national system (Mauritius), private technologies shall be bought with public funds and transferred (Samoa on behalf of the Alliance of Small Island States).

China has submitted the most upfront proposition on behalf the G77 on how to implement technology transfer under the UNFCCC. It includes the suggestion that Annex II parties compile a list with relevant technologies while non-Annex II parties assess their needs. All parties then create enabling environments to stimulate private investment while simultaneously setting up a technology transfer mechanism, which assists developing countries in receiving environmentally-sound technology at preferential terms.

### **2.2.3.2 Second period: 2006 – 2008**

From 2006 to 2008, more countries made submissions on technology transfer to the UNFCCC than previously. All Annex-II countries have made submissions (the EU speaks under the UNFCCC for all EU member states) so we can state that we have an adequate sample of

developed country positions. Fourteen countries from the group of Non-Annex I countries have made submissions. All of these except South Korea are members of the G77. As China has additionally made a submission on behalf of the G77, we can assume to have an adequate sample of the position of developing countries. Table 6 summarises the suggestions for how to implement technology transfer under the UNFCCC. Relevant quotes from the country submissions are listed in appendix A to the thesis.

**Table 1: Annex II and Non-Annex I Country positions on technology transfer**

	Existing Mechanism	New Mechanism	Enabling Environments	Fund	Private Public Cooperation	Markets/ Private Investment	Public Intervention	Market rates	No cost/ Subsidised Rates	Joint Technology Development	R&D	Market based instruments	Voluntary Technology Agreement	IPR Protection/ Strengthening	IPR Buy out/ Loosening	Technology Centres	Forced Licencing	Incentives Private	Technical Training	Technology Demonstration	Innovation	Adaptation	Local Production
<b>Annex II</b>																							
Australia						X					X	X		X									
Canada	X		X			X						X											
EU	X		X			X	X				X		X										
Iceland						X						X											
Japan	X		X		X	X					X			X									
New Zealand	X		X				X				X	X		X									
Turkey		X		X		X						X											
USA	X		X		X	X								X									
<b>Non-Annex I</b>																							
Antigua and Baruda	Same as China																						
AOSIS			X				X		X		X				X	X							
Argentina		X	X	X			X		X		X				X		X				X	X	
Bolivia		X	X	X											X								
Brazil		X					X									X							
China (+G77)		X		X			X		X		X				X		X				X	X	
Indonesia					X	X	X				X				X								
India		X		X																			
Pakistan		X													X		X						
Panama*							X																
South Africa						X	X																X
South Korea						X		X				X											
Trinidad and Tobago						X	X																
Venezuela		X													X								
*COSTA RICA, EL SALVADOR, HONDURAS, NICARAGUA, PANAMA																							

Source: Author, based on country submissions.

The table indicates quite clearly that Annex II and Non-Annex I countries continue to have considerably different ideas on how to implement technology transfer. Annex II countries aim to implement technology transfer within existing institutions, with the sole exception of Turkey, while Non-Annex-I countries favour the creation of a new mechanism. Annex II countries underline the importance of enabling environments (with the exception of Turkey and Australia). Enabling environments are usually defined in a similar manner as introduced within the UNFCCC technology transfer framework discussed in section 4.3.3 of this thesis. They are, as discussed above, a precondition for technology transfer, but not a mechanism for direct

transfer as such. Annex II countries do see enabling environment as a precondition for market-based technology transfer by private actors, which is reflected in their positions on the role of markets and the importance of public intervention within direct technology transfer. All Annex II countries underline the importance of private actor technology transfer while they make no statements regarding public interventions. The only exception is the EU. However, in the EU conception, public intervention is limited to “gaps” not covered by private investments. While supporting enabling environments is clearly some form of public intervention, it is not a form of direct support of technology transfer.

Non-Annex I countries demand a number of public measures that directly support technology transfer. The measures suggested may differ from country to country, but what they have in common is that they rely on some form of market intervention through governments. At the same time, a number of Non-Annex I countries embrace the idea of supporting enabling environments.

Another clear difference between Annex II and Non-Annex I countries is the application of market-based policy instruments (most notably in form of a global carbon market) to deliver technology transfer. A global carbon market’s primary goal is the reduction of CO<sub>2</sub> emissions, and technology transfer is left to private actors that have the option to invest in green technologies in order to raise tradeable carbon permissions. Comparable to enabling environments, technology transfer is only indirectly supported and left to the goals and strategies of private actors. Non-Annex I countries, for the most part, demand the establishment of a fund that directly supports technology transfer. The only Non-Annex I country pursuing the idea of technology transfer through market-based instruments is South Korea.

Another difference between Annex II and Non-Annex I countries is their position towards intellectual property rights (IPR). While the former demand the protection of IPR, the latter usually suggest some sort of weakening IPR or funds to buy out innovations. The idea of forced licensing<sup>9</sup> aims in a similar direction. Yet, the only topic where both country groups seem to have similar positions is R&D.

#### **2.2.4 The position of the Indian government**

As this PhD thesis empirically investigates a GEF project in India, the position of India was established in more detail through interviews with former Indian high-level government officials that had also served as negotiators to the UNFCCC.

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<sup>9</sup> Forced licensing is a measure that would require companies to license their technologies to certain developing countries.

Both interviewees underlined that technology transfer in relation to climate change and the UNFCCC is from the perspective of India more than a purely commercial transaction. Any form of technology transfer under the UNFCCC must also involve public subsidies and related financial instruments backed by developed countries. If elements of public financial support were lacking, any technology transfer was in the perspective of the Indian government not in accord with the UNFCCC. Both interviewees saw the subject of intellectual property rights (IPR) at the heart of the technology transfer debate. While both agreed that IPR should be respected, both also saw a lot of leverage in relaxing IPR. Both interviewees took the case of recent developments in intellectual property rights in relation to AIDS drugs as an illustrative example how IPR could be designed to benefit developing countries.

Both also emphasized the need to increase public research and development. One of the interviewees underlined that, in the perspective of the Indian government, compulsory licensing could be one option to accelerate technology transfer. Forced localised production of low-carbon technology (producers of low-carbon technology forced to localise production in developing countries instead of importing end-use low-carbon technology into developing countries) would lead to lowered production costs and hence to increased diffusion. Another mechanism considered important by India was a global venture capital fund that could support R&D, but also market development as well as the acquisition of licences for certain technologies from private companies. When asked to what extent the Indian position was representative of other developing countries, both interviewees underlined that India would associate with the group which includes China and the G77, but speak independently for itself.

A presentation by the highest energy advisor to the Indian Planning Commission revealed which parts of PV technology the Indian government expects to access via technology transfer under the UNFCCC: organic and polymer solar cells, new material-based thin-film solar (telluride & indium thin-film cells), solar-based regenerative fuel cells (Sethi 2006). These technologies represent state-of-the-art PV technology. If Indian firms successfully learned how to further develop and commercialise these, they would possess the technological capabilities of the most innovative PV cell producers in Germany, the US and Japan (see also chapter 2.3.4 of this thesis on PV technology).

### **2.2.5 Summary**

As seen, developed and developing countries' governments have considerably different positions on how to implement technology transfer under UNFCCC. However, they hardly ever explicitly communicate their goals regarding technology transfer to the UNFCCC secretariat. Also, despite the differences in country positions on technology transfer, country submissions are not very detailed. By considering country submissions to the UNFCCC and the suggested

measures on how to implement technology transfer, we can discern not only goals but also the ranking of goals in relation to technology transfer.

As seen above, developed countries stress the importance of enabling environments, market policy frameworks, and, in general, improvements to investment conditions for private actors. Some parties, especially the USA, speak quite openly about improving the conditions for diffusion rather than for transfer. Enabling environments focus on the demand side, but are broader in their conception, as the UNFCCC definition contains markets and policy frameworks, on the one hand, and R&D as well as institutions supporting innovation on the other. The latter two aspects possibly support technology transfer by supporting technological learning of recipient firms and increasing their absorptive capacity. This is however also indirect support, as the best absorptive capacities are of no use if there is no ensuing technology transfer.<sup>10</sup> We can therefore infer that the positions of developed countries indicate that technology transfer shall primarily support the diffusion of technology and thus environmental goals.

Developing countries favour measures that clearly and directly support technology transfer by underscoring publicly organised transfer, weakening of IPR, etc. This gives evidence to the assumption that they prioritise access to technology and the increase of technological capabilities over diffusion. Measures supporting diffusion are not dismissed but of lesser importance. We can therefore state that the positions of developing countries tend to emphasize support for access to technology and thus development goals. In terms of normative frameworks, developed countries primarily pursue environmental goals via technology transfer while developing countries pursue development goals.

This is in line with the existing literature that, for a long time, has pointed out that developed countries primarily pursue environmental goals in international environmental policy (Najam, Huq, and Sokona 2003; Missbach 1999). The result, though, draws attention to an aspect that is underplayed in the literature, which is that it does not only matter whether technology is transferred or not, and that hard and soft technology transfer has to take place, but also that the choice of instruments for supporting technology transfer reflects normative goals, and affects technology transfer outcomes accordingly.

A theory of international technology transfer for achieving both environmental and development goals does not exist. However, as we will see in the following, there is a large amount of literature explaining how technology transfer supports economic development.

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<sup>10</sup> Developed country UNFCCC submissions on the subject are too abstract to decide whether their ideas of enabling environments include measures to strengthen absorptive capacities.



### 2.3 International Technology Transfer

This section will give a more detailed description of the international technology transfer process. Most of the literature on technology transfer cited in the following is more than ten years old. The reason for relying predominantly on older literature is that I was trying to present a generic theoretical framework that was relevant to a number of technology transfer mechanisms. More recent research on international technology transfer focuses on specific mechanisms for technology transfer. There is, for example, extensive research on foreign direct investment joint ventures and on outsourcing (Ivarson and Alvstam 2005; Hobday and Rush 2007; Pack and Saggi 2001). These studies investigate how very specific mechanisms contribute to the technological learning (although not all studies use this term) of recipient firms in developing countries. Choosing one specific mechanism and related theories on how such a mechanism supports technology transfer seemed inadequate as my aim is to give a broader, open picture of participating actors and generic processes.

Framing the process of international technology transfer on a theoretical level is challenging. Reddy and Zhao state that although international technology transfer is a clearly identifiable process, there is no general theory; but, “given the inherent complexity of the subject, findings, conclusions, and contentions of what we know about international technology transfer are fragmented along various specialities” (Reddy and Zhao 1990). They group the existing literature in three categories: research on technology suppliers, research on technology recipients, and research on the transaction process itself.

Castro and Schulze identify six interacting variables that determine the outcome of transfer processes for the technology recipient: firm strategy, human resource development, type of technology acquired, industry structure, government policies, and rate of technology acquisition (Castro and Schulze 1995). In the following, I will put in the centre of my considerations the roles of the supplier and the recipient, as it is between them that the process takes place. Firms are the most important suppliers and recipients in technology transfer, although other actors might be either supplier or recipient.

Martinot et al. list 23 sets of literature (including technology innovation, development, and diffusion, international trade, technology choice and appropriate technology transfer, FDI, etc.) as relevant theoretical frameworks for the international transfer of low-carbon technology (Martinot, Sinton, and Haddad 1997). I will primarily draw on economic theory, most notably on its evolutionary variants, as well as the concepts of technological learning and technological capabilities. Nonetheless, I will also take advantage of pertinent insights from business and management literature. More recent discussions on technology transfer focus on specific mechanisms, e.g. joint ventures or specific issues of considerable relevance like intellectual property rights. More recent discussions on the contribution of technology to economic

development in developing countries take the perspective of these countries, e.g. an innovation systems perspective and discuss the particular role of technology transfer. Although results of both sets are occasionally cited in the following, my aim to reconstruct a generic process led me to use “older” literature which still focused on the broader notion of technology transfer. The application of this set of theoretical insights to low-carbon technologies is relatively recent.

### **2.3.1 Definitions and basic concepts**

In its most generic sense, the literature distinguishes between vertical and horizontal technology transfer. Vertical technology transfer occurs when knowledge is transmitted from basic research to applied research, and from there to development and production. Horizontal technology transfer takes place when knowledge used in one organisation is transferred to another organisation (Mansfield 1975). International technology transfer denotes the geographical relocation of technology from one country to another. In practice, both processes are rarely as linear, as is suggested by these definitions.

The Intergovernmental Panel on Climate Change (IPCC) defines technology transfer as encompassing “the broad set of processes that cover the flows of knowledge, experience, and equipment for mitigating and adapting to climate change among different stakeholders. These include governments, international organizations, private sector entities, financial institutions, NGOs and research and/or education institutions. It comprises the process of learning to understand, utilize, and replicate the technology, including the capacity to choose it, adapt it to local conditions, and integrate it into indigenous technologies (IPCC 2000).

I found only one definition of technology transfer within an official UNFCCC document, a definition which dates back to 1998 as part of a technical paper. It reads “the international transfer of environmentally-sound technologies and know-how can be considered as a process originating from the countries and the companies that developed and produced them to the countries and subjects that will receive and facilitate their effective implementation and dissemination. This process follows different pathways and in each case there are different entities that can intervene and influence the process” (FCCC/TP/1998/1: 5).

Fransman defines international technology transfer as a process in which “knowledge relating the transformation of inputs into outputs is acquired by entities in a country from sources outside the country” (Fransman 1985).

Miles defines international technology transfer as the “acquisition, adaptation, integration, and use of technological knowledge by a nation other than the one that developed the technology” (Miles 1999).

The UNCTAD draft International Code on the Transfer of Technology defines technology in relation to technology transfer as “systematic knowledge for the manufacture of a product, for the application of a process or for the rendering as a service” (cited in UNCTAD 2001: 5).

Maskus defines technology transfer as “shifting information across borders and its effective diffusion into recipient economies ... ranging from innovation and international marketing of technology to its absorption and imitation” (Maskus 2004).

What these definitions have in common is that they refer to technology as knowledge for the application in production processes.<sup>11</sup> This knowledge is either embodied in machinery, codified in blueprints, licences and manuals, or tacit within a person or a group (Rosenberg and Fritschak 1985).

The definitions cited above include a broad set of activities and different dimensions of the technology transfer process, but they render international technology transfer as a relatively simple passing on of knowledge from one institution to another. I want to argue in the remainder of this chapter that international technology transfer is a costly and much more complex process influenced by the goals and capabilities of technology supplier and technology recipient.

### **2.3.2 Mechanisms and actors**

The geographical relocation and application of knowledge takes place through mechanisms. Such mechanisms (sometimes called modes or channels) include foreign direct investment, sale of technology, licensing agreements, joint R&D, exchange of personnel, joint ventures, overseas development aid, etc. Mechanisms are, in practice, transactions like the sale of a machine, the explanation of how to calibrate a machine within a joint venture, the handing of a blueprint, the training of personnel etc. The mechanisms relevant for the transfer of low-carbon technology are, in principle, equal to those in which non-climate technology is transferred (Ott, Curtius, and Maroulis 2008).

There are several ways to classify the different mechanisms for technology transfer. Maskus differentiates between market and non-market channels.<sup>12</sup> Market-mediated mechanisms include sales, FDI and Joint Ventures. Non-market-mediated mechanisms include government activities, NGO activity or church activities (Maskus 2004). Lall makes a distinction between

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<sup>11</sup> A number of publications related to technology transfer use the term ‘technology cooperation’ (Ott, Curtius, and Maroulis 2008). They refer to a definition of the term suggested by Ueno who understands technology cooperation in relation to the UNFCCC as the coordination of energy and environmental policy between nation states to support the development and the diffusion of low-carbon technology. This includes joint R&D programs, as well as support in drafting and implementing national regulation to provide for the application of low-carbon technology. Following Ueno, technology transfer is a subset of technological cooperation (Ueno 2006).

<sup>12</sup> For brief explanations of the various channels, see appendix.

‘externalised’ and ‘internalised’ mechanisms. Externalised mechanisms of technology transfer include mechanisms in which the supplier relinquishes control over technology, as, for example, through sale. Internalised technology transfer includes all mechanisms in which the supplier retains formal control (fully or partly) over technology, as for example within foreign direct investment or joint ventures (Lall 1998).

The UN Centre on Transnational Corporations (UNCTC) differentiates between conventional and non-conventional mechanisms. Conventional channels include FDI, joint ventures, licensing, turnkey contracts, subcontracting, etc. Non-conventional mechanisms include reverse engineering and ‘poaching’ staff from competitors (UNCTC 1987).

Import of capital goods, foreign direct investment, joint ventures and licensing have been the most important mechanisms in transferring technology to developing countries, although the relative importance of each mechanism varies from country to country (Kim 1991; Mowery and Oxely 1995). Japan, South Korea and Taiwan absorbed technology through imitation and licensing from multinational corporations while Singapore and Ireland absorbed technology through direct foreign investment (Rasia 2004). More recent mechanisms relevant to technology transfer are technical alliances, networks, and strategic partnerships (Radosevic 1999).

Technical assistance (TA) in form of overseas development aid is also one mechanism of technology transfer. Developed countries transfer technologies and knowledge, usually project-based, to support economic development of developing countries (Wilson 2007).

Any international technology transfer process requires two participating parties or actors as a minimum: a technology supplier and a technology recipient. These actors can be any form of institution holding a technology or desiring a technology, such as companies, universities, NGOs, private persons, governments, etc. As most technology is held in firms, firms are the most common technology suppliers, as well as the most common recipients (Patel and Pavitt 2000). In practice, many more actors, especially governments setting rules and consultants facilitating the process, may participate (Wilkins 2002).

### **2.3.3 Low-carbon technology**

Relevant for transfers in relation to climate change are technologies mitigating global warming and supporting the adaptation to climate change effects. In the following, only technologies supporting the mitigation of climate change will be considered. Technologies mitigating climate change seek to reduce the emission of greenhouse gases.<sup>13</sup> Of the greenhouse gases, I will focus on carbon dioxide (CO<sub>2</sub>), as the GEF primarily supports technologies reducing CO<sub>2</sub> emissions.

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<sup>13</sup> The gases considered as most important in causing climate change are carbon dioxide (CO<sub>2</sub>), methane (CH<sub>4</sub>), nitrous oxide (N<sub>2</sub>O), hydrofluorocarbons (HFCs - this is really a family of gases, there are many individual gases), perfluorocarbons (PFCs - this is also a family of gases) and sulphur hexafluoride (SF<sub>6</sub>).

Pacala and Scolow have identified 15 sets of technologies to reduce carbon emissions, which can be grouped into four technology groups (see Table 1).<sup>14</sup>

**Table 2: Climate change mitigation technologies**

	<b>Group</b>	<b>Example</b>
<b>1</b>	(More) energy-efficient industrial technologies (capital goods and production processes)	Steel production technology requiring less energy input than comparable processes with similar results
<b>2</b>	(More) energy-efficient end-use products	More energy-efficient cars, insulation technologies in buildings
<b>3</b>	Less carbon-intensive energy generation technology	More efficient coal-based power stations, increases of gas-based power plants
<b>4</b>	Low-carbon energy generation technologies	Renewable energy technologies (large scale and small scale)

Source: Modified after (Pacala and Socolow 2004)

### 2.3.4 Photovoltaic technology

Photovoltaic (PV) describes the process which converts sunlight into energy. There are two basic solar technologies: solar cells and solar collectors. Solar cells convert insolation into electricity while solar collectors convert insolation into heat. As the PVMTI project discussed in Chapter 6 supports solar cell application, solar cells will be discussed in the following.

Solar cells are composed of two layers of different semiconductors united by a so-called junction. The semiconductor layers are also called ‘wafers’ and are usually made from silicon. The efficiency of a commercial cells ranges from 12 to 16 per cent, although cell manufacturers and research institutions have achieved higher efficiencies. Cell efficiency is a common indicator to consider the technologic capabilities of PV cell manufacturers, as achieving higher efficiencies requires different discrete knowledge sets of production processes.

There are two different types of solar cells used in 90 per cent of all applications: monocrystalline silicon solar cells and multicrystalline silicon solar cells. Monocrystalline cells make up about 43 per cent of current solar cell production. Commercial cells can reach an efficiency of 16 per cent, although the bulk of the cells produced have an efficiency of between 12 and 15 per cent. The average thickness of a monocrystalline cell is 200 µm. Multicrystalline silicon solar cells make up about 47 per cent of current solar cell production worldwide.

Multicrystalline cells are more economical than monocrystalline cells but are less efficient due to contamination of the silicon. Research institutions expect their commercial efficiency for both types to increase up to 20 per cent in the near future (Fraunhofer ISE 2007; European Photovoltaic Technology Platform 2007).

<sup>14</sup> Pacala and Scolow also list examples of changes in technology-user behaviour (less car use) and changes in land use practices (carbon sinks) that will be neglected in this context. I have also excluded carbon capture and storage technologies as they do not reduce the carbon dioxide emissions but rather enable alternate disposition.

As silicon wafers make up roughly 40 per cent of the cost of a cell, one focus of PV cell R&D is to apply cheaper alternatives to silicon in wafer production. The most common alternatives are the so-called ‘thin-film cells’, by which the wafers are made of amorphous silicon (a-Si, still silicon, but in a different form), or of polycrystalline materials: cadmium telluride (CdTe) and copper indium (gallium) selenide (CIS or CIGS). All materials are strong light absorbers, and wafers can be much thinner compared to silicon-based wafers. However, achieved efficiencies have been much lower than silicon-based cells (see Table 3). Some research is also undertaken regarding the application of nanotechnologies to PV cells.

**Table 3: Typical and maximum module and cell conversion efficiencies at standard test conditions**

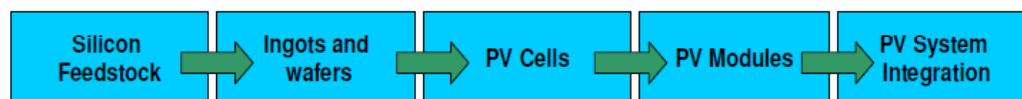
Type	Typical module efficiency [%]	Maximum recorded module efficiency [%]	Maximum recorded laboratory efficiency [%]
<b>Monocrystalline silicon</b>	12-15	22.7	24.7
<b>Multicrystalline silicon</b>	11-14	15.3	19,8
<b>Amorphous silicon</b>	5-7	-	12.7
<b>Cadmium telluride</b>	-	10.5	16.0
<b>CIGS</b>	-	12,1	18.2

Source: [www.iea-pvps.org/pv/index.htm](http://www.iea-pvps.org/pv/index.htm)

#### 2.3.4.1 The PV value chain

The PV value chain can be separated into three main components which depend on each other: feedstock production, cell and module production, system integration and sales. Value chains for other required components feed into module production. What is essential is the balance of systems (BOS) components and batteries for non-grid applications.

**Figure 1: The PV value chain**



Source: Author

Feedstock production comprises the production of PV grade silicon, ingot casting, and wafer slicing. The production of PV-grade silicon is highly concentrated. In 2006, four companies produced sixty per cent of the worldwide output.<sup>15</sup> The remainder was produced by a small number of companies, mainly in China and Russia. Ingot casting and wafer slicing is undertaken by a slightly larger number of firms situated for the most part in Europe and Japan (International Energy Agency 2007).

<sup>15</sup> Wacker (Germany), REC Solar Grade Silicon and Hemlock Semiconductor Corporation (USA), Tokuyama (Japan).

More companies produce solar cells but production is again concentrated in Europe, the US and Japan, with the exception of a significant increase in cell production in China. In 2006, 10 companies produced almost three quarters of all solar cells (see appendix F). Module manufacturing is even less concentrated and systems are usually integrated in the country of manufacturing.

#### **2.3.4.2 Innovation in PV cell manufacturing**

Ninety per cent of PV cells are still silicon crystalline wafer-based, a technology first used in the 1970s and now considered mature (Jäger-Waldau 2006). The most likely alternative is thin-film cells, but experts assume that silicon cells will dominate production in the foreseeable future. The European Commission, e.g., assumes that learning curves for PV silicon cells will continue for at least 10 to 15 more years. The share of thin-film cells is expected to increase: roughly 25 per cent of the overall installed production capacity for PV is expected to be for the manufacturing of thin-film cells by 2010/2011 (Jäger-Waldau 2007; PV-TRAC 2003). As most of the production capacity in India is based on silicon wafers, only silicon-cell technology will be considered in the following.

Innovation in PV cell technology is primarily concerned with the reduction of cost (\$/Wp) in order to make the technology cost competitive with other technology sources. Although costs have fallen significantly over the past 30 years, PV technology is not commercially competitive in relation to conventional energy technologies.

The highest cost factor is the material. For wafer production, material costs make up 70 per cent; for cell production 40 per cent and for module assembly 60 per cent. The largest share of material cost for the module is silicon (Arthur D. Little 2001). Nemet has back cast where actual cost reductions have been achieved from 1975 to 2001 and found that 18 per cent were achieved through increase in cell efficiency, 13.5 through increase of plant size, 7.9 through reduction of silicon cost, 1 per cent through reduction of silicon consumption, 0.8 through increasing yield (less defunct modules produced), 0.7 through increase in wafer size, and 0.4 through the application of polycrystalline silicon (Nemet 2006).<sup>16</sup>

Cost reduction can theoretically be achieved through increasing the production scale, making further improvements in cell efficiency and by reducing material and manufacturing costs. Scale increase means increasing plant size. Further cost reductions through economies of scale are projected through higher volume purchases of materials and equipment, optimised balancing of production lines, and smaller depreciation cost per unit produced (Arthur D. Little 2001). Cell efficiency improvements result from incremental or radical process innovation. Industry experts

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<sup>16</sup> There is a residual 28 per cent of the overall cost reductions observed which cannot be accounted for by the factors listed above.

agree that cell efficiency will improve, but the limits of efficiency are debated. Many processes used to achieve certain cell performances in laboratory conditions are not (yet) commercially viable.

Cost reductions for materials could be achieved through an increase in the silicon supply which is slowly taking place as a result of additional production capacity (Jäger-Waldau 2006), as well as a decrease in the necessary material input (i.e. the reduction of wafer thickness) (Nemet 2006). Manufacturing costs maybe decreased through higher yields, more efficient plant operation, thinner wafers, and reduced labour costs through the automation of production.

Innovation in PV production results from internal sources (learning by doing, learning by searching (R&D)) and external sources (technology purchase, collaboration, equity-based technology transfer, interaction in value chains, vertical integration, and technology spillover).

Mature production technology for silicon cells is available on the market without licences since related patents have expired (Siemer 2005). More advanced technology might be patented and breakthrough research is likely to be the result of research and development institutions.

### **2.3.5 International technology transfer and economic benefits for developing countries**

Four types of economic benefits can be associated with the international transfer of low-carbon technology from the perspective of the recipient country: the avoidance of future costs through climate change effects, the avoidance of costs for developing or constantly buying<sup>17</sup> such technologies, possible economic effects through the electrification of previously non-electrified areas through low-carbon technologies, and positive economic effects through domestic industrial development in the recipient country (Stern 2007; Foley 1992; Maskus 2004; Chakrabarti and Chakrabarti 2002). There are, however, considerable differences in these four effects. As we have seen, definitions of technology transfer used in the context stress that transfer includes the economically productive application of the transferred technology. Increased productivity is a key goal of industrialisation and innovation and relates to input factors and output. In the context of this thesis, the relation between international technology transfer and industrial development will be considered.

The generation of knowledge, its application in the form of technology, and technological change are key factors in achieving industrial development and economic growth (Mowery and Rosenberg 1991). Innovation activities have always been unevenly distributed within and between nations. Developing countries often have only a limited capacity to generate knowledge and develop technology domestically (Freeman 2001).

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<sup>17</sup> Rather than buying it once and learning how to produce the technology domestically (Barton 1997).



International technology transfer may contribute to the advancement of the competitiveness of an existing industry (via increased productivity and/or the qualitative development of new products), to the diversification of an existing product range, to the capturing of a larger share of the value chain of a certain product, and to the establishment of new industrial sectors (Lall 1998; Barnett 1994; Gereffi et al. 2001; Maskus 2004). The addition of new technologies to the existing technology stock is neither yet a contribution to the company's economic success nor to the wider development of the recipient country's economy, but may serve as a starting point to any of these effects.

Whether or not international technology transfer is beneficial to developing countries has been the subject of considerable debate. While the general importance of technology and especially innovation as a contributing factor to economic development is undisputed, this debate considers the geographical origin of the technology. Those in support of technology transfer argue that although technology suppliers usually have a strategic interest in transferring technology, transfer improves products and processes of recipients and facilitates access to export markets (Kim 1991). Those opposing technology transfer fear that technology imports will ultimately have negative effects on employment and replace the development of technologies within domestic industries. Rawski, for example, writes "imports prevent domestic firms from learning to implement new techniques without purchasing foreign equipment" (Rawski 1975). As developed countries have expressed the desire to receive technologies from industrialised countries, we will assume that technology transfer is generally beneficial.

Important in this context is the distinction between consumer goods and capital goods. Capital goods are the production technology necessary to produce a certain type of goods (e.g. a weaving machine to produce a shirt). Many developing countries understand industrialisation as the process leading to the establishment of industrial capacities to produce certain goods themselves for domestic consumption and export rather than importing them from abroad (Amsden 2002).

### **2.3.6 Cost of technology transfer**

Our understanding of the technology transfer process is based on our understanding of technology and technological change. The literature distinguishes between neo-classical and evolutionary perspectives on technology and innovation (Radošević 1999). Neo-classical economic theory assumes implicitly that technology is a form of information that might be costly to produce but, once embodied in machines or codified within manuals, is easy to transfer from one user to another. Arrow, for example, assumes that any buyer of information is able "reproduce the information at little or no cost" (Arrow 1959). Krugman builds his model of technology transfer between North and South on a similar notion by assuming that all

technology may in theory be transferred and put to productive use (Krugman 1979). Romer's new growth theory likewise assumes that technology is easily transferable by his treatment of technology as a “non-rival good”. A non-rival good is a good with the property that its use by one actor does not limit its use by another actor (Romer 1990). Parente and Prescott build their model on technology adoption on the assumption that “after a finite number of time periods all firms will have identical technology capital stocks, provided that investment is uniformly bounded away from zero” (Parente and Prescott 1994). Also, some more recent economic modelling exercises on the effects of technology transfer assume that the process is relatively effortless by not including transfer or learning cost and considering technology as a quasi “public good” in case the technology owner decides to transfer it (Ruffin and Jones 2004).

Evolutionary economists stress that the process of transferring knowledge between firms is costly, requires specific learning efforts, and is not necessarily successful. The reasons for “cost” in transferring knowledge are that, in their perspective, some parts of the knowledge are not easily codifiable but tacit. In turn, firms differ in their skills and competencies. Dose defines tacit knowledge as those parts of knowledge “that individuals have which are ill defined, uncoded, unpublished, which they themselves cannot fully express, and which differ from person to person” (Dosi 1988). Cantwell states that knowledge may not only be tacit among single persons but also within groups like a marketing unit or a R&D unit, thus mirroring the collective and interactive experience of knowledge accumulation of that particular group (Cantwell 1993). Tacit knowledge can, in the reasoning of the evolutionary perspective, not be easily traded. It must be transferred either through “face to face” interaction (Diez and Berger 2003), or the recipient has to acquire it through imitating the learning process of the technology supplier (Cantwell 1993). At the same time, codified knowledge has to be internalised into the recipient firm by becoming tacit.

Firms differ with regard to their accumulated knowledge because their management make choices over time to produce certain goods and/ or provide certain services, which requires coherency and concentration on innovation related to the competencies and skills for that particular product or service. In the interpretation of the evolutionary economist, deciding and learning to do one thing will to a certain extent predispose the direction of future innovation as “the learning and complementary strengths developed in the former effort provide a base of the next round (Nelson 1991). Acquiring certain skills and competencies in one area, however, excludes the development of skills in other areas and firms will develop what Nelson calls “core capabilities” that differ among firms to varying degrees. Nelson states “when one firm comes up with a successful innovation, its competitors may differ significantly among themselves in their ability effectively to imitate or develop something comparable” (Nelson 1991). Contrary to many economic models, effective technological imitation very often requires the imitating firm

to go through many of the same design and development activities as did the innovator, and to implement similar production and other supporting activities. Thus, firms with similar strategies and capabilities and core capabilities are in a much better position to imitate or learn and build from each other's work than firms with different strategies and capabilities (Nelson 1991).

While the choice of technologies is usually not completely at the discretion of the firm but also influenced external factors like the structure of the market, macro-economic factors, policy intervention, and external institutions, it is important to underline that firms differ in their capabilities and these differences influence their ability to acquire new technology. The greater the differences, the greater the cost required for the learning process in the form of staff training, hiring external expertise, trial and error processes, etc.

The differing theoretical notions of technology transfer have strong implications for the notions of access to technology. If technology is easily transferable at the mere costs of codifying knowledge or replicating technology, "access" becomes facilitated through the mere exposure of the recipient to technology. Assuming that most knowledge is tacit, firm-specific, and difficult to transfer, then mere exposure might not be sufficient and the recipient has to undertake a (costly) learning process. Radosevic summarises the main implications from both perspectives in the following table (table 3):

**Table 4: Differences in the conceptualisation of technology**

	<b>Information</b>	<b>Firm-specific knowledge</b>
<b>Unit of analysis</b>	Technique	Capability
<b>Characteristics of technology</b>	Flexible/ substitutable/ reversible	Local/ cumulative/ specific/ path-dependent
<b>Dominant view</b>	Static	Dynamic
<b>Access</b>	No problem	Limited
<b>Concept</b>	Transaction	Investment
<b>Focus</b>	Price	Spillovers, dynamic externalities
<b>Transfer mode</b>	'Arm's length' as a norm	Various forms
<b>Transfer costs</b>	Negligible	High

Source: (Radosevic 1999)

Depending on the perspective taken, transfer of technology is either effortless (going hand-in-hand with the purchase of technology) or the result of a costly and uncertain learning processes which differs from firm to firm (Rosenberg and Fritschak 1985). Conceptualising international technology transfer as an industrial learning process means that the relocation and application of a certain technology does not necessarily constitute a case of technology transfer. This difference can be characterised by Archibugi and Iammarino's notion of "international exploitation of nationally-produced technology." Profit-seeking firms pursue the international

exploitation of nationally-produced technology in the form of exports, licences, patents and foreign direct investments. Technology transfer in their interpretation results from international exploitation in case learning takes place and additional technological capacities are created within firms of the recipient country (Archibugi and Iammarino 1999). This means that technology imports (e.g. solar photovoltaic water pumps) do not necessarily constitute technology transfer as recipients have not learned to (at least partly) produce the imported technology (e.g. through reverse engineering). In many cases, technology exploitation abroad will not be successful without local learning, but this might not necessarily always be the case.

Furthermore, suggested policy actions to support technology transfer processes depend on the theoretical perspective chosen. Neo-classical theories recommend an increase of free trade and a reduction of state intervention, reduction of distorting factor prices, and the support of functioning markets. One example of such thinking is a relatively recent OECD publication in which Phillibert assumes that knowledge (R&D output) is easily appropriated by companies and efforts in technology development arise in developing, improving, and commercialising a technology – but not in learning how to use a technology.<sup>18</sup> Consequently, once a technology is developed, its international transfer is best pursued through trade and market reforms, decreasing cost, supporting diffusion measures, and the creation of carbon markets (Phillibert 2004). Evolutionary approaches favour policies to support the learning process of firms (Lall 1992; Fu 2009). Most recent theorising on technology transfer actually places the learning environment of the recipient at the centre of international technology transfer considerations. Soete and Freeman write “from a global growth and development perspective, it is indeed no longer the impact of the transfer of industrial technologies on economic development which should be at the centre of the debate but rather the broader organisational, economic and social embedding of such technologies in a development environment and the way they unleash or block particular specific development and growth opportunities” (Freeman and Soete 2007).

### **2.3.7 The assimilation of technology and technological capabilities**

The assimilation of technology by the recipient is one of the desired end-results of a transfer process, and transfer may lead to various degrees of assimilation. Bell and others differentiate between four levels of assimilation: operational assimilation (acquisition of designs, equipment, operational know-how), adaptive assimilation (acquiring or developing skills for adaptation/incremental improvement), replicative assimilation (acquiring skills to replicate a technology), and innovative assimilation (developing and acquiring capabilities for substantial development) (Bell 1997; Baranson and Roark 1985; Lall 1998).

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<sup>18</sup> The only factors limiting appropriation are strategies of knowledge generators (e.g. firms) to avoid knowledge sharing in order to maintain competitiveness.

Adaptive assimilation is a condition for operating imported technology at optimal production levels insofar as it usually must be adapted to local conditions (Wei 1995). The replication of a technology is obviously important for the domestic diffusion of a technology without further imports. Innovative assimilation is a condition to successfully operate in international or domestic competitive markets. Nelson argues “simply producing a given set of products with a given set of processes will not enable a firm to survive very long. To be successful for any length of time a firm must innovate” (Nelson 1991).

Achieving each of these stages requires a firm to build up specific sets of ‘technological capabilities.’ The concept of technological capabilities tries to capture the ability of firms to make use of technology as well as to engage in technological change (Romijn 1999; Ernst, Mytelka, and Ganiatsos 1998; Madanmohan, Kumar, and Kumar 2004).

Bell and Pavitt define technological capabilities as “the resources needed to generate and manage technical change, including skills, knowledge and experience, and institutional structures and linkages” (Bell and Pavitt 1993: 163). Bell and Pavitt differentiate technological capabilities from production capacity, which describes the ability of a firm to produce a product without ever changing production input and organisation.

There are various classifications of the technological capabilities required to put a firm into the position to successfully innovate. Lall for example distinguishes between pre-investment, project execution, process engineering, product engineering, industrial engineering, and linkages within economy capabilities, which differ according to technological complexity (Lall 1992). In relation to technology transfer, recipient firms must also possess the capabilities to evaluate and select technologies (Madanmohan, Kumar, and Kumar 2004).

The technological capabilities of firms are spread unevenly, not only between firms but also between countries. It usually assumes that developing country firms lack technological capabilities in particular and especially in contrast to industrialised countries (Archibugi and Coco 2004; Lall 1998).<sup>19</sup> Lack of technological capabilities on a firm-level and the difficulties of building them through national efforts explain the importance of technology transfer for developing countries.

Technological capabilities are the result of technological learning, for which there are a number of sources: investments in different knowledge inputs (R&D, prototyping, design activities,

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<sup>19</sup> Important differentiations must be made in relation to countries and technologies. Although the USA, Western Europe and Japan are generally considered the most industrialised countries, other nations have caught up significantly. They are usually referred to as newly industrialising countries NICs. The first generation of NICs includes the so-called four Asian Tigers: Hong Kong, Singapore, South Korea, and Taiwan. Second generation NICs include Brazil, China, India, Mexico, South Africa, Thailand, and Turkey. NICs show considerably different levels in industrialisation and technological development, but they are considered to be substantially developed further than the rest of developing countries (Amsden 2002).

taking advantage of tacit knowledge embodied in single persons or teams, the hiring of staff, interactions in inter-firm linkages (like supply chains and networks), technology imports, past learning efforts, investments in human capital, “learning by doing,” and linkages to public knowledge sources (R&D labs, technology intermediaries)) (Lall 1993; Bell and Pavitt 1993).

### **2.3.8 The quality of the knowledge flow**

Bell has developed a useful model to illuminate the possible contribution of the international technology transfer of industrial technology to the technological capabilities of the recipient (Bell 1989). He distinguishes three different types of technology flow from technology supplier to technology recipient, each with different qualities. Flow A comprises the capital goods and services needed to create the physical facilities of a new production system. Flow B refers to the skills and know-how needed to operate and maintain the newly-installed production facility. Some of the skills might be found in the host country, but usually, as Bell states, if transfer projects involve elements of flow A, at least some elements of the whole transfer process fall into the category of flow B.

Flow C refers to the skills and knowledge necessary to generate technical change. Those include the capabilities to adapt the technology to local, changing needs, to enhance it and eventually create new products, and to replicate the technology and localise its production.

And although, as Bell points out, there is no sharp distinction between C- and B-type flows, C-type flows are significantly different and additional to the knowledge needed to operate a production facility. C-type flows also lead to an augmentation of the host’s technological capabilities, while A and B flows lead to the creation of new production capacity.<sup>20</sup>

The differences underlined by Bell are partly mirrored in normative claims often made in the context of the UNFCCC. Any technology transfer or low-carbon technology should include the hardware but also the know-how to operate, modify, adapt and replicate the imported technology (Davidson et al. 2008; Ockwell et al. 2007; Kathuria 2002).

### **2.3.9 The role of the private supplier in international technology transfer**

The primary condition for international technology transfer and any form of assimilation is the availability of technology (Wei 1995). As firms are the most important suppliers of technology, their role in the international technology transfer process is important to consider.<sup>21</sup>

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<sup>20</sup> Earlier typologies make similar distinctions but put less emphasis on innovation and the development of new products. Mansfield, for example, differentiates between material transfer, design transfer and capacity transfer (Mansfield 1975).

<sup>21</sup> In practice, donors buy technology from private firms for international technology transfer or support a direct transfer. Although private firms might behave differently in both cases, I assume that they behave at least similarly to the way outlined in the following.

The goals and strategy of the supplier inform the availability of technology to developing countries, including choices of what to transfer and where to transfer it. Firms have a variety of motives for international technology transfer although their genuine goal remains, in most cases, the “welfare maximisation of their owners” (Narula and Dunning 2000). According to Goulet, firms aim to increase market share, to lower production cost, to diversify product outreach, to gain strategic advantages over competitors, and to gain knowledge about local markets. They will transfer technology in relation to the achievement of one of these goals (Goulet 1989). In more economic terms, firms transfer technology abroad in order to take advantage of cost and market factors (Bruun and Bennett 2002) or the purely monetary return of such transfers in the form, for example, of licensing fees. According to Narula and Dunning there are four main motives for FDI: (1) to seek natural resources, (2) to seek new markets, (3) to restructure existing production through rationalisation and (4) to seek strategically related created assets (Narula and Dunning 2000). Firms have often supplied their less valuable technology to a developing country in reaction to their governments’ intention to industrialise (Lall 1993).

While firms have a number of incentives to transfer parts of their technology internationally, at the same time, they also have an interest in controlling their technological assets. The interest in control over technology stems from the importance of technological advantage for the economic performance of the business firm. For Schumpeter, innovation incorporating technical change is the most important source for quasi-monopolistic profits (Schumpeter 1961). New or modified products or processes are the source for these profits, which derive from the various sources of technical change (R&D, customer feedback, incremental product improvement on the production site, learning by doing, etc.). As Porter has pointed out, while innovation is a source of competitive advantage for a firm it can also “erode the competitive advantage of even-well entrenched firms” in the case that competitors innovate more successfully (Porter 1985). While firms may gain a competitive advantage from a variety of sources, the productive application of knowledge may be one of them (Kogut and Zander 1993). Likewise, Teece and Pisano suggest that successful and competitive firms not only innovate and safeguard innovation but also possess what they refer to as “dynamic capabilities.” These make it possible to quickly adapt internal processes (including innovation processes) to changing environments (Teece and Pisano 1995). If rapidly innovating firms are transferring their latest innovation, they might not transfer their knowledge about how to organise and re-organise innovation processes.

Suppliers therefore might therefore not only critically select recipients and countries but also engage in “international technology transfer management” by trying to retain some parts of their specific knowledge despite all inherent interest in the success of the transfer process (Cannice, Chen, and Daniels 2003; Liebeskind 1996). The literature suggests that one way of maintaining control is by choosing internalised modes of technology transfer, especially foreign direct

investment. FDI is therefore considered to include more complex and more recent technology (Lall 1998).

A number of empirical studies support this assumption by revealing that different expectations exist between supplier and recipient regarding goals as well as the content of international technology transfer processes. Bennett et al. find only partly overlapping goals in their survey on UK supplier and Chinese recipient attitudes towards technology transfer. UK firms transfer technology to China to gain access to the Chinese markets, which matches the Chinese recipient's aim to increase their competitiveness. However, British firms approve less of the ambition of Chinese recipients to enter world markets with the help of imported technology. They also find diverging expectations regarding the sophistication of the technology. While only 34 percent of UK firms would be willing to transfer "advanced" technology, around 85 percent of the Chinese firms would like to acquire "advanced" technology from UK firms (Bennett et al. 1997).

Empirical studies on low-carbon technology come to similar conclusions. Evans concludes that suppliers of energy technology to China transferred capital goods and equipment but were hesitant about sharing design and production know-how (Evans 1999). Haum finds that German wind turbine manufactures are hesitant to transfer their latest technology to China despite a large market for their products. Within the joint-ventures they formed with Chinese companies, predominantly vintage models of their turbine range are manufactured (Haum 2004).

From a supplier perspective, the problem of losing a technological advantage through international technology transfer is framed in the terms of techno-economic security or technology leakage. Many firms transferring technology are aware of this problem and react with different strategies: transferring outdated technology, retaining core technology, increasing R&D efforts, changing ownership structures of subsidiary, accepting leakage, attempting to keep personnel (Bruun and Bennett 2002; Cannice, Chen, and Daniels 2003). In summary, reviewed theory suggests that firms have complex and diverse goals to internationally transfer technology that do not necessarily coincide with the goals of policy makers or technology recipients.

### **2.3.10 The role of the recipient**

Many early post-World War II studies of technology transfer between developed and developing countries frame the supplier-recipient relations in terms the Schumpeterian struggle over technology control. Kaplinsky, as one example for an early position, states that the interest of the recipient firm stands in sharp contrast to the interest of the supplier firm since the technology transferred is essential to create surplus in either profit or growth on the firm level (Kaplinsky 1974). Any form of transfer took place, according to these early theoretical



framings, under conditions clearly favouring the interest of the supplier. The main postulated reason was an unbalanced power relation resulting from monopolistic control over the technology on the side of the supplier, and limited knowledge on the value of technology on the side of the recipient. Both were considered to result in excessive prices for technology (Bell 1997). According to Vaitos “the price ..... is, in turn, determined solely through crude relative bargaining power” (Vaitos 1970). Mytelka concludes that foreign ownership of firms in Latin America is detrimental “towards a strategy of technological self reliance” (Mytelka 1978). Many of these early accounts also assumed a purely linear relation between the supplier’s willingness to share technology and the recipient’s ability to achieve different levels of assimilation. Contractor and Sagafi-Nejad for example claimed that “the composition of a technology transfer, typically a bundle of information, rights, and services, determines the effect on the user company” (Contractor and Sagafi-Nejad 1981). Accordingly, the major obstacles to obtaining technology through international transfer were lack of access and inadequate prices (Ernst, Mytelka, and Ganiatsos 1998).

Qualitative case studies revealed over time that technology assimilation also depends on the efforts and the abilities of the technology recipient (Dantas, Giuliani, and Marin 2007; Pack 2006). Baranson underlined in 1966 that technology transfer between developed and developing countries requires “a high calibre of engineering and technical personnel at both the dispensing and receiving ends” (Baranson 1966). Case study research made two observations that challenged the idea that the degree of technology assimilations depends exclusively on the technology supplier. Firstly, studies revealed that technology suppliers sometimes actually wanted to increase the technology flow but were constrained by the recipient’s ability to handle technology (Scott-Kemmis and Bell 1988). A second set of qualitative studies revealed that those firms were better able to exploit transferred technology that made efforts to generate technological knowledge through other channels and complemented the imported technology (Romijn 1997).<sup>22</sup> Technological efforts are a set of activities comprising active technology search processes, negotiations with suppliers, active learning, and the desire to upgrade and improve the received technology. Technological effort means, in other words, allocating additional knowledge and other resources to build the internal capacities to achieve various degrees of assimilation (Dahlmann and Westphal 1981; Baranson and Roark 1985). Romjin has defined technological efforts as “a purposive commitment of time, human and physical resources to activities leading to technological learning” (Romijn 1997). These activities include the build up of new technical and organisational skills, the generating and accessing of knowledge, the specialisation and creation of links to suppliers, and the use of customers and

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<sup>22</sup> A number of quantitative survey-based studies have given further evidence on the positive relation between recipients’ technological capabilities and international technology transfer results (Yin 1992).

institutions as possible knowledge sources (Lall 1998). Describing the role of the “active effort” in technology transfer represents a significant departure from previous framings of the relationship between the import of foreign technology and the development of domestic technological capabilities as purely linear.

While the idea of technological efforts makes no suggestions regarding what kind of activities are needed in a given situation or stage of assimilation, it underlines that the assimilation of technology is not a passive process. What needs to be done seems to depend on the specific situation and may contain all or selected elements of the technological learning process described above. From a theoretical perspective, it is more important to consider that reaching each stage of assimilation requires “purpose change generating activities” and “setting in motion a process of technological and organisational change” (Bell 1997), in addition to any technology received (Amsden 2002). One example often cited for the successful assimilation of imported technology after WWII is the Japanese recipient firms’ investment in R&D that helped to evaluate, to adapt and modify the technology (Mowery and Oxely 1995).

Technological capabilities play a double role in international transfer technology. Firstly, they describe the extent to which a firm can use and manipulate a transferred technology. Teece states in this context “the fact that different individuals, organisations, or nations possess different types of knowledge and experience creates opportunities for communication and mutually profitable transfer ..... (but) the greater these similarities, the easier it is to transfer technology” (Teece 1981). In other words, the more technological capabilities exist, the better the chances of assimilation. Cohen and Levinthal for example find positive links between company R&D efforts and the ability of firms to absorb technology. They call technological capabilities to integrate technology “absorptive capacities” (Cohen and Levinthal 1990). In other words, if companies do not possess the capabilities to engage in innovation and choose to internalise innovations or build innovative capabilities, e.g. through international technology transfer, they must at least possess the capabilities to introduce new products and processes into their operations (Hagedorn and Duysters 2002)

Important qualifications have to be made regarding the complexity and sophistication of the technology. Simple technologies might just be imported, others need licensing, and others for equity participation by the supplier (Lall 1993). The importance of absorptive capacities depends on the age of the technology, the complexity of the technology and the mechanism of transfer (Mowery and Oxely 1995).

Secondly, technology transfer can enhance technological capabilities at all levels of assimilation. As Perez and Soete point out, if there is a large discrepancy in technological capabilities between supplier and recipient, the costs of the transfer process is made up of the

acquisition cost of the technology and the learning cost for mastering the technology. In theory, these costs can be distributed between the supplier (in case it is willing to sell relevant knowledge) and other learning efforts (Perez and Soete 1988).

### **2.3.11 Institutional aspects of capability building**

As the literature reviewed above has pointed out, recipients that successfully assimilate technology from international technology transfer processes do so because they also undertake related, additional learning efforts. These learning efforts of the recipients may be internal and / or a result of learning through linkages with other sources of relevant knowledge. This points to the fact that learning and the development of technological capabilities may be an act of engaging in a wider institutional framework.

A systems approach to learning and innovation emphasizes that the development of new capabilities within a firm takes place within a wider institutional set-up and production structure. Both support and restrain a company's ability to learn and innovate. Innovation – as seen from a systemic perspective – is a result of internal learning processes of companies in combination with learning through linkages within the innovation system, e.g. to universities or suppliers. Linkages and learning processes change as the industry evolves (Malerba 2006).

Different concepts of innovation systems, including various ways of defining their components and interactions between components are now well established in the literature. A basic definition of a technological system is given by Carlson and Stankiewicz: “A technological system may be defined as a network of agents interacting in a specific economic / industrial area under a particular institutional infrastructure” (Carlson and Stankiewicz 1991: 122). The institutional infrastructure consists of formal (e.g. regulations) and informal (e.g. values) rules and organisations, which direct the learning and innovation process of firms. Institutions comprise, for example, the capital market, the educational system, the R&D landscape, the regulatory framework, intellectual property rights, values favouring certain strands of research over others etc. (Jacobson and Johnson 2000, Bergek et al. 2008).

From the perspective of company learning and the development of technological capabilities, those components of the institutional infrastructure are most relevant that offer the opportunity to assimilate further technological knowledge such as research laboratories or dedicated agencies that act as knowledge brokers. Technology recipients may build or use existing links to directly influence their technological capabilities. These sections of the technological system will be referred to as institutional aspects of the development of technological capabilities

### **2.3.12 Critique: Measuring technological capabilities and the economic performance of the recipient**

Two of the most common critiques relate to the measurement of technological capabilities and their contribution to the economic performance of the recipient. In practice, there are difficulties in precisely identifying capabilities on a firm, regional and country level and estimating their exact contribution to technological change within a firm. Also, technological capabilities are only one of many factors influencing the growth and competitiveness of a firm. While acquiring technological capabilities is necessary to achieve the innovative assimilation of a technology, the relation to economic performance is less evident (Jonker, Romijn, and Szirmai 2006). Technological capabilities contribute to the increased productivity of the firm as they interact with capital accumulation, but they seem not to be in all cases a necessity as industries might grow without upgrading their capabilities or increasing their technological learning (Dijk and Bell 2007).

Different opinions exist on the importance of considering technological capabilities in relation to international technology transfer. Chudnovsky states that research on technological capabilities complements previous research on the complex relationship between supplier and recipient, and considers access – and the terms of access – to be of similar importance (Chudnovsky 1991). Radosevic claims that the capabilities of firms to use imported technology are far more important in determining innovation effects than any contractual arrangements between supplier and recipient (Radosevic 1999).

Nevertheless, the concept and relevant empirical findings suggest that both leaving technology transfer to the market and labelling it as a passive diffusion process are insufficient if the dedicated technology transfer of low-carbon technology transfer is a policy goal. If there are differences in technological capabilities between countries in low-carbon technology, using the market is one way of arranging for transfer mechanisms. If they should be transferred to places where insufficient absorptive capabilities exist (which the market is unlikely to do as it aims at directing transfer to recipients with a minimum of suitable capabilities), policy will either complement market-based technology transfer or support the creation of technological capabilities.

### **2.3.13 Summary**

As we have seen, from the perspective of the recipient firm, international technology transfer is a technological learning process. The availability of technology, the strategy of the supplier, the level of existing technological capabilities, and the technological efforts of the recipients each determine the costs and outcome of the process within a specific context.

I can therefore define international technology transfer as a *transboundary, strategically informed and contextualised industrial learning process between a supplier and a recipient that might not necessarily share the same goals*. This definition shares with the definitions cited above the importance of knowledge and learning but also extends them by including the strategic nature of the relationship between recipient and supplier.

The relationship between supplier and recipient is nonetheless ambiguous. Technological capabilities on the recipient side are a condition for successful transfers. From the perspective of the supplier, if a recipient has sufficient technological capabilities, these will reduce transaction costs; they offer financial returns on transfer insofar as they allow the transfer in the first place (Teece 1981). Companies in industrialised countries therefore tend “to supply technology to potential competitors in other industrialized countries than to firms in the developing countries”, which is somewhat paradoxical as technology transfer is needed mostly where technological capabilities are low (Baark 1991). At the same time, existing technological capabilities of a recipient might pose a competitive threat to the supplier who might react by selling at very high price, attaching conditions or not selling at all (Lall 1993).

In addition, including hardware and software in technology transfer processes seems insufficient to achieve the innovative assimilation of technology, especially since active learning efforts by the recipient are required. International technology transfer also entails the possibility of failure resulting from lack of supply, inadequate knowledge transfer within the chosen mechanism, as well as the lack of technological effort from the recipient.

For the remainder of the thesis, I will conceptually distinguish between three interlinked ways technology transfer might be supported: directly, indirectly, and privately. Policy supporting technology transfer directly supplies technology and/or increases the quality of knowledge which flows to recipients. Measures include R&D or the acquisition of technology from third parties. Policy supporting technology transfer indirectly supports the absorptive capacities and technological learning effort of the recipient. Policy supporting private technology transfer gives incentives to private investors to supply technology to recipients. Measures include the creation of demand for a certain product in the recipient country and tax breaks for foreign direct investments, etc. (Radošević 1999; Hoekmann, Maskus, and Saggi 2005; Arnold and Thuriaux 1997).

## **2.4 Diffusion of low-carbon technology**

In the following, I will shift the discussion towards the second strand of theory relevant for my research: the diffusion of low-carbon technology. Mansell and Steinmüller define technology diffusion as “the aggregate outcome of individual choices to adopt new technologies” (Mansell

and Steinmüller 1996). Other studies define diffusion in a similar manner. Mohapatra and Sahe define the diffusion of innovations as “the process by which an innovation spreads among members of a social system” (Mohapatra and Saha 1993). Rogers stresses the importance of communication in the diffusion process by defining diffusion as “the process by which an innovation is communicated through certain channels over time among the members of a social system” (Rogers 1995).

As already stated above, the effect of a certain technology regarding its effects on reducing CO<sub>2</sub> emissions depends on the effectiveness of its operation as well as on how often and how long the technology is put to use. Reductions of CO<sub>2</sub> emissions are therefore, firstly, a result of the diffusion of low-carbon technology and, secondly, of its efficient operation. In the following, I want to summarise the main findings of diffusion theory and discuss the specifics of the diffusion of low-carbon technology in developing countries. Insofar as I have described international technology transfer in terms of a process of learning, I will also discuss the aspect of learning more specifically.

Shapira and Rosenfeld state that “technology can diffuse in multiple ways and with significant variations, depending on the particular technology, across time, over space, and between different industries and enterprise types” (Shapira and Rosenfeld 1996). In contrast to innovation, the concept of diffusion implies that a certain innovation exists and is ready to be diffused. It is important to distinguish between adoption and diffusion. Adoption analysis considers the decisions of agents to adopt a new technology while diffusion studies consider the effects of technology diffusion like productivity increases within an industry of pollutant emission reduction, the search for drivers of certain diffusion patterns or try to forecast diffusion (Metcalf 1988; Montalvo and Kemp 2008). Both levels are intertwined as diffusion and its effects are the result of aggregate adoption (or non-adoption) decisions. Adoption decisions are micro-level decisions that are influenced by micro-, meso- and macro-level factors (Montalvo 2008).

Diffusion studies usually have two results in common. The first is that not all potential adopters adopt a technology at the same time. The diffusion of a technology throughout the relevant population may take between five and fifty years. The second is that the diffusion of technologies takes place in an s-shaped curve. The s-shaped curve indicates that a technology diffuses slowly in the beginning, then increases in speed and then slows down again (Barreto and Kemp 2008; Blackman 1997). In the following, I want to give a short overview of the relevant factors influencing technology adoption found in theory before I turn to the more specific issues of learning and low-carbon technology. The diffusion of technology is driven by four sets of factors: demand factors, supply factors, sectoral factors, and factors concerning the characteristics of the technology. In the following I will briefly consider supply and demand

factors before turning to the issues of diffusion and learning, as well as the diffusion of low-carbon technologies.

### **2.4.1 Demand**

Two sets of factors drive diffusion through changing demand. The first set of factors relates to information about the technology. Adoption is influenced by whether and when adopters receive information. Diffusion rates differ because some adopters learn faster about certain technologies than others. In addition, the quality of the information is relevant as it must be sufficient to allow adopters to consider risks and benefits of adoption (Karshenas and Stoneman 1993; Geroski 2000). Models stressing the importance of communication as a factor determining the rate of diffusion usually assume that all adopters are the same. Also, adoption will be affected by increasing information about the technology. With increasing usage, more information concerning the performance and the effects of a technology will be available (through spill-over or the formalised communications of its users). Thus, reluctant firms will be in a better position to consider its benefits as well as difficulties (Geroski 2000). The idea of a “communication perspective” is usually associated with Everett Rogers, who started his research in rural sociology but aimed to develop an interdisciplinary theory of diffusion. For Rogers, diffusion is predominantly a social process; attitudes of adopters may be influenced through the way agents (e.g. opinion leaders) communicate, and are conditioned by social norms (Rogers 2002).

The second set of factors relates to the different characteristics of the adopter. Firms have different internal characteristics (available capital, willingness to pay, size, competencies, vintage technology stock, search cost, input prices, factor productivity and regulatory cost) that will lead to different perceived benefits in relation to the cost of adopting a technology. Adopters perceiving benefits to be high will adopt the technology while others will do so later or not at all. If costs fall over time and perceived benefits change, the number of adopters is likely to increase (Blackman 1999). Cost reduction of technologies may result from five factors: technological progress, input price changes, internal efficiency improvements, learning by doing, and economies of scale (Ibenholt 2002). Furthermore, search costs might decrease or capital depreciation might change cost structures of the adopter (Blackman 1999). Another relevant factor is the access to or possession of a scarce resource necessary for adoption (e.g. specialised staff, access to finance). Adopters being able to secure this crucial input first will find adoption profitable (Blackman 1997).

### 2.4.2 Supply side factors

Supply relates to availability and characteristics like the cost of technology. One important aspect is the willingness of the technology owner to let the technology diffuse (Mansfield 1985). Perez and Soete point to two important differences between end-use products and industrial technologies that are also relevant to low-carbon technologies. They relate to the motivation to distribute a technology. The producer of an end-use technology is very likely to sell this technology and hence push the diffusion and adoption of the technology. The owner of a production technology is likely to behave in a number of ways. On the one hand, he might have developed it for its own business goals and will aim to monopolise it. On the other hand, he might treat the technology in question similar to an end-user product and aim to sell it as much as possible (Perez and Soete 1988).

In addition, ongoing R&D shapes the diffusion of a technology. Ongoing R&D might improve the technology in question or its related processes, or decrease the costs of both. Both are likely to affect perceived benefits of the adopter, adapt supply to demand and increase demand (Stoneman and Dideren 1994). Metcalfe points out that technology supply has to be considered in the light of technology competition. While one technology improves, competing technologies might improve as well (Metcalfe 1988). There is a long and broad discussion on the specific relation of supply and demand. The central and yet unsolved question is whether increased demand will stimulate increased efforts in developing supply or whether changes in technology supply through innovation will increase demand. The current answer to the question is that both factors must exist (although not necessarily simultaneously) and their exact relationship is technology specific and depends on the stage of technology development (Mowery and Rosenberg 1979; Nemet 2007; Metcalfe 1988). As Dosi has argued, most radical innovations are made before any form of demand has been articulated (Dosi 1982). Nemet found, for example, that demand created for wind technology mobilised significant private investments in R&D leading to incremental innovation and cost reduction. However, this was by a time when wind technology as a new innovation existed and was already prototyped. With regard to PV he finds that demand did not create innovation to the same extent as with wind energy (Nemet 2007).

Griliches, in his famous paper on the diffusion of hybrid corn in the USA, exemplifies the relation between supply and demand in the diffusion of technology. He investigates why farmers in some US states were much slower in adopting the technology (geographically protracted diffusion) than in others. His explanation is that seed producers first had to develop new hybrids that matched the local circumstances and find the right communication institutions (stores and salesmen) before the adopting farmers of different US states could change their perception of the profitability of adopting hybrid seeds. However, developers worked on the



variations of these seeds because they assumed that demand existed (Griliches 1957). Supply and demand factors are not exclusive of each other and the diffusion of a technology is likely to be determined by a number of factors that also differ between industries and countries (Montalvo 2008).

### **2.4.3 Technology diffusion and learning**

We can now consider the role of learning in relation to the diffusion of technology. There are four aspects that relate to learning and diffusion: the first relates to learning “about the technology” also referred to as “signalling.” Signalling includes the communication about a technology and the acknowledgement of its existence within the adopter community (Attelwell 1992). The second aspect of learning relates to the adaptation of a technology to local demand. Some technologies might need alterations in design to suit distinct preferences or internal changes to suit input factors. The adaptation of a technology to local demand might be undertaken by a technology owner, intermediary organisations, or the adopter (Griliches 1960). The third aspect relates to acquiring sufficient knowledge to consider possible benefits and risks. For simple technologies, signalling might be a sufficient learning process related to adoption and, once a community of potential adopters is informed (e.g. through trade fairs or advertisements), diffusion becomes determined by other factors (e.g. the availability of capital or finance). For more complex technologies, signalling might not be sufficient and significant learning about the technology might be necessary to make a decision. In the case of the transfer of technology to developing countries, learning might also make more difficult cultural differences between context of its development and its application (Scheraga, Tellis, and Tucker 2000). The fourth aspect relates to learning in order to productively apply the acquired technology within a business organisation, and learning to change and to adapt the technology (Kemp and Volpi 2008). In the words of Barreto and Kemp, the diffusion of technology depends on “continuous experimentation” with the technology, which is nothing else than a learning process (Barreto and Kemp 2008). Blackman states adopters undertaking R&D efforts or employing trained staff, and which is nothing else than adding technological capabilities, are more likely to be early adopters (Blackman 1999). The similarities and differences with the concept of international technology transfer will be undertaken in a separate paragraph further below.

#### **2.4.4 Low-carbon technologies and the role of policy**

The diffusion of low-carbon technologies differs from conventional technology because their diffusion usually requires some policy intervention. Low-carbon technologies are a sub-set of environmental technologies. Environmental technologies can be defined as all technologies that lead to an improvement of environmental quality in the form of less or no environmentally-damaging emissions compared to similar technologies, or less or no resource input than similar technologies (Klemmer, Lehr, and Löbke 1999).

A number of academic disciplines have underlined that the development, but also the diffusion of environmental technologies, requires some sort of policy intervention in markets.

Environmental economists argue that polluters do not invest in environmental technologies due to a double market failure. The first market failure is that polluting firms cannot pass additional costs resulting from investments in environmental technologies on to customers. Customers are considered unwilling to pay additional costs for environmentally-friendly goods. The second market failure is due to the public nature of the environmental firms investing in environmental technology which, as a result, cannot fully claim the benefits of their investments. Competitors not investing in clean technologies also benefit from the reduced pollution as the need to invest further decreases with investments taken by others (Rennings 2000). Industry will only adopt environmentally-friendly technologies if induced by the state.

Technical change leading to clean technologies requires both classical and new instruments of environmental policy, ranging from command and control and market-based instruments to new so-called soft instruments like labelling or voluntary agreements. Some commentators suggest that the likelihood of the adoption through policy increases if environmental policy is designed with reference to science and technology policy to ensure necessary technology supply (Jaffe, Newell, and Stavins 2002).

In addition, political science, most notably in the form of the concept of ecological modernisation, has argued that policy intervention is a necessary condition for the diffusion of environmental technologies (Jacob et al. 2005). Beise et al. state that the diffusion of environmental technologies without policy support “seems to be rather rare” (Beise et al. 2003). The more complex concept of transition management likewise underlines the central role of government in the spread of environmentally benign technologies. Transitions are large-scale social processes intertwined with micro-level changes that lead to long-term structural changes of society (Rotmans, Kemp, and Asselt 2001). The concept of transition management assigns specific roles to governments to steer such long-term processes to support radical changes in the diffusion and application of environmentally benign technologies like the shift from fossil fuels to renewable generation technologies (Bergh et al. 2007). And while all three disciplines cited assign differing roles to governments and suggest differing policy instruments, they all

underline the importance of policy intervention as a prerequisite for any diffusion of environmental technologies. Supply, demand, and markets for environmental technologies are therefore primarily created through governments (Lanjouw and Mody 1996).

Empirical studies also confirm the decisive role of policy for the diffusion of renewable energy and energy-efficient production technologies (Jacobsson and Johnson 2000; Mulder, Groot, and Hofkes 2003; Kounetas and Tsekouras 2008). Despite the central role of policy, its implementation is likely to lead to the same s-shaped diffusion curve spanning long periods of time because the factors affecting diffusion beyond policy are the same as related to conventional technology (Montalvo 2008). One explanation for the unpredictable relationship between regulation and technology diffusion is, according to Kemp and Volpi, the existence of various technologies that can be adopted in response to regulation. In addition, adopters might protract or ultimately resist adoption of environmental technology (Kemp and Volpi 2008).

Critical commentators have pointed out that, until today, the relationship between the type and level of policy intervention and diffusion is unclear and that the enforcement of policy does not automatically guarantee success (regarding technology diffusion as well as pollution reduction) (Montalvo 2008). Klemmer et al., for example, find that similar policies have different effects in different contexts (Klemmer, Lehr, and Löbbe 1999). Jänicke underlines that there is no direct relationship between instruments and effects on technology so every policy instrument has to be carefully designed with regard to case-specific context factors (Jänicke 2006). Furthermore, a number of commentators point out that firms adopt environmental technologies for other reasons than environmental policy. These include pressure from external stakeholders (NGO's or business partners) as well as efficiency gains from a firm's internal product or process development efforts. In addition, markets are starting to find incentives to adopt environmental technology through conscious consumers. However, these still seem to be exceptions (Berkhout 2005).

The relationship between environmental technology and policy is nonetheless dynamic. Efforts are being made to reduce the costs of low-carbon technology through increased R&D. It is expected that increasing demand will lower the costs of low-carbon technology through learning curves and economies of scale. Once the cost of technology decreases, the role of policy will change. Decreased prices are one condition for the unsupported diffusion of technology although they are not necessarily sufficient.<sup>23</sup>

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<sup>23</sup> Costs are only one barrier to the diffusion of environmental technology as, for example, political science as well the literature on socio-technical systems points out (Smith, Stirling, and Berkhout 2005; Jänicke 2000).

### **2.4.5 Diffusion of environmental technology within developing countries**

While there is agreement about the crucial role in public policy for the diffusion of environmental technologies in industrialised countries, the literature is divided over the role of environmental policies in relation to it. Some authors directly assume the importance of policy by underlining missing implementation. Many developing countries have introduced governmental institutions and corresponding policy necessary for reducing industrial pollution, but implementation as well as enforcement is generally considered to be weak (Hettige et al. 1996).<sup>24</sup>

The World Bank claims that the role of government policy is partly taken over by communities. As the World Bank understands, the diffusion of green technology in developing countries depends equally on markets, governments, and communities (World Bank 2000). Since this model has formed some of the more recent empirical studies on the diffusion of clean technology, I will consider it in more detail. If communities would be in the position to take over the role of policy, this might have far reaching implications for the design of policies to diffuse low-carbon technologies in developing countries.

The World Bank (WB) claim is based on three studies carried out by the World Bank (Pargal and Wheeler 1995, 1993; Huq and Wheeler 1993; Hartman, Huq, and Wheeler 1995) and a review paper summarising the studies (Hettige et al. 1996). The review paper claims that the three studies present evidence to support the assumption that polluting industrial plants adopt environmental technology as a result of direct pressure exerted by neighbouring communities (Hettige et al. 1996: 1891). However, the empirical evidence presented in the three studies is weak. The first study summarises the cases of four fertilizer plants and three paper mills in Bangladesh (Huq and Wheeler 1993). While the review paper claims that out of three “pressurised” plants two “undertook to clean up” (Hettige et al. 1996:1898), the Huq and Wheeler study instead reported that one plant paid compensation to the community and the other increased the staff for pollution control (Huq and Wheeler 1993). Both are not examples of technology diffusion.

The second study models the impact of various factors on plant-level pollution in Indonesia. The study finds that pollution increases with age (old plants pollute more), decreases with size (large plants are cleaner), depends on ownership (privately-owned plants are cleaner), and locations (plants in areas of wealthy and educated inhabitants also pollute less). Wealth and education are taken as proxies for increasing pressure on plants to adopt clean technology (Pargal and Wheeler 1995). The review paper states, in relation to the second study, that

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<sup>24</sup> Important differentiations have to be made with regard this claim as case studies of successfully implemented policies for cleaner production exist, for example, in Asia (Angel and Rock 2000). The more general assumption of weak implementation is often made in the relevant literature.

community-level education has a “very powerful effect on pollution intensity” (Hettige et al. 1996:1900). The study, however, does not examine several alternative explanations for the relationship between pollution intensity, education, and community income. If pollution is related to the age of plants, it might be that new plants concentrate in wealthy and educated areas, as they need educated labour. Also, if pollution decreases with size (plants in the sample employ between 22 and almost 42,000 people) it might also be possible that areas with large, clean plants are wealthier because they offer increased employment.

The third study presents the results of a survey of 26 pulp and paper plants in Bangladesh, India, Indonesia, and Thailand (Hartman, Huq, and Wheeler 1995). The review paper states that it presents “quite strong” results showing that communities support adoption of clean technologies (Hettige et al. 1996). The actual study finds that abatement efforts (the number and cost of end-of-pipe measures) depend on size, competitiveness, and ownership (internationally-owned plants undertake most abatement efforts, followed by private- and publicly-owned plants). Abatement efforts also increase with community income. Again, income is taken as a proxy for exerting pressure. Abatement efforts also increase with location. Plants in sparsely populated, rural areas undertake more abatement efforts than plants in densely populated areas (towns). The authors take this result as an indicator for community pressure as they assume that the polluting activities are more visible in sparsely populated areas. The authors of the studies also state that plants in rural areas use more polluting production processes than plants in cities (Hartman, Huq, and Wheeler 1995). Again, alternative explanations are possible. Dirty plants in the countryside might, for many reasons, have undertaken abatement efforts. Furthermore, community income might again be a result of the more competitive and cleaner plant. In addition to the three studies, the review paper also cites a paper by Robert Cribb as a source of “many accounts” in which communities successfully pressurise plants to adopt cleaner technology. The paper, however, contains no such accounts but concludes that pollution control in Indonesia “highlights the important trend – the growing capacity of the Indonesian civil bureaucracy to take the bit between its teeth and deliver difficult policy goals” (Cribb 1990:1134).

Despite the weak nature of the empirical evidence, the role of the community in the conceptual model of the World Bank outlined above is directly based on the studies and the review cited (World Bank 2000:78). The model relies on one further study which considers the role of citizens in informing regulatory authorities about industrial pollution in China. According to the paper, Chinese environmental authorities responded on average to 100,000 complaints from citizens per year between 1987 and 1993. The econometric model of the paper indicates that the number of complaints increases with income, exposure to tangible pollution (dust), and education (Dasgupta and Wheeler 1996). While this paper also does not discuss the possible

relationship between income and exposure to pollutants (the most polluted areas in China are also the most wealthy), its usefulness as evidence for the importance of communities in diffusion of clean technology is limited for two reasons. Firstly, the community acts obviously with and not instead of environmental authorities. Secondly, the paper gives no indication about the nature of regulatory response (the paper does not describe what kind of responses regulators pursue) nor how far responses contribute to the adoption of environmental technology. Furthermore, the literature forming the model excludes a World Bank study on pollution control in India that finds no statistically significant relationship between industrial pollution abatement and community income (Pargal, Mani, and Huq 1997).<sup>25</sup>

Later studies underline the role of environmental policy for diffusion by finding that it is (where implemented) the most important or at least an important adoption factor (Montalvo 2003; Luken and Rompaey 2008; Luken, Rompaey, and Zigova 2008).

Studies investigating the international diffusion of environmental regulation give further evidence that the diffusion of green technology depends in the first instance on environmental policy. Kemp and Volpi explain the differing rates and speeds of diffusion between countries and regions partly with national and regional differences in corresponding regulation (Kemp and Volpi 2008). Patent analysis indicates that environmental technology is usually not transferred between developed countries in reaction to related environmental policy. Once policy is implemented within a developed nation state, corresponding technology is developed within the specific country despite the existence of such technologies abroad (although exceptions exist) (Popp 2006). The case is different between developed and developing countries. Patent analysis indicates that, once environmental policy is implemented within a developing country, corresponding environmental technology is usually imported from developed countries (Lanjouw and Mody 1996). In all cases, the diffusion of policy precedes the diffusion of technology.

#### **2.4.6 The diffusion of low-carbon technology in developing countries**

In the following, we will briefly consider whether the role of policy in the diffusion of low-carbon technologies in developing countries is of similar importance as it is for the more general class of environmental technologies. Few diffusion studies on low-carbon technologies in developing countries exist and the empirical evidence is therefore very limited. In the case of renewable energy technologies, this might be partly explained by the limited diffusion of such

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<sup>25</sup> It is for one additional reason unlikely that communities will play a dominant role in the diffusion of low-carbon technologies. The World Bank finds in its research an important pre-condition for alleged community pressure: the environmental pollution must be directly experienced (dust, death of fish) to evoke community reaction. Due to the difficulties of the affected population to effectively differentiate between the natural variability of the climate and the lasting effects caused through human-induced climate change, it is doubtful that communities will start exercising pressure (Schneider, Easterling, and Mearns 2000).

technologies so far.<sup>26</sup> There is a consensus in the literature that existing diffusion has largely been the result of government efforts (Barnett 1990; Goldemberg 2006)<sup>27</sup> China, Brazil and India has set renewable energy development goals and is developing relevant policy to achieve them. Markets for renewable energy technologies without government intervention do exist in developing countries due to a lack of energy supply via centralised grids; they seem to be limited to small niches as end-consumers lacking the financial means to actually acquire renewable energy technologies themselves (Hurst 1990; Mulugetta, Nhete, and Jackson 2000; Velayudhan 2003).

Blackman states energy-efficient technologies could diffuse “spontaneously” without government intervention insofar as they hold the potential to decrease production costs and reduce emissions (Blackman 1997). There is, however, little empirical evidence to support this claim. China, for example, has made considerable advances in increasing industrial energy efficiency but these are the result of a large government program (Yanjia 2006). Orshita and Ortolano also underline the importance of policy as they find the diffusion of clean coal technology in China to be severely restricted by inefficient government institutions and a lack of implementation of Chinese air pollution policies (Orshita and Ortolano 2002). In the light of these studies, one can conclude that policy is of similar importance to the diffusion of low-carbon technologies.

### 2.4.7 Summary

The diffusion of low carbon-technology can be described as a process of spreading technologies among a constituency of users. Public policy support is the most important driver, representing a necessary but not sufficient condition. Policy intervention is not only able to speed diffusion through intervention in the supply and demand, but it seems a necessary condition to ensure distribution beyond technology niche markets. Learning is a substantial element of the diffusion process insofar as it shapes adoption decisions in different ways. Developing countries lag behind industrialised countries in the diffusion of low-carbon technologies and policy seems to be an equally important factor in this diffusion as it is in developed countries.

Policy to ensure diffusion will increase demand and ensure supply. Demand-side policy includes the full range of environmental policy in the form of standards, economic incentives, or information campaigns. Supply-side policy will aim to ensure the availability of technology

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<sup>26</sup> OECD countries generate on average 0.7 per cent of their primary energy demand from renewable energy sources (excluding biomass, hydro and waste). The corresponding figures for the Commonwealth of independent States and Eastern Europe (0.0), Sub-Saharan Africa (0.1), Middle East and North Africa (0.1) Asia-Pacific (0.5), as well as Latin America and the Caribbean (0.4) are significantly lower (UNDP 2004).

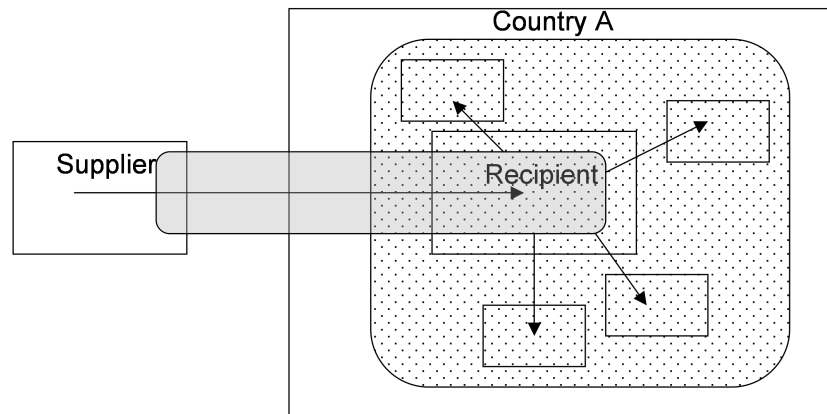
<sup>27</sup> The role of ODA in diffusion is unclear. ODA has most certainly transferred technology through demonstration and rural electrification projects but it is not known to what extent these projects have supported wider and faster diffusion.

through import (international technology transfer) and its adaptation to local demand. The development of low-carbon technologies is, strictly speaking, not necessary as they already exist (or are being developed) in industrialised countries (Heaton and Resosudarmo 2000).

## 2.5 Comparing international technology transfer and diffusion of low-carbon technologies

The literature qualifies the relationship between international technology transfer and diffusion, maintaining that a certain technology first has to “enter” a country before it can then spread to its various users (Lee 1984; Enos and Park 1988). The combined process can therefore be broken down into the following steps: the supply of technology, the adoption of technology by a recipient, and the further spread of technology. The most basic relationship between international technology transfer and diffusion can be rendered as shown in figure 2:

**Figure 2: A basic relationship between international technology transfer and diffusion**



Source: Author

The grey shaded area marks the process of international technology transfer while the dotted area marks the process of national technology diffusion. This relation somehow suggests that the production of the technology is in some form localised (e.g. through the purchase of production equipment, FDI, or the fact that existing industries having learned through reverse engineering/imitation). The grey shaded area also stands for a more intense knowledge base into which the transfer must be embedded. As seen from the theory above, knowledge for production and innovation requires larger absorptive capacities on the side of the recipient and/or more “intense” knowledge flow. The knowledge base required for diffusion (in the form of the knowledge flow and absorptive capacities) is “lighter” and therefore indicated by dots.

A further relationship is possible: a technology might diffuse within a country but each adopter imports the technology from abroad. In that case, every adoption decision would, strictly



speaking, be a process of international technology transfer. In that case, production would not be localised.

International technology transfer relates to a micro-process between a technology supplier and a recipient. Within the context of industrial development, technology transfer includes the productive application of technology. From the perspective of the recipient, technology transfer is essentially a learning process. Diffusion is a macro-process that consists of aggregate micro-technology adoption processes. The first obvious difference is, therefore, the number of occurrences each process consists of. Supporting the spread of a technology will most certainly require different policies than the supporting transfer of technology.

However, if diffusion is an aggregate of micro-adoption decisions, a more detailed comparison with technology transfer has to be undertaken in relation to the adoption decision. Only this comparison will reveal whether processes of technology transfer and of the adoption of technology show differences. I will first compare international technology transfer with the adoption of conventional technology and then, in turn, compare it with the adoption of low-carbon technology.

### **2.5.1 International technology transfer and the adoption of technology**

A number of economists do not differentiate between technology transfer and diffusion. Neo-classical economists often use the terms “international technology transfer” and “international technology diffusion” interchangeably with the underlying assumption that they capture the same processes when investigating the spread of imported technologies through industrial sectors (Hoekman and Javorcik 2006; Keller 2004; Rouvinen 2006). This interchangeable use is, however, based on a clear distinction between innovation and the adoption of technology. As seen in the section devoted to international technology transfer of this chapter, neo-classical economists consider the adoption of technology as effortless once it has been developed and commercialised.

Authors relating evolutionary theories of innovations stress that the distinction between innovation and technology diffusion is somewhat artificial as the adoption of a technology among a group of users depends to differing extents on the ability of the user to change and improve the technology in question (Bell and Pavitt 1993; Foxon and Pearson 2008; Haum and Petschow 2003). If we assume that the introduction of a new technology to an organisation also involves innovation, the boundaries between international technology transfer and adoption are likewise blurred. Similarities between international technology transfer and technology diffusion are found in all aspects of learning.

Firstly, theories about international technology transfer point out that recipients need the capabilities to select and to evaluate relevant technology. Theories of diffusion, on the other hand, have pointed out that adoption depends on the adopter being informed about the technology and its potential benefits. Secondly, both sets of theories stated that recipients need to learn how to operate technology and that technology needs adaptation and incremental improvements in order to be successfully transferred/adopted. Bell and Pavitt differentiate between four stages of technology change that are inextricably linked to technology adoption and likewise depend on learning and innovation. The first level relates to the mere incorporation of technology and its adaptation to a specific situation. The second level relates to the modification of the technology to “conform to changes in inputs and product markets” which might lead to substantial efficiency gains. The third level relates to changes undertaken, in the case that the recipient accumulates relevant technological capabilities, in order to “modify existing products, produce substitutes, diversify into the production of input materials or equipment, or improve the technologies by supplier industries.” The fourth level relates to “the kinds of technical change that are usually thought of as innovation” (Bell and Pavitt 1993).

Studies on adoption and diffusion usually do not consider the fourth level, as they are concerned with adoption and not with the question whether an individual adoption decision leads to particular economic benefits.<sup>28</sup> Studies on international technology transfer will focus on what level is reached, while adoption studies might be more concerned with the reasons for adoption related to levels one and two. We can, however, assume two things: firstly, firms adopting a technology with an economic goal will strive towards innovation if aiming to be successful in competitive markets. Secondly, the likelihood that the new technology will positively contribute to the overall economic performance of the recipient/adopter will increase with the stage of technical change achieved. However, the prerequisite for any economic gains are, as Bell and Pavitt underline, the successful learning processes in adopting a certain technology on the firm level. To summarise, the processes of international technology transfer and adoption of technology include similar elements regarding the role of learning in relation to conventional technology adopted for business purposes. As learning takes place, some form of learning cost will be involved as a number of empirical studies point out (Pack and Saggi 2001).

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<sup>28</sup> Diffusion studies are concerned with economic effects but usually on a multi-adoption level, e.g. through the spread of a technology. From a diffusion perspective, economic aspects are considered on an aggregate level like a sector or a region. From a diffusion perspective, the speed and number of adoption decisions matter. As Rosenberg states “new techniques exert their economic impact as a function of the rate at which they displace older techniques and the extent to which the new techniques are superior to the old ones” (Rosenberg 1973).

### **2.5.2 International technology transfer and the adoption of low-carbon technology**

In the following I want to compare international technology transfer with the adoption of low-carbon technology to further elaborate whether the observed similarities in the previous section hold for low-carbon technology. A difference results from the depth of the learning process necessary to achieve the goals underlying the adoption decisions. The conceptual model by Bell concerning knowledge flows and the Bell and Pavitt distinction between productive and innovative capabilities underline that the quality of the knowledge, as well as the complimentary knowledge gained by the technological effort of the recipient, leads to different degrees of assimilation and qualitatively different sets of technological capabilities. The implicit assumption of Bell, Pavitt, Lall, and others is that international technology transfer and learning takes place for the recipient in order to innovate as a step towards industrial development and economic gains. The question in the context of climate change is whether the quality of the knowledge flow, as well as the results of any technological learning effort to pursue the goal of GHG emission reductions, must be similar to those leading to learning for industrial development.

From a strictly environmental perspective they must not necessarily be similar. The literature review of technology diffusion has shown that operating low-carbon technology requires capabilities to adapt technology to local conditions and incrementally change it to improve efficiency. Hence, recipients of low-carbon technology must build up the capabilities accordingly to reach level one and two of technical change as outlined above by Bell and Pavitt.<sup>29</sup> Innovation (achieving level three or four of technical change on the side of the adopter) is not necessary to achieve an environmental goal. This difference gets more tangible if we look at some examples.

Low-carbon technology consists of four technology sub-sets: consumer products (small PV systems, building insulation technology, clean cars), more energy-efficient industrial technology, clean electricity generation technology (renewable energy technologies) and cleaner energy generation technology (replacing coal-based power plants with gas-based power plants). Let us take the example of hybrid cars. The core technology of hybrid cars is its engine that allows reducing carbon emission by combining a conventional combustion engine with a battery-driven electric motor. As Ockwell et al. point out, a number of different demand-side measures would be necessary to support the diffusion of hybrid cars in developing countries in order to give the current producers signals to invest in further development of the technology (Ockwell, Watson, MacKerron et al. 2008). From a strictly environmental perspective,

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<sup>29</sup> The related question is then how much and what kind of knowledge must be transferred to protect the environment? This question will be very difficult to answer: as Bell has already indicated it is very difficult to distinguish between B- and C-type flows.

importing the complete hybrid car could cater to the demand created through the demand-side policy in any developed country. Economic benefits within the developing country would accrue from selling these cars. Any form of further economic benefits to the developing country depends on the technology supplier's strategy for international technology transfer and the recipient country's policy to support industrial development and technological learning.

A similar argument can be made for clean and cleaner energy generation technology. While energy infrastructure is a crucial input to economic development, the generation of clean energy as such will not produce any additional economic effects to the generation of energy from "dirty" power plants. Wind turbines operating in a large wind farm on the coast of India are likely to require some changes in operating procedures in order to adapt to local conditions but these changes will not necessarily result in the need for localised production. This would open the possibility of economic benefits in addition to energy generation. Deeper local technological learning through the supply of wind turbines might take place but is neither a necessity for its operation, nor guaranteed through the mere presence of the turbines. As Bell and Pavitt show, "technological accumulation of technology does not necessarily follow from policies to achieve other objectives; it must become a policy objective in its own right" (Bell and Pavitt 1993).

Only the transfer of more energy-efficient technology might lead to increased economic benefits through the increased factor productivity of an existing industry without the localised production of such technologies.<sup>30</sup> Here again, some learning will be necessary to operate technology (Worrell et al. 2001), but learning leading to innovation is, from a strictly environmental perspective, not necessary.

Economists using the terms international technology "transfer" and "diffusion" interchangeably do so because they are interested in the spread of a technology, not the geographic location of its production. The same holds true in relation to the diffusion of low-carbon technology. From a diffusion perspective aiming primarily at an environmental goal, the geographical location of production is irrelevant.

## **2.6 Implications: governing international technology transfer**

Nelson defines governing structures as institutions with two different functions: "First they determine the values and interests that are to count in determining how much of what is to be provided and distributed. Second, they assign responsibility for provision, and provide a system

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<sup>30</sup> This assumption holds true only in a world without global carbon markets. If carbon is priced within industrialising and developing countries as well, economic benefits might accrue from the diffusion of renewable energy and carbon capture and storage technologies etc. They might be cheaper or some form of tradable emission credits might be sold on the carbon market.

of incentives and controls for enforcing accountability" (Nelson 2002). In other words, they have policymaking or administrative functions.

Currently, no international policy regime similar to the numerous environmental conventions or organisation similar to the World Trade Organisation (WTO) in the field of technology transfer exists. Any attempts to negotiate international rules for technology transfer between developed and developing countries failed in the late 1970s and early 1980s (Missbach 1999; Patel, Roffe, and Yusef 2000). After the liberalisation of world trade, developing countries' governments have lost direct influence on technology transfer. Radosevic describes this loss as a shift from contract bargaining in which developed countries negotiated technology, to improving the environment for local sourcing in which governments establish incentives and policy environments for multinational companies to transfer technology (Radosevic 1999). The dominant mode of governance of international technology transfer currently is the market shaped by the rules of world trade, from which the question of intellectual property rights emerged as the most controversial issue between developed and developing countries during the recent years (Maskus and Reichmann 2005).

Technology transfer under the UNFCCC is one possible alternative to market-governed technology transfer.<sup>31</sup> The UNFCCC has the role of the policy-making body, while the GEF has administrative functions. The question that shall close the theoretical chapter is how policy can support technology to achieve economic and environmental goals in developing countries assuming that technology is not developed within developing countries.

The theoretical analysis suggests that any policy to support international technology transfer for industrial development should support the technology supply as well as technological learning on the recipient side. In order to increase the chances of success, the UNFCCC should design integrated measures taking account of both. Technology supply depending on firm strategies is unlikely to be automatic, especially if the technology holder perceives the learning process within a recipient country as a competitive threat.

In order to reach environmental goals, a technology must be transferred and accompanying knowledge flows must put the recipient ideally into a position to adapt the technology to local conditions. Additionally, it must diffuse. These requirements form the design of policy under the UNFCCC. Policy to support the diffusion of low-carbon technology for environmental purposes should support demand as well as minimum technological learning by the recipient. In the second case, policies must create demand by developing an adequate environmental policy. Measures regarding technology supply are of secondary importance because demand can be

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<sup>31</sup> In fact, a number major multilateral environmental agreements contain clauses related to the issue of technology transfer (Sanusi 2005).

tailored to existing technology supply, technology owners are ready cater to markets and the learning requirements of the recipient are different than with regard to economic goals.

Policy that aims at supporting development and environmental goals, no matter whether it is called technology transfer policy or diffusion policy, is likely to need different measures to support each goal. Technological learning and the formation of technological capabilities are supported by science, innovation, and industrial policy, including measures giving incentives to investors to increase technology access to recipients (Cimoli et al. 2006). Diffusion of low-carbon technology is supported by environmental and energy policy (Jänicke 2000; Jacobsson and Johnson 2000). In the case of industrialised countries, it has been pointed out that any environmental policy effectively aiming not only at environmental protection but also at economic effects through innovation should be integrated with innovation policy (Klemmer, Lehr, and Löbbe 1999; Foxon and Pearson 2008). In the context of international technology transfer and environmental protection this case, however, has not yet been made.

I can summarise that the UNFCCC has three choices in designing technology transfer policy from the perspective of goals:

1. UNFCCC aims to design policy to support technology transfer for development. This would mean developing measures supporting learning and the cultivation of technological capabilities to a significant extent. Here, three sub-categories can be identified: policy supporting direct technology transfer by creating access to technology, policy supporting technology transfer indirectly by strengthening the opportunities for technological learning, and policy supporting the absorptive capacities of recipient firms. Policy supporting the incentives for private actors to transfer technology are unrelated to any increase of technological capabilities of recipients. Direct, indirect, and private actor-based support require different policy instruments. Ensuring direct access could be achieved by providing finance for technology acquisition or changing the rules of intellectual property rights. Indirect access could be supported through the education of the recipient firm's staff, setting up networks, or strengthening the links between recipient firms and technology intermediaries. Private actors could be supported by giving incentives or increasing demand in developing countries.
2. UNFCCC aims to design policy to support technology transfer for the environment but not for industrial development. This would mean developing measures supporting learning and the cultivation of technological capabilities to a lesser extent. It would, however, include measures to support the diffusion of transferred technology. Most of these would be actually some kind of policy transfer and transfer of knowledge to support capacity building for policy implementation.

3. UNFCCC aims to achieve both goals and will then need to combine measures from alternative 1 and 2.

What kind of policy needed, therefore, initially depends on the specific goals of the technology transfer process. After these goals are established, the selection of instruments and the consideration of specific cases may begin.

Deciding on the goals and specific instruments is one important aspect of policy making. It institutionalisation<sup>32</sup> and implementation are of similar importance. The current dominant model of international environmental policy making follows a strict top-down approach. Decisions are made on the international level. They get institutionalised in their majority on the national level (in form e.g. of national legislation for energy efficiency standards for buildings) and implemented on a local level (e.g. within new building projects). This thesis investigates a similar setting, with the exception that UNFCCC decisions do not get institutionalised within a nation state but through the GEF as implementing agency. Decisions are made on the UNFCCC level, are institutionalised through some form of GEF developed principles or approaches to project design, and finally implemented on a local level within a specific developing country through a GEF project. The open question is whether in such a top-down framework decisions taken on the international level can be successfully implemented. Successfully bridging these three levels would require a high-level of co-ordination, integration, and steering.

In the following, I will develop a theoretical framework that will allow me to discuss in how far policy developed at the different levels may support international technology transfer for environmental and economic benefits. I will also discuss in how far it corresponds with the positions of developed and developing country on international technology transfer.

## **2.7 Summary: Analytical framework**

In the following, I will summarise the theoretical insights of the preceding parts of the chapter in order to guide and structure my empirical analysis. The aim of the theoretical chapter is to develop a framework to evaluate and discuss different policy options under the UNFCCC, the technology transfer approach of the GEF and the PVMTI project in India.

### **International technology transfer**

As seen in the preceding paragraphs, an evolutionary perspective understands international technology transfer as a technological learning process between a technology supplier and a technology recipient requiring different kinds of resources. The learning process is dynamic and its outcomes are determined by the strategy of the supplier, the existing technological

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<sup>32</sup> With institutionalisation I mean that a political decision must be put into some legal form like a law or regulation.

capabilities of the recipient and the extent to which the recipient manages to complement the knowledge received by additional technological learning (either within its organisation or through capitalising on links to the technological system it is embedded in). Furthermore, international technology transfer takes place through different modalities usually referred to as mechanisms that set part of the context to the learning process.

### **Economic benefits and learning**

Evolutionary approaches stress that there are different levels of knowledge that are required to achieve different levels of usage of the technology by the recipient. From an evolutionary perspective, different levels of usage and learning have different economic effects. This perspective therefore helps explain why some transfer processes have different economic outcomes than others.

Bell differentiates firstly between the transfer of capital goods and services needed for the physical facilities of a new production system. This includes the production machinery and equipment as well as the managerial/technological services to carry out the installation of the production machinery. These knowledge flows correspond with the neo-classical perspective on international technology transfer.

Bell secondly refers to the skills and know-how needed to operate and maintain the newly-installed production facility. Some of the skills might be found in the host country but usually, as Bell states, if the transfer projects involve elements of the first type, at least some elements of the whole transfer process fall into the second category. Bell thirdly refers to the skills and knowledge necessary to generate technical change. Those include the capabilities to adapt the technology to local, changing needs, to replicate it, to enhance it and, eventually, create a new product. In addition, as Bell points out, although there is no sharp distinction between the second and third type of flows, flows of the third type are significantly different and additional to the knowledge needed to operate a production facility (Bell 1989: 5).

As Bell and Pavitt have pointed out, only technology transfer of the third type will lead to an augmentation of the host country's technological capacity, while the two others will lead to creation of new production capacity. It is important to underline that the pure installation of production capacities does not automatically lead to technical change in the host country. Additional knowledge and deeper understanding beyond operating and maintaining the technology are necessary to alter and modify it productively.

Lall and others make a similar point by noting that recipients may assimilate the transferred technology to different degrees. They distinguish between operational assimilation, adaptive assimilation, replicative assimilation, and innovative assimilation. Bell puts the focus on the different types of knowledge that may be included in the actual transfer process. The academic perspective emphasizing the level of assimilation leaves open whether assimilation is achieved



through the knowledge as part of the exchange between supplier and recipient or through additional activity on the side of the recipient. According to Lall and others, international technology transfer can hence consist of learning processes leading to four different levels of technological assimilation on the side of the recipient.

- Type 1 processes comprise acquisition of designs, equipment etc. as well as operational know-how and lead to operational assimilation.
- Type 2 processes include the knowledge for local adaptation and minor improvements leading to adaptive assimilation.
- Type 3 processes include knowledge to replicate the technology leading to replicative assimilation.
- Type 4 processes include the knowledge for substantial development and improvement of the technology leading to innovative assimilation.

Relevant knowledge can be part of the actual transfer process between supplier and recipient. The different levels of assimilation can also be reached through complementing the knowledge received within the actual transfer process either through existing technological capabilities or the development of additional capabilities. Additional capabilities may be built through internal learning processes (e.g. internal R&D activities) and/ or engaging into learning processes with institutions offering knowledge as described in chapter 2.1.12. (Lall 1998).

The importance of achieving a high-level of technological learning and gaining the ability to innovate has been highlighted within the most recent discussions about the technological catch up of developing countries and their industries' ability to jump or leapfrog to the most advanced technology by leaving out earlier versions of the technology (e.g. learning to produce 2 MW wind turbines without learning to produce 0.2 or 0.5 MW wind turbines). Lee, for example, differentiates between duplicative imitation, creative imitation and real innovation (Lee 2005).

### **International technology transfer for environmental benefits**

As seen in chapter 2.4, international technology transfer for environmental benefits relates to the import and spread of a technology through a constituency of users and is the result of individual adoption decisions (diffusion). Diffusion is driven by the characteristics of the technology (within the theoretical work reviewed usually related to as supply) as well as the characteristics of the users, which determine the willingness to adopt a certain technology (in theory usually related to as demand). In the context of developing countries we assume that the low-carbon technology is not entirely produced nationally but must be at least partially imported, as otherwise there would be no international component in the transfer process.

Due to the specific characteristics of low-carbon technologies (more costly than alternatives, early stage of development) their diffusion requires policy to change its characteristics (supply-side, e.g. R&D) as well to increase demand because, without policy intervention, this is usually low. If immediate environmental benefits are to be achieved within a developing country, a minimum of demand-side policy is required. Supply-side policy aiming to achieve a change of the characteristics of the technology does not make sense as long as the technology is not produced within the developing country. The supplier's strategy determines access to a certain low-carbon technology. Demand-side policy is a necessary (though not sufficient) condition for large-scale adoption. It might be insufficient as other barriers (lacking awareness etc.) might be in place.

If demand side policy is in place, learning processes similar to those discussed in relation to international technology transfer are required for adoption of the low-carbon technology. Type 1 learning is necessary for the operation of the technology. Depending on the technology and local circumstances, Type 2 processes might also be necessary in order to adopt a technology to operate efficiently. Type 3 processes leading to the knowledge to replicate a technology are, from a strictly environmental perspective, not necessary. All low-carbon technology could be imported from abroad. Local replication in form of localised production may be desirable from an economic point of view but is not necessary from an environmental point of view. Type 4 processes might open the possibility to change the characteristics of a technology which may be desirable from an environmental point of view as new characteristics might influence adoption and have implications for demand-side policies. Therefore, they are also relevant from an environmental perspective. However, type 4 processes are only relevant for producers of such technologies but not for adopters. Furthermore, as long as adopters, for example power companies operating wind farms, do not aim to turn into producers of low-carbon technology via type 4 processes, these do not need to take place in order to achieve environmental goals within a specific country.

### **Analysing actor positions, policies and their implementation**

The summary of the preceding paragraphs has shown in a condensed way that international technology transfer for economic benefits can be seen as a learning process that leads to different kinds of capabilities on the side of the recipient. The capabilities to innovate are, from an economic perspective, the most important. The outcomes of the process are determined by technology supply, existing level of capabilities of the recipient and the recipient's learning effort through links with institutions offering knowledge of the technological system the recipient is embedded in. This view differs from more neo-classic theoretical positions, which do not differentiate between different types of knowledge or differing efforts to achieve different levels of capability building and technological assimilation. From a neo-classic

perspective, the market is a sufficient vehicle for international technology transfer, as it considers primarily technology as capital goods and not as different types of knowledge.

Technology transfer aiming to achieve environmental benefits outcomes are determined by the same factors as for economic benefits plus demand side policy must be in place to support diffusion. Also, only learning of the types 1 and 2 are required to achieve environmental benefits although, in practice, learning of the types 3 and 4 may be an intended or unintended result. From a neo-classic perspective, the establishment of a market in form of demand policy would be sufficient for diffusion.

From the evolutionary perspective adopted here, policy supporting international technology transfer may therefore address technology supply, the recipient's capabilities, the knowledge institutions of the technological system into which the recipient is embedded, and domestic diffusion through demand policy. Furthermore, it might want to support the four different levels of learning outlined above. As seen in chapter 2.3, there is no fixed set of rules how the different outcomes of learning are achieved. Empirical analysis has shown that type 4 learning processes tend to be achieved more successfully if the recipient has a certain level of technological capabilities and is able to expand capabilities by drawing on linkages to knowledge offering institutions of the technological system it is embedded in. We can therefore assume that policy addressing technology supply, recipient capabilities and the institutional aspects of capability building is *ceteris paribus* more likely to achieve type 4 learning processes than policy addressing only selected aspects. Also, policy addressing technology supply, capabilities, technological system and the issue of demand policy is more likely to achieve environmental benefits than policy addressing only technology supply or only demand side policy.

Within the empirical chapters, each policy addressing international technology transfer will therefore be asked whether it intends to achieve economic or environmental goals or both. Its design but also its results through implementation will then be discussed with regard to its goals and with regard to the following aspects: the four different levels of technology assimilation, technology supply, recipient technological capabilities, institutional aspects of capability building and demand policy. Also, it will be asked how the results of the discussion relate to the positions of developed and developing countries' governments.

### **3 Methodology**

The previous chapter presented the theoretical framework underlying this research. This chapter provides the appropriate research design and methodology to answer the research question. The chapter is divided into two parts. The first part presents my research design. The second part presents the rationale for my chosen method.

#### **3.1 Research Design**

The research design is the plan from the initial research question to the conclusion of the study. It contains the questions to be studied, offers provisional answers (in relation to propositions/hypotheses) to the questions based on existing literature (theory), defines the units of analysis, links data to propositions, and develops criteria for data analysis (Yin 2003).

##### **3.1.1 Choice of case study**

The first step of choosing a case study consisted in refining my overall research interest. The overall research interest of this thesis lies in better understanding how international policies and related government-funded projects may support international technology transfer for low-carbon technology.

As initial research showed, international technology transfer was a prominent topic under the UNFCCC but subject to much debate between developed and developing countries' governments. Further scoping research indicated that developed and developing countries' governments appeared to pursue considerably different goals in relation to international technology transfer under the UNFCCC.

Based on the understanding that international technology transfer could serve different purposes, I developed two analytical requirements in relation to my thesis. Firstly, my investigation of the international technology transfer activity of low-carbon technology should not only lead to a better understanding of how to politically support international technology in general, it should also include a discussion of how far it could serve as an example for any international technology transfer policy under the UNFCCC. Secondly, results of the analysis of my still undetermined, empirical research object should be discussed in relation to the differing goals in relation to the international technology transfer of developed and developing countries' governments.

This decision meant that I had to study the positions of developed and developing countries' governments under the UNFCCC in more detail. The literature on UNFCCC negotiations

suggested that considerable differences between both country groups existed, but no detailed analysis of their positions could be found in the academic literature. I undertook this analysis in chapters 2.2.1 to 2.2.4.

Once I had decided that I would like to learn from real-world technology transfer activity for policy development under the UNFCCC, I had two choices to make. Firstly, I had to decide whether it would be more beneficial to the project to examine the international transfer of any technology or the international transfer of low-carbon technology. Secondly, I had to decide whether I would like to draw lessons from private or publicly-supported international transfer activity. As I had the impression low-carbon technology was slowly being manufactured in selected developing countries and I knew from previous research that international technology transfer played a role in developing these industries, I became certain that research on international transfer of low-carbon technology was possible. Also, as international technology transfer of low carbon-technology was prominent on the policy agendas of developed countries' governments, I felt that sufficient government-supported activities in this field would exist to serve as research objects. So I decided to focus on publicly-supported international technology transfer activity of low-carbon technology.

Once I had made these decisions, the choice of the case study depended on a number of criteria that had to be fulfilled. The aim was to find an example of international technology transfer of low-carbon technology from a developed to a developing country that was politically supported. In order to be suitable for social science enquiry, the project had to be finished or almost finished, otherwise I could not be certain about its results. Also, it should not have taken place in the too distant past. Interviewees should have relatively fresh memories of the project and its implementation. Key documents needed to be either in German or English and the interviewees should be able to communicate in either German or English. German and English are the languages in which I was able to undertake research and limited financial resources left no room for interpretation and translation. Also, the empirical object should stand for wider group or a certain type of politically supported transfer activity in order to ensure generalisability of findings. Another important aspect was whether my academic department had research links to the developing country in which the case study should take place. Personal contacts were considered crucial for successful field work.

To find a suitable case study, I undertook the following activities: Firstly, the national communications of developed countries to the UNFCCC were scrutinised as developed countries were urged to include their technology transfer activities in relation to climate change in their national communications. However, it turned out that information about the listed projects is not only scarce, but also (in many cases) activities listed had in reality never

materialised or had only a very remote relation to international technology transfer. No project was found that was suitable for my purposes.

Secondly, I screened websites as well as annual reports of national development ministries/agencies in the UK, the USA, Germany and Scandinavia (for their tendency to publish most of their activities also in English). However, it turned out that international technology transfer was rarely supported and most activities with regard to low-carbon technology concerned capacity building for regulatory aspects, export promotion or feasibility studies evaluating possible deployment of renewable energy technologies. Several agencies were contacted directly by phone in order to gather further information, but in most cases promising projects were delayed or cancelled without giving public notice. Some relevant projects could not be considered as they were implemented in countries where English was not widely spoken.

Thirdly, I screened the project databases of the World Bank, IFC and the Global Environment Facility. It turned out again that few projects were concerned with international technology transfer on low-carbon technology. The Photovoltaic Market Transformation Initiative (PVMTI) stood out and fulfilled all relevant criteria. It was modelled after the principle of market transformation, which is an approach that abounded in the late 1990s in international development cooperation at all levels. PVMTI had started within a reasonable period before the commencement of this doctoral research and was almost finished. It supported photovoltaic technology, which is an important low-carbon technology. It was partly implemented in India, where English was widely spoken and my academic department had a prominent research institution as a partner, TERI in New Delhi. Also, the GEF linked the transformation of markets to international technology transfer in their strategy documents and public relations material. An initial visit to the GEF in Washington confirmed the assumptions about the projects and PVMTI was ultimately chosen as part of my case study.

As I learned that the GEF acts as the financial mechanism to the UNFCCC, I decided not only to investigate the extent to which the GEF approach to international technology transfer relates to positions of developed and developing countries' governments under the UNFCCC. I decided to include in my analysis whether the UNFCCC had an influence on the approach the GEF had developed toward international technology transfer. Also, I needed to understand the overall approach of the GEF to international technology transfer in order to fully understand the goals of PVMTI and the underlying principles of how they should be achieved.

### **3.1.2 Design of case study, units of analysis, and data sources**

Yin distinguishes four basic designs of case studies: the single case study that observes one case and its context, the multiple case study that observes a number of cases and their context, the embedded case study that observes one context and one case with different units of analysis, and the multiple embedded case study that observes a number of cases with different units of analysis (Yin 2003).

To investigate the GEF and its technology transfer approach, a single embedded case study with three different units of analysis is most appropriate. The units of analysis are the UNFCCC decisions on international technology transfer (1), the GEF and its approach to international technology transfer (2) and implementation of the GEF approach in form of a GEF project (3). The reasons for choosing the level-case study are rooted in the research question and theory.

The research question asks how far the GEF might fulfil the goals of developed and developing countries under the UNFCCC. Choosing the GEF and its approach to technology transfer as a research unit is therefore inevitable. The way the GEF conceptualises international technology transfer will have impacts on the results of any GEF activity with regard to international technology transfer approach. Of interest in relation to the research question is how the GEF operationalises and implements international technology transfer.

In order to better understand the GEF approach in practice a GEF project needs to be investigated. The value of the GEF policy can only be discussed by looking at micro-level processes in the form of a GEF project to gain empirical data. I have selected one GEF project implemented in one developing country: India. Investigating a single project is, of course, limited in generating generalisable results. Due to the resource constraints within a PhD project, an inclusion of further GEF projects was out of reach. In order to increase the explanatory power, a comparative element was introduced. The GEF program was compared to an Indian government program supporting the same technology and aiming at the same goals.

As the GEF acts as the financial mechanism to the UNFCCC, any UNFCCC policy on international technology transfer constitutes part of the GEF policy context and might (should) influence the GEF approach on technology transfer. The UNFCCC is, therefore, a necessary level of analysis beyond establishing the positions of developed and developing countries as undertaken in chapter 2. Parties to the convention should set the rules and frameworks of the GEF in relation to GEF activities carried out on behalf of the UNFCCC. What remains to be investigated in relation to the UNFCCC is how far these positions have been translated into UNFCCC policy on international technology transfer in the form of decisions taken during the conferences of the parties to the convention.

The theoretical part of this thesis underlined that international technology transfer is basically a learning process. The outcomes of the learning process need to be somewhat different for the achievement of either environmental or economic goals. The central variables are technology supply, the technological capabilities of the recipient and the learning effort made through engaging in institutions offering knowledge. For the achievement of environmental goals, the learning process needs, in most cases, to be supplemented with some measures supporting the adoption of transferred technology within a wider user group.

Both benefits are, if at all, achieved through the implementation of the GEF project within the context of the country of its implementation. In order to understand how far economic and environmental benefits result from project activity through influencing (or neglecting) the four variables mentioned above, an in-depth case study will be undertaken (Unit of analysis 3).

As the project follows the GEF approach to international technology transfer, the specifics of the approach also determine the project outcomes. The GEF approach to technology transfer represents part of the policy context of the micro-level technology transfer process supported by the GEF project. Depending on the nature of the GEF approach, it might also relate to the innovation system the international technology transfer process takes place in (Unit of analysis 2).

Another layer of policy context, which that might have an impact on the micro-process of technology transfer taking place within the GEF project, is the UNFCCC (Unit of analysis 1). The UNFCCC gives guidance to the GEF including international technology transfer which might have had an influence on the GEF approach.

As stated before, the research does not aim to understand why there was an influence of one level on another. The research aims to explain whether or not the GEF approach to international technology transfer might fulfil the requirements of developing and developed countries governments under the UNFCCC. Parts of this explanation are possible influences from the UNFCCC on the GEF technology transfer approach, and from the approach to GEF project design and implementation. As we will see in the empirical chapters, these three levels are much more loosely coupled than might be actually necessary for effectively achieving the goals of both developed and developing countries in form of environmental and economic benefits.

The value of my specific case study design lies in its innovation (I do not know of any similar design to investigate technology transfer programs). I render the complexity and challenges in trying to achieve micro-level technological change for the environment and development in developing countries through a decidedly macro-level policy development. Effectively, I am combining top-down macro-policy analysis with bottom-up micro-implementation analysis. One advantage is that I am undertaking primary research on all three levels to gain an detailed



understanding of country positions on international technology transfer under the UNFCCC, an in depth understanding of the GEF approach to international low-carbon technology transfer, and an analysis of its practical implementation. Also, the perspective chosen will give evidence on whether and how these three levels interact.

### **3.1.3 Unit of analysis 1: Technology transfer and the UNFCCC**

Investigating the subject of international technology transfer at the UNFCCC level was undertaken for three reasons: to gain contextual and background information on the subject of international technology transfer, and to establish what kind of policy with regard to international technology transfer was decided upon.

This part was originally planned to be a review of the secondary literature. However, given the fact that the existing literature has not considered the issue in an in-depth manner primary research needed to be undertaken. In terms of method, I used document analysis and expert interviews to verify the results of the document analysis. Document analysis seemed an adequate method as I aimed to establish the results of the UNFCCC processes in form of policy rather than aiming to explain why a particular decision had been taken or a certain policy had been formulated in a certain way. As the issue of technology transfer is also addressed in the Kyoto Protocol, it was included. All official results of UNFCCC processes are published by the UNFCCC secretariat in PDF form and are available online. The research questions for this unit of analysis are:

- What are the positions of the parties to the convention on technology transfer?
- What provisions are made regarding technology transfer in the UNFCCC convention text and the Kyoto Protocol?
- What have parties to the UNFCCC decided on technology transfer during the conference of the parties (COP) negotiations?
- What kind of policy is formulated based on UNFCCC decision

The following types of UNFCCC documents were included in the analysis:

**Table 5: UNFCCC documents**

Texts of the Convention as well as the Kyoto Protocol
Decision of the Conference of the Parties
Submissions by parties to the convention on technology transfer
Technical papers related to technology transfer
UNFCCC workshop reports
Reports of the consultative process on technology transfer
Documents from the UNFCCC Expert Group on Technology Transfer
Documents produced by the UNFCCC subsidiary bodies

Source: Author

A full list of UNFCCC documents consulted is found in the literature section. To develop a normative framework, I was looking for building blocks in the form of decisions on norms, guidelines, budgets, actions or concrete aims regarding technology transfer. Additionally, I was looking for propositions or suggestions on norms, guidelines or aims of technology transfer even if they were not agreed upon by the parties to the convention. A normative framework should ideally include the quality and quantity of economic benefits as well as a way to achieve them.

I conducted interviews with members of the UNFCCC secretariat and the GEF secretariat to verify my interpretations. Experts were selected on the basis of their familiarity with the results and decisions concerning technology transfer under the UNFCCC. Members of the technology transfer sub-unit of the UNFCCC were identified as most suitable. The expert interviews were semi-structured containing open questions. The questionnaire is found in appendix H.

### **3.1.4 Unit of analysis 2: The GEF and its technology transfer approach**

The main research questions for this part of the thesis are:

- What is the GEF approach to international technology transfer?
- What role has the UNFCCC played in developing this approach?
- How does the GEF support the achievement of environmental and economic benefits

The second unit of analysis had three main tasks: to understand the GEF relationship to the UNFCCC, to understand the GEF approach to technology transfer, and to understand how the GEF aims to achieve environmental and economic goals both more generally and as specifically articulated under the UNFCCC.

The GEF – UNFCCC relationship was established by reviewing pertinent literature, by undertaking a UNFCCC document analysis, as well as by conducting expert interviews. Relevant UNFCCC publications include documents stating the legal status of the relationship

between the UNFCCC and the GEF, and official communications between the UNFCCC and the GEF. The parties to the convention give guidance to the GEF in form of COP decisions. The GEF responds to guidance with an annual official response. Furthermore, the UNFCCC secretariat produces regular reviews of the GEF activity. The basic terms of cooperation between GEF and UNFCCC are spelled out in the so-called “memorandum of understanding.” A full list of documents considered is included in the appendix. The document analysis yielded a formal representation of the GEF relation towards the UNFCCC including GEF duties and GEF activities carried out. To a certain extent, it also reflects the positions of developing and developed countries towards the GEF. The formal representation was then refined and extended through expert interviews with representatives of the UNFCCC secretariat, the GEF secretariat, as well as representatives of the GEF implementing agencies.

The GEF approach to technology transfer was established through GEF document analysis, GEF background publications as well as expert interview with representatives of the GEF secretariat and representatives of the GEF implementing agencies. The aim was to establish the intellectual roots of the approach, the theoretical relationship to technology transfer as articulated within the approach, its goals, as well as the perspective of representatives of the GEF and its implementing agencies on the effects and the value of the approach. Experts were identified through the snowball approach (Yin 2005). An Internet and literature search was conducted to identify experts with working relationships to the GEF or its implementing agencies on the subject of technology transfer. These were contacted regarding expert interviews and the identification of further experts. The GEF as well as the UNFCCC secretariat were contacted directly for the identification of experts on the subject within their respective institutions. Each interview conducted included the request to identify further experts. Identifying experts was stopped, as interviewee suggestions did not lead to yet unknown experts.

### **3.1.5 Unit of analysis 3: The PVMTI Project in India**

While the focus of the investigation within the previous units of analysis focused on understanding formal relationships, positions, debates and generic frameworks (especially the GEF approach) found in documents and conceptual understandings of relevant actors, the third unit of analysis investigates the much more complex reality of project implementation. A method was needed to evaluate the outcomes of the PVMTI project, as well as the processes leading to these outcomes. Special attention was given to developing an evaluating framework that does justice to the requirements of project evaluation but also considers the relationship of the PVMTI project results to the wider context of the UNFCCC and the GEF. Thus, I will briefly elaborate on the specific challenges of integrating project evaluation into a case study

and then explain how these challenges were addressed. I will then explain how I embedded the research on PVMTI into a wider Indian context to integrate the certain aspects of the UNFCCC and GEF technology transfer approach.

Identifying a GEF project suitable for my research needs proved particularly challenging. It had to fulfil several criteria:

- it had to be based on the market transformation approach
- it had to support a low-carbon technology
- it had to be completed or be at least near to completion in order to show some results
- completion should have taken place in the not too distant past to ensure that project participants still had adequate memories of project occurrences

Although the GEF operates a database containing GEF projects and publishes a bi-annual project overview with basic information on all GEF projects, obtaining more detailed information proved very difficult. Obtaining information on the status of individual projects turned out to be time- and effort-consuming. Often published project running times were not updated. In addition, further research (examining project reports, project websites, reviews and reports by the GEF, their implementing agencies, or contacting project participants) often revealed that projects had never really taken off, were considerably delayed, or were cancelled.

The PVMTI project was chosen because the project website revealed that project funds were spent, considerable project activity had taken place and some results had already been achieved. The PVMTI project was mentioned within various GEF publications and reviews indicating that the project was actually being implemented. The project website listed the project running time from 1999 until 2008 which was a suitable time span to be considered within this research project. The PVMTI project is financed by the GEF and implemented by the International Monetary Fund (IMF). Its goal is to increase demand for small-scale PV applications within rural areas of India, Morocco, and Kenya through the financial support of vendors of such systems. Although technology transfer is not an explicit goal of the project – as no technology push measures are included in its design – technology transfer is expected to take place as demand grows through the successful support of PV vendors. The project follows the market transformation approach. Due to the resource limitations within this project, only research in India could be undertaken.

Yin states that project evaluations face four particular challenges which have to be overcome: changes within the program during evaluation, changes in accessibility to the whole or parts of the program, high attrition rates, and strained relations between evaluator and those evaluated (Yin 1992). Of the four particular challenges, I have encountered three. The GEF and the IFC denied any access to project documents on the ground that the project was not closed and that

the participation of private actors required confidentiality. The evaluation is therefore based on public project documentation and expert interviews. This represents a limitation to evaluative purposes. However, I contend that the empirical basis of my research is sufficient to claim that my results reflect the PVMTI project results and processes adequately. My claim is based on three arguments: the initial PVMTI project document containing a detailed explanation of the project rationale and its goals is a public document; project participants talked freely about the project and its results; one additional report on the project was gathered revealing a number of further project particulars. Triangulation of all available sources revealed no contradictions regarding project implementation and results.

Regarding the problem of attrition, during fieldwork it turned out that the responsible IMF desk officer in charge of PVMTI as well as the country manager in India had changed. Senior members of the companies participating in India had left their employers. However, expert interviews did not leave any relevant knowledge gap that could not have been filled.

While most of the PVMTI project participants talked openly about their project experience, project staff in Washington as well as the company acting as project manager in India met my research interest with considerable suspicion and limited cooperation to the absolute minimum.

Yin furthermore suggests a specific design of the evaluative case study. It should include a review of the literature, carve out project goals, construct a program logic model, and define key components as separate units of analysis if required. Data collection should include multiple sources (Yin 1992). Project goals are derived from the initial project report, the project website, and GEF documents. Based on the same documents an abstract model of the project model was derived. The model acts as a hypothetical understanding of the project that guides analysis. Comparing evaluation results with the hypothesized model reveals any deviations from planned processes and points to implementation problems. Having a hypothesized model of the program logic allows one to differentiate between effects caused by the implementation of the project and effects caused by the project design. For evaluating the PVMTI project further units of analysis were not defined. However, experts from all institutions involved in the design and the implementation of the project were asked to be interviewed. These included representatives of GEF, IMF, IMPAX (the company operating the project funds), IT Power (the firm responsible for project implementation in India) and all PV vendors that received finance from PVMTI funds. To trace effects on technology transfer, the PV manufacturers supplying PVMTI vendors were interviewed. To contextualise the interviews by PV vendors that received PVMTI funding one additional PV vendor, operating in the same area not supported by PVMTI funds, was interviewed. Adding a second regional perspective was deemed necessary to increase the understanding of the local market context within which PVMTI funded companies were operating. Representatives of the Indian government that had been involved in the early stages

of PVMTI implementation, as well as Indian experts with knowledge of PVMTI, were additionally interviewed. The interviews were based on a questionnaire containing open semi-structured questions that can be found in the appendix.

### ***Criteria for the evaluation of the PVMTI project***

Projects can be evaluated in light of their project goals or in relation to norms derived from theories external to the project. The initial idea of this research was to evaluate the PVMTI according to a normative framework developed within UNFCCC negotiations to reflect upon the way it relates to UNFCCC provisions on technology transfer. As it turned out, parties to the UNFCCC have not agreed to any normative framework regarding technology transfer. They have not successfully decided on the modalities and outcomes of any technology transfer. In order to maintain the “link” to the UNFCCC framework I decided to discuss the GEF approach and PVMTI project results in light of the different positions on technology transfer under the UNFCCC. These positions are not mutually exclusive but prioritise different goals. Developed countries tend to favour the reduction of carbon dioxide emissions while developing countries place more emphasis on assimilation of technology. For both goals criteria must be developed and applied to the PVMTI project. The criteria developed by the GEF to measure their goals for the PVMTI project and, market transformation will be discussed in the chapter on the PVMTI project.

### ***CO<sub>2</sub> Emissions***

Environmental benefits regarding CO<sub>2</sub> are measured by two related concepts: reduction and avoidance. CO<sub>2</sub> reductions are calculated if an existing technology is replaced with a technology emitting less or no CO<sub>2</sub>. Reductions can be calculated by comparing emission figures before and after technology switching. If a PV system replaces a kerosene lamp completely, the annual CO<sub>2</sub> reduction equals the CO<sub>2</sub> emissions from burning kerosene for one year. Calculating CO<sub>2</sub> avoidance is a much more complex concept. CO<sub>2</sub> avoidance tries to estimate CO<sub>2</sub> emissions that do not occur because one technology has been installed instead of another technology. For example, when a PV system is installed and no other more CO<sub>2</sub>-intensive technology taken out of service (for example a kerosene lamp) than it is assumed that the installation avoided the installation of additional carbon emitting technologies and respective emissions. The amount of avoided emissions is calculated by estimating the energy generated through the PV module. It is then estimated how much carbon would have been emitted by a comparable fossil fuel-based technology to generate the same amount of energy.<sup>33</sup> Using both concepts is far beyond the

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<sup>33</sup> CO<sub>2</sub> avoidance for PV systems is essentially a result of the type of the technology (operational characteristics of PV module plus supporting equipment), the number of applications, the duration of operation, the quantity of energy generation per unit of operation time (operational efficiency + insolation), and the amount energy substituted from fossil fuel sources.

scope this thesis. I will use selected rough proxies for the reduction and avoidance of CO<sub>2</sub> emission, which are summarised in table 5:

**Table 6: Indicators for CO<sub>2</sub> reduction and avoidance through PV systems**

	CO <sub>2</sub> emission reduction indicator	Source
1	Sales volume PV systems	Firm data/ project documents
2	Number of installed PV systems	Firm data/ project documents
3	Still operational since installation (yes/ no)	Firm data/ expert estimation/ field visit (selected)
4	Duration of operation	Firm data/ user data/ user estimation
5	Total amount of energy produced	User records
6	Level of efficiency during operation	Firm data/ user data/ user estimation

Source: Author's compilation of the relevant literature

The indicators 1 and 2 will be obtained through interviews and public project documents. Indicators 3-6 cannot be established, as I am not undertaking a user study. Indicator 3 will be substituted by establishing whether PV vendors entertain PV service networks.

### ***Technology transfer***

What constitutes technology transfer depends largely on the underlying theoretical notion of technology transfer. Neoclassical approaches would consider the investment in some sort of capital equipment as a sufficient indicator for technology transfer. Evolutionary approaches would include a stronger learning aspect on the side of the recipient and measure changes in technological capabilities as indicators for technology. As I am not undertaking an in-depth study of technological capabilities, I will use a set of indicators combining both views to trace investments. I will then establish rough proxies for learning effects and changes in technological capabilities. The evaluation will be qualitative in nature. Technology transfer effects will be established through expert interviews with PV cell and PV module manufacturers. The questionnaire asked for information regarding technology transfer with open questions which were specified in the ensuing discussion (investments in new production technology through different technology transfer mechanisms as well as any activity indicating learning efforts such as hiring new staff, establishing links with firms and institutions, change in processes, etc. that resulted from PVMTI).

### ***The integration of Unit 3 with the themes of UNFCCC technology transfer and the GEF approach***

In order to increase the relevance of the PVMTI evaluation beyond the project as such to the questions answered in units of analysis 1 and 2, as well as to the wider theme of this thesis, I broadened the scope of my fieldwork in three directions. Firstly, I researched the position of the Indian government on the issue of technology transfer at the UNFCCC level. This was done by

interviewing two former high-level officials who had participated at UNFCCC COPs as negotiators.

Secondly, I broadened the PV industry study in order to understand what the importance of technology transfer is to the industry, how new capabilities were acquired, and what kind of constraints the PV industry was facing regarding knowledge access. Including a broader picture of international technology transfer dynamics within the Indian PV industry seemed necessary, as it turned out during research at the UNFCCC-level, since the issue of technology transfer remained controversial. Further research in adequate policy intervention for technology transfer within industry dynamics offered a chance to compare the UNFCCC debates with on-the-ground industry needs. Establishing a wider picture in the PV industry also helped to understand the requirements, the advantages, and the shortcomings of market-based projects like PVMTI regarding technology transfer. To capture effects along the value chain, PV cell and PV module manufacturers were interviewed. Research in the PV industry was carried out through literature reviews and expert interviews. The sampling process, based on an Indian government compilation of manufacturers and an Indian PV trade fair catalogue is described in more detail in chapter 6.

Thirdly, research was carried out by investigating the Indian government program concerning PV technology. The program shows similar goals to PVMTI but takes a completely different approach. Comparing the PVMTI project with the government PV program helps to draw out the specific merits of the underlying approach (as opposed to the merits of individual project implementation) and, more generally, increases the relevancy of research results regarding the GEF market transformation approach. The investigation of the Indian government program was undertaken through a literature review, an analysis of official government program reviews, and by conducting interviews with experts. Experts included representatives and former representatives of the Ministry of New and Renewable Energy, consultants and the heads of the State Renewable Energy Agencies of the states in which PVMTI funded projects were operating. In addition, PV industry experts were questioned about their experiences with the Indian government program. It has to be emphasized that the results of this part of my research should be treated with caution for two reasons. Firstly, a number of Indian academic experts on PV in India underlined that government sources were unreliable and that government program reviews are usually optimistic regarding results. Secondly, the program started in the early 1970s and has been implemented in all Indian states. A thorough consideration would have required much more time and resources than available within this research project. The existing literature partly makes up for this constraint but it is usually descriptive in nature and fairly shallow. Therefore, the results of the Indian government investigation carried out for this thesis can be only be considered preliminary and might be of limited scientific value if considered on



their own. However, by placing them in the context of my wider research on PVMTI and the PV industry, they become very valuable insofar as they both contribute to the holistic perspective required for a case study and address my research question.

### 3.1.6 Data analysis

Data analysis followed a process called “iterative explanation building.” This is a technique which aims at iterative explanations of the object of study to trace causal links (Yin 2003). In order to trace relations between the three units of analysis, each chapter contains an analysis of the unit of research as such and an analysis relating findings to the other units of analysis. The linking of the three units of analysis is done to trace possible causal links and to support the holistic picture of the case study.

## 3.2 Choice of approach and method

Approach and method should be selected according to the research question and the related object of research. For the purpose of this research, I have chosen a single case study approach. The case study approach is adequate as a research approach if the dynamics of a certain historical period or a particular social unit in a holistic manner shall be investigated (Verschuren 2003). Eisenhardt defines a case study as “a research strategy which focuses on understanding the dynamics present within single settings” (Eisenhardt 1989). The case study approach allows “to retain the holistic and meaningful characteristics of real-life events - such as individuals’ life cycles, organizational and managerial processes, neighbourhood change, international relations, and the maturation of industries” (Yin 2003). Additionally, the case study approach allows investigating complex structures and processes (Verschuren 2003) and is a suitable strategy to answer “How” and “Why” questions (Yin 2003). Most importantly, the case study approach allows establishing causal explanations for events. According to Bennet, inferring causal connections and establishing relevant variables is one of the comparative advantages of case study research (Bennet 2007).

The reasons for choosing the case study approach for this thesis are the following:

**Research question:** The thesis seeks to understand the extent to which the GEF and its approach to technology transfer may do justice to the positions of developed and developing countries under the UNFCCC. Answering the question requires an understanding of the causal relations between all relevant factors determining the GEF project results and an identification of the specific role of the GEF approach.

**Complexity of the case:** Results of the GEF projects are determined by a number of variables at different levels. The first level is the UNFCCC and the guidance it might give the GEF. The second level is the GEF and the way its particular approach influences results towards both

goals. The third level relates to the most important variables determining the project results at the level of implementation. A case study approach is needed explain what variables at which level influence GEF project results and what specific role the GEF actually plays. Not all relevant variables are yet known. Therefore, a holistic approach is needed.

**Limited number of cases:** Although a large number of climate change programs are implemented worldwide, only very few multilateral financial mechanisms like the GEF exist. Similar institutions are, for example, the Asian Development Bank, the World Bank, and the African Development Bank, which all offer finance and operate or at least co-operate climate and environmental protection programs with similar approaches (Martinot 2001). The clean technology fund pursues a strategy “that will combine public sector reform and private sector action” sound similar to the GEF approach (World Bank 2010). The GEF is a unique case in that it is the only multilateral finance mechanism operating on behalf of a multilateral environmental agreement dedicated solely to the solution of global environmental problems, or “global environmental goals.” However, it also a typical case as funding sources, operation procedures, project approaches, and project implementation are similar to those of other institutions: Renewable Energy and Energy Efficiency Partnership (REEP), World Bank environmental programs. National development agencies also operate with similar project approaches. Market-based approaches like the GEF’s market transformation approach are currently used more frequently to solve global environmental problems. Almost all European Union Member states, for example, use market-based policy to preserve biodiversity (Bräuer et al. 2006).

In addition, the case I am investigating stands as one example for two other trends: the integration of technology transfer mechanisms within the MEA, the implementation of these mechanisms through the setting up of funds which can be accessed by private companies to undertake climate protection-relevant projects in developing countries.

### 3.2.1 Type of case study

A number of authors have stated that different types of case studies can be undertaken. Yin differentiates between exploratory, explanatory, and descriptive case studies. Exploratory case studies are often conducted to define research questions and hypotheses. Explanatory case studies aim to link an event with its effects and are suitable for establishing causality.

Descriptive case studies are often used to illustrate events in their contexts. Each type can study single or multiple cases and cases can either be conducted to discover and explain changes within cases over time or in a comparative setting to explain differences between cases (Yin 2003). For my purposes, the explanatory case study is the appropriate category as I seek to

understand what has determined the results of the GEF approach regarding environmental and economic benefits.

In another article, Yin explains the particularities of one further type of case study which is a variant of the explanatory cases study: the evaluative case study. Yin defines evaluation as a type of research that assesses and explains the results of programs operated in a variety of field settings (Yin 1992). In his understanding, evaluative case studies are a type of research that can be used for testing, as well as generating new hypotheses. Although my research is not a purely evaluative case study, as will be explained in more depth in the section on research design, a substantial part of it is devoted to the evaluation of a GEF program. The specific requirements for evaluative case studies mentioned by Yin will therefore be included into my research design.

A single case study design is justified when the case provides a vital test for theory, embodies an exceptional or unique event, is a distinguished or typical case, or provides a longitudinal or revelatory aim (Yin 2003).

### **3.2.2 The role of theory and the limitations of the case study**

Theories are the building blocks of what Ragin refers to as “analytical frames.” Analytical frames are concepts that shape the research process, direct investigation, and inform data collection. Analytical frames result from the researcher’s engagement with theory guided by the research question of the research problem. Analytical frameworks are “fundamental to social research as they constitute ways of seeing” (Ragin 1994). Framing decides which aspects or facts of a case study are relevant and which are not. By using and discussing analytical frames, researchers “accumulate general knowledge about social life” (Ragin 1994). Of particular importance to Ragin are “framing by case” and “framing by aspect.” Framing by case means establishing why the object of research stands for something wider or more general. Framing by aspect means indicating the variation of the particular researched case to other relevant cases.

Expressed more formally, theories are used to develop hypotheses about observed empirical objects. Case studies can then be used to test hypotheses in a formal procedure, which require the identification of dependent and independent variables, and their operationalisation (Mitchell and Bernauer 2007). Fisher and Freudenburg argue that theories explaining the achievement of environmental and economic goals (win-win situations) require a specific kind of test. Testing is not only urgent to refine the theory but also to determine its practical implications, as the theory promises a new solution to environmental problems. Testing does not mean finding examples for or against the theory, as both obviously exist, but identifying “conditions under which win-win outcomes are more or less likely” (Fisher and Freudenburg 2001). Ragin points out that the formal procedure described by Mitchell and Bernauers is not always possible as theories are fuzzy, contradictory, or simply not suitable for the research question.

An often-expressed criticism regarding single case studies is their alleged limited ability to be generalised or to provide insights about similar cases. The case studied might not be the case typical for other cases but a unique case (Ragin 1994). Yin states that this criticism is based on an analogy of survey-based research, where a smaller sample stands for a larger population. While survey research relies on statistical generalisation, case study research relies on analytical generalisation. Hence, case study research must state for which wider variety of cases the investigated case might serve as an example (Yin 2003: 34). Case study research does not produce results that explain other cases but rather informs other cases. This argument mirrors Ragin's argument of the importance of "framing by case." Yin also underlines that the general applicability results from the methodological rigor applied in constructing the case through the research design.

### **3.2.3 Method and empirical research period**

As my research question required drawing a detailed picture of qualitative particularities, I have chosen to use qualitative methods in my case study. In order to first get an in-depth understanding of the GEF approach, its results, and its relation to the UNFCCC, and, in turn, to establish causality, I will use the qualitative methods of document analysis and expert interviews. I will integrate numerical evidence when possible. Also, all parts of the case study are contextualised through an analysis of existing secondary academic publications, grey literature, news sources, etc. All these will help me to construct a holistic and complex representation of my case. The empirical research period dates from March 2007 to December 2009. Any policy developments on the UNFCCC as well as GEF level taking place later could not be taken into account.

## 4 Technology Transfer and the UNFCCC

As already explained in the introduction, this thesis aims to establish the extent to which the GEF and its technology transfer approach serve to achieve the goals of developed and developing countries concerning technology transfer under the UNFCCC. As a first approximation, I have stated in the introduction that these are primarily environmental goals on the side of the developed countries, and development goals on the side of the developing countries. The topic of technology transfer has been controversial between developed and developing countries even before the adoption of the UNFCCC, and parties to the convention have not managed to agree on the issue until today (Roberts and Parks 2007).

In order to establish the suitability of the GEF for both country groups, this thesis does not consider the GEF approach to technology transfer and its results through criteria derived from theory external to the UNFCCC process. This means it does not screen the general literature on technology transfer for any criteria for how to evaluate the transfer of low-carbon technologies under the UNFCCC. Rather, it aims to establish a normative framework based on both suitable UNFCCC Conference of the Parties (COP) decisions and individual country positions. A normative framework is a list of value judgements (made by the parties to the UNFCCC) on what goals should be achieved through certain actions – in this case international technology transfer. Normative frameworks are important as they may not only express certain goals but also reflect how different people or groups of people assign different values and goals to outcomes of certain actions (Alkire and Deneulin 2009). Only after a normative framework is established, criteria will be derived that indicate how far goals expressed within the normative framework have been pursued.

A normative framework can be derived from decisions on the design of technology transfer mechanisms, committed budgets, concrete plans of actions, or a specific framework developed by the UNFCCC. If no evidence for a normative framework is found, publications and statements by UNFCCC bodies on the subject of technology transfer might give indicators for the formulation of such a framework.

Relevant objects of analysis are secondary literature on UNFCCC negotiations and primary UNFCCC documents. In order to structure the search process, only UNFCCC documents were considered that were published within UNFCCC procedures related to technology transfer, or consider it as a subject.

After reviewing the literature, I found no systematic analysis of COP decisions regarding technology transfer and country positions. There are only a few condensed summaries (Bazilian

et al. 2008; Murphy, Ham, and Drexhage 2005) of COP decisions, and a few very limited UNFCCC publications (UNFCCC 2002, 2007). Therefore extensive primary research in form of an UNFCCC document analysis had to be undertaken.

This chapter analyses the decisions taken during COPs that are relevant to technology transfer. I will assess how far parties have progressed toward a decision, how to implement technology transfer, whether normative frameworks concerning how to implement technology have been developed and what party positions exist on the subject of technology transfer. In addition to explicit normative frameworks, I will also investigate whether COP decisions lead either directly or indirectly (e.g. through the decision to set up a committee related to technology transfer) to any text or document that could be used as an element of, or as a basis for, a normative framework on technology transfer.

The overarching goal of the chapter is the development of a normative framework to discuss the GEF and its market transformation approach. This will either be done by adopting a normative framework that already has been decided upon by the COP or, in case no such thing yet exists, by developing a new normative framework based on relevant COP decisions and country positions on technology transfer.

The main questions this chapter wants to answer are:

- What provisions are made regarding technology transfer in the UNFCCC legal text?
- What have parties decided regarding technology transfer during COP negotiations and how have decisions been implemented?
- Have any of the COP decisions included normative frameworks or led to elements that could serve as the basis for a normative framework?

The remainder of the chapter is organised according to the four questions listed above. Each question will be answered in its own subchapter. The chapter will end with the development of a normative framework and discussion of implications for the following empirical chapters.

## **4.1 Technology transfer under the UNFCCC and in COP decisions**

As the Conference of the Parties (COP) is the highest formal authority of the UNFCCC, any decisions made at this level – at least in theory – set the goals, rules, and framework conditions for the implementation of technology transfer. The goals and rules guiding the implementation of technology transfer are important as they inform the choice and design of technology transfer mechanisms. The specific design of technology transfer mechanisms influences the outcomes of technology transfer taking place within these mechanisms (Jann and Wegrich 2005).

#### 4.1.1 The UNFCCC

The UNFCCC entered into force in 1994. The main goal of the convention is the reduction of greenhouse gas (GHG) emissions.<sup>34</sup> The goal of the convention is laid down in Article 2:

“stabilization of greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system.”

The convention makes no claim regarding the absolute figure of the concentration. Reduction commitments have first been specified with the Kyoto Protocol, which entered into force in 2005 and will finish by 2012. Parties to the Convention are currently negotiating a succession regime.

It is the responsibility of the parties to the Convention to achieve its goals. Signing and ratifying the Convention means the acknowledgement of climate change as a problem and allows for participation at the COPs to decide on further action to achieve the goals of the Convention (Torvanger et al. 2001). All parties to the UNFCCC meet once a year at the COP to review the implementation of the Convention and to decide on adequate measures to prevent dangerous climate change. Two main subsidiary bodies support the COP: the Subsidiary Body for Scientific and Technological Advice (SBSTA) and the Subsidiary Body for Implementation (SBI).

#### Parties to the UNFCCC

Parties to the Convention are categorised in three groups. Annex I to the UNFCCC lists industrialised countries and so-called “economies in transition.” Economies in transition (EITs) comprise the countries of Central and Eastern Europe and the former Soviet Union. Annex I comprises 41 mostly developed countries (including the European Union). Annex I parties “were aiming to return their emissions by 2000 to 1990 levels” (UNFCCC 2002: 15) (UNFCCC 2002). Annex II is a subset of Annex I and comprises the 24 highly developed countries. Annex II parties must reduce their GHG emissions and support developing countries in achieving the goals of the convention.<sup>35</sup>

Non-Annex I parties represent the rest of the world’s countries. They are usually developing countries with a general commitment to reduce GHG (but few obligations to do so) and the possibility to rely on external support. They are, however, requested to envision future steps regarding GHG reduction, to produce emission inventories, and to estimate future emission.<sup>36</sup>

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<sup>34</sup> The following summary is, unless otherwise stated, based on UNFCCC 2002.

<sup>35</sup> The first attempt to quantify emission reduction obligations has been the Kyoto Protocol which assigned emission reduction goals to some Annex II countries.

<sup>36</sup> The UNFCCC describes the groups as follows: “The Convention divides countries into three main groups according to differing commitments: Annex I Parties include the industrialized countries that were members of the OECD (Organisation for Economic Co-operation and Development) in 1992, plus countries with economies in

#### **4.1.1.1 General commitments to parties under the UNFCCC**

All parties to the Convention are taking a number of commitments spelled out under Article 4, Paragraph 1 of the Convention. The paragraph lists ten commitments: the preparation of national GHG inventories, the formulation and implementation of national/regional programs for mitigation/adaptation, promotion and cooperation for the diffusion and transfer of technology, the promotion of sustainable development and sink protection, cooperation in the preparation for adaptation measures, integration of climate change into national policies, cooperation in climate relevant research, cooperation in information exchange, cooperation in training, education and public awareness, communication regarding implementation to the COP.

In addition to the above listed commitments, countries listed in Annex I to the Convention commit themselves to adopting and implementing policies to mitigate climate change, to protect sinks, to communicate policies and results to the COP, to take the best available scientific methods into account when accounting for the results of policies (UNFCCC 1992).

The chapeau of Article 4.1 reads that parties may be “taking into account their common but differentiated responsibilities and their specific national and regional development priorities, objectives and circumstances.” According to Yamin and Depledge, this sentence means that each country may in effect “determine its own level of commitments” (Yamin and Depledge 2004: 93).

Since Article 4.3, 4.5 and 4.7 (see below) stress that the fulfilment of commitments of developing countries depends on financial and technological assistance from developed countries, there is a debate whether developing countries can be expected to commence fulfilling their commitments before they receive adequate assistance (Yamin and Depledge 2004).

#### **4.1.1.2 Technology transfer commitments**

Technology transfer is touched on in Articles 4, 9 and 11. Four paragraphs in Article 4 directly relate to technology transfer. The most general is Article 4.1 c. It is one of the commitments for

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transition (the EIT Parties), including the Russian Federation, the Baltic States, and several Central and Eastern European States. Annex II Parties consist of the OECD members of Annex I, but not the EIT Parties. They are required to provide financial resources to enable developing countries to undertake emissions reduction activities under the Convention and to help them adapt to adverse effects of climate change. In addition, they have to “take all practicable steps” to promote the development and transfer of environmentally-friendly technologies to EIT Parties and developing countries. Funding provided by Annex II Parties is channelled mostly through the Convention’s financial mechanism. Non-Annex I Parties are mostly developing countries. Certain groups of developing countries are recognized by the Convention as being especially vulnerable to the adverse impacts of climate change, including countries with low-lying coastal areas and those prone to desertification and drought. Others (such as countries that rely heavily on income from fossil fuel production and commerce) feel more vulnerable to the potential economic impacts of climate change response measures. The Convention emphasizes activities that promise to answer the special needs and concerns of these vulnerable countries, such as investment, insurance and technology transfer” (<http://www.unfccc.int>).



all signatories to the convention listed above and the only explicit reference in the convention text mandating that all parties shall cooperate in the transfer of technologies. It reads as follows:

“All parties, taking into account their common but differentiated responsibilities and their specific national and regional development priorities, objectives, and circumstances, shall: Promote and cooperate in the development, application and diffusion, including transfer, of technologies, practices and processes that control, reduce, or prevent anthropogenic emissions of greenhouse gases.”

Article 4.3 reads:

“The developed country Parties and other developed Parties included in Annex II shall provide new and additional financial resources to meet the agreed full costs incurred by developing country Parties in complying with their obligations under Article 12, paragraph 1. They shall also provide such financial resources, including for the transfer of technology, needed by the developing country Parties to meet the agreed full incremental costs of implementing measures that are covered by paragraph 1 of this Article and that are agreed between a developing country Party and the international entity or entities referred to in Article 11, in accordance with that Article.”

The commitments resulting from this Article for developed countries are therefore:

- Transfer of financial resources to support developing countries in meeting their communication requirements (national inventory, progress in implementing convention, other information) (§ 12)
- Transfer of financial resources and technology to meet the incremental cost of measures listed in Paragraph 1 of Article 4 of the convention (as listed above)

Article 4.5 is more general on technology transfer but assigns a clear commitment to developed countries. It reads:

“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.”

Winkler interprets this article in such a way that if developing countries shall mitigate climate change, they are to receive appropriate technology from developed countries beforehand (Winkler 2005: 357).

Article 4.7 stresses that the fulfilment of commitments of developing countries hinges on assistance from developed countries and underlines their respective commitments. It reads:

“The extent to which developing country Parties will effectively implement their commitments under the Convention will depend on the effective

implementation by developed country Parties of their commitments under the Convention related to financial resources and transfer of technology and will take fully into account that economic and social development and poverty eradication are the first and overriding priorities of the developing country Parties.”

UNFCCC reporting guidelines require Annex II parties to include information on technology transfer regarding § 4.3 and § 4.5. They should provide information on any other technology transfer activity and its success, granting financial means to developing countries for the acquisition of relevant technology as well as efforts to mobilise the private sector for technology transfer (Yamin and Depledge 2004: 306).

Article 9.2 c states that the Subsidiary Body for Scientific and Technological Advice shall identify relevant technologies for transfer and advise on how to effectively implement development and transfer of technology (UNFCCC 1992). Article 11.1 states that providing resources for technology transfer shall be one of the functions of the financial mechanism to the convention. The financial mechanism to the UNFCCC is the Global Environment Facility (GEF).

Hence, developing countries have committed themselves to technology transfer, yet their commitments are not precise. The pledged commitments to technology transfer are general statements without any blueprint for the realisation of, or schedule for, technology flows.

#### **4.1.2 Definitions of the term technology transfer within the UNFCCC**

Hardly any official UNFCCC definition of technology transfer exists. The only definition found is given in a technical paper of the UNFCCC. It reads “the international transfer of environmentally-sound technologies and know-how can be considered as a process originating from the countries and the companies that developed and produced them to the countries and subjects that will receive and facilitate their effective implementation and dissemination. This process follows different pathways and in each case there are different entities that can intervene and influence the process ”(FCCC/TP/1998/1: 5). The paper contains no goals or further specifications of the term. The definition is descriptive and does not contain any normative dimensions.

The IPCC definition cited in the previous chapter has been adopted by a number of development institutions and academics to provide a normative framework for technology transfer regarding economic effects (UNEP 2001; Kathuria 2002; Ockwell, Watson, MacKerron et al. 2008). This definition views technology transfer as a learning process and bears some resemblance to the evolutionary perspective on technology transfer discussed in the theory chapter 2.3. It lacks some critical success conditions like existing technological capabilities and technological efforts by the recipient. As a body set up by the World Meteorological

Organisation and UNEP, however, the IPCC is not formally part of the UNFCCC. It has no formal effect on the subject of technology transfer under the UNFCCC although it might have informed negotiations in practice.

## **4.2 Overview of COP decisions**

The UNFCCC text is to be understood as a starting point for further negotiations concerning how to address the subject of climate change and the role of technology transfer. The UNFCCC Secretariat identifies three main periods in which technology transfer was dealt with at the international climate change negotiations: The Berlin Mandate and subsequent negotiations (COP 1 to 4), the Buenos Aires Plan of Action and a resulting consultative process on technology transfer (COP 4 to 7), and the Marrakech Accords with ensuing activity (COP 7 to 12) (UNFCCC 2006). In the following, I will summarise the decisions by COPs directly relating to technology transfer.

### ***COP 1 Berlin***

The first COP in Berlin in 1995 adopted the so-called Berlin Mandate, which initiated a new negotiation process regarding the limitation of GHGs, and took a number of technical decisions regarding the finance mechanism (discussed in the chapter 5 on the GEF) and on the policies, priorities, and eligibility criteria of the financial mechanism. Parties took a number of decisions regarding the transfer of technology. These included:

- Requesting the Convention Secretariat to prepare a progress report regarding Annex II countries' progress regarding technology transfer
- Collecting information on environmentally-sound technologies relevant to mitigation and adaptation, including transfer modalities
- Urging Annex II countries and other countries to include in their national communication measures of technology transfer
- Reviewing at each COP the implementation of article 4.5 and 4.1. (c)
- Supporting the development of capacity and technology for developing countries (FCCC/CP 1995). The COP also stated that it recognised the importance of technology transfer and concluded that discussion on the ways to implement article 4.5 of the convention should continue (FCCC/CP 1995: 38).

Parties made a decision with potential but indirect relevance to technology transfer when they decided in accordance with article 4.2 (a) of the convention to begin the “Joint Implementation” (JI) of projects to reduce GHG emissions. JI means that developed countries might undertake reduction projects in developing or transition economy countries, and have the reduction

credited towards their national emission reduction goal. Due to a number of concerns of developing countries, it was decided that any JI activity leading to reduction credits should be preceded by a test phase called “Activities Implemented Jointly” (AIJ). The AIJ phase started in 1995 and lasts to the present. It was reviewed externally in 2000. The last summary of AIJ activity produced from the UNFCCC dates from 2006 FCCC/SBSTA/2006/8). AIJ aimed at understanding this new instrument and learning from experiences (Dixon and Mintzer 1999). In theory, AIJ offers the possibility of technology transfer as mitigation projects under AIJ may include the application of low-carbon technology (Karani 2001). However, as AIJ does not include a technology transfer mandate, no official framework to assess technology transfer results was developed.<sup>37</sup>

After the convention entered into force, discussions were held to set up Technology Assessment Panels (TABs). The aim of these panels should have been the identification of the technology needs of developing countries in cooperation with investors. This aim was never achieved due to disagreement over who would be allowed to participate, and whether technology should be transferred at market rates or publicly subsidised (Grubb et al. 2001: 105).

### ***COP 2 Geneva***

During COP 2 at Geneva, the COP expressed concern about the slow implementation of decisions taken regarding technology transfer during COP 1. Report FCCC/CP/1996/12 stated that a “comprehensive portrayal of technology transfer is not possible at this stage.” Parties decided that the secretariat should speed up its report on access to EST, suggest improvements in the reporting format of technology transfer activities in national communications, identify current activities in technology information centres, prepare reports in technology for adaptation and mitigation, and organise a roundtable on technology transfer during COP 3.

Annex II parties were urged to include information on TT in their national communication, and to speed up their activities to fulfil Article 4.5 of the convention. All other parties were urged to include information on TT in their communications, to improve enabling environments for technology transfer, which includes “the removal of barriers and the establishment of incentives, for private sector activities that advance the transfer of technologies” (FCCC/CP/1996/15/Add.1: 13). Furthermore, parties were urged to share information on technology transfer, and Non-Annex I Parties were urged to communicate their technology needs.

The SBI prepared a report on “activities to facilitate the transfer of technology as reported by Annex II Parties” (FCCC/SBI/1996/5: 5). The document summarises the reporting of Annex II

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<sup>37</sup> Joint Implementation under the UNFCCC started before Joint Implementation under the Kyoto Protocol (Bush and Harvey 1998).

countries without any judgement on the quantity or quality of the activities undertaken. It nevertheless underlines poor and disorganised reporting ambitions in general.

### ***COP 3 Kyoto***

In 1997, parties to the convention adopted the Kyoto Protocol. Annex I countries to the convention took the obligation to reduce their GHG emissions by a precisely quantified amount. The commitments differ for each country, but amount to an overall reduction of 5.2 per cent below 1990 levels during the first commitment period, 2008 to 2012 (Grubb et al. 2001: 116). While the reduction should primarily be achieved via domestic reduction measures, the Kyoto Protocol provides three flexible mechanisms to achieve reductions abroad: emission trading, joint implementation, and the clean development mechanism. These have an important relation to technology transfer and will be discussed further in section 4.3.2 of this chapter.

Regarding technology transfer, the COP reaffirmed previous decisions regarding technology transfer, requested the secretariat to continue the dissemination of information on the subject and to consult with other institutions with technology information centres. Finally, it urged parties to create enabling environments and to improve reporting (FCCC/CP/1997/7/Add.1: 40). Also, four progress reports were presented to the COP: FCCC/SB/1997/1, 3 and 4; and FCCC/SBSTA/1997/10. The reports present information on the activities of the UNFCCC institutions (secretariat, etc.) on the subject, but do not contain any information concerning technology transfer from developed to developing countries, or on the implementation of Article 4.5 of the convention.

During the year preceding COP 3, SBSTA issued another report on the technology transfer activities undertaken by Annex II countries as reported in their national communications. The report is more detailed in terms of figures, but also lacks completeness due to poor reporting and missing communications. It also lacks any criteria or other content that could serve as a normative framework (FCCC/SBSTA/1997/13).

The COP requested the secretariat to produce a technical paper on barriers and opportunities to technology transfer. The paper contains the definition of technology transfer that has been presented above but does not add any further criteria for the implementation of technology transfer (FCCC/TP/1998/1).

### ***COP 4 Buenos Aires***

At COP 4 in Buenos Aires, parties decided on the Buenos Aires Plan of Action. The plan includes four pages of decisions regarding technology transfer. In essence, they repeat and expand many aspects stated in previous COP decisions (FCCC/CP/1998/16/Add.1.).

Of main importance are the requests for Annex I countries to support capacity building in developing countries, and for developing countries to communicate their technology needs (Yamin and Depledge 2004: 308).

The COP agreed on establishing a consultative process on 18 different issues (listed in an annex to the relevant decision) regarding technology transfer. The ultimate aim of the consultative process was to “achieve agreement on a framework for meaningful and effective actions to enhance implementation of Article 4.5 of the Convention” (FCCC/CP/1998/16/Add.1: 13).

The issues and related questions to be answered through the consultative process were broad. Issues included more technical aspects like the removal of barriers or listings of publicly-owned technology but also issues which were right at the heart of the North-South conflict on technology transfer: what multilateral efforts are needed? Are existing mechanisms sufficient? Can specific technology transfer goals be set? What is the role of private investment? Regional workshops for the consultative process did not take place until a year later, and results were produced in 2000. The consultative process and the framework will be discussed in more detail further below. The COP also urged all countries to create enabling environments to stimulate private investment in relevant technology transfer.

### ***COP 5 Bonn***

The COP decided in relation to technology transfer to extend the consultative process (FCCC/CP/1999/6/Add.1: 23).

### ***COP 6 I + II The Hague and Bonn***

Parties did not reach an agreement and decisions including those on technology transfer were forwarded to COP 7.

### ***COP 7 Marrakech***

At COP 7, the COP decided on the establishment of an expert group on technology transfer (EGTT). It aimed at enhancing Article 4.5 of the convention by identifying ways of transferring technologies and making recommendations to the SBSTA. The work shall be reviewed at COP 12. The COP also decided to adopt the framework on technology transfer to progress on the implementation on Article 4.5 of the convention. The framework and the EGTT will be discussed in the following subchapter. COP furthermore urges developed country parties to provide technical and financial assistance for the implementation of Article 4.5 of the convention (FCCC/CP/2001/13/Add.1: 22-23). The COP also decided on a number of procedural measures with regard to the CDM.

The COP also decided to establish two new funds under the convention (the Special Climate Change Fund and the Least Developed Countries Fund) and one under the Kyoto Protocol (Adaptation Fund) (FCCC/CP/2001/13/Add.1: 43-44).

During COP 7, parties also made the decision that parties to Annex II should meet the commitments resulting from Articles 4.1, 4.3, 4.4, 4.5, 4.8 and 4.9 (this means including technology transfer) through funding in the areas of:

- “(i) Increased Global Environment Facility replenishment;
- (ii) The special climate change fund to be established under this decision;
- (iii) The least developed countries fund to be established under this decision;
- (iv) Bilateral and multilateral sources” (FCCC/CP/2001/13/Add.1: 43).”

### ***COP 8 New Delhi***

During COP 8, no decision regarding technology transfer was made (FCCC/CP/2002/7/Add.1).

### ***COP 9 Milan***

No decisions regarding technology transfer were made (FCCC/CP/2001/13/Add.1, FCCC/CP/2003/6/Add.2). During COP 9 a “Round table discussion among ministers and other heads of delegation” was held. The official summary contains no statement regarding goals or criteria for the implementation of technology transfer (FCCC/CP/2003/CRP.1).

### ***COP 10 Buenos Aires***

At COP 10, held in Buenos Aires in 2004, parties decided to urge parties to carry out joint research for the development of environmentally sound technologies, requested the EGTT to make recommendations how to implement the TT-Framework (FCCC/CP/2004/10/Add.1).

### ***COP 11 Montreal***

At COP 11, in Montreal in 2005, it was decided to review the EGTT (FCCC/CP/2005/5/Add.1: 15). No other decisions were made regarding TT. The results of the review will be discussed in the section on the EGTT further down.

### ***COP 12 Nairobi***

The COP parties decided for the continuation of the EGTT (FCCC/CP/2006/5/Add.1).

### ***COP 13 Bali***

During COP 13 in 2007, the parties adopted the so-called “Bali Action Plan.” The Bali Action Plan is effectively the decision to initiate a new negotiation process to implement the convention. It runs parallel to the negotiations for new commitment reductions within a new protocol that will replace the Kyoto Protocol. Technology transfer is a central topic and the Bali process is supposed to lead to decisions on:

“Enhanced action on technology development and transfer to support action on mitigation and adaptation, including, inter alia, consideration of:

- (i) Effective mechanisms and enhanced means for the removal of obstacles to, and provision of financial and other incentives for, scaling up of the development and transfer of technology to developing country Parties in order to promote access to affordable environmentally sound technologies;
- (ii) Ways to accelerate deployment, diffusion and transfer of affordable environmentally sound technologies;
- (iii) Cooperation on research and development of current, new and innovative technology, including win-win solutions;
- (iv) The effectiveness of mechanisms and tools for technology cooperation in specific sectors” (FCCC/CP/2007/6/Add.1: 5).”

While the Bali Action certainly emphasises the importance of technology transfer, it contains no decision other than to have yet another series of discussions and negotiations.

The COP also decided “the following points are important for funding through existing vehicles and new initiatives:

- The implementation of technology needs assessments
- Joint research and development programs and activities in the development of new technologies;
- Demonstration projects;
- Enabling environments for technology transfer;
- Incentives for the private sector;
- North-South and South-South cooperation;
- Endogenous capacities and technologies;
- Issues associated with meeting the agreed full incremental costs;
- Licences to support the access to and transfer of low-carbon technologies and know-how;
- A window for, inter alia, a venture capital fund related to, or possibly located in, a multilateral financial institution”( FCCC/CP/2007/6/Add.1: 26-27).

The COP also requests the EGTT to develop a set of indicators that can be used to monitor the implementation of the technology transfer framework (FCCC/CP/2007/6/Add.1\*: 27). Till now, the EGTT has decided on the terms of reference on how to develop such indicators. Indicators as such have so far not been produced (FCCC/SBSTA/2008/INF.2).



### ***COP 14 Poznan***

During COP 14 in 2008, parties took no decision regarding technology transfer. They nonetheless welcomed the Poznan strategic program on technology transfer, which was a suggestion made by the GEF concerning how to implement technology transfer (FCCC/CP/2008/7/Add.1: 3). Insofar as the Poznan strategic program has not yet been decided upon by the COP, it is treated as a GEF contribution on technology transfer and discussed in chapter 5.

### ***Summary***

As we have seen, the COP has not yet decided on any normative framework related to technology transfer. It has also not yet made any decision concerning how to implement technology transfer. However, it has decided on a number of issues that might entail technology transfer, although they have no relationship to Article 4.5 of the convention: AIJ, the flexible mechanisms of the Kyoto Protocol, and three new funds. Furthermore, the COP has made a number of decisions that shall lead to a future ruling. These are the Technology Transfer Framework and the Expert Group on Technology Transfer. Additionally, it has welcomed the Poznan strategic program on technology transfer. Each of these will be discussed in the next section.

## **4.3 COP decisions on technology transfer: Detailed description**

Before I discuss the achievements of the COPs regarding technology transfer, I want to establish the distinction between *substantive* and *procedural* commitments as introduced by Yamin and Depledge (2004). Substantive commitments are either qualitative (requirement to adopt a specific policy) or quantitative (a target achieved by a certain point in time). Procedural commitments establish a certain process and “aim to advance preparatory efforts to address climate change” (Yamin and Depledge 2004: 75). The achievements of procedural commitments may serve as important catalysts for policy change or lead to information allowing substantive action. While Yamin and Depledge introduce this distinction in relation to GHG mitigation targets, I will apply it to technology transfer commitments. In this sense, a substantive technology transfer commitment would simply be the successful transfer of technology or a policy that directly aims at the transfer of technology. A procedural commitment would be the carrying out of technology needs assessments or the establishment of an expert group on technology transfer.

During all COPs, no substantive commitments regarding technology transfer were made. Substantive commitments with relation to technology transfer were taken with AIJ and the flexible mechanisms (discussed below). Decisions on normative frameworks were also not

made. The COP took a number of procedural commitments potentially leading to a normative framework and commitments that are discussed below. No criteria were developed to monitor the progress of the implementation of Article 4.5 (FCCC/SBSTA/2006/MISC.10).

### **4.3.1 Activities Implemented Jointly**

In the opening plenary at COP 1, COP president Angela Merkel, then German Federal Minister for the Environment, directly associated technology transfer with AIJ by stating: “For the developing countries, it is crucial that joint implementation measures are linked to additional transfer of technology and knowledge” (Comeau 1995). In the text of the actual COP decision, technology transfer is not included as a goal of the AIJ phase. The aim of AIJ is described in the decision as leading to “real, measurable and long-term environmental benefits related to the mitigation of climate change that would not have occurred in the absence of such activities” (FCCC/CP 1995: 19). However, other effects beyond reductions of greenhouse gas emissions were expected when the COP decided to develop a monitoring framework to report (among other aspects) the “national economic, social and environmental impacts” of any AIJ projects (FCCC/CP 1995: 19).

Historically, a controversial debate on the possibility of technology transfer concerning AIJ emerged. Academics and multilateral institutions considered the transfer of technology to be a possible positive externality or additional benefit of JI projects (Michaelowa 1997; Wisaksono 1995; International Energy Agency IEA 1997; Dixon and Mintzer 1999). Critics pointed out that technology transfer should be additional to AIJ (Comeau 1995, Gupta 1997) and that technology transfer with AIJ projects might have detrimental effects to local markets (Maya 1995). Representatives of developing countries stated that technology transfer is a prerequisite for the South to benefit from JI activity (Yaker 1995).

In practice, some projects entailed technology transfer as they included investments in low-carbon technologies that needed to be imported to the country in which the project took place. Some projects even aimed directly at the transfer of technology (Sathaye/ Bradley 1999, US Initiative on Joint Implementation 2000). However, a systematic analysis of all projects regarding technology transfer is still missing. Since technology transfer was not the explicit aim of AIJ, no systematic criteria were developed on the UNFCCC level that could serve as a normative framework.

### **4.3.2 The Flexible Mechanisms of the Kyoto Protocol**

Under the Kyoto Protocol framework, national governments are supposed to achieve GHG emission reductions mainly with domestic measures. In addition, the protocol introduced three so-called mechanisms that allowed for a certain “flexibility” in the sense that national

governments can support emission reduction measures abroad but have the reduction credited towards their domestic GHG emission reduction target (Michaelowa, Greiner and Dutschke 2001: 2). Of potential relevance to my thesis are Joint Implementation and Clean Development Mechanism, while Emission Trading does not entail any elements with direct relevance for technology transfer.

#### **4.3.2.1 Joint Implementation**

Since Joint Implementation under the Kyoto Protocol is confined to cooperation between Annex I countries, it has no relevance for North-South technology transfer.

#### **4.3.2.2 Clean Development Mechanism**

Projects within the Clean Development Mechanism (CDM) explicitly combine two goals: the reduction of GHG emissions and sustainable development within less-developed countries (Michaelowa, Greiner and Dutschke 2001: 4). The corresponding Article 12 of the Kyoto Protocol however does not make any direct reference to technology transfer but states rather vaguely that the CDM shall assist developing countries in “achieving sustainable development” (paragraph 2) and that developing countries shall “benefit from project activities” (paragraph 3). The Marrakech accords, which were decided upon during COP 7 and contain a number of procedural decisions for the CDM, touch upon technology transfer but do not make it into an explicit goal of the CDM. The text of the accords reads “further emphasizing that clean development mechanism project activities should lead to the transfer of environmentally safe and sound technology and know-how in addition to that required under Article 4, paragraph 5, of the Convention and Article 10 of the Kyoto Protocol” (FCCC/CP/2001/13/Add.2: 20).

A discourse on technology transfer and the CDM emerged which was similar to that on AIJ. Critics taking a developing country view expressed concerns regarding CDM that were similar to JI/AIJ. Other commentators considered technology transfer as one option to fulfil CDM’s dual goal of sustainable development and emission reduction (Kolshus et al. 2001; Dutschke and Michaelowa 1998; Mathy, Hourcade, and Gouvello 2001). Research projects on the expected scope of technology transfer were undertaken. The IPCC stated that the CDM “could be a vehicle for transferring environmentally-sound technologies” if it was “well structured” (IPCC 2000). However, Grubb et al. point out that there is no explicit connection between the JI/CDM and the transfer of technologies, which is treated as a different subject under the convention (Grubb et al. 2001: 139).

In 2007, 750 CDM projects were registered with the CDM Executive board, and a further 1543 were awaiting registration. The CDM has still not been assigned a technology transfer mandate by the COP. A study on the technology transfer content concluded that 38 per cent of these

2293 projects involved technology transfer, based on the analysis of project design documents necessary for registration. Technology transfer was framed as “the use of equipment and/ or knowledge not previously available in the host country by the CDM project” by most project developers. This definition was taken over by the study authors due to the lack of an UNFCCC definition. The IPCC definition was rejected with an argument given by the IPCC itself, namely that the IPCC definition was “broader than that in the UNFCCC or of any particular Article of the convention” (Seres, Haites, and Murphy 2007). No agreed rules on technology transfer or similar conceptual underpinnings for CDM projects were developed. Despite the lack of any official definition of the term, which would be a prerequisite for any technology transfer mandate, the CDM does in practice operate on a specific definition of technology transfer, namely technology transfer as investment. A technology transfer investment is, however, neither required, nor are its outcomes somehow specified. Technology transfer is hence left to project designers and the market for CDM projects; no criteria were, to my knowledge, developed under the UNFCCC.

### **4.3.3 The Technology Transfer Framework**

The Technology Transfer Framework (TTF) is one of the three UNFCCC COP decisions that are intended to lead to a future ruling regarding TT, as described above. The purpose of the framework is to “develop meaningful and effective actions to enhance the implementation of Article 4, paragraph 5, of the Convention by increasing and improving the transfer of and access to environmentally sound technologies (ESTs) and know-how” (FCCC/CP/2001/13/Add.1: 24).

TTF is divided into five areas relevant to technology transfer: technology needs and needs assessment, technology information, enabling environments, capacity building, and mechanisms for technology transfer. It maps out the various dimensions to be considered for successful technology transfer. The description of the overall approach reads:

"The successful development and transfer of ESTs and know-how requires a country-driven, integrated approach, at a national and sectoral level. This should involve cooperation among various stakeholders (the private sector, governments, the donor community, bilateral and multilateral institutions, non-governmental organizations and academic and research institutions), including activities on technology needs assessments, technology information, enabling environments, capacity building and mechanisms for technology transfer".

The text then proceeds to give a definition, a rationale, and concrete implementation steps for each of its five dimensions. In the following, I will not discuss all of these dimensions extensively. I would rather like to point out that the first four dimensions have clear definitions, sound rationales, and comprehensible steps of implementation. The fifth, despite being the only one addressing technology transfer, does not.

#### ***Technology needs assessments***

Technology needs assessments are defined as activities to identify the priorities of developing mitigation and adaptation technologies to become objects of related transfer projects. Their purpose is to identify the technology priorities of a country as a basis for TT projects and programs. Implementation is achieved through actual needs assessments, which are already being undertaken. Till now, 70 countries have made their technology needs assessments available on the UNFCCC website.

### ***Technology information***

Technology information is defined as the means to facilitate all necessary information flows between relevant stakeholders planning TT activities. Relevant information concerns technical parameters, economic and environmental aspects of environmentally-sound technologies, and identified technology needs. Its purpose is to increase the quality and level of information of the TT to UNFCCC parties, especially developing countries. Implementation steps include a web-based information database, expert workshops,<sup>38</sup> etc. Technology information is an important precondition for successful technology transfer, as seen in the theoretical chapter part 2.3.7. Information is necessary to actually evaluate and adopt technology. It changes the bargaining power between parties in the transaction process.

### ***Enabling Environments***

“Enabling Environments” are defined as government activities to create an environment “conducive to private and public sector technology transfer” (FCCC/CP/2001/13/Add.1: 26). The purpose of such environments is to identify possible transfers and to remove related barriers. Practical implementation is expressed in the establishment of such environments. According to the UNFCCC, enabling environments include:

- (a) National institutions for technology innovation;
- (b) Involvement of social and managing technologies in a macroeconomic policy framework;
- (c) Underpinnings of sustainable markets for EST;
- (d) National legal institutions that introduce codes and standards, reduce risk, and protect intellectual property rights;
- (e) Research and technology development; and
- (f) Means for addressing equity issues<sup>39</sup>

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<sup>38</sup> The most prominent part that has been implemented is TT:Clear, a UNCCC hosted online database Technology transfer projects and programmes containing information on: “Case studies of successful technology transfer, Environmentally-sound technologies and know-how, Organizations and experts, Methods, models and tools to assess mitigation and adaptation options and strategies, Relevant Internet sites for technology transfer, Ongoing work of the Parties and the EGTT such as issues under negotiation, documents and meetings, and implementation of the technology framework” (UNFCCC 2009 Web).

<sup>39</sup> <http://unfccc.int/ttclear/jsp/EEEnvironment.jsp>

From a theoretical point of view, not all of these features are necessary for the successful transfer of technology. Technology innovation institutions (a) may support and innovation and may be two key factors for successful transfer. Feature (b) is somewhat difficult to understand. Feature (c) is not strictly necessary to exist in the recipient country for successful technology transfer. Technology, as seen in the theoretical part, can be internationally transferred for production purposes and markets can be abroad. Markets are a means to support the domestic diffusion of a transferred technology. The existence of domestic markets might also increase the chance of private investment from abroad or technology import from domestic companies to better cater for these markets. They are, however, no prerequisites for technology transfer defined as a learning process and they have no direct influence on the learning outcomes of a particular transfer project. Feature (d) is important for technology diffusion, though less for the success of a technology transfer project. Institutions reducing risks are clearly relevant for technology transfer and diffusion. Whether or not intellectual property rights (IPR) hinder or support the technology transfer of low-carbon technology is still under debate (Ockwell et al. In Review). Feature (e) is important for the adaptation of technology, and of importance for both technology transfer and diffusion. Feature (f) is ambiguous in this context.

The UNFCCC lists the following means for implementing enabling environments:

- (a) All Parties, particularly developed country Parties, are urged to improve, as appropriate, the enabling environment for the transfer of environmentally sound technologies through the identification and removal of barriers, including, inter alia, strengthening environmental regulatory frameworks, enhancing legal systems, ensuring fair trade policies, utilizing tax preferences, protecting intellectual property rights and improving access to publicly-funded technologies and other programs, in order to expand commercial and public technology transfer to developing countries;
- (b) All Parties are urged to explore, as appropriate, opportunities for providing positive incentives, such as preferential government procurement and transparent and efficient approval procedures for technology transfer projects, which support the development and diffusion of environmentally sound technologies;
- (c) All Parties are urged to promote joint research and development programs, as appropriate, both bilaterally and multilaterally;
- (d) Developed country Parties are encouraged to promote further and to implement facilitative measures, for example export credit programs and tax preferences, and regulations, as appropriate, to promote the transfer of environmentally-sound technologies;
- (e) All Parties, particularly developed country Parties, are encouraged to integrate, as appropriate, the objective of technology transfer to developing countries into their national policies, including environmental and research and development policies and programs; and
- (f) Developed countries are encouraged to promote, as appropriate, the transfer of publicly owned technologies.<sup>40</sup>

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<sup>40</sup> <http://unfccc.int/ttclear/jsp/EEnvironment.jsp>

Means A and B are demand-side measures aiming at the diffusion, but not primarily at the transfer, of technology as seen in the theoretical part of the thesis. Mean C is relevant to both diffusion and transfer. The instruments summarised under D support the transfer of technology by private actors. Mean E relates to policy integration as another indirect lever for technology transfer. Mean F relates directly to the transfer of technology transfer, although limited to publicly-owned technologies.

Enabling environments relate to the establishment and change of regulations that shall support technology transfer as well as the diffusion of technology. This distinction is important because, as we will see later on, the interpretation of enabling environments by developed country parties exclusively focuses on the measures supporting the diffusion of technology. More generally, the regulatory changes suggested do not serve in any way as a normative framework.

### ***Capacity Building***

The framework cites a convention definition of capacity building as “a process which seeks to build, develop, strengthen, enhance and improve existing scientific and technical skills, capabilities and institutions in Parties other than developed country Parties, and other developed Parties not included in Annex II, particularly developing country Parties, to enable them to assess, adapt, manage and develop environmentally-sound technologies” (FCCC/CP/2001/13/Add.1: 27). The purpose of capacity building is to increase the ability of developing countries to “the widespread dissemination, application and development of environmentally-sound technologies and know-how” (FCCC/CP/2001/13/Add.1: 27).

The scope of capacity building envisioned to take place is very broad and ranges from skills enhancement for the adaptation of EST, to the support to technology transfer institutions. Capacity building is yet another important prerequisite for successful technology transfer. Implemented successfully, it may contribute to the strengthening of innovation systems that are important for the technological learning processes of technology recipients. Technological capability building is a form of indirect support for technology transfer, as defined in the theoretical part of this thesis (section 2.3.7).

### ***Mechanisms for Technology Transfer***

The definition of mechanisms for technology transfer is very particular and should be looked at in more detail:

“The mechanisms for technology transfer, as identified in this section, are to facilitate the support of financial, institutional and methodological activities (a) to enhance the coordination of the full range of stakeholders in different countries and regions; (b) to engage them in cooperative efforts to accelerate the development and diffusion, including transfer, of environmentally sound technologies, know-how and practices to and between Parties other than developed country Parties and other developed Parties not included in Annex II, particularly developing country

Parties, through technology cooperation and partnerships (public/public, private/public and private/private); and (c) to facilitate the development of projects and programs to support such ends.”

The purpose of these mechanisms is to “enhance the implementation” of Article 4.5 of the convention (FCCC/CP/2001/13/Add.1: 29).

Regarding implementation, the COP defined a function of an “institutional arrangement for technology transfer” which should “provide scientific and technical advice on the advancement of the development and transfer of environmentally-sound technologies and know-how under the Convention, including the preparation of an action plan to enhance the implementation of Article 4, paragraph 5, of the Convention” (FCCC/CP/2001/13/Add.1: 29). The text then lists the term of references for the Expert Group on Technology Transfer.

In other words, the framework establishes the EGTT as the mechanism for technology transfer and effectively defers any conceptual basis on the nature of technology transfer under the UNFCCC to the work of an expert group. The expert group shall rather facilitate decisions on technology transfer mechanisms by the COP in the future.

The installation of the EGTT as the mechanism to facilitate future mechanisms is not very explicit in the framework as such, but is more directly worded in the EGTT review of the TTF: “Under this theme (Mechanisms for Technology Transfer, R.H.), EGTT was established as an institutional arrangement to facilitate the implementation of the technology transfer framework” (FCCC/SBSTA/2006/INF. 4: 16). In other words, the only mechanism established under the UNFCCC to implement technology transfer is responsible for the implementation of the TT framework, which does not concern technology transfer directly.

In 2006, the EGTT assessed the implementation of the technology transfer framework on behalf of the COP. Through its assignment to review the implementation of the framework, the EGTT comes into the paradoxical situation of having to review itself as part of the framework (as said above, the EGTT is the only mechanism for technology transfer within the technology transfer framework).

The group report states “much of the work to date has provided understanding of technology transfer at the conceptual and/or general level” (FCCC/SBSTA/2006/INF.4 7). As practical results, the EGTT points to technical papers produced by the UNFCCC on adaptation technologies, finance, and engaging the private sector. In relation to “mechanism of technology transfer” the review lists two activities in its overview: cooperation with other experts on the convention, and cooperation with other conventions (FCCC/SBSTA/2006/INF.4 8).

The review of these activities suggests that “mechanisms of technology transfer” are a somewhat neglected aspect of the framework. The only real activities mentioned are two



workshops on finance for technology transfer, including a technical paper, as well as a workshop on the inclusion of adaptation technology into the technology transfer.

The paper on finance is a long list of general statements about finance for technology transfer, some of which are surely useful when designing projects (some are surely not: “access to private-sector financing can be improved by involving the private sector” (FCCC/TP/2006/1: 44)). Yet what is missing is a real discussion of which finance options would be suitable in relation to the UNFCCC, and how they could be implemented effectively. The paper has the character of notes summarising a textbook. No further activity is reported. As “gaps in implementation” the EGTT lists insufficient reporting of the GEF concerning their financial contribution to the framework and lack of funding for the travel costs of EGTT members.

I conclude from my brief description of the framework of technology transfer that four important aspects of technology transfer have received a rudimentary conceptual framework, but nothing has been laid down regarding the core of technology transfer, the transfer as such. A refined normative framework is still missing. The minimal official output produced under the dimension “mechanisms for technology transfer” by the EGTT relates only to one, although important aspect: finance. Although finance is an important aspect of technology transfer, the paper on finance produced does not address the questions of how technology transfer should take place under the convention, and what kind of effects should it have.

#### **4.3.4 The Global Environment Facility**

The GEF acts as the financial mechanism to the UNFCCC, but also operates a large portfolio of climate change mitigation projects outside the guidance of the convention (Eberhard et al. 2004). Article 11 of the UNFCCC designates a financial mechanism in relation to the convention. Paragraph 1 reads:

“A mechanism for the provision of financial resources on a grant or concessional basis, including for the transfer of technology, is hereby defined. It shall function under the guidance of and be accountable to the Conference of the Parties, which shall decide on its policies, program priorities and eligibility criteria related to this Convention. Its operation shall be entrusted to one or more existing international entities.”

The role of the GEF in technology transfer will be discussed in Chapter 5 of this thesis.

### 4.3.5 Expert Group on Technology Transfer

The Expert Group on Technology Transfer (EGTT) has the aim to enhance technology transfer activities and the implementation of Article 4.5 of the convention. Its role is to “analyse and identify ways to facilitate and advance technology transfer activities.”<sup>41</sup>

It consists of 20 members meeting twice every year. The group works in all five areas of the TT framework with tasks ranging from initiating collaboration between international organisations, reviewing different relevant activities under the UNFCCC (e.g. technical assistance for needs assessment), and providing expert input/advice on various subjects. Output manifests itself in workshops, presentations, technical papers, and recommendations to the SBSTA. The results of the work of EGTT seem a likely place for more substantiated ideas about how to implement technology transfer. In order to find those, the annual reports of the group were reviewed regarding output under heading five of the technology transfer framework “mechanisms of technology transfer.”

While the first annual report of EGTT mainly concerns organisational matter, the second one only reports who are the chairs of the EGTT, the members of the Least Developed Countries Group, and that the Chair of the SBI had met and decided to meet again (FCCC/SBSTA/2003/12: 7). In the third annual report the EGTT reported that it had met representatives of the Convention of Biological Diversity (CBD) in order to explore synergies regarding future work on technology transfer (FCCC/SBSTA/2004/INF.17: 6). In its fourth annual report, the EGTT reported that a representative of the CBD had presented on technology transfer activities and announced that it would continue to explore ways of possible cooperation (FCCC/SBSTA/2005/INF.10: 6). The annual report for 2006 is still missing. The work program for 2006 contains three items: explore ways to reap synergies with other conventions, enhance cooperation with other bodies under the convention, and consider work produced by the Commission on Sustainable Development on technology transfer (FCCC/SBSTA/2005/INF.10: 12). In summary, one may conclude that the EGTT has, at least according to official documents, not substantially progressed regarding the design of any mechanism for technology transfer.

The achievements of the EGTT in relation to my question of normative frameworks have been discussed in section 4.3.3.

### 4.3.6 The consultative process on technology transfer

Another possible arena to look for elements of a normative framework is the consultative process (established through a decision during COP 4) on technology transfer. The Chairman of

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<sup>41</sup> [http://unfccc.int/essential\\_background/convention/convention\\_bodies/constituted\\_bodies/items/2581.php](http://unfccc.int/essential_background/convention/convention_bodies/constituted_bodies/items/2581.php), accessed 9 October 2009

the SBSTA organised three regional workshops (Africa; Asia and the Pacific; Latin America and the Caribbean) on the subject of technology transfer during 1999 and 2000.

All reports of the workshops show that a wide range of issues was addressed and that discussions included a variety of aspects, which are necessary to successfully transfer technology. In the section on “possible elements of a framework” (which summarises the ideas of the workshop participants), different ideas on how to inscribe technology transfer into future UNFCCC decisions emerged. However, different ideas were not associated with specific workshop participants, and no suggestions were made to refine, select, or integrate the suggested measures. They read like a compilation of developed and developing country suggestions discussed in the next section of this chapter. They do not contain any criteria or specified goals for technology transfer (FCCC/SBSTA/1999/11, FCCC/SBSTA/2000/INF.2, FCCC/SBSTA/2000/INF.6).

#### **4.3.7 The new funds**

Of all new funds, the “Special Climate Change Fund” seems to be the most promising in relation to a normative framework insofar as one of its aims was to provide funding for technology transfer (FCCC/CP/2001/13/Add.1: 44). In 2003, parties decided “Technology transfer and its associated capacity-building activities shall also be essential areas to receive funding from the Special Climate Change Fund” (FCCC/CP/2003/6/Add.1: 11). However, all decisions regarding operation were made during COP 12. Any project development and further elaborations of how to implement technology transfer are to be expected in the future. The Special Climate Change Fund is operated by the GEF. The GEF had not yet published any documents on the subject of technology transfer in relation to the Special Climate Change Fund by the close of the empirical research stage of this thesis.

The adaptation fund was established to manage concrete adaptation projects. However, decisions on initial guidance to the operation of the fund during 2005 did not contain any reference to technology transfer (FCCC/KP/CMP/2005/8/Add.4: 3). Currently, the criteria for the management of the fund are under development. Technology transfer is listed as a possible project priority in the latest draft decision on the fund (FCCC/SBI/2006/L.18).

The least developed country fund was started to support the adaptation plans of least developed countries. Technology transfer did not feature within the initial guidance to the operators of the fund (FCCC/CP/2001/13/Add.4). Najam et al. are very sceptical about the effectiveness of these funds as they are voluntary, managed by, in their eyes, the controversial Global Environmental Facility, and poorly funded (Najam, Huq, and Sokona 2003).

### 4.3.8 Summary

The COP decided on three major issues with relation to technology transfer: AIJ, CDM, and the three “new funds.” AIJ and CDM do not include technology transfer as a primary goal; hence no normative rules for technology transfer were elaborated.<sup>42</sup> The new funds are too young to have elaborated any concepts regarding how to implement (if at all) technology transfer.

Decisions regarding substantial commitments on technology transfer were not made. As for procedural commitments, the framework for technology transfer seems to be the most likely place for any form of normative agreement. However, despite considerable activity regarding four important aspects of technology transfer, it lacks any substantial content regarding the most important aspect of “mechanisms of technology transfer” that would address technology transfer directly.

## 4.4 Summary and discussion

- What provisions are made regarding technology transfer in the convention text and the Kyoto protocol?

The UNFCCC is very clear about the roles and responsibilities regarding technology transfer but does not include any details on the questions of “how?”, “how much?”, and “until when?”. The issue is treated in a very broad and vague manner.

Parties to the convention have made a number of decisions regarding procedural commitments to technology transfer and a number of substantive commitments that might indirectly lead to technology transfer. The former includes the technology transfer framework and the expert group on technology transfer. The latter comprises the flexible mechanisms of the UNFCCC, the UNFCCC funds, and the flexible mechanisms of the Kyoto Protocol. All of these decisions have not led to any agreed document spelling out details of implementation or possible modes of future technology transfer under the UNFCCC. The TT Framework has left out the subject “mechanisms of technology transfer,” and the EGTT has not produced any specific suggestions on how technology transfer could or should be implemented under the UNFCCC. The substantive commitments discussed have not led to the production of any material on technology transfer from the UNFCCC, as it is not one of their officially assigned goals.

- What have parties decided regarding technology transfer during COP negotiations and how have decisions been implemented?

In summary, it does not seem that any significant steps have been undertaken conceptually to prepare the implementation of the technology transfer provisions articulated in Article 4.5 of the

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<sup>42</sup> E.g. the criteria to evaluate CDM projects before registration do not include technology transfer. Expert Interview Representative German Environmental Agency, 27.1.07.

UNFCCC. The conflict over the modalities of technology transfer between developed and developing countries has not been resolved. No concrete suggestions, roadmaps, rules, norms, or goals for how to implement technology transfer have been developed under the UNFCCC. Neither any of the substantial commitment with possible effects on technology transfer (CDM, funds, etc.) nor any procedural commitments (EGTT) have lead to the development of rules or norms for how to implement technology transfer. A number of procedural commitments regarding technology transfer have been decided upon. The most important procedural commitment has been the consultative process in technology transfer leading eventually to the adoption of the Framework for Technology Transfer and the Expert Group on Technology Transfer. As the Framework for technology transfer is the most comprehensive piece of policy on technology transfer and shall guide the development of further policy on international technology transfer under the UNFCCC, it will be discussed within the theoretical framework.

#### **4.5 Theoretical discussion of the UNFCCC Technology Transfer Framework**

The aim of the Technology Transfer Framework (TTF) is to serve as a frame of reference for future decisions and actions on international technology transfer under the UNFCCC. It contains five sections: Technology needs and needs assessments, Technology information; Enabling environments; Capacity-building and Mechanisms for technology transfer. As seen in chapter 4.3.3, all sections contain suggestions for measures and actions supporting technology transfer. The only exception is mechanisms for technology transfer. This section contains no measures or actions but a reference to the Expert Group on Technology Transfer, which is a body of government representatives and scientists that shall develop suggestions for actions in the future.

The following discussion will establish how likely it will be to support international technology transfer leading to economic and environmental benefits from a theoretical point of view. In line with the theoretical framework developed in chapter 2.7, I will firstly establish how the aspects of technology supply, recipient's technological capabilities, institutional aspects of technological capability-building, and demand policy are addressed. The discussion of each aspect will include if any references are made to learning processes and the different levels of assimilation are made. If no reference to the type of assimilation was made, then I assume that at least operational assimilation is aimed for. I will then discuss how far the technology transfer framework might support international technology transfer leading to environmental and economic benefits.

**Technology supply:** The issue of technology supply in the sense of the actual supply process and the role of the supplier and its transfer strategies is not addressed in the framework. The

section titled technology information includes activities that increase the recipient's knowledge of the existing low-carbon technology stock and possible sources of such technologies. This is an important aspect before technology transfer is actually planned and negotiated between supplier and recipient. But it is only one aspect with regard to the whole aspect of technology supply that relates to the strategies of suppliers and the conditions under which they engage in international technology transfer. The section on enabling environments states that government actions should create an "environment conducive to private and public technology transfer" (FCCC/CP/2001/13/Add.1: 26). This is a very general statement that could comprise a wide variety of measures supporting or giving incentives for technology holders to supply technology. The other sections of the TTF do not contain any reference to the topic of technology supply.

**Recipient technological capabilities:** The aspect of recipient capabilities is addressed indirectly under the area of capacity building in the technology transfer framework. Capacity building shall serve the "widespread dissemination, application and development of environmentally sound technologies and know-how". Possible activities include "enhancement of skills in the adoption, adaptation, installation, operation and maintenance of specific environmentally sound technologies" and strengthening "the endogenous capacities and capabilities in research, development, technological innovation, adoption and adaptation" (FCCC/CP/2001/13/Add.1: 28). The framework is very general about which organisations shall build capacity and no specifics are spelled out in particular. It therefore seems to include firms as recipients but could also relate exclusively to any other form of organisation and institution forming part of the technological system of a country. However, the strengthening of recipients' technological capabilities is not mentioned explicitly anywhere.

The two parts of framework quoted above address the capacities to operate, adapt, develop and improve technologies and therefore aim at learning processes that support the assimilation levels 1, 2 and 4. The aspect of replication is not explicitly mentioned although one can assume that innovative assimilation will also have an influence on the capabilities to replicate a technology.

**Institutional aspects of technological capability building:** Institutions supporting the technological capability building are addressed in the section of capacity building and in the section of enabling environments. As the quotes discussed above show, the TTF includes the capacity-building of institution in relation to technology transfer. This is a very general statement and does not include one important aspect: the linkages between institutions and actors of the system and the technology recipients through which learning takes place. In addition, the different levels of technological assimilation are supported.

The section of enabling environments primarily addresses contextual issues that shall support the initiation and facilitation of international technology transfer process such as legal systems and regulatory environments. The aspects of an environment that would support the learning process between a technology supplier and a recipient are not directly addressed. The section does include, however, joint research and technology development programs in a very general manner. These might relate to some sort of technological research, also indicating support for learning processes that lead to innovative assimilation of the transferred technology (type 4).

**Demand policy:** This aspect is addressed in the sections of enabling environments and in the area of capability building. The section of enabling environments within the framework mentions “opportunities for providing positive incentives, such as preferential government procurement and transparent and efficient approval procedures for technology transfer projects, which support the development and diffusion of environmentally sound technologies” (FCCC/CP/2001/13/Add.1: 26). The section on capacity-building states at various occasions that measures shall be taken that support the operation, maintenance and application of environmentally sound technology.

**Discussion:** The technology transfer framework is very broad and allows for a large range of central measures to be taken that support international technology transfer for economic and environmental benefits. The lack of any guidance in the section of "mechanisms for technology transfer" for policy implicates that a core part of international technology transfer for economic benefits as well as environmental benefits is so far missing. Technological learning processes that lead might lead to the four different levels of technology assimilation are also included, though in a vague manner.

Addressing technological capabilities and institutional aspects of technological capability-building means that central aspects of international technology transfer for economic benefits are included. The lack of addressing the question of technology supply is possibly a disadvantage but as seen in the theoretical chapter, supporting recipient technological capabilities and institutional aspects of technological capability-building are effective means that increase the level of assimilation of technology. The aspect of demand policy is also addressed which is a basis to support wider diffusion of a technology and therewith increase environmental benefits. Also, it includes elements that would support the four levels of technology assimilation.

Despite its vagueness and lack of considering technology supply, the technology transfer framework contains elements that could support both economic and environmental benefits in case it serves as guidance to design and implement further international technology transfer policy under the UNFCCC. It therefore reflects the goals of both developed and developing

countries' governments under the UNFCCC. It could not be established how different actors on the UNFCCC level influenced the development of technology transfer framework.



## 5 The Global Environment Facility

As seen in the previous chapter, the GEF has a mandate to finance international technology transfer on behalf of the UNFCCC. During COPs and until now, large disagreements between developed and developing countries on technology transfer became visible, including a differing prioritisation of goals. This chapter is directly tied to the previous one by establishing the formal relation between the UNFCCC, guidance on technology transfer received from the UNFCCC, and its technology transfer approach. The aim of this chapter is to understand the GEF approach, how it has evolved, which role the UNFCCC played in its evolution and how it relates to the positions of developed and developing countries under the UNFCCC.

Understanding the GEF approach and the way it was shaped by the UNFCCC gives a first indication of how to answer the overall research question outlined in the introduction. Considering the contentiousness of the subject on the UNFCCC level, the lack of decisions regarding technology transfer implementation, and the variety of ways in which transfer mechanisms can be designed, it is important from a policy as well as from a methodological perspective to understand whether and how the GEF frames and conceptualises technology transfer of low-carbon technologies. It can be expected that the kind of framing the GEF chooses influences project results. Hence, understanding the rationale of the GEF approach is necessary before evaluating a GEF project in practice in chapter six.

The chapter is divided in three sections. The first section will introduce the GEF, its role in solving global environmental problems, and its current objectives. The second section will reconstruct the evolution of the GEF approach to technology transfer. The third section will reconstruct the relation between the GEF and the UNFCCC. The chapter will conclude a number of framing assumptions for the evaluation of the PVMTI project undertaken in chapter six.

The first section is based mainly on secondary literature and on some more recent GEF strategy documents. Since no research exists on the GEF approach to technology transfer approach, nor on the UNFCCC-GEF relationship, sections two and three are based on expert interviews and document analysis, and therefore represent primary research.

### ***Literature on the GEF and its technology transfer approach***

The literature in the GEF can be divided into three sets. The first set is concerned with the foundation and evolution as well as the role of the GEF within international environmental governance (Gan 1993; Jordan 1994; Sjöberg 1994; Clémençon 2006; Streck 2001; Matz 2005). It does not address the GEF technology transfer activities beyond mentioning that technology is

an issue to the GEF. It will serve as background information introducing the GEF in the corresponding empirical part. The second set of literature, being rather small, evaluates the results of GEF projects. It does not consider technology transfer in particular (Gerlak 2004; Heggelund, Andresen, and Ying 2005; Mulugetta, Nhete, and Jackson 2000). The third set is even smaller and discusses the role of GEF in solving the problem of climate change.<sup>43</sup>

## 5.1 Introduction to GEF

Depending on the author consulted, the establishment of the GEF falls into the period from November 1990 to March 1991. Its foundation was a result of growing concern for international environmental problems by industrialised countries dating back to the early 1970s, and a protracted and contentious negotiation process between North and South governments and multilateral institutions beginning in the mid-1980s (Sjöberg 1994). In organisational terms, the GEF consists of a secretariat, an assembly, and a council. It is supported by three so-called Implementing Agencies (IAs), the World Bank (WB), United Nations Environment Program (UNEP), and United Nations Development Program (UNDP). The IAs support the GEF in project design and implement GEF financed projects. A Science and Technology Advisory Panel (STAP) has supported the GEF from the beginning. The function of the STAP is “drafting scientific and technical criteria and guidelines for GEF project approvals and operations” (Gan 1993: 260).

The GEF was first set up as a pilot scheme for three years (until 1994) with the aim of financing the incremental cost of projects in developing countries to “generate global environmental benefits,” firstly in four areas: climate change, biodiversity, pollution of international waters, and ozone depletion (Jordan 1994: 265). During the pilot phase, the three IAs co-managed the GEF. Each implementing agency had different mandates. The World Bank chaired the GEF, administered the central Trust-Fund, and identified and appraised projects. UNDP managed pre-investment and technical assistance projects and the small-grants program. UNEP was responsible for policy guidelines and strategic planning in relation to multilateral environmental agreements (MEAs) (Gan 1993).

Already during the pilot phase (before becoming the financial mechanism to the UNFCCC), the GEF funded 42 projects under its climate change focal area totalling US \$281.3 million (GEF 1994).

The GEF was restructured after the pilot phase in 1995. While the World Bank, UNEP, and UNDP still serve as implementing agencies, they had to yield their governing roles. The GEF is

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<sup>43</sup> Böhmer- Christiansen and Young argue “the political complexities of keeping the peace between so many interests and ‘missions’ while ensuring the GEF’s own sustenance“ is likely to hinder any effective intervention to mitigate climate change (Young and Boehmer-Christiansen 1998).

since thus overseen by a council. The council has sixteen members from developed countries and sixteen members from developing countries. Decisions shall be made on consensus, but if no consensus can be found a vote can be taken with a double majority: “This requires a 60 per cent majority of all member countries as well as approval by donors representing at least 60 per cent of contributions” (El-Ashry 1994).

The GEF was assigned the role of financial mechanism to the UNFCCC in 1994, firstly on an interim basis, by Article 21 of the UNFCCC. The Article already foresees a permanent role, but only after a restructuring of its governance body had taken place. In 1998, the Conference of the Parties (COP) to the UNFCCC decided to make the GEF the permanent financial mechanism to the convention and to review it every four years.

### ***The GEF and developing countries***

The foundation of the GEF, its restructuring, and its becoming the financial mechanism to the UNFCCC have been controversial issues between governments of developed and developing countries. Developing countries and representatives of NGOs have criticised the GEF since its inception for its governance structure dominated by industrialised countries, serving primarily developed countries’ interests, the exclusion of non-governmental actors, and the neglect of local stakeholders directly affected by their projects (Jordan 1994, Young 2002).

On the more technical side, the GEF has been criticised for having insufficient funding compared to the magnitude of global environmental problems, long, protracted, and bureaucratic project cycles, difficulties in estimating incremental cost, uncritical evaluation of projects, limited impact of projects, institutional inertia, focus on finance, implementation problems by governments, NGOs, and its official evaluators (Ravindranath/ Sathaye 2002, Young 2002, GEF 1994).

Making the GEF the financial mechanism to the convention is at best seen as a compromise between industrialised and developing countries. The USA fully opposed a financial mechanism, while developing countries wished for a new, fully independent climate fund. Developing countries opposed the GEF as the facilitating agency because of its strong connection to the World Bank and their view that the World Bank has limited capacity to successfully address environmental problems (Gupta 1997). Appointing the GEF and its rules of financial support furthermore brings a number of disadvantages to developing countries. There has been, until recently, no compensation for damages through climate change,<sup>44</sup> the absolute amount of money raised through the GEF is not foreseeable since there are no fixed contributions (the GEF budget does not depend on developed countries’ needs but on the political will of donor countries), and developing countries’ desire to have a say in the

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<sup>44</sup> The UNFCCC has now requested the GEF to set up an adaptation fund.

utilisation and control of financial means was denied (Missbach 1999: 282, GEF 2008). Gupta states that developing countries were “induced” and accepted the GEF “since there was no alternative offered to them and they wanted to access available funds” (Gupta 1997: 115).

***Areas of activities and goals:***

The GEF activity is currently concentrated on six focal areas: persistent organic pollution, ozone depletion, land degradation, international waters, climate change, and biodiversity.<sup>45</sup> From 1991 to 2007, the GEF spent 33 per cent of its overall budget within the focal area of climate change (GEF 2008). It hosts 12 operational programs (OP), which outline the boundaries and focal points of funded project activity. Four of these operational programs fall under the focal area of climate change. They are:

OP 5: Removing Barriers to Energy Conservation and Energy Efficiency

OP 6: Promoting the Adoption of Renewable Energy by Removing Barriers and Reducing Implementation Costs

OP 7: Reducing the Long-term Costs of Low-Greenhouse-Gas-Emitting Technologies

OP 11: Promoting Sustainable Transport

The aim of the GEF is to “protect the global environment” (Porter et al., undated). The rationale behind creating global environmental benefits is at least in theory a concern for the global commons by the GEF initiators (developed countries) and their interest in convincing developing countries to act against environmental problems not confined to national states or otherwise limited geographical areas (Young 2002).

The reduction of GHG emissions shall be achieved by administering grants for relevant projects in developing countries. The GEF Climate Change program constitutes “the largest and most comprehensive global portfolio of investments in energy efficiency, renewable energy and other climate-friendly projects” (Eberhardt et al. 2004: 1). It consists of 500 projects for which it has allocated US \$1.63 billion between 1991 and 2004. According to its operational strategy, “the overall strategic thrust of GEF financed climate change activities is to support sustainable measures that minimize climate change damage by reducing the risk, or the adverse effects, of climate change. The GEF will finance agreed and eligible enabling, mitigation, and adaptation activities in eligible recipient countries” (Eberhardt et al. 2004: 1). A GEF document released to specify the GEF business plan shows that strategic priorities are developed consisting of two

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<sup>45</sup> The Independent Evaluation of the pilot phase already made the remark that the selection of the focal areas was not transparent and no adequate overall strategies to mark the role of the GEF in solving the selected environmental problems were missing (GEF 1994: xiii).

parts: replication of proven approaches and market transformation (MT) (GEF/C.21/Inf.11: 15).<sup>46</sup>

An internal overview of project results based on interviews with senior managers of the GEF and its three IAs states the following goals of the climate change focal point (Nichols/ Martinot 2000):

“Remove market barriers so that the level of market penetration of sustainable technologies and practices in given country markets is increased during and after GEF-supported market interventions. In short, GEF promotes market transformation and technology transfer and diffusion through barrier removal

Build policymakers’ capacity to address challenges ranging from meaningful participation in the UNFCCC, to incorporating climate change objectives in economic policy, to reformulating specific regulatory, tax, or other economic policies

Build business infrastructures by triggering additional development aid, public financing, or private investment, and by demonstrating the business viability of sustainable energy products and services

Add to social reservoirs of both expert and community awareness and knowledge about climate change issues in general and sustainable energy technologies in particular, and translate such awareness into active involvement of non-governmental and private sector groups in activities related to climate change

Demonstrate creative project approaches that promote climate-friendly economic growth, including impacts on improved quality of life, by bringing together mixes of government, business, community, and other stakeholders in ways that bridge gaps and cause change. (Demonstration effects may occur at scales from local to global, short term to longer term, and individual to national.)”

## 5.2 The GEF and technology transfer

The following chapter will analyse the technology transfer approach of the GEF, reconstruct its origin, put it in relation to the positions on technology transfer on the UNFCCC level, and discuss implications for the investigation of the GEF project in India in chapter six.

Of particular importance is not only the question of how the GEF approach relates to the UNFCCC requirements as expressed in the differing country positions, but also whether there are differences between a general GEF approach to technology transfer and a possible specific approach in relation to the UNFCCC.

As a financial mechanism to the UNFCCC, the GEF is not in the position to transfer technology itself, but to finance projects that include transferring technology. The GEF approach, therefore, serves as a yardstick to select but also to design projects, since grant seekers will try to shape their projects in accordance with GEF provisions.

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<sup>46</sup> The document reads: “The identification of strategic priorities for the focal area follows the agreed principle of building on existing foundations by selectively facilitating the replication of proven approaches, and by creating, opening and transforming markets for new technologies and demonstrated approaches.”

The support of technology is central to GEF activities. Already in 1992, the GEF leadership chose a “GEF class of technologies” to reduce GHG emissions, which comprise a number of renewable energy sources and energy-efficient end-use technologies (Gan 1993). In 2000, the GEF states in its communications to the COP that “technology transfer and capacity building are central elements of GEF climate projects and include a wide range of approaches commensurate with the diversity of technologies, needs, and circumstances” (FCCC/CP/2000/3: 24).

The following reconstruction and analysis of the GEF approach to technology transfer is mainly based on interviews with the staff of the GEF secretariat and the IAs. In order to conduct informed interviews, I consulted publicly available GEF documents which I gathered through extensive searches of the public UNFCCC online database and as well as the internet.<sup>47</sup>

### **5.2.1 The GEF approach to technology transfer**

In 1995, the GEF Council approved the Operational Strategy (OS) of the GEF. The OS “lays the foundation” for different operational programs and includes, according to the strategy, “guidance from the conventions it serves.”<sup>48</sup>

According to the OS, GEF projects fall into three categories: long-term, short-term, and enabling activities.<sup>49</sup> References to technology are only found in the section on long-term projects. Long-term activities are described as promoting “back-stop technologies” preventing GHG emissions and cost reductions for such technologies. Programs aiming to achieve these goals will do so by trying “to expand, facilitate, and aggregate the markets for the needed technologies and improve their management and utilization, resulting in accelerated adoption

<sup>47</sup> However, despite being a public institution, it is difficult to access GEF documents online as no systematic search routine exists and documents are grouped in relation to council meetings rather than by subjects. It is therefore virtually impossible to determine which internal documents are related to technology transfer and to determine the relevance of those related to technology transfer without undertaking a survey of all documents. The GEF lists only one thematic publication on technology transfer on its website. It is a list of technology transfer case studies but contains no explanation or definition of technology transfer (Global Environment Facility 2000). The GEF reviews climate change activities every four years. These reviews are called program studies. Only the 2000 climate change program study is available in the form of a summary using a www search engine. It contains, however, no explanation or definition of technology transfer. Three so-called overall performance studies of the GEF exist but all three hardly touch upon the issue of technology transfer (Global Environment Facility 1999). Since, on the one hand, no full survey of internal documents could be undertaken due to time constraints but, on the other hand, document selection should not be completely arbitrary, I decided to rely on the GEF documents related or submitted to the UNFCCC containing statements on technology transfer.

<sup>48</sup> All citations of the OS are based on: <http://www.gefweb.org/interior.aspx?id=72>

<sup>49</sup> The GEF defines short-term projects as “climate change projects that reduce greenhouse gases in the short term, even if they are not part of an operational program. Such projects will be funded if they are country priorities, cost-effective in the short term, and likely to succeed” (<http://www.gefweb.org>). There is no further definition on the chosen approach or any reference to technology transfer.

Enabling activities are defined by the UNFCCC as “planning and endogenous capacity-building, including institutional strengthening, training, research and education, that will facilitate implementation, in accordance with the Convention, of effective response measures” (<http://www.gefweb.org>). So far, this concept has only been assigned to support for the preparation of national communications, which has no relevance to technology transfer in our understanding.

and diffusion.” Special emphasis is given to the removal of barriers and to cost reduction. Barriers shall be removed by contributing “to the cultural, institutional, administrative, technical, policy-related, and financial learning processes necessary to remove barriers.” Reduction of production and transaction cost shall be “induced” by supporting “market size, prospective market development, and depth of distribution channels”. The OS also reads: “in cases in which substantial cost reduction can be achieved through greater use of local manufacturing capacity, the GEF will pursue technology transfer, local procurement, and the development of appropriate industrial infrastructure.” The OS thus supports the creation of demand for technology but also the supply of technology.<sup>50</sup>

In 2008, the GEF produced a document outlining how it could implement technology transfer under the UNFCCC.<sup>51</sup> The approach consists of four steps. The first step aims to identify relevant technologies from the perspective of a developing country with help of the UNFCCC technology needs assessments (GEF/C.33/7: 7). The second step assesses the market for selected technologies in the developing country. The third step assesses the market and any barriers to diffusion within the developed country. The GEF differentiates between market barriers (e.g. market failures, inappropriate taxes) and non-market barriers (e.g. limited local capacities, weak protection of intellectual property rights). The third step develops strategies to improve markets and remove barriers in order to support the diffusion of technology. The fourth step consists in the implementation of the strategies developed beforehand.

Apparently, the formerly distinct approaches to support technology diffusion and transfer directly outlined in the OS have merged into one approach. The notion of direct support for manufacturing through technology transfer has vanished. Activities supporting the creation seem to have become predominant and seem to have also taken over the function supporting technology transfer. This assumption is further supported through similar short quotes documents submitted to the UNFCCC characterising the GEF approach to technology as market creation and removal of demand side barriers (FCCC/SBSTA/1999/MISC.5: 105; FCCC/SBI/2004/18: 13).

## 5.2.2 Interview Results

In order to deepen the understanding of the GEF technology transfer approach, six expert interviews were conducted. Two representatives of the GEF secretariat, and one representative of each of the three implementing agencies in charge of relations with the GEF was interviewed. One interview was carried out with a representative of the International Finance Corporation

<sup>50</sup> All previous quotes from <http://www.gefweb.org/interior.aspx?id=72>

<sup>51</sup> The COP had requested the production of such a suggestion in decision 4 at COP 13 in 2007 (FCCC/CP/2008/7/Add.1).

(IFC), who had substantial expert knowledge on the subject. The IFC is part of the World Bank group and serves as implementing agency for the PVMTI project. Additionally, information given by the two UNFCCC secretariat representatives interviewed was included.

Interview results are organised in four parts. Firstly, the GEF technology transfer approach in its most recent form and its historical evolution will be described. This will be undertaken through interviews plus relevant literature and documents. Cited literature can only be discussed in relation to the interviews, as only through interview sources the importance and relevance of a number of other theoretical discussions could be established.<sup>52</sup> Secondly, the specific strengths and weaknesses of the GEF approach will be discussed. Thirdly, the relation of the GEF approach to UNFCCC requirements regarding technology transfer as well as UNFCCC guidance will be discussed. Fourthly, implications for the investigation of the PVMTI project will be laid out.

### ***Evolution of the GEF approach to technology transfer***

All interviewees agreed that the GEF technology transfer approach evolved over time and that its development cannot be separated from the overall GEF project approach.

An overall project strategy to achieve global environmental goals was firstly developed after the evaluation of the GEF pilot phase (1991-1994) inform of the development of Operational Programs 5, 6 and 7 and the adoption of the notion of “incremental cost.”<sup>53</sup>

Operational programs 5 (“Removal of barriers to energy efficiency and energy conservation”) and 6 (“Promoting the adoption of renewable energy by removing barriers and reducing implementation cost”) represent the focus in the creation of markets and demand found the OS for climate change. Operational Program 7 (“Reducing the long-term cost of low greenhouse gas-emitting energy technologies”) represents the direct technology transfer. One set of

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<sup>52</sup> Many technical GEF documents were only accessible through the additional input from experts. Only through interviews could I make sense of many of the GEF documents. Interviewees, for example, pointed out that the evolution of the World Bank approach to supporting renewable energy technologies is central to the evolution of the corresponding GEF approach. The WB approach is therefore one among relevant documents included in the chapter on PVMTI.

<sup>53</sup> The GEF OS defines incremental cost as follows: “The incremental cost is the difference in cost between the climate-friendly means of satisfying the country’s sustainable development needs and the baseline means” (<http://www.gefweb.org>).

Taking an example from Young (2002: 63), this means that a South government would raise funds for the construction of a coal-fired power plant and then turn to the GEF to raise the extra-money it would cost to produce the same amount of electricity, not with coal but with wind turbines. The global benefit of the climate change focal area is expressed in reduced GHG emissions. The concept has been criticised on a number of occasions mainly for problems in determining the exact incremental cost, the determination of global benefits and the unwillingness of the GEF to finance domestic benefits from a project (e.g. tourism revenues from a park protecting biodiversity) (GEF 1994, Young 2002, Ravindranath and Sathaye 2002). One interviewee pointed out that the fund established under the “Montreal Protocol on Substances That Deplete the Ozone Layer” was an important model for the GEF as it had had also adopted an incremental cost approach. The fund would finance the differential cost between the production of the harmful substances and the production of ozone layer friendly substitutes. The incremental cost approach still underlies, according to interviewees, all three operational programs relevant for climate change.



activities financed by the GEF OP7 lists “investment in the most promising applications conforming with operational program guidance. Cost reductions will be accomplished by promoting technology transfers, joint ventures, local manufacturing, learning by doing, and achieving economies of scale” (GEF undated: 6). While the GEF initially supported projects under all three OPs, interviewees explained that the emphasis changed towards OP5 and OP6 and therefore to market creation and demand.

As the support for direct technology transfer under OP7 faded and markets became a primary focus of project activity, the notion of “market transformation” developed as the main conceptual approach underlying GEF activities. The term “market transformation” was according to the representatives of the GEF secretariat first used around 2001/ 2002, but it was not until 2004 that it was officially used. It aims to summarise activities of OP5 and 6.

In the context of energy policy, market transformation denotes an umbrella term describing a range of different policy instruments. These aim at enhancing the diffusion of clean (or cleaner) energy technologies by increasing demand. A significant feature of market transformation projects is that they aim to transform the market in such a way that the demand increases even after the project intervention, which has only limited duration (Schlegel et al 1997, Blumstein et al. 2000). Krause (1996) defines market transformation policies as all policy instruments that increase demand through other methods than changes in energy prices. Relevant instruments include standards, labels, end-user subsidies, voluntary agreements, procurement incentives, etc. (Krause 1996; Mahlia 2004).

According to interviewees, the notion of market transformation as employed by the GEF has its roots in the above mentioned policy context, but is used in a much broader sense. It captures the idea that the overall goal of the GEF was to develop markets. As one interviewee put it “We are trying to set the framework for markets, to get markets for technology in place that move efficiently.” Interviewees underlined that there was no deep conceptual development from the GEF concerning the term.<sup>54</sup> It was more often used “as an operational framework” that guided project design through the past experience of the GEF.<sup>55</sup>

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<sup>54</sup> Interviewees from the WB and IFC explained that the foundations of the concept of market transformation were originally developed by Word Bank staff, the GEF and the GEF STAP.

<sup>55</sup> Official GEF documents on the market transformation approach mirror statements of GEF interviewees, particularly regarding the fact that it is not very refined or grounded in theory. The GEF definitions are brief, general, vague, and change over time without obvious coherence. The term is used interchangeably as a project goal and as an indicator to measure project results. The GEF definitions include the main features of market transformation: increased up-take of a clean or cleaner technology and effects lasting beyond the duration of a specific project. A 1999 document describes the aim of GEF projects as “accelerated replication and adoption of technology applications than would otherwise occur” (Martinot 1999). Another document framing market development as an indicator describes market transformation as the “level of market penetration of sustainable technologies and practices in given country markets” (GEF 2000). According to the interpretation of the GEF, the pilot phase was technology based in their overall approach focussing on demonstration projects and cost reductions. This overall approach was over time substituted with a market based approach: “In broad terms, there has been a discernable shift from technology demonstration to the removal of barriers to renewable energy and Energy Efficiency penetration, and then to market

Interviewees stated that the GEF currently speaks of the five pillars of market transformation. These five pillars are policy environment, the availability of financing, business models and management skills, information and awareness, and technological factors. In the understanding of GEF staff, the appropriateness of each of these pillars is a “necessary” condition for market development. Otherwise it may impose barriers<sup>56</sup> to market development. These five pillars “evolved from the five categories of barriers that emerged from ten years of portfolio experience” (interview source).

The meaning of each pillar differs in broadness. The pillar access to finance is relatively straightforward. Finance for firms and end-users are central components of any market and must be available in sufficient quantities.

The pillar of “policy environment” is broader. According to interviewees, it is not clearly defined but relates in concrete project implementation to development of standards, codes, testing, certification, and labelling related to end-use products. Appropriate business models and management skills relates to firms being able to sell low-carbon technology including a functioning business model and management personnel being able to undertake typical management functions. The pillar “sufficient information and awareness” relates to knowledge about the technology and its functions for end-users and sales companies. The pillar “technological factors” relates to aspects like size, age, or cost of a technology and how these prevent its application. According to GEF staff earlier projects supplied technological knowledge to change the properties of technologies. For example, project in China supplied more energy efficient industrial boiler technology to Chinese manufactures. The goal was to enable Chinese manufacturers to produce these more efficient boilers for the Chinese mass market. According to GEF staff, GEF projects do not address technological factors any more, as it would entail supplying technology or knowledge directly. It was listed in some GEF documents and the official language of the GEF merely for political reasons. The statements by GEF official are reflected by a number of GEF documents, which list the aspect of technological factors neither explains its meaning nor include technology supply in more detailed descriptions of GEF activities (e.g. GEF/C.28/14, GEF/C.33/7).

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aggregation and the removal of economic barriers” (Eberhardt et al 2004: 10). A more recent document states that GEF project outcomes should be “favourable conditions for market development in terms of: policy, finance, business models, information and technology.” The absence of named conditions would hence be “barriers to market transformation” (GEF 2006: 20). Essential to the GEF notion of market transformation is the idea of “replicability.” Replicability means that project measures can be replicated by actors not directly involved in GEF projects leading to project outcomes beyond the actual GEF project (GEF 2006).

<sup>56</sup> Key to market transformation is the idea of barrier removal through projects. Interviewees explained that projects aimed at supporting one, some or all of the mentioned “pillars of markets”. Conditions that hindered the installation of the pillars were considered barriers which in their view differed from country to country.

### ***Market Transformation and Technology Transfer***

The practical implication of the adoption of the market transformation approach is that the GEF is not supplying technology directly, but rather removing barriers to its diffusion. Technology shall be supplied by the private sector as a reaction to growing demand. Interviewees stated that there was a clear split between the public sector taking care of the framework conditions, and the private sector doing the investment. As one interviewee put it: “Our goal is stimulating market demand. The supply question should take care of itself. It should follow the demand.” All interviewees agreed that technology transfer is effectively left to the private sector. As GEF projects aim at paving the way for technology transfer and for supporting the national diffusion of technology, the GEF argues that it is justified to claim all GEF projects “involve technology transfer.”

Three issues emerged as controversial between interviewees. Firstly, there was disagreement as to whether the market transformation approach was sufficient to initiate technology transfer. UNDP, UNFCCC secretariat, and UNEP representatives pointed out that the mere construction of markets in case projects, where successful, was insufficient to support technological transfer. Representatives of the GEF secretariat as well as the World Bank stated that technology was transferred if projects were successful. Linked to this disagreement were different understandings as to what goals shall be reached through technology transfer. Representatives of UNEP and UNDP linked technology transfer with development goals of developing countries. Representatives of the GEF secretariat seemed to consider any form of technology transfer to be a sufficient project result, and did not associate any goals with technology transfer. Representatives of the UNFCCC secretariat pointed out in this context that the GEF had not developed an indicator to monitor technology transfer and therefore could not effectively track any technology transfer triggered through their projects.

The second issue triggering controversial responses related to the capacities and theoretical role the GEF should take regarding technology transfer, although all interviewees agreed that the market transformation approach was an important component of technology transfer and the only currently feasible approach in the light of limited financial resources. Representatives of UNEP, UNDP, and the UNFCCC secretariat stated the GEF could, and actually should, take a more active stance regarding direct technology transfer. They saw no reason why the GEF should limit its activities to barrier removal in case more finance was provided. And although they welcomed the GEF efforts to integrate the private sector into climate change mitigation in developing countries, the GEFs should go beyond market assistance. Representatives of the GEF secretariat and the representative of the World Bank held a different view. In their perspective, the GEF did not only have the wrong competencies to support direct technology transfer, but it was also doubtful whether another technology transfer strategy was actually

reasonable. Their position directly challenges the positions on technology transfer taken by developing countries. As seen in chapter two, developed countries tend direct supply measures to implement technology transfer.

One representative of the GEF secretariat framed the issue as “new vs. old” technology transfer. The “old” understanding in its semantic understanding means taking a technology somewhere and making it work. In contrast, the “new” understanding is related to market transformation.<sup>57</sup> He referred to “old” technology as transfer that had taken place during the 1980s in order to close the technology gap between developed and developing countries. Specifically referring to Latin America, direct technology transfer had, in his opinion, largely failed. “New” technology transfer, in contrast, was understood by him as the way technology transfer is supported by the GEF (private investments in response to market incentives). Representatives of the WB likewise stated that they saw no alternative to the actual strategy carried out by the GEF. Developing countries, one interviewee said “had to accept that the transfer of environmental technology cannot be different then the transfer of any other technology.”

Thirdly, differing perspectives emerged between GEF and WB representatives on the one side and representatives of UNEP and UNDP on the other towards issues of whether the GEF was adequately following UNFCCC guidance and doing justice to the interests of both developed and developing country parties. Representatives of the GEF stated that UNFCCC guidance was scarce and limited in its usefulness. They pointed out, however, that the technology transfer framework was serving as guidance on technology transfer. About the GEF response to the TT framework it was said that “we actually do most of these things. Most of our projects flow to capacity building and create enabling environments.” In the understanding of the GEF secretariat representatives, notions of technology transfer held by the UNFCCC (as expressed by the EGTT), and those held by the GEF do overlap, especially with regard to the facilitation of private sector access, and cross-country collaboration on new technologies. GEF secretariat members also expressed that they were “on good terms” with the EGTT. Confronted with the question as to whether the GEF was doing justice to developing countries, the interviewees stated: “It is hard to say.” It was acknowledged that expectations were different, but the positions of developing countries were described as “political” and “provocative” and “many developed countries expect this issue not to move forward at all.” GEF representatives did indicate that they were fulfilling developing countries’ expectations through successful projects, and they mentioned PVMTI as an example. GEF secretariat members also stated that developing countries were in opposition to GEF activities not because of their nature, but because of wider political reasons within the negotiation process. Developing countries, in their

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<sup>57</sup> This distinction can also be found in the publications of ex-GEF employee Eric Martinot to whom interviewees repeatedly pointed as the source for GEF thinking (Martinot, Cabraal, and Mathur 2001; Martinot et al. 2002).

understanding, opposed the GEF activity because they needed the inactivity of the GEF as a political argument to show that industrialised countries were inactive regarding technology transfer.

Representatives of the WB and the IMF took similar positions. When asked whether the GEF was doing justice to developing countries' interests, they stated that in relation to technology transfer those were "unrealistic." In their opinion, developing countries were expecting similar governance structures for the GEF as under the Montreal Protocol, objected to the veto opportunity of the donors and tried to gain political capital out of criticising the GEF for being donor-driven. The WB representative stated also that developing countries should change their understanding of technology transfer and accept that higher costs for emission reduction should be covered through changing incentives and the institutions underlying markets. He added "technology transfer for climate change is not different from technology transfer for a can opener." In other words, developing countries should accept that market-based transfer is the only way of doing it.

Comments on one particular project reflect the differences in opinion on GEF activities more generally between WB and the GEF on the one hand, and UNFCCC, UNDP, and UNEP on the other. As part of their project activities, GEF has financed market research on efficient lighting and developed business models for the sale of more efficient lighting systems in Africa. The IMF interviewee praised the market research as the optimal and only sensible way to give incentives to private companies to become active in Africa. Lighting businesses not undertaking market research themselves were considered as market failures. Representatives of the UNFCCC secretariat took an opposite position. They considered the GEF's undertaking market research not as wrong or inadequate, but as completely insufficient to mitigate climate change and support sustainable development.

Three additional aspects were criticised by UNFCCC, UNDP and UNEP representatives. One interviewee stated that GEF activity is not embedded in country development strategies and does not follow the priorities of a given country. The interviewee also said that by itself the market transformation approach is not sufficient to support development. A greater plan is needed since markets alone are not sufficient and investments in China and India are not driven by climate change concerns. Environment and Development, in his understanding, have to be linked and UNEP is mediating these two goals. Donors, in his understanding, put important emphasis on the environment but developing countries needed more support. A second interviewee stated that the GEF Technology Transfer Approach was oversimplified. A third interviewee stated both that the GEF lacks clarification of the market transformation approach and a real vision of what technology transfer could be under the convention.

### ***Drivers for adopting the market transformation approach***

Interviews revealed three main “drivers” for the increased application of the market transformation approach within the GEF: lacking financial resources, missing skills to pursue other forms of technology transfer, and donor influence.

All interviewees agreed that the main driver for pursuing the market transformation approach is the lack of financial resources. Considering the large number of countries the GEF was serving and the number of operational programs adopted, the support of a market environment to give incentives for private investments is considered more “do-able” than providing technology directly. One interviewee stated that adopting the market transformation approach was “a concession to the reality of the climate change markets” as the GEF had substantial financial resources but “not enough to solve the climate change problem.”

Members of the GEF secretariat and the WB also pointed out that early projects under OP7 including direct technology transfer “were not particularly successful.” From their perspective, the GEF and their IAs were “not good at such projects.” Getting a technology ready for the market, as outlined in OP7, including technology transfer, could not be achieved by the World Bank as they had no “competence in technology management and commercialising technologies.” Another interviewee expressed the same understanding by stating that the World Bank “is not a hardware procurement agency.” Interviewees did not go into detailed explanations why they were not successful. The Climate Change Program Study of 2001 explains “technological know-how transfer is more difficult than projects anticipate given problems with technology acquisition and application to domestic conditions” (GEF/C.17/Inf.5: 3).

Interviewees disagreed on the importance of donor influence stating it ranged from minor to substantial. More critical perspectives from the IAs as well as the UNFCCC secretariat suggested that the chosen approach was also a result of particular interests in the majority of the donors funding the GEF. Until 2006, donors had been exclusively industrialised countries. In 2006, India, China, South Korea, Mexico, Nigeria, Pakistan, Turkey, and South Africa provided financial support to the GEF. It could not be established within the interviews whether increased funding from developing countries is changing GEF policies.

### ***Conclusion***

While the GEF initially supported projects aiming to transform markets and direct technology transfer, the market transformation approach is now the only GEF project approach. Technology transfer became one of the goals of market transformation.

The idea behind the market transformation approach is that the creation of markets for a certain technology through project assistance will result in the investment of private firms in the newly

established market. Technology transfer is not a primary goal of any GEF activity but hinges on the decision of the investor.

Also, in relation to describing its five pillars of market transformation, the GEF has excluded direct and indirect technology transfer as a measure supported. The revised GEF strategy for climate change reads “using the barrier-removal approach reliant upon the five pillars of market transformation, GEF support has been aimed not at subsidizing individual investments but rather at creating the market environment in which the technologies and practices can saturate the target markets”.<sup>58</sup> Activities that would fall under GEF Operational Program 7 on “Reducing the long-term cost of low greenhouse gas emitting energy technologies“ are, according GEF interviewees, “not part of the current climate change strategy.” In other words, direct technology transfer as defined in the theory chapter of this thesis (section 2.2.11) is currently not supported. The technology transfer adopted by the GEF is the same for all GEF climate change related activity, yet there seems to be no specific approach to be applied by the GEF in its role as the financial mechanism of the UNFCCC.

Interviews revealed three main “drivers” for the increased application of the market transformation approach within the GEF: lacking financial resources, missing skills to pursue other forms of technology transfer, and donor influence.

The interviews also revealed that the split between developed and developing countries observed under the UNFCCC seems to be reproduced among the GEF and is implementing agencies. On the one hand, the GEF, IFC and World Bank staff suggested that technology transfer is achieved by means of market creation and as reaction to technology diffusion, reflecting the developed country position under the UNFCCC. On the other hand, UNEP and UNDP representatives argued that supply and demand measure should be implemented by the GEF reflecting developing country positions under the UNFCCC.

Furthermore, the logic of the MT approach (that was developed by World Bank staff) follows the hierarchy of goals found in developed country positions under the UNFCCC. The main goal of the GEF lies in achieving environmental benefits through technology diffusion. Other goals like access to technology are subordinated to the main goal.

The focus on markets is also reflected in the barriers addressed by the GEF. Although no fixed list of barriers exists and the GEF has underlined that barriers are project specific, they all relate to the establishment of functioning markets as expressed in the five pillars framework. Lacking technological capabilities or absorptive capacities for technology are not listed as relevant barriers, though academic sources do list both as crucial barriers to technology transfer (Lall and

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<sup>58</sup> [gefweb.org/Operational\\_Policies/Operational\\_Strategy/documents/FocalAreaStrategy\\_GEFAGCCStrategy-February162007-forcirculation.pdf](http://gefweb.org/Operational_Policies/Operational_Strategy/documents/FocalAreaStrategy_GEFAGCCStrategy-February162007-forcirculation.pdf).

Narula 2004). Ravindranath and Sathaye, for example, include “poorly developed technical and institutional capabilities and inability to assess, select, import and adapt ESTs suitable to the country, location or sector” (Ravindranath and Sathaye 2002).

### **5.3 GEF relations to the UNFCCC**

After having established the rationale of the market transformation approach and the role of technology transfer within the market transformation approach, the next section will investigate the relation of the GEF to the UNFCCC. Special attention is given to the extent to which the COP has both legitimised and played a role in developing the market transformation approach.

#### **5.3.1 COP Governance of the GEF**

The GEF has to adhere to the guidance of decisions by the respective conventions’ COPs. The relevant Article 11 Paragraph 1 of the UNFCCC reads: “It [a financial mechanism, RH] shall function under the guidance of and be accountable to the Conference of the Parties.” The GEF correspondingly states in its Operational Strategy that “all GEF-funded activities in climate change will be in full conformity with the guidance provided by the Conference of the Parties (COP) to the FCCC.”

The relation between the UNFCCC and the GEF is spelled out in a memorandum of understanding (MoU), which took legal effect in 1994. The MoU contains the modalities regarding guidance and intervention of the COP to the GEF, and reporting and accountability of the GEF towards the COP (FCCC/CP/1996/9).

Paragraph 2 of the MoU reads that the COP will make the decisions on “policies, programme priorities and eligibility criteria related to the Convention for the financial mechanism which shall function under the guidance of and be accountable to the COP” (FCCC/CP/1996/9).

Yamin and Depledge note that “the phrase ‘under guidance of and accountable to the COP’ was used in preference to the stronger language ‘under the authority’ proposed by developing countries because donors considered the stronger language might unduly limit the GEF’s operational freedom” (Yamin/ Depledge 2004: 285).

Despite its right to guidance, the COP cannot directly intervene in the project funding decisions of the GEF, but can only ask for further clarification of a decision if a party raises concerns or objections in the first place (Yamin/ Depledge 2004: 286).

Likewise, while the COP reviews the GEF every four years, it is not obliged to consider the result of these reviews. In practice however, Yamin/ Depledge suggest that the GEF “has demonstrated its responsiveness” (Yamin/ Depledge 2004: 289).



Interaction between the UNFCCC secretariat and the GEF also takes place through networking. The UNFCCC secretariat is, for example, present at meetings of the GEF Operations Committee, where he or she presents his or her views on the project proposals discussed. Members of the secretariat also attend meetings of the GEF Climate Change Task Force (FCCC/SBI/1996/10).

### **5.3.2 COP guidance regarding technology transfer**

This section will establish what kind of guidance in the form of COP decisions the GEF has received, how it is responding to COP guidance on technology transfer, and how much leverage the GEF has in implementing COP guidance.

Decisions taken at COPs regarding the GEF often (but not necessarily) have the word “guidance” in their title. Yamin and Depledge note that the GEF only takes COP decisions into account which do carry “guidance” in the title. In every annual report the GEF lists which COP decision it considers as guidance (Yamin/ Depledge 2004: 285). Relevant in this context is what kind of guidance the COP gives to the GEF regarding technology transfer and how the GEF perceives this guidance.

The decision to involve the GEF in technology transfer was already taken before the first COP. During its tenth meeting, the Intergovernmental Negotiating Committee (INC) for a Framework Convention on Climate Change, founded in 1990, decided on a “temporary agreement between the committee and the Global Environment Facility.” However, this document does not give any guidance regarding technology transfer other than stating that if technology is transferred, than it should be environmentally sound (GEF/ C.2/ 11: Attachment 1).

The decisions adopted during COP 1 include by far the most extensive general guidance to the GEF.<sup>59</sup> The COP decided that the GEF should address Articles 4.1, 4.7, 4.8, 4.9 and 4.10 of the Convention. However, Article 4.5, which ultimately establishes technology transfer as a means through which developing countries could be put in a position to contribute to the mitigation of climate change, is left out (FCCC/CP/1995/7/Add.1: 34) (see chapter four).

Furthermore, the COP stated that it had realised the importance of technology transfer in Article 4.5, and that discussions concerning how to operationalise technology transfer should continue (FCCC/CP/1995/7/Add.1: 38). In other words, the COP communicated that the GEF would receive guidance for how to implement technology in the future. The same paragraph states that

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<sup>59</sup> Most guidance given represents organising or procedural principles. Guidance on the concrete design of projects is very limited but exists under the subheading of “programme priorities.” COP 1 requested the GEF to focus on the initial period on financing enabling activities in developing countries. COP 1 also made “improving national public awareness and education on climate change and response measures” a programme priority. COP 1 also asked the GEF to finance “formulation by developing country Parties of nationally determined programmes to address climate change” (FCCC/CP/1995/7/Add.1: 35).

the COP took note of document A/AC.237/88 on technology transfer but considered it to be out of the scope of the GEF.<sup>60</sup>

The COP indirectly decided that GEF projects should include technology transfer by deciding that GEF projects should embrace a mixture of long- and short-term priorities (FCCC/CP/1995/7/Add.1: 39). The GEF had communicated beforehand to the COP that projects with long-term priorities “would probably comprise ... technology transfer” (GEF/ C.3/ 10: 5).

The COP decided also on a normative, non-binding framework for all GEF activities. These *should* be supportive of national development priorities contributing to a “climate change response,” consistent with Agenda 21, the Rio-Declaration, and other agreements related to the UN conference on Environment and Development, sustainable, and cost-effective (FCCC/CP/1995/7/Add.1: 34-35). While this framework contains strong normative elements, a further discussion is not pursued in this context, as it is non-binding.

The GEF reported during **COP 1** how it would include climate change into its operational strategies and initial activities in the field. Concerning the former topic, the GEF reports that it will wait for further guidance from the COP, stating that “the main operational implications for the GEF will depend on which strategic direction is taken by the COP.” (GEF/ C.3/10: 4)

The GEF also states that its council had agreed to include “a number of preferential, demonstration or innovation projects” for 1995 (GEF/C3/10: 6). The GEF also “confirms” that all guidance given to GEF by the INC had been taken into account. The first GEF report to the COP goes on to state that the preferential projects “include energy-efficiency and renewable energy projects and programs” (GEF/C3/10: 6).

As we will see in the following, the way the COP and GEF interact on technology transfer during COP1 is paradigmatic for later COPs. The UNFCCC gives no direct guidance on technology transfer; guidance is given at best indirectly. At the same time, the GEF signals that it will await guidance (including guidance on technology transfer), but meanwhile will develop

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<sup>60</sup> The document in question is a note prepared by the interim secretariat on behalf of the INC on the subject of how technology transfer could be operationalised in relation to the corresponding articles of the convention. The paper presents clear suggestions for a framework for technology transfer and a clear role for the financial mechanism. Its role is described as: “funding for the transfer of technology is to be provided through the financial mechanism” (A/AC.237/88: 7). The paper envisions technology transfer to consist of supply and demand measures co-ordinated through governments and private actors. The suggested framework for operationalising technology transfer reads as follows: “Transfer of technology will take place in the context of productive activities generally involving investments, private or public, foreign or domestic.” The suggested concepts to achieve successful technology transfer are that of “strengthening of technological capabilities” and “information exchange.” While the concept of “information exchange” includes a number of measures to increase communication about available technologies and transfer options, the concept of “technological capabilities” suggests how technology transfer should be implemented. It suggests a combination of science push measures (provision of technological knowledge) and demand pull as well as measures to increase the capability of recipients to use this knowledge (improving absorptive capacities). Technology transfer shall be achieved through “co-ordination at the national level” as well as the private sector (A/AC.237/88: 7-8).

its on approach to technology transfer. While not having developed a detailed approach at the time of COP1, the internal GEF document “Guidance for Programming GEF Resources in 1995” shows that the GEF is actively developing its own approach to technology transfer by stating priorities in designing technology transfer projects (GEF/C.2/5: 7).

During **COP 2** and **COP 3**, the COP gave no guidance regarding technology transfer.<sup>61</sup> The GEF reported to COP 2: “Transfer of technology is a significant factor in GEF-financed climate change activities, particularly those concerned with renewable energy and energy efficiency” (FCCC/CP/1996/8: 9, FCCC/ CP/ 1997/MISC.1).

During **COP 4** in 1998, the COP noted in relation to the financial mechanism the “concerns and difficulties encountered by developing country parties with the availability and disbursement of financial resources, including for the transfer of technology” (FCCC/CP/1998/16/Add.1: 5). The COP decided that the GEF should provide funding for technology needs assessment and capacity building in order to improve access to technology information, and to identify technology sources and the modalities of technology absorption. The COP also made the decision to make the GEF the permanent financial mechanism to the Convention, and to review it every four years (FCCC/CP/1998/16/Add.1: 7-8). As seen in the theoretical chapter, these are important activities for the successful implementation of technology transfer, but again represent no guidance on technology transfer as such.

The GEF had reported beforehand in its annual communication to the COP that the 1997 Project Implementation Review had found out that “the policy framework and enabling environment are extremely important for the successful adoption and replication of alternative energy and more energy-efficient products and technologies” (FCCC/ CP/1998/12: 9). This quote indirectly refers to the diffusion (adoption) and production (replication) of technology, and signals to the COP that the GEF has already developed modes of technology support before having received guidance.<sup>62</sup> It also indicates that the GEF is selectively shaping its GEF technology support

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<sup>61</sup> Developing countries expressed their concern about a number of aspects regarding the GEF. These include its “operational policies on eligibility criteria, disbursement, project cycle and approval, the application of its concept of incremental costs, and guidelines which impose considerable administrative and financial costs on developing country Parties” (FCCC/CP/1996/15/Add.1: 53). In their decision on guidance, the COP requested the GEF to focus on supporting developing countries in enabling activities (preparation of national communications, etc.).

<sup>62</sup> The cited Project Implementation Review, however, does not lend any support to the GEF’s claim about the importance of policy frameworks and enabling environments. The report is based on overall reviews of the implementing agencies (IAs) plus an additional assessment called “Lessons Learned during the GEF Pilot Phase.” The review of the World Bank states: “With regard to working with private sector partners, it is no surprise that appropriate policy framework and enabling environment are cited frequently as key to success in developing new products or technologies” (GEF 1997: Appendix 3: 5). While this quote might justify the interpretation given to the COP, two other conclusions are suppressed by the GEF. The review of UNDP contains positive references to technical assistance and demonstration projects. The UNEP review makes no claim regarding technology transfer or enabling environments. Hence UNDP stresses two aspects of technology support which do not comply with the policies of the GEF and have not made it into the GEF review. What the GEF actually did in its communication to the

approach (which eventually lead to the market transformation approach) and promotes it to the UNFCCC – although it should, at least in theory, do so according to UNFCCC guidance.

During **COP 5**, no guidance was given to the GEF in relation to technology transfer. The GEF reported that it had presented its view on technology transfer to the SBSTA in FCCC/SBSTA/1999/MISC.5, Paper No. 10. It explains the GEF approach to technology transfer by stating “a significant aim of these programs is to catalyze sustainable markets and enable the private sector to transfer technologies” (FCCC/SBSTA/1999/MISC.5: 105). The straightforward statement shows again that the GEF is actively communicating its technology transfer approach to the GEF.

During **COP 6**, parties reached consensus regarding guidance for the financial mechanism but postponed its adoption until COP 7. The guidance includes no reference regarding technology transfer (FCCC/CP/2001/5/Add.1).

GEF reported to COP 6 that “technology transfer and capacity building are central elements of GEF climate projects and include a wide range of approaches commensurate with the diversity of technologies, needs, and circumstances” in their synthesis on climate related projects (FCCC/CP/2000/3: 24).

During **COP 7**, the COP decided that parties to Annex II should meet the commitments resulting from Articles 4.1, 4.3, 4.4, 4.5, 4.8 and 4.9 through “Increased Global Environment Facility replenishment” (FCCC/CP/2001/13/Add.1: 43). The inclusion of paragraph 4.5 means that technology transfer is included in GEF activity.

The COP requested the GEF to “provide financial support for the implementation of the annexed framework through its climate change focal area and the special climate change fund established under decision 7/CP.7” (FCCC/CP/2001/13/Add.1: 22). This request is of importance because the annexed framework is the UNFCCC framework for technology transfer discussed in chapter 4.3.3. As seen, the TT-Framework is the most comprehensive effort of the COP to engage the subject but it has substantial limitations when it comes to the actual transfer of technologies. The GEF reported nothing substantial in relation to technology transfer (FCCC/CP/2001/8).

COP 7 is important insofar as the decision to implement Article 4.5 through increased replenishment of the GEF addresses the GEF to implement technology transfer. By requesting the GEF to act according to the technology transfer framework of the COP seems to provide guidance on how to implement technology transfer for the first time. The discussion of the framework in chapter 4.3.3 has however shown that the framework addresses a number of

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COP is stress the importance of its own approach (enabling environments, see below) by selectively picking feedback from its implementing agencies.

important contextual aspects of technology transfer but contains no provisions regarding the mechanism of technology transfer.

In practice, as we will see further down, suggesting TT-framework served as a form of legitimisation for the existing GEF market transformation approach rather than shaping it, as GEF staff did not perceive it as a request to modify the market transformation approach but as a conformation in their perception that there is congruence between the UNFCCC requirements regarding technology transfer and the GEF approach.

During **COP 8** in 2002, the COP noted that the GEF had “effectively performed its role” for the convention (FCCC/CP/2002/7/Add.1: 13). At COP 8, the parties turned the request regarding technology transfer, stated during COP 7, into a decision (FCCC/CP/2002/7/Add.1: 16). In other words, from COP 8 onwards, the technology transfer framework is the official COP guidance for the GEF on how to implement technology transfer.

The COP also requested the GEF to take into consideration both the second review of the GEF and the Second Overall Performance Study (OPS). This request is also relevant regarding technology transfer. I will discuss both in the following section because they include selective propositions on technology transfer and are somehow emblematic for the political nature of COP – GEF communication and the review process.

### ***The second COP review of the GEF***

The second review of the GEF is based on country submissions, country statements before the SBI (16th session), and GEF evaluations. The review concludes that the GEF “has effectively performed its role as an entity operating the financial mechanism in providing financial and technical support for the implementation of the Convention” (FCCC/SBI/2002/14: 33). It suggests that the GEF should improve stake-holder engagement, private sector participation, improve the “catalytic” effect of the GEF and further streamline the project cycle.

The second COP review also states: “The general perception of some parties was that the GEF, on the whole, had been effective in providing financial resources for the transfer of technology” (FCCC/SBI/2002/14: 5). Reading the country submissions to the second COP review of the GEF, one sees that the quoted statement on technology transfer is not false, but rather biased. Out of the seven country submissions to the review, two are critical towards GEF technology transfer efforts. Chile remarked in its submission that some countries had problems with the financial mechanism and “strongly encourages this mechanism to find the ways to improve its financial and technical assistance to those countries” (FCCC/SBI/2002/MISC.2: 3). The submission of Kenya states: “There is the urgent need to assist African countries implement more investments projects which involve significant transfer of technology” (FCCC/SBI/2002/MISC.2: 6). The submissions of Denmark on behalf of the EU, Samoa on the

behalf of the Alliance of Small Island States, New Zealand, and Uzbekistan make no reference to technology transfer. Only the submission of the USA expresses “that the Convention’s financial mechanism has, on the whole, been effective in providing financial resources for the transfer of technology and capacity building” (FCCC/SBI/2002/MISC.2: 11). Since the review also considered fifteen oral statements of countries to the SBI which are not documented, it is possible that more than one country expressed satisfaction regarding technology transfer.

### ***The second Overall Performance Study***

In order to complete the second Overall Performance Study (OPS 2),<sup>63</sup> the GEF compiled a “fully independent” (GEF 2002: 117) team of consultants who conducted their evaluation on the basis of GEF project documentation and evaluations, reports from the implementing agencies, stakeholder meetings, and country visits.<sup>64</sup> The aim, in relation to climate change, was to “assess impacts and other results in the climate change focal area in terms of the market advancement of renewable energy and energy efficiency efforts” (GEF 2002: 115). The OPS2 also found that the “GEF has been responsive” to COP guidance (GEF 2002: 47). The OPS2 asked the COP to provide more clarity in its guidance.

The second OPS found that “project impacts from the climate change focal area are slow in emerging” because the majority of the projects had not yet been completed (GEF 2002). The beginning of the review of climate change consisted of a number of slightly positive, general comments and goes on to summarise selected successful projects.<sup>65</sup> It gets a bit more nuanced in the overall conclusions where it states that GEF had been “most effective” in promoting energy efficiency, had “more modest success” regarding on-grid renewable energy (RE) and “least success” with off-grid rural development RE (GEF 2002: 23).

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<sup>63</sup> The GEF commissions periodically external reviews that aim to examine the impact of GEF’s financial support to countries regarding the environmental problems addressed by the GEF. In 2009, the fourth overall performance review was conducted.

<sup>64</sup> Looking at the procedure, one may question how independent the team in practice was. The focal areas were reviewed by the GEF’s Monitoring and Evaluation team, in cooperation with the GEF implementing agencies in order “to facilitate the work of the OPR 2 team” (GEF 2002: 121). GEF, STAP and implementing agency staff in cooperation with another set of external consultants carried out these evaluations. It is also uncertain how deep these programme studies are. The GEF states that, in the climate change area, its GEF Monitoring and Evaluation Team had only evaluated seven countries by 2002 while projects had taken place in 120 countries (GEF 2002: 126). 28 of these were completed, 15 were at least two years in operation by 2000 (GEF 2002: 15). The OPS2 team was only allowed to visit selected projects in 11 countries. Countries were chosen by the team after discussions with the GEF and consultation of the terms of references (GEF 2002: 122). The OPS2 team reports that the main sources of information were four focal area Programme Studies and an external evaluation report of GEF’s ozone program (GEF 2002: 121). The country visits, the only chance to gather first-hand information for the OPS2 team, are described as “also very helpful” (GEF 2002: 121). In practically all assessment steps, staff of the GEF or the IAs participated.

<sup>65</sup> It also reports a number of technology development programmes were successful because the technology used was successfully replicated. The largest grid-connected renewable energy impact from various demonstration projects has occurred in India. Off-grid solar photovoltaic systems for rural electrification form the largest part of the GEF climate change endeavours. 18,000 systems were installed by 2002, and 600,000 are expected to be installed when all 23 projects are completed. Progress is also reported on micro-finance models for PV systems, awareness, and increased technical standards. (GEF 2002: 16). The OPS reports also success in projects supporting market oriented approaches and highlights a few success stories (GEF 2002: 17).

Regarding further action, OPS2 suggests that GEF should support the sharing of experiences and push for the stronger replication of successful projects. As one of the major obstacles to project replication, the OPS2 considers the lack of enabling environments and private sector participation. The OPS2 concludes concerning the matter of replication that its “findings demonstrate that a clear understanding of the scope for technology development and demonstration, an emphasis at the project design stage on market transformation, the demonstration of viable business models, and other approaches that effectively engage the private sector could help improve replication” (GEF 2002: 22). Since the lack of market development is considered a major obstacle to project success, the OPS recommends the stronger engagement of the World Bank and the IFC due to their skills in market transformation (GEF 2002: 24).<sup>66</sup>

By asking the GEF to consider the second COP and review OPS2, the COP gives indirect guidance and justification to the GEF with regard to technology transfer. Prompting the GEF to consider the second COP review means giving the GEF official approval of their technology transfer approach, avoiding the criticism of developing countries. Likewise, requesting the GEF to consider OPS2 results is a similar approval of their approach to technology transfer as the OPS2 basically suggests to the GEF to strengthen elements of its market transformation approach. The UNFCCC does not address the subject directly but effectively asks the GEF to pursue more vigorously what it considers as vital to technology transfer anyway: market development and removal of related barriers.

During **COP 9** in 2003 in Milan, the COP decided, in relation to technology transfer, that the GEF should continue support for technology needs assessments. The COP also decides that “technology transfer and its associated capacity-building activities shall also be essential areas to receive funding from the Special Climate Change Fund” (FCCC/CP/2003/6/Add.1: 11). The COP decided further, in regard to the Special Climate Change Fund, that it shall consider the following priority areas (FCCC/CP/2003/6/Add.1: 12): Implementation of the results of technology needs assessments, technology information, capacity-building for technology transfer, and enabling environments. These priorities again leave out direct technology transfer as such, just as the technology transfer framework does. It might support indirect technology

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<sup>66</sup> It is not my task to criticise the GEF for its review practices, although it seems to completely lack a central aspect of evaluation: the development of adequate indicators. This is consistent with another critique of GEF self-evaluation. It states: “the match with performance indicators and M&E is incomplete and inconsistent. The 2000 GEF report on measuring results from climate change programs sees market transformation as the “level of market penetration of sustainable technologies and practices in given country markets” yet indicators on market penetration and barrier removal are unclear and proxy indicators inconsistently applied in project formulation. The strategic priority indicators present considerable challenges at the project level. Thus, aggregation and reporting for the GEF portfolio on intended results will remain ad hoc” (Eberhardt et al. 2004: 67).

What is striking about the climate change section of the review is that it neither discusses success and failures nor gives any differentiated overview about all projects considered. Technology transfer is not considered other than in the already above-cited examples of technology replication.

transfer via the aspect of “capacity building for technology transfer,” but this is not clearly specified.

During **COP 10** at Buenos Aires, the parties gave no guidance to the GEF regarding technology transfer. The GEF reported on guidance given, during COP 9 on technology transfer, that it “reviewed current practices and considered whether new measures would be needed to ensure that the guidance was implemented” (FCCC/CP/2004/6: 7).

During **COP 11** in Montreal 2005, no guidance to the GEF was given regarding technology transfer. The GEF communicated beforehand quite clearly its position on technology transfer. Technology transfer is framed around the central notion of “transforming markets,” and the aim of projects is to “catalyze transfer of climate friendly-technology.” Another aspect is the removal of barriers to technology usage and technology transfer. The GEF supports “providing information, creating an enabling environment by strengthening local technical knowledge and capacity, and financing and supporting the use of the actual technology” (FCCC/CP/2005/3: 20). This framing of the subject sounds very familiar to other GEF interpretations of technology transfer. The inclusion of the aspect of “strengthening local technical knowledge and capacity” is noteworthy, as it has so far not appeared in GEF statements. Since technical knowledge and capacity may refer to a variety of practical aspects, gaining further insights in its concrete meaning would be desirable. So far, I have not found a more detailed description.

The document also mentions a GEF framework for technology transfer “based on different types of barriers, such as lack of awareness of consumers and suppliers, initial higher up-front costs, policy barriers due to obsolete technology standards, lack of business models and delivery capacity” (FCCC/CP/2005/3: 21). Unfortunately, no further explanation or reference for a more detailed elucidation is given. The document claims, however, that the framework is in line with the IPCC recommendations on technology transfer, allegedly emphasising the removal of barriers to the unimpeded growth of the markets for these new technologies (FCCC/CP/2005/3: 21). Yet this GEF communication again demonstrates that the GEF claims to follow UNFCCC guidance.

**COP 12** asked the GEF to “continue to provide financial support for the implementation of the technology transfer” (FCCC/CP/2006/5/Add.1: 9). The GEF repeated its position on technology transfer and lists two projects as examples (FCCC/CP/2006/3: 10-11). Both projects are demand-oriented, although one includes a demonstration component. It is however not clear whether technology is imported for demonstration. Again we can see that the UNFCCC remains unspecific in its guidance and the GEF quite clearly communicates its own approach.

During **COP 13** at Bali in 2007, parties committed themselves in the Bali Plan of Action to take “enhanced action on technology development and transfer,” but did not take any specific decisions on rules, commitments or action. The GEF was requested to scale up its investments



in technology transfer and to further the implementation of the technology transfer framework (FCCC/CP/2007/6/Add.1: 28). The GEF reported beforehand that no projects of the Special Climate Change Fund regarding technology transfer were underway, but only discussions concerning how developing countries could increase capacities to create enabling environments for technology transfer. COP 12 and 13 openly ask the GEF to pursue technology transfer the way it has done so before. This is no direct guidance but direct confirmation of the GEF approach to technology transfer.

### **5.3.3 COP reviews**

The UNFCCC COP reviewed the GEF three times so far. The report to the first review of the GEF took place in 1997. Regarding technology transfer, it states that parties had pointed out that “progress in transferring technology had been insufficient” (FCCC/SBI/1997/8: 8). The review, however, did not include any recommendation regarding technology transfer. The second review and its implications have been discussed above. The third review was carried out in 2005 and then discussed at COP 12 in 2006. The review report merely lists the COP guidance on technology transfer, and then cites the reaction of the GEF towards COP guidance as expressed in their annual reports to the COP (FCCC/SBI/2006/7: 15). It does not contain an evaluation of GEF technology transfer activities.

#### ***Summary***

In summary, my document analysis shows that the UNFCCC never gave direct guidance to GEF on direct technology transfer. During COP 1, the parties merely decided that the GEF would receive guidance on technology transfer in the future. Nothing was decided at COP 2 and 3. At the same time, the GEF confirmed that it will await guidance but also started communicating to the COP how it will implement technology transfer, at this time a mixture of supply and demand measures, reflecting its operational strategy and OS 5, 6 and 7. It was not until COP 8, in 2002, that the UNFCCC decided upon the technology transfer framework. The frameworks were meant to give guidance on technology transfer, but only touched on framework issues and indirect aspects of technology transfer, thus lacking guidance direct technology transfer. By 2002, the GEF approach had already been firmly developed towards market transformation, leaving out direct technology supply. As seen in chapter 4.3.3, the technology transfer framework is relatively straightforward in enabling environments and other framework conditions, but leaves out the issue of direct technology transfer. At various occasions the UNFCCC justified the GEF approach to technology transfer although it was not based on UNFCCC guidance. Indirect justification took place during COP 8, when the UNFCCC concluded that the GEF should take into account the second GEF Overall Performance Study and the second COP review. Both seem to be politically biased and both

seem to offer indirect guidance on technology transfer, reaffirming the GEF market transformation approach. During COP 12 and 13, the COP directly justified the GEF approach by asking them to continue their support of technology transfer.

The GEF communicated that, on the one hand, it would await guidance but, on the other hand, actively developed its own technology transfer. The GEF strategically promoted its own approach in front of the COP through merely communicating the GEF understanding of technology transfer but also through selectively communicating forged praise of its own approach. The lack of guidance is a direct result of the lack of disagreement on the subject within UNFCCC negotiations. The GEF seems to have used the vacuum on guidance created to pursue its own agenda and goals on technology transfer.

#### **5.3.4 Interview results: COP guidance on technology transfer**

The document analysis suggests that the UNFCCC gave no direct guidance to the GEF, but on various occasions indirectly and directly supported the GEF approach to technology transfer which the GEF had developed independently of the COP. In order to give further credibility to the results of the document analysis and to better understand the role of COP guidance, these issues were included in the interviews conducted in relation to the market transformation approach.

Representatives of both UNFCCC and GEF secretariats agreed that the GEF follows UNFCCC guidance only in a very limited way and acts, for the most part, independently. Interviewees were hesitant to quantify to what extent the GEF responded to guidance. Only one representative of the UNFCCC secretariat stated that the relationship is good.

The reasons for the GEF's independence are complex. As one interviewee pointed out, the GEF acted independently as the GEF secretariat acted according to their interpretation of UNFCCC guidance. Effectively, the interpretation of guidance by the GEF secretariat was considered more important than that of the GEF council, who should, in theory, guide the GEF secretariat. The council had, in her view, neither time nor the competence to effectively consider UNFCCC guidance. This perspective was confirmed by the WB representative who stated "I don't think the GEF council cares or gets it."

Representatives of all agencies agreed that there was little guidance given by the UNFCCC in the first place, and in many cases it was only of limited use due to its general and unspecific wording. As guidance was a political text that was usually "negotiated to the comma," it was unsurprising to all interviewees that it did not contain precise and clear instructions. Interests of developed and developing countries differed too strongly (according to interviewees) to allow for precise guidance. One GEF representative pointed out that the Operational Strategy for

Climate Change depended on guidance given at COP 1 which was, in his eyes, meaningless regarding specific project contents and goals. As a result, representatives of the GEF secretariat explained the GEF would report back similarly “meaningless reports” as they wanted to stay out of additional political discussions.

All interviewees agreed that guidance on technology transfer was also minimal. As one interviewee explained, Annex I countries would strictly refrain from “getting concrete” on how to implement technology transfer, as this would possibly increase their commitment towards Non-Annex I countries. They also agreed that the only substantial piece of guidance is the technology transfer framework.

Interviewees from the GEF stated that there was high overlap between the technology transfer framework and the five-pillar approach of the GEF. One GEF interviewee stated “this is what we do as most of our project flows to capacity building and enabling environments.” When asked whether the UNFCCC had played any role in the development of the market transformation approach, interviewees stated that it had not. Furthermore, it emerged, during interviews, that projects that merely related to technology in any given area were automatically associated to technology transfer.

Interviewees considered the role of the Expert Group on Technology Transfer (discussed in section 4.3.5) to be very limited, as members were mostly country negotiators. EGTT’s importance was seen not in guidance or ideas on how to implement TT but to keep the discussion around it alive and to assign it a high profile.

Several interviewees stated that the GEF was an organisation with its own agenda and goals, which not necessarily matched the agenda and goals of parties to the UNFCCC. UNFCCC and GEF representatives, however, had different perspectives on the GEFs independence which partly stemmed from differing understandings of the GEF’s role in relation to the UNFCCC. Representatives of the UNFCCC secretariat pointed out that the role of the GEF was to serve the UNFCCC and other conventions. In their perspective, the GEF existed (despite its foundation prior to becoming the financial mechanism to the convention) because of the UNFCCC and other conventions, and GEF staff in their interpretation failed to realise this particular role. In the interpretation of one member of the UNFCCC secretariat, the acknowledgement of this particular role was the most important condition for successful GEF activity with regard to their UNFCCC tasks. Only one member of the UNFCCC secretariat admitted that GEF was an organisation with an own strategy, and the UNFCCC “was only one of their clients.”

GEF representatives gave quite another description of the UNFCCC – GEF relationship. They underlined that the GEF existed prior to the UNFCCC and continues to exist as a body

independent of it. This “fact” was in the interpretation of GEF representatives not sufficiently acknowledged by the UNFCCC. The GEF duties to the convention (funding enabling activities, operating the special funds, funding adaptation) are, from the perspective of the GEF, only minor tasks in comparison to what is understood as the main task: the operation of the trust fund for climate change mitigation. GEF representatives admitted that UNFCCC work was not in their focus and they had their own climate change agenda. As one interviewee put it: “So what we have to do as a GEF trust fund in order to preserve the global commons is to work on mitigation projects. So most of these projects are not directed towards the UNFCCC, especially since the GEF was up and running before the UNFCCC.”

In the GEF perspective, their independence from the UNFCCC is furthermore justified through the different temporal dynamics of both institutions. Guidance from the UNFCCC emerges in their eyes too slowly and too incoherently to effectively support what they consider the main goal of the GEF: preserving the global commons.

It emerged also through the interviews that UNFCCC and GEF relations were not only strained by dissatisfaction about the quality and implementation of guidance but also through institutionalised biases and disrespect for the other organisation. Representatives of the UNFCCC secretariat stated that GEF staff considered UNFCCC related tasks as “burdens” and considered UNFCCC staff as incompetent. GEF representatives described GEF – UNFCCC relations as a “pissing match.” Interviewees had few explanations for the mutual disregard.

### **5.3.5 Summary: COP Guidance on technology transfer**

Both document analysis and interviews revealed that the COP gave little guidance to the GEF on technology transfer. The GEF developed its market transformation approach independently of COP decisions and, according to my findings, without UNFCCC influence.

The only piece of guidance given was the technology transfer framework. The technology transfer framework, in practice, served to confirm the GEF approach on technology transfer (rather than shaping it) because it shows certain similarities to the market transformation approach that has been firmly established by the time the UNFCCC COP decided to make the technology transfer framework a form of GEF guidance.

Interviews also revealed that the GEF operates with considerable independence, and that GEF staff justify the vagueness of UNFCCC guidance more generally by considering the GEF as an institution independent of the GEF with its own rationale and goals. Furthermore, GEF staff underlined that they openly communicate their activities (as already revealed in the document analysis) but did not feel that their report would make any difference to the COP. As no alternative guidance on technology transfer was received, it seems likely that the GEF will

continue to design and implement support for international technology transfer in accord with the market transformation approach.

## **5.4 Overall summary and discussion**

The goals of the chapter have been to understand the GEF approach to technology transfer, the role of the UNFCCC in its development, and the relationship of the approach to positions of developed and developing countries of the UNCCC. The results are then used to inform the investigation of the PVMTI project in India.

With regard to the GEF technology transfer approach, it was found that technology transfer is currently supported through the wider market transformation approach. The market transformation approach evolved from the foundation of the GEF in 1991 until today. The original concept was an incremental cost approach out of which GEF staff (primarily former World Bank staff) then developed the market barrier approach, before they finally arrived at the market transformation approach. It has its conceptual roots in domestic US energy policy aiming to increase the diffusion of energy-efficient technology through increasing demand. Its overall aim is to establish or facilitate markets for certain technologies in developing countries by removing barriers to market development. Barriers are country specific but relate to the five pillars mentioned above.

Once markets are set to work, private investment shall serve the markets including those for the transfer of technology. Leveraging private investment through MT projects is the central long-term goal. Other approaches to technology transfer existed historically within the GEF in the form of direct technology supply but have, for various reasons, (negative project experience, lack of funds, donor policy, GEF staff preferences) seemingly been marginalised in the project portfolio.

Depending on the view of the interviewed expert, the MT framework is either considered flexible enough to accommodate a broad range of projects or been very vague and ill-defined. However, it is clearly a demand-side approach that supports technology transfer indirectly by supporting establishing markets for end-use products. Demand-side approaches could theoretically comprise important contextual aspects that are important for technology transfer (technology information, technological capabilities, etc.) as discussed in section 2.3.10 of the theory chapter. It became evident from interviews that the MT approach in practice supports diffusion of low-carbon technologies in order to reduce CO<sub>2</sub> emissions, but is also not designed to support technological learning and absorptive capacities. Technology transfer is, at best, a secondary goal and left to the decision of private investors.

Differing perspectives emerged as to whether the GEF and its implementing agencies possess the capabilities to actually support technology transfer differently than through market transformation. GEF and WB staff argued that there was no other way to transfer technology because other approaches, like direct technology transfer, would not work. Representatives of the UN agencies stated that other ways were possible and feasible, and primarily the lack of funds was responsible for focusing on the market transformation approach. The amount of funding available to the GEF is of course, in the first instance, a donor decision. At least in theory, the GEF and its implementing agencies could acquire the skills necessary to support technology transfer differently than through the market transformation approach. The Scientific and Technical Advisory Panel (STAP) to the GEF advised it in 1998 on technology transfer in the energy sector. The aim was to develop strategies which could foster developing countries' energy markets and improve domestic technology development. The primary recommendation of the STAP on that occasion was that "elements of technology transfer be built into GEF's operational program by requiring capacity building in as many projects as possible and by facilitating greater private sector participation and energy R&D activities" (STAP 1998: 6). The definition of capacity building given by the STAP in this document deserves further attention: "Capacities should be built to assess, select, import or develop, manage, adapt or replicate innovative energy technologies" (STAP 1998: 6). The capacities suggested by the STAP are those, as seen in the theoretical chapter, that are needed to successfully conduct international technology transfer from a recipient perspective. The way the market transformation approach developed shows that the STAP advice was not taken into account. The recommendation however shows that alternatives seem feasible.

Reasons for including the private sector in GEF projects are additional project resources, opportunities for technology transfer, and the chance to achieve replicability of projects even without further public funding (GEF/C.13/Inf.5). Although these are all sound reasons to include the private sector, they are no arguments for exclusively leaving technology transfer to the private sector.

While it sounds realistic that there are no sufficient public financial resources to finance all technology transfer, there is, in principle, no argument why there should not be more resources than presently available through GEF funds. Private firms do sell their technologies and it seems unlikely that they would refuse to sell it only because it is publicly acquired.

The GEF is in organizational terms relatively independent of the UNFCCC and, in practice, operates primarily according to its own rationale. Activities for the convention are in the understanding of GEF staff only a minor task in their operations. This is mainly due to lacking or imprecise UNFCCC guidance, institutional biases, and differing GEF goals informing the

large majority of GEF projects. The exact juridical relationship between the COP and GEF could however not be established within this thesis.

The GEF approach to technology transfer evolved without UNFCCC influence. The reasons are lacking or imprecise UNFCCC guidance and the GEF's ambition to develop the market transformation approach independently of the UNFCCC. Even the most comprehensive guidance given in form of the technology transfer framework lacks any guidance on how to implement direct technology transfer. Furthermore, when the COP decided the framework to be guidance to the GEF, the market transformation approach had already been developed and implemented. The framework served as a form of confirmation or justification for the GEF staff in their choice of an approach, rather than in their shaping of an approach. Additionally, the COP approved the GEF technology transfer activity of the GEF directly and indirectly at various occasions.

With regard to the position of developed and developing countries, the GEF market transformation approach is closer to the positions of developed countries than to those of developing countries. The GEF approach follows the central demands of developed countries by strengthening markets, contextualizing aspects, and assigning the actual transfer of technology to private actors. Thus the proximity of GEF policy on technology transfer to the positions held by industrialised countries, namely the USA, Australia, Canada, and Japan, is very obvious.

Is only partly doing justice to the political will of developing countries under the UNFCCC with regard to technology transfer. Developing countries do acknowledge the need for contextual and demand-side factors but they also expressed the need for direct access to technology and finance for technology rather than finance for demand measures. In the case of India, government representatives interviewed demanded exclusive and direct access to technology and did not mention any demand-side or contextual aspects. This might be related to the specific needs of India. It already possesses (in comparison to other developing countries) a relatively developed "context" for technology transfer in the form of technology institutions, industry, bureaucratic capacity, regulatory environmental mechanisms, etc. But even countries lacking such a context would eventually need an established context for both technology transfer and for the technology as such.

The congruence between developed country positions and the GEF approach to technology transfer seems to be unsurprising as developed countries constitute the large majority of GEF donors. Thus a closer investigation of donor influence in the shaping the GEF market transformation approach was not undertaken within this research project. A further implication from my findings is that the GEF approach to technology transfer is a test case for the argumentation of developed countries under the UNFCCC.

### 5.4.1 Theoretical discussion

The GEF market transformation approach is the main conceptual basis that guides the development of GEF projects in supporting low-carbon technologies. In the following, I will discuss the market transformation approach in the light of the theoretical framework to understand how far it is likely to support international technology transfer for environmental and economic benefits.

In line with the theoretical framework developed in chapter 2.7, I will firstly establish how the aspects of technology supply, recipient technological capabilities, institutional aspects of technological capability building, and demand policy are addressed. The discussion of each aspect will include any references made to the learning processes and different levels of assimilation. If no reference to the type of assimilation was made, then I assume that at least operational assimilation is aimed for. I will then discuss in how far the market transformation approach might support international technology transfer leading to environmental and economic benefits.

As seen in chapter 5.2.1, the market transformation approach has two dimension of support: first, it has an institutional side that relates to the necessary infrastructure, organisations and rules which facilitate the purchase of a technology. The second dimension is that it aims at increasing the number of purchases.<sup>67</sup> The core assumption of the market transformation approach with regard to international technology transfer is that any technology transfer will take place as a reaction to growing demand resulting from GEF project implementation.

The GEF-supported projects intervene in developing country markets in accordance to the five pillars of market transformation (access to finance, policy environment, appropriate business models and management skills, information and awareness, technological factors) (see chapter 5.2.2 for a short description). In the understanding of the interviewed GEF staff each market rests on those five pillars. If aspects of the pillars are non-existent or inappropriate, they must be supported or corrected through a GEF project.

To find out how far the GEF market transformation approach supports international technology transfer and how this leads to environmental and economic benefits depends on the size and type of demand created through measures included in GEF projects related to the five pillars of market transformation.

**Technology supply:** The market transformation approach contains no measures to intervene in markets to support technology supply directly. The pillar of technological factors is not part of GEF projects anymore.

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<sup>67</sup> These two dimensions are certainly intertwined, as the establishment of the institutional aspects of markets might increase demand without any further means in case there is already latent demand.



**Technological capabilities:** The augmentation of technological capabilities is not part to the measures comprising the five pillars of market transformation. For example, finance is supplied for private end-consumers or sales infrastructure but not for the acquisition of production technology or training of engineers. The aspect of information and awareness comprises only informational measures (learning about a technology) that at the most included knowledge for its operation. Its main purpose, according to GEF sources, is to inform end-consumers about the availability of a certain low-carbon technology and its benefits. Lacking local capabilities is explicitly considered as one barrier to the transformation of markets. As interviewees stated on the contrary, in GEF understanding and practice, these did not include technological capabilities of recipient firms. In case GEF projects addressed capabilities, they address general management skills or the capabilities to successfully participate in GEF projects. The pillar of technological factors is not part of GEF projects anymore, although some operational capabilities will be acquired by default in cases where new technology is deployed through a GEF project.

**Institutional aspects of technological capability-building:** Measures of the five pillars approach neither include any measures to strengthen the institutional aspects of technological capability-building nor the interaction between recipients and institutions. The "policy environment" pillar focuses on policy measures that support the application of such technology (e.g. standards for the installation of PV systems on buildings) but not any form of measure that facilitate technological learning. The technological factors pillar is not part of GEF projects anymore.

**Demand policy:** As one of the main goals of the market transformation approach is to increase demand for a certain technology it contains demand policy elements. The pillar of access to finance aims at overcoming one of the main barriers to the diffusion of low-carbon technology, which is higher cost than comparable technologies. Also, the pillar of information and awareness supports demand as it informs a potential adopter about a certain technology. Likewise, the pillars of appropriate business models and management skills, as well as concise policy environments to actually establish the conditions to satisfy demand, are therefore equally important.

**Discussion:** As seen above, the GEF market transformation approach does not directly support technology supply, recipient's technological capabilities and institutional aspects of capability-building defined as institution supporting technological learning. It does not support the assimilation of knowledge for minor adaptation, replication and innovation. It refers to international technological transfer as a reaction to growing demand. The only aspect of the market transformation approach that addresses technological learning is the pillar of technological factors, which - according to GEF sources - is not implemented in GEF projects

anymore. The question of technological learning is not addressed explicitly in related GEF documents. GEF staff pointed out that learning to operate and repair a technology was usually considered sufficient within GEF projects that did not consider any technological factors. At the same time, the market transformation approach directly supports selected institutional aspects of markets as well as demand.

From a theoretical perspective, the market transformation approach focuses on demand side aspects and seems more suited to support international technology transfer for environmental benefits as most measures support increased adoption of low-carbon technologies through increasing demand for end-use products. Learning for adaptive assimilation that would allow recipients to change technology to their needs and local circumstances is not supported at the time of this research, although it is a key element for diffusion and related environmental benefits - as pointed out in the literature.

The market transformation approach thus seems less suitable to support international technology transfer for economic benefits. Firstly, because it does not directly support the relevant factors driving technological learning leading to the four levels of assimilation described as crucial for long-term economic benefits in the theoretical literature.

Secondly, the circumstances under which demand leads to international technology transfer are specific. As seen in the theoretical part, international technology transfer does occur as a reaction to local demand. If demand exceeds domestic production capacity, the technology supported by the GEF project might get either imported from abroad in the form of end-use products or foreign or domestic manufacturers that might invest in additional production capacity. In other words, international technology transfer not only depends on demand per se but also on the size of demand in relation to existing production capacity. The technological learning experience that accompanies investment in new production technology also depends on the quality of the demand. If demand created can be met with existing technological capabilities, there is no incentive for manufactures to engage in additional technological learning. So while it is certain that increasing demand will lead through economic benefits through sales of technology, it is uncertain whether or not it will lead to economic benefits from international technology transfer understood as a learning process. As seen in the theoretical chapter the installation of production capacity, this does not necessarily lead to technological change. We will see in the following by looking at the PVMTI project in how far the suggestions about the market transformation approach are confirmed or refuted.

With its direct support for environmental benefits and the relegation of economic benefits to demand, the market transformation approach reflects the interest of developed countries' governments with regard to international technology transfer more strongly than the interest of

developing countries' governments. As seen in chapter 5, the GEF managed to effectively develop its approach to technology transfer in form of the market transformation approach, despite COP guidance in form of the technology transfer framework. This is interesting, as on the GEF level, different notions on how to support international technology transfer were found. World Bank( IFC and GEF staff favoured the market transformation approach in its current form, while UNDP and UNEP staff underlined additional project elements directly supporting were necessary to actually achieve successful international technology transfer.

If the framework had been appropriated in all its dimensions (see chapter 4.5), GEF projects would also include measures to support recipient technological capabilities and institutional aspects of technological learning. The conference of the parties to the UNFCCC is obviously not able to give guidance to its financial mechanism on international technology in such a way that the interest of developed and developing country governments are integrated in GEF operations with equal importance.

## 6 The PVMTI Project in India

In the two previous chapters we have seen that developed and developing countries under the UNFCCC have considerably different ideas on how to implement technology transfer and tend to prioritise different goals. We have also seen that the GEF has increasingly followed a market transformation approach, which directly supports diffusion and aims at technology transfer through private actors. The following chapter will investigate the Photovoltaic Market Transformation Initiative (PVMTI) in India as one example of the GEF market transformation approach. In order to better understand whether projects following the market transformation approach are able to do justice to the expectations of developed and developing countries on a UNFCCC level, three questions will be asked in line with the indicators identified in section 3.1.5 of the methodology chapter:

1. To what extent did the PVMTI project in India contribute to the reduction of CO<sub>2</sub> emissions?
2. To what extent did the PVMTI project in India contribute to technology imports from abroad?
3. What factors are responsible for both outcomes?

The investigation of the PVMTI project will be placed in the context of the development of the Indian PV industry and the development of Indian markets for PV technology. Both are strongly intertwined with Indian government PV policy which consists mainly of the Solar Photovoltaic Programme (SPP).

To gain a first-hand and up-to-date understanding, the existing literature was reviewed and semi-structured interviews were conducted with three groups of experts relevant for answering the questions listed above: experts with knowledge of markets of PV applications (especially the SPP), representatives of the Indian PV industry, and direct stakeholders of the PVMTI project. As these three groups overlap, a modular questionnaire was developed (to be found in appendix I). Interviewees were identified with primary relevance for each topic (the PV industry, SPP/markets, PVMTI,) but also questioned in relation to the other two. The chapter starts with a short description of the Indian PV industry based on the available literature and an analysis of the industry's technological capabilities, its sources of innovation, as well as its importance of technology transfer. In total, representatives from eleven cell and module manufacturers were interviewed based on a semi-structured questionnaire. The whole industry consists of nineteen cell and module manufacturers. The distinction between cell and module manufacturers is somewhat misleading, as firms' activities usually span several steps along the

value chain. Since cell and module manufacturing requires different production technologies, firms combining both tasks were asked questions related to technology transfer and innovation with regards to the respective step of the value chain.<sup>68</sup> The sample included two public companies, one international-Indian joint venture, and one former international-Indian joint venture. Manufacturing capacities ranged from 5 to 80 MW.

The industry analysis is followed by a discussion of the markets for PV applications in India. In brief, I will reconstruct the history, status and results of the Solar Photovoltaic Programme (SPP) of the Indian government, as it constitutes the largest market for PV applications in India. It is also a suitable program to compare with PVMTI as it shares its goals (the diffusion of off-grid PV applications) but uses a very different approach. My comparison will highlight the specific strengths and weaknesses of the PVMTI project. It is based on secondary literature review, document analysis,<sup>69</sup> and interviews with active and retired government officials, heads of state renewable energy agencies, and Indian experts.

Following the discussion of Indian PV markets, I will analyse the PVMTI project. The group of interviewees consists of a representative of the capital management firm responsible for the administration of the PVMTI funds (1), the company responsible for the implementation of the project in India (1),<sup>70</sup> representatives of PVMTI-funded companies (5), as well as those who were considered for, but ultimately did not receive, funding (1), their technology suppliers (3), officials of the Ministry for New and Renewable Energy (active as well as retired) (4),<sup>71</sup> heads of State Agencies for Renewable Energy (2), and Indian PV experts (3). In total, twenty interviews were conducted.

One of the main methodological constraints was the level of secrecy assigned to project documents that displayed project progress and results. Although GEF and IFC are public institutions, all official documents were declared confidential with the argument that they contained information related to private investors. Interview statements regarding installed systems, etc., could hence not be verified with official figures.

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<sup>68</sup> In relation to PVMTI, five system integrators were interviewed.

<sup>69</sup> The most important documents are the annual reports of the Indian Ministry of New and Renewable Energy. These were very hard to obtain, and various visits to the Ministry did not result in a complete set of reports. The TERI library also holds no complete series.

<sup>70</sup> Representatives of the IFC and the GEF were not available for comments on the IFC project.

<sup>71</sup> Retired members showed considerable knowledge of the PVMTI Project despite the official non-involvement in PVMTI.

The reasons are that the Indian PV “scene” is relatively small and all government officials have good informal relationships to the PV industry.

In the following, I will summarise the development of the Indian PV industry by focusing on the reasons for current growth and the importance international technology transfer. Afterwards, I will summarise the development of the Indian markets for PV technology. Finally, I will introduce the PVMTI project, and discuss its results for India. The chapter ends with a discussion of the contribution of PMTI towards CO<sub>2</sub> reduction and technology transfer.

## 6.1 PV Industry in India

Understanding the role international technology transfer plays within the Indian PV industry is important for understanding in how far PVMTI affected the industry and what role projects like PVMTI might play in contributing to technology transfer. In addition, an industry perspective on the importance of technology transfer and, more specifically, on technology access allows for a more differentiated picture on the largely political discussions on technology transfer under the UNFCCC. Furthermore, understanding industry dynamics and the role of technology transfer will help reveal how far PVMTI might be an adequate channel for the needs and interests of the Indian PV industry.<sup>72</sup>

Information on the Indian PV industry is scattered and eclectic. The beginnings of the Indian PV industry go back to the Indian government Solar Photovoltaic Programme (SPP). The SPP started in 1975 and aimed to create a PV cell and module manufacturing base for the development and commercialisation of PV applications. Government efforts included R&D programs for PV cell development, the installation of testing facilities, and the development of PV cell production technology. Initial research activities were started in 1976, but the first major activities were made during two research programs taking place between 1980 and 1992 (Bhargava 2001). Two state companies, Central Electronics Limited (CEL) and Bhahrat Heavy Electrical Limited (BHEL), were mandated to develop PV cell production technology. Other project components included the field-testing of applications, the training of engineers for field installation, and the attempt to raise awareness for PV technology among government agencies and ministries. State companies undertook R&D, system development, system production, and reviews of field tests. CEL reached a production capacity for PV cells of 1MW in 1985 that was developed completely in-house (DNES 1985). BHEL imported production technology from Japan for its pilot plant near Delhi and also sent its staff operating the pilot plant for training to a PV production technology manufacture in the USA (DNES 1989). In 1990, three state companies manufactured PV cells (BHEL, CEL, Udhaya) while four produced PV modules (BHEL, CEL, REIL, Udhaya). In addition, the state companies Metkem and Siltronics produced PV silicone and single crystal wafers (DNES 1990). The efficiency of PV cells achieved 7 per cent in 1990 (DNES 1992).

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<sup>72</sup> For a full list of interviewees see appendix C.

The entry of private companies into PV cell and module production was permitted from 1989 onwards. In 1992, the newly founded Ministry of Non-conventional Energy Sources (MNES) introduced fiscal support for the production of renewable energy technology. It granted a 100 per cent rate depreciation for income tax for renewable energy technology investments and exempted them from excise duty, general sales tax, and customs duty (including raw materials). The first prominent foreign investment was the formation of the Joint Venture between the Indian company Tata and British Petroleum – and others followed (MNES 1993).

The industry grew slowly until the mid-1990s, mainly through procurement by the Indian Department of Telecom, the Indian Railway and other government corporations. PV systems were used for telemetry on oil platforms, railway signalling, low-power TV transmitters, microwave repeaters and rural radiotelephones (Sastry 1997; Bhargava 2001). In the mid-1990s, procurement through the abovementioned institutions stopped as PV technologies were replaced by other technologies.

At the same time, the Indian government expanded its rural electrification part of the SPP program. Export and rural electrification opened commercial alternatives for the Indian PV industry, the former being more significant than the latter. Existing production capacity could, however, not be completely put to use (interview source, see also table 8) (Srinivasan 2005).

The development of the Indian PV industry was, and is, mainly driven by the government's concern for rural energy supply and export markets, rather than environmental protection and the reduction of greenhouse gas emissions (Srinivasan 2005).

### **6.1.1 The Indian PV industry today**

The PV industry consists of government, joint sector, and private sector companies. Private firms include firms of complete Indian ownership, joint ventures with multinationals and fully foreigner-owned subsidiaries (Srinivasan 2007). In 2007, nineteen companies operated in India producing wafers, cells, modules and systems (see Table 7). This table is slightly misrepresentative, as all cell manufactures also produce modules. There is no Indian manufacturer of solar cell production equipment. The Indian PV companies vary in their level of integration. Some companies just cover one step of the PV value chain while others cover up to three. Sales and service companies, however, do not seem to manufacture at all, although some assemble systems.

**Table 7: Indian PV companies along the value chain**

Step	Casting silicon ingots	Wafer slicing	Cell production	Module production	System integration	Sales/Service
No. Firms	1	1	9	19	80	???

Sources: (Solar Tech 2007), interviews,

### ***Wafer production***

In 1999, 80 per cent of wafers for the manufacturing of cells were imported (TERI 2001). More recent figures do not exist. Currently, one company is producing wafers with wafer production facilities of 2.5 MW consuming the output completely for their own cell production.

### ***Cell and module production***

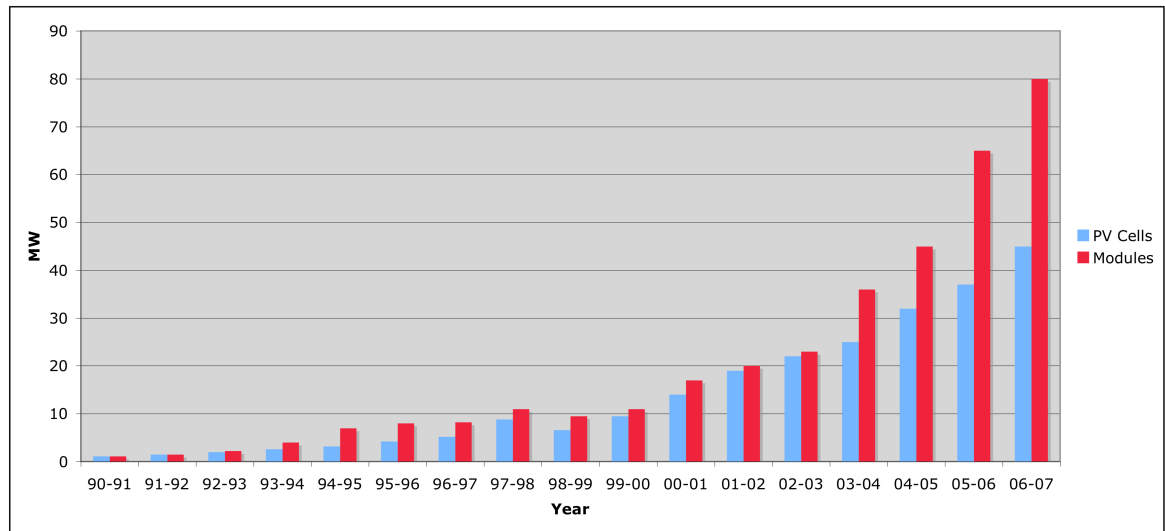
95 per cent of commercial PV module manufacturing in the country is based on crystalline silicon cells. Only one manufacturer produces amorphous silicon thin-film cells. However, cell manufacturer Moser Baer announced the establishment of a 600 MW thin-film plant in early 2008. In 2005, the estimated turnover of the industry was US \$150 million (TERI 2006). Some research and development effort continues to go into thin-film modules. India's competitive advantage lies in low-cost manufacturing for small (< 70 Wp) modules (Srinivasan 2005).

In 2007, India produced 1.4 per cent of the worldwide solar cell output with efficiencies from 12 to 16 per cent. Cell and module production in India increased significantly over the past years.<sup>73</sup> India is the second largest producer of solar cells and modules in the developing world after China (see graphs appendix F).<sup>74</sup>

<sup>73</sup> China produced 50, 150 and approx. 380 MW of cells in 2004, 2005 and 2006 respectively (Hirshmann, Hering, and Schmela 2007; Schmela 2005, 2006).

<sup>74</sup> China produced approx. 90 MW of modules in 2004 and approx. 270 MW in 2005.



**Figure 3: Annual manufacturing of modules and cells**

Source: Sastry 1997, Bhargava 2001, Tripathi 2007

Solar cell production has grown at an average rate of 28 per cent *per annum* and module production 30 per cent from 1996 and 2005 (TERI 2006) (see also figure 2). The Indian PV industry has significant excess production capacity at its disposal despite the growing production volumes (Table 8).

**Table 8: Installed production capacity and annual production for solar cells and modules**

Year	Solar Cells		PV Modules	
	Capty.	Prod.	Capty.	Prod.
2004-05	40	32	75	45
2005-06	53	37	103	65
2006-07	130	43	225	80

Source: (Tripathi 2007)

In 2007, one major company (Tata BP) dominated cell and module production by covering over 40 per cent of each market (TERI 2006, interviews). This is very likely to change since all cell and module manufacturers interviewed plan to increase their production capacities. Some module manufacturers are considering cell production. Furthermore, the US manufacturing company Signet Solar announced that it will establish a module manufacturing plant in India with a capacity of 60 MW per year in 2007. When the research period for this dissertation ended, it was unclear to what extent these announcements would be realised.

### **Export**

The industry is strongly export-driven. In 2005, the cumulative PV production (domestic and export) was 248.8 MW. Aggregate installed capacity in India was roughly 89 MW in various PV applications. 160 MW went into export (TERI 2006). The annual export share has grown

from 15 per cent in 1999 and 28 per cent in 2000, to more than 65 per cent in 2005 (Sharma 2000, TERI 2001, TERI 2006).

Manufacturers export modules to neighbouring countries as well as to Africa, the USA, Europe, and Japan (TERI 2005). The government supports the export market by duty exemption on imported material destined for re-export and subsidized loans on working capital facilities etc. (Srinivasan 2007). No solar cells are exported, as almost all cell manufacturers use their cells for module production. Only one Indian cell manufacturer sells cells to other Indian module manufacturers. India is the largest manufacturer of solar home systems (Liming 2008).

### ***Government Policy***

The Indian government currently supports the Indian PV industry with the following industrial policy measures: no licence requirement for PV production, 100 per cent foreign direct investment allowed, no or low custom and excise duties on materials and intermediary goods, tax holidays for manufacturing in specified areas, soft loans for manufacturing investments, 50 per cent grants for R&D activities (Tripathi 2007).

## **6.1.2 Technology access and sources of innovation**

### ***Technological capabilities***

All six cell manufactures stated that they could repair, adapt, and improve the production technology they acquired. Two had actually built their whole production technology by themselves. All companies mentioned the possibilities of incremental innovation, like an increase in the efficiency of cells from 12 to 14 per cent or a decrease in the thickness of cells.

Three manufacturers produce cells with 16 per cent efficiency. Two of them are parts of larger industrial groups. The third operates independently. All of them had to import production equipment to reach 16 per cent. One manufacturer achieves a maximum efficiency of 15.4 per cent. According to the company representative, some parts were imported. A fifth manufacturer stated that it would have to buy new production technology if it wanted to increase cell efficiency from 14 to 16 per cent. The sixth manufacturer did not comment on achieving higher efficiencies. Two of the manufacturers who were unable to produce cells of 16 per cent efficiency stated that, although an increase was easily possible through acquisition of production technology, it was not interesting from a commercial point of view as their business goals were achieved with current equipment.

The interviewed companies framed “breakthrough technology” differently, either as the producing of thin-film cells or as the achieving of efficiencies of 20 per cent and higher. Two framed breakthroughs in terms of thin-film cells or nanotechnologies. They also stated they could easily achieve breakthrough innovation through their own technological capabilities. One

of the two said they actually owned a thin-film PV cell plant but were not operating it because it did not fit their current business model. The other stated they were actively involved in international research regarding thin-film and nanotechnology cells, and expressed no doubt that they had realistic chances of matching their capabilities with competitors in Europe, Japan, and the US.

The remaining four companies framed breakthrough technology in terms of achieving efficiency levels of 20 per cent and higher. One of the four companies stated it could also achieve 20 per cent partly through their own capacities and partly through imports. If critical parts could not be imported, the interviewee was confident that the company could develop viable alternatives in the long run.

Two of them stated that they had to purchase the relevant production technology because they could not build it themselves. One of the manufacturers stated that breakthrough R&D was the responsibility of the government and the company had no plans to undertake efforts in that direction.

All six module manufactures stated they could adapt and incrementally improve their production technology. Some had built at least parts of their production technology themselves. Breakthrough technology as such does not exist in PV production. Two companies stated that they will introduce automatic production lines.

### ***Sources of innovation***

Five of the six **cell manufacturers** mentioned their in-house capacity as the most important source of innovation. The sixth named international production and international cooperation as the most important source, although in-house capacity was also considered important. Three of the six cell manufactured operated their own R&D units, and one operated an R&D plant. One of the three even operated R&D facilities in Europe. The two remaining cell manufacturers stated they were undertaking R&D “on the job.”

International research linkages were mentioned as another important source of innovation. Two of the manufacturers cooperated with R&D institutions in Europe. One of those two stated the company was able to modernise production beyond incremental innovation with the help of a Dutch laboratory. One cell manufacturer had research co-operations in Europe, the USA, and Japan. Only two mentioned international R&D cooperation with other companies as sources of innovation. One manufacturer had acquired companies in Europe specifically to undertake research, and one manufacturer stated that it benefited from the expertise of the international company group it was part of.

All cell manufacturers had acquired international certifications for their products, but only one of them mentioned them as a source of innovation through learning from the institution giving

out the certification. For the others, acquiring certifications was a reason to innovate through other sources in order to be granted certification. Only one cell manufacturer mentioned that their production technology supplier supported innovation.

Three manufacturers stated that they had links to Indian R&D institutions, but only one stated they were beneficial to its company. Generally, it seemed that Indian R&D did not play a crucial role in innovation, although only one cell manufacturer stated explicitly that there was not enough R&D support through the Indian government.

Five of the seven **module manufacturers** named their in-house capacity as the most important source of innovation. Three had fixed supplier links with cell manufacturers in either Europe or the USA, and all three stated this partnership helped to increase product quality. One of the three considered supplier links to be the most important sources of innovation. Two company representatives mentioned that international certifications needed for export were an important source of innovation. None of the module manufacturers maintained any form of R&D facility or links.

### ***Importance of technology transfer***

When asked about the importance of technology transfer, all interviewees referred exclusively to the acquisition of production technology. Most cell manufacturers also mentioned research links abroad as important technology sources. These links, as well as any possible access restrictions, need to be taken into account when considering the importance of technology transfer. It is likewise important that companies framed the importance of technology transfer and the severity of access restrictions in relation to their business goals. They did not necessarily frame it as, for example, policy makers do: in relation to how much of the totality of PV knowledge could be accessed and absorbed.

Only one of the **cell manufacturers** stated that technology transfer had no importance for its business activity. The company considered itself as technologically independent, since the company had built all cell and module production technology themselves.<sup>75</sup> The manufacturer, a public company, also owned an early production plant for thin-film cells, which was not operating because the Indian government had neglected it. Since thin-film cells were not considered to be conducive to the existing business model, the lack of operation of the thin-film plant was considered unproblematic. Although the thin-film plant technology was outdated, the interviewee expressed certainty that up-to-date thin-film technology could be accessed if needed. At the same time, the manufacturer admitted that for the modernisation of its production technology, it had needed the support of a Dutch research laboratory.

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<sup>75</sup> However, early production equipment was imported from the USA and Japan in 1988 (DNES 1989).

A second cell manufacturer stated that the importance of technology transfer was relative as it depended on the commercial goals of the company. Importing technology and access to research from abroad was only one way of achieving the goal if similar technology was not available in India. If a technology was not available, the interviewee expressed certainty that the company would find a way to achieve its goals without it. The company had built its cell production almost entirely themselves and only imported “a number of critical parts” as they were of better quality in Europe. The production of cells of higher efficiency was possible, but did not fit the company’s current business model.

The remaining four companies stated that technology transfer was very important because all or most of their production technology was imported, the latest technology was developed abroad, and no Indian manufacturer of cell production technology existed.

One of the four actually had acquired companies in the USA and Europe to access knowledge on thin-film technology, and to undertake research on nanotechnology cells. It had also hired experienced research staff from the USA, and bought a research cell plant in Europe to lower the cost of silicon production. If successful, the company would consider internalising the production in India. All these activities were undertaken with an eye to narrow the perceived gap in technological capacities between the company’s Indian staff and employees of the companies within technologically more advanced countries.

The second of the four manufacturers stated that technology transfer was indeed important as the company had acquired their production technology through a no longer existing joint venture with an Italian cell manufacturer. In addition, the company stated that it had to buy new production technology abroad if cell efficiency should rise to 16 per cent. Access to that particular technology was perceived as unproblematic, but technology to achieve 20 per cent efficiency was not available on the market. The company had also R&D links to Europe it considered to be important. Their links to European R&D institutions, though, were perceived as of lower quality than the links European cell manufacturers maintained.

The third manufacturer considered technology transfer as crucial since much of their production technology was imported. However, this importance was contextualised insofar as the company could rely on the expertise of two international companies of which it was a joint venture.

The fourth of the companies stated that technology transfer was important because all production technology, including that for wafer slicing, was imported. However, the company also expressed that there were no restrictions to technology acquisition, and even thin-film technology would be available. The only limitation expressed was that the company was in a position to incrementally change acquired technology, but lacked the capabilities to use it to achieve breakthrough innovation.

In general, interviewees stated that the technology transfer was not considered problematic, as restrictions on access were hardly felt and did not contradict the employed business models. It was acknowledged by smaller manufacturers that being dependent on technology imports meant in some cases waiting until a technology was on the market; yet at the same time this was unproblematic because if demand was high enough they would not necessarily have to sell the latest cell technology. That production technology available on the market could be used to increase competitiveness was ensured to in-house adaptation of the technology.

The **module manufacturers** also considered technology transfer to be important, since most were importing at least parts of their production equipment. Only one got its production technology completely on the Indian market. Furthermore, Indian production technology was not necessarily considered as inferior. One stated that technology import would actually save time and money as importing represented the latest technology. Another company framed the relationship between supplier and the company he represented in the opposite manner. Technology suppliers had developed the basics, which had to be adapted to become state of the art. One module manufacturer stated that his company had recently acquired two parts of a certain production technology only to test the difference in equipment.

Two module manufacturers said that technology transfer would become important once they started cell and wafer manufacturing. Two stated that technology imports would gain in importance if they would start introducing automatic module manufacturing lines as no Indian supplier existed.

Despite the assigned importance of technology imports, all module manufacturers did not see it as problematic due to unrestricted access and their capability of adapting it to their needs and thereby improving it.

### ***Restrictions to innovation and technology access abroad***

Five of the six **cell manufacturers** expressed that they did not feel any constraints regarding access to technology. According to their statements, they could either purchase the technology necessary or build it themselves.

The only cell manufacturer expressing constraints stated there might be a problem in obtaining the latest technology from the technologically more advanced companies in the West.

Technologically-advanced companies able to produce cells with 22 per cent efficiency would not sell this technology at this point in time. Furthermore, if the company wanted to introduce wafer slicing it could not acquire the latest technology (so-called ribbon slicing) as companies would not sell it. The same company also stated that their R&D links to European research institutions were, in practice, not as good as the links established between European companies

and the same institutes. European companies would be favoured insofar as they had access to the latest knowledge.

Some companies expressed other constraints. Four mentioned the lack of finance as a main constraint to accessing technology although it remained unclear whether there was a lack of specific finance (as in “there was no finance offered for these purposes”) or whether it was just meant in a general way (as in “there is never enough money as you need”). One company stated that the only severe constraint to their business operation was the price of a cell, which represents 80 per cent cost of the raw material. The only way to bring these costs down was to localise the production of PV-grade silicon.

Four cell manufacturers stated that they could undertake only incremental, but not breakthrough innovation for upgrading silicon cell efficiency to 18 or 22 per cent. However, three did not consider the lack of capabilities regarding breakthrough innovation as a constraint to their ongoing business operations. They were certain that they could either buy the necessary technology in the future, or receive it through the international branches of their company. One interviewee stated that even if a technology was not directly available, its company was skilled enough to work around this problem and achieve its goals without it.

One company stated that, despite not having access constraints, companies in Europe, the US, and Japan were in a much better position regarding access to R&D institutions. However, the representative was optimistic that these disadvantages could be counter-balanced by the technological capabilities of the company. There was, e.g., no calibration laboratory in India. Indian companies had, however, worked around this problem by finding ways to calibrate production machines in-house.

All **module manufacturers** stated they did not feel any constraints in innovation. All who were planning to add cell manufacturing to their business stated that they saw no problem in acquiring the technology compatible with their business model. All but one stated they would not have any problem in accessing the technology, provided they had sufficient finance. One company considering the future manufacturing of cells stated it might be possible that access to thin-film cell production technology could be restricted. The company, however, expressed certainty that with the future growth of the Indian market, the latest technology would be introduced to Indian companies.

### ***Summary***

All PV manufacturers have operational capabilities to produce PV systems but limited innovative capabilities to improve them. Innovative capabilities are sufficient for minor improvements in production technology. PV cell manufacturers have insufficient innovative capabilities to innovate towards the latest technology. Only one company intended to build such capabilities, a company which is aspiring to acquire and integrate state-of-the-art production technology. With regard to technology access, most companies felt no access restrictions.

## **6.2 Markets for PV applications in India**

In 2001, about 745 million Indians (72.2 per cent of the Indian population) lived in rural areas (Indian Census 2001). It is estimated that 70 to 80 million households still depend on kerosene for lighting purposes, of which 92 per cent are located in rural areas (Srivastava and Rehman 2006; Bhattacharya and Dey 2006). The introduction of solar home systems in non-electrified rural areas displaces the use of kerosene lamps (as well as other hydrocarbon lightning systems, but kerosene is assumed to be the most common) as well as charging lead-acid batteries from a grid connection or a diesel or gasoline generator.<sup>76</sup> As the largest impact is usually expected to derive from kerosene displacement, GEF projects usually quantify CO<sub>2</sub> emission reductions through an estimate of the displacement of average monthly kerosene consumption per household. For Zimbabwe, the GEF assumes that one installed SHS will displace 2.8 litres of kerosene per month, for Indonesia the figure is 16.4 litres (Kaufman et al. 2002). The reason behind this difference is that rural households with higher incomes burn more kerosene than their poorer counterparts. It is generally assumed that higher income households switch earlier to SHS than poorer households. The actual percentage varies depending on the size of the system, disposable income and household energy usage patterns. According to empirical studies, displacement of kerosene by SHS ranges from 100 to 65 per cent within households (TERI 1998; Kaufman et al. 2002). The burning of one litre of kerosene results in the emission of 2.45 kg CO<sub>2</sub>. In other words, not burning one litre of kerosene avoids 0.00245 tons of CO<sub>2</sub> emissions (Kaufman et al. 2002; TERI 1998). If each household in India operates one kerosene lamp the weekly consumption averages according to estimations carried out by TERI 0.435 l per week and 22.66 l per year. This to an overall Indian consumption of 1880.2 million l per year (Pal et al. 2004). Complete substitution would lead to a CO<sub>2</sub> emission reduction of around 4.6 million tonnes of CO<sub>2</sub> annually.

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<sup>76</sup> As the emission reductions through SHS and other small scale rural PV applications is very small compared to the substitution potential of other emission sources, some others suggest that SHS should not be seen as a means to reduce emissions but rather that financial mitigation mechanisms like the CDM should be used to reduce emissions from other sources (Duke and Kammen 2003).



The relevant literature frames the market for PV applications according either to geographic or to public-private features. Geographically, one can differentiate a rural, semi-urban, and an urban market. The customers within the rural market differ significantly regarding electricity needs, preferences, and income from urban markets (Chaurey et al. 2004). With respect to public-private features, the Indian market can be divided into a subsidy market and a private market (TERI 2006). Each market segment is characterised by a different policy environment, actors, and technology supply and demand.

### **6.2.1 The private market**

The private market denotes the market outside the government subsidy program. It consists of two different market segments: the individual or household market and the community market (TERI 2006). The household market comprises small applications like solar lanterns, solar home systems, and power packs etc., purchased by private consumers without a direct government subsidy in rural, semi-urban, and urban areas. This market segment is considered small but growing.

The community market comprises village-level power plants or other community owned infrastructure (water pumps, street lights and vegetable storage halls) powered through solar PV. This market segment has grown more important only recently as community-level PV applications which were traditionally provided through the government subsidy schemes are no longer being provided.

The overall growth rate of the private market is estimated to be currently nine per cent per year. From 1998 to 2002, the accumulated installed capacity grew from approx. 5 MW to 7 MW (TERI 2006). Figures on the different segments of the private market are not publicly available. It is unclear from existing market research whether the growth of the private market takes place in urban, semi-urban or rural areas. Results from my research interviews indicate that growth in the private market takes place almost exclusively in urban areas. Furthermore, the private market seems to evolve geographically unevenly. Private sales of small PV systems tend to be concentrated in the south-west, in and around the state of Karnataka and neighbouring states, while sales in other states depend more strongly on government programs (Srinivasan 2005). Detailed information on the private market (e.g. a breakdown on the Indian states) is not publicly available. The Indian government supports sales to the private market by financially supporting so-called Ayudita solar shops. Companies or NGOs aiming to set up a solar shop receive grants and subsidised loans during the first two years of operation. Solar shops are, however, not allowed to sell subsidised systems.

The PVMTI project theoretically targets the private market insofar as it was designed to operate independently of (while not necessarily replacing) the Indian government program. The size of

the private market is delimited by a number of factors. Firstly, households need to be willing to buy PV systems and have the spending power to do so. Secondly, the government operates various schemes to electrify villages through conventional grid connections and different renewable energy electrification programs (including the Solar Photovoltaic Programme). According to a number of experts, these programs are not coordinated with each other, are based on unreliable planning and suffer implementation problems. It is therefore virtually impossible to estimate the potential size of the market for small-scale PV applications on the basis of the literature since no estimations are available concerning which part of the rural population will be electrified through grid connections or other renewable energy sources.

All companies agreed that the Indian government program for off-grid rural electrification is the factor predominantly responsible for the diffusion of PV in India. Demand for unsubsidised systems existed before, but was considered small. Only one company mentioned that private sales were increasing due to the unreliable power supply through the public electricity grid. One interviewee stated that in recent years, solar PV applications to power wireless IT (solar kiosks) equipment had diffused to rural areas without any government support. However, these seemed to be niche applications.

### **6.2.2 The Government-supported market**

The government market is currently constituted through the Solar Photovoltaic Program (SPP).<sup>77</sup> In the following, I will discuss aspects concerning its diffusion. The program supports the diffusion of solar powered water pumps, solar street lighting, solar home systems (SHS) and small off-grid power stations. Since the most successful applications sold under PVMTI are SHS, the following discussion will focus on SHS. Only very few publications are concerned with the SPP. According to a former high-ranking official of the MNES, a comprehensive government review of its achievements does not exist. A number of texts written by representatives of the Indian energy administration introduce the SPP (Sastry 1997, Bahrgava 2001). Later summaries of the SPP are found in reports from TERI, The Energy and Resources Institute (TERI 2001, 2004, 2006).

The main limitation of my review is that there is no reliable data about the programs beyond the number of installed systems, and probably even those are imprecise.<sup>78</sup> It also has to be emphasised that the following discussion cannot do full justice to the SPP considering its long

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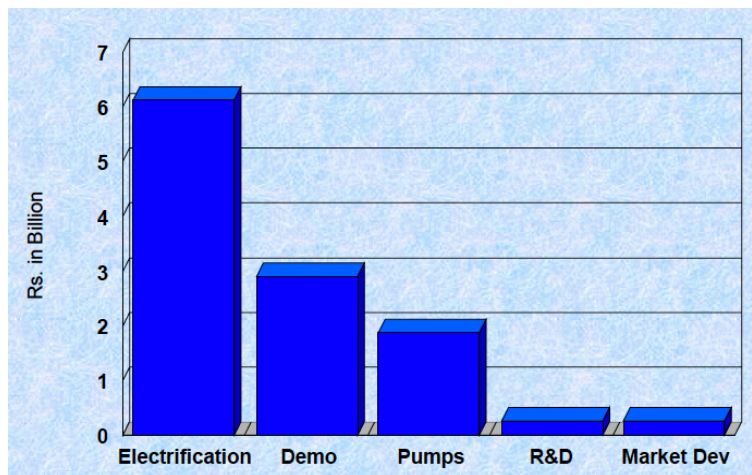
<sup>77</sup> During the late 1980s, the Indian government created additional demand as various government ministries and agencies procured PV technology for communication applications but these procurements stopped in the early 1990s. The main goals of the SPP are development of a PV industry and rural electrification through diffusion of off-grid PV applications (Gosh et al. 2002).

<sup>78</sup> Interviewees made conflicting claims about the existence of a reliable internal evaluation of the programme carried out by the MNES. If it exists, it is certainly not public. External evaluations do not exist. Two experts also questioned the reliability of the figures of installed systems published officially by the MNES.

history, its evolution over time, and the numerous different contexts of its applications resulting from the size and the variability of Indian state, regional and local circumstances. Although the program started in the early 1970s, official government publications were only available from 1984 onwards in the form of the annual reports of the Ministry of New and Renewable Energy. Reports were not available for all those previous years. However, this discussion is sufficiently detailed for the purposes of this thesis, as the aim is a broad comparison of significantly detailed approaches.

Under the SPP, the federal government assigns budgets for rural PV electrification to the state renewable energy agencies. The state renewable energy agencies draw up regional programs through which SHS are diffused. Within these programs implemented by the state agencies' field offices, an end-consumer may buy subsidised SHS. The underlying rationale is that the average rural dweller is not in the position to afford PV applications without financial help by the government. The subsidy is a direct subsidy, which means that the price for SHS is reduced at the amount of the subsidy (for the changing amount of the subsidy, see appendix D). Within these programs, SHS are procured by the state agency through tenders. In some Indian states private companies are allowed to sell SHS to end-users and then reclaim the subsidy from the state agency (Sastry 1997, Sharma 2000, TERI 2003, interviews). As figure 4 shows, Indian government spent six billion rupees on rural electrification with PV technology. This sum equals approximately US \$150 million at 2007 prices.

**Figure 4: Indian government spending on PV technology 2002 to 2007**



Source: (Barua 2007)

From the perspective of all PV manufacturers interviewed, the government subsidies were needed to successfully sell on the Indian market. The reason for the importance of the government program was entirely linked to the cost associated with generating energy from PV. Solar PV applications were considered to be far too expensive to be sold without subsidy. Only

one interviewee mentioned donor-supported micro-finance programs as a driver for the diffusion of PV systems. All interviewed companies except for one considered the Indian market as important to their business activities and considered it to have great potential. However, as a new government policy that would significantly increase the market (for off-grid as well as grid-connected PV applications) was not expected in the near future, any planned investments in production were taken with hindsight for export. All producers said that there was no difference in the technology produced for the Indian and the export market other than packaging and module size. Therefore, the switch from service to the domestic market to the world market is relatively easy, at least from the manufacturing side.

#### **6.2.2.1 Achievements regarding diffusion**

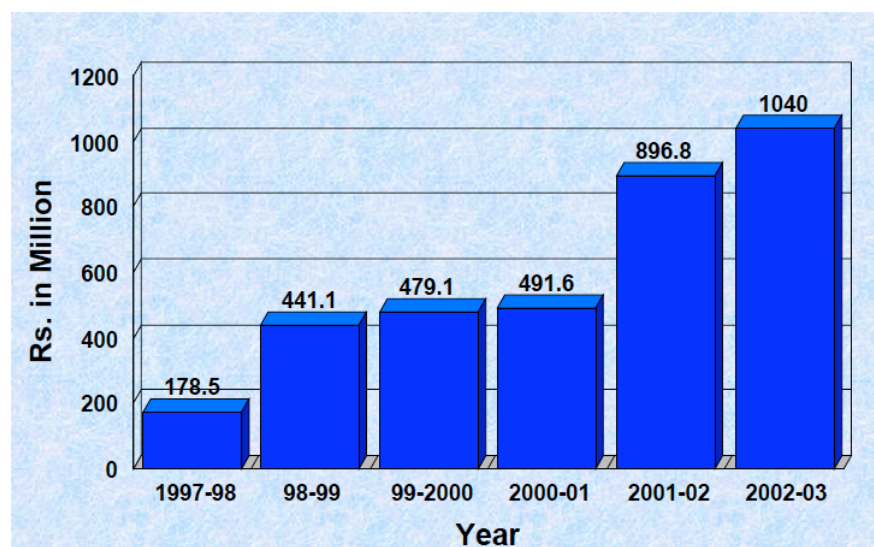
According to the Ministry of Renewable Energy, a total of 450,000 SHS were installed by July 2009. Indian PV experts interviewed doubt the government figures because the claim that no reliable accounting procedure exists. The numbers of annual installed SHS from 1986 to 2006 represented in Table 9. As figure 5 shows, government spending on PV technology has increased significantly from 1997 to 2003.

**Table 9: Number of installed SHS within the SPP per year**

<b>Year</b>	<b>1986</b>	<b>1987</b>	<b>1988</b>	<b>1989</b>	<b>1990</b>	<b>1991</b>	<b>1992</b>	<b>1993</b>	<b>1994</b>	<b>1995</b>	<b>1996</b>
<b>SHS</b>	40	200	505	531	94	n.a.	290	4376	n.a.	n.a.	12720

<b>Year</b>	<b>1997</b>	<b>1998</b>	<b>1999</b>	<b>2000</b>	<b>2001</b>	<b>2002</b>	<b>2003</b>	<b>2004</b>	<b>2005</b>	<b>2006</b>	<b>2007</b>
<b>SHS</b>	11865	15206	14923	20437	24,782	n.a.	58239	16530	n.a.	60000	n.a.

Source: Author based on (MNRE 2005; MNES 1999; MNES 1994; DNES 1985, 1986, 1989, 1990, 1992; MNES 1993, 1998, 2001, 2002; MNES 2003; MNES 2004; MNRE 2006)

**Figure 5: Indian government spending on photovoltaic technology**

Source: (Barua 2007)

### ***Regional Achievements***

To better contextualise the results of the PVMTI subprojects, the number of installed solar home systems in all states where PVMTI subprojects are active were collected. Likewise, interviews with the heads of the respective state renewable energy agencies were conducted. These turned out to be of limited value because the interviewees were not willing to critically discuss achievements and tended to see the results in a purely positive light underlining their own role in the process.

### ***Andrah Pradesh***

The Non-Conventional Energy Development Corporation of Andrah Pradesh (NEDCAP) is in charge of implementing the central government renewable energy programs. It was impossible to gain any information on the solar PV program beyond obtaining the installation numbers, as the NEDCAP has no official website and does not make available an annual report (or similar publication). NEDCAP staff also declined to be interviewed. The state of Andrah Pradesh is the state in which the PVMTI funded company B is operating (see section 6.3.4 and appendix G).

**Table 10: Achievement in the State of Andrah Pradesh**

	Cumulative till 2002	2003		2004		2005		2006		2007		TOTAL	
<b>No. SHS</b>	1,016		200		280		-		34		99		1629

Source: NEDCAP T= Target, A= Achieved

Andrah Pradesh has around 80 million inhabitants of whom 72 per cent live in rural areas. According to TERI, 5.1 million rural households (40.5 per cent) were not electrified in 2006

(Barua 2007). The government's definition of an electrified village is if at least one line of energy from the national grid is connected to the village, regardless of how many village households are connected to that line (Nouni, Mullick, and Kandpal 2008). No figures are available on how much villages were electrified by the time PVMTI was started in India (1997). Considering the bare figures, the government program achievements in absolute number as very low (see table 10).

### ***West Bengal***

The West Bengal Renewable Energy Development Agency (WEBREDA), founded in 1993, is responsible for implementing the Indian government renewable energy policy. As a number of Indian PV experts pointed out, WEBREDA is one of the most successful state renewable energy agencies with regard to PV diffusion. The most important reason for the success of WBREDA mentioned was the determination and enthusiasm of the head of the agency. He was, according to interviewees, an enthusiastic supporter of PV technology, which was reflected in the effort of the state agency to implement rural PV electrification programs. In addition, he encouraged private PV business sales and was one of the first heads of the state renewable energy agencies who permitted private companies to sell PV systems directly to end-users and reclaim the subsidy from the government.

**Table 11: Achievement in the state of State of West Bengal**

	<b>1999</b>	<b>2000</b>	<b>2001</b>	<b>2002</b>	<b>2003</b>	<b>2004</b>	<b>2005</b>	<b>2006</b>	<b>Total</b>
<b>SHS</b>	2000	2008	n.a.	n.a.	n.a.	7809	23501	6247	63850

Source: WEBREDA

West Bengal had a population of almost 39 million in 2001. In 2006, 8.9 million households (79.7 per cent) were not electrified (TERI 2007). The absolute number of systems is increasing over time with an extraordinary peak in 2005, for which no explanation could be obtained. West Bengal is the state in which the PVMTI-funded company A is operating. The PV program in West Bengal is one of the most successful in India regarding absolute numbers of installations (see table 11).

### ***Karnataka***

Karnataka Renewable Energy Limited (KREDL) is responsible for implementing the Indian government renewable energy policy in the state of Karnataka. According to the director of KREDL, the sharp increase in installations in 2002 is a result of increased efforts and attention to the SPV which previously had been neglected in favour of other renewable energy technologies.

**Table 12: Achievement in the state of State of Karnataka**

	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	Total
<b>SHS</b>	23	1	98	596	687	2615	2786	5732	No Pr.	2000	8500	23038

Source: KREDL

Karnataka had a population of nearly 58 million 2008. In 2006, 1.9 million households (27.8 per cent) were not electrified (TERI 2007). The state of Karnataka is the state in which the PVMTI-funded companies C and D are operating (see section 6.3.4 and appendix G). In terms of absolute numbers, the government program has improved significantly over the years (see table 12).

### ***Effects of government programs on the development of the private market***

Interviewees mentioned several effects of the government program on the private market and therefore indirectly on the performance of PVMTI. Some interviewees pointed out that the SPP had paved the way for private sales because it helped to spread the knowledge about PV systems and, especially after the inclusion of private actors, supported the reputation of SHS as a proven technology. One interviewee stated that the SPP supported the private markets mainly through its inefficiencies. According to his explanation, obtaining a SHS under the SPP depended in a number of states purely on social power and informal relations to the administration in charge of field implementation. Those lacking both had no choice but to buy a system on the private market.

On the other hand, it was seen as direct competition to private initiatives as it offered better financial terms through the subsidy. Two representatives from PVMTI companies stated their companies' commercial success was partly impaired by end-consumers willing to wait for government subsidies rather than buying directly from them. This claim is supported by an official in-depth review of a previous World Bank renewable energy project stating that the biggest "drawback was the competition between the immediate 50 per cent MNES subsidy on solar home systems and PVMTI's credit and leasing scheme" (World Bank 2003).

### **6.2.2.2 Strengths and weaknesses of the SPP**

All interviewees from the industry agreed that the SPP was still the most important factor for the diffusion of PV applications in India. Furthermore, there was complete agreement that, from the business perspective, a subsidy was needed to ensure profitability in rural areas.

Unsubsidised demand was picking up significantly in urban areas only. In addition, five interviewees pointed out that the government program had brought considerable awareness about PV technology to rural areas and, in doing so, created demand which was partly paving

the way for additional unsubsidised purchase of systems. The government representatives also shared this view.

However, the manufacturers mentioned severe limitations of SPP. Three pointed out that state agencies were unreliable in paying for delivered systems. Three stated that the budget of the program was too small regarding the potential number of systems that could be sold. Three were critical of the subsidy approach. In their perspective, it created no sense of ownership as people did not pay with their own money. A system based on soft loans would be more effective because end-users would treat systems better if they had to pay for them completely. Three interviewees stated that program officials were corrupt and would assign contracts on the basis of bribes. Two interviewees also stated that program officials would misappropriate money. Another one said that his company had turned to a 100 per cent export-oriented unit because of the payment issue. Two interviewees stated that the program was inefficient. One interviewee mentioned that large parts of the annual government budget were not used, as the state agencies were not making sufficient efforts to develop and implement subsidised PV schemes.

The only two interviewees from the PV industry who did not criticize the government program were two representatives of state companies. In their opinion, the program was running well and had created a good reputation for PV technology. Likewise, the active ministry official was highly favourable of the program and stated that all initial problems like the lack of after-sales services and coordination between different government agencies were solved. Its only constraint was, in his view, the size of the budget. The heads of the state renewable energy agencies gave similarly positive evaluations.

The heads of the state agencies nevertheless had different views on the subsidy system. One was critical of the subsidy approach as he saw the problem of subsidy dependence.<sup>79</sup> He welcomed the entry of private players, as that would open the possibility of decreased prices. The other head of the state agency stated the people had a right to a PV subsidy, as kerosene was equally subsidised.

The former officials of the Ministry were more critical of the government program. One stated that there were severe shortcomings in the local implementation of PV projects, as authorities would implement projects in some states inefficiently and sell systems “to selected beneficiaries rather than to the common man.” Every year, large sums were left unspent and returned to the government budget. Institutional inefficiencies were among the main reason for the existence of a private market as some rural people had no means to exert pressure on local government officials to sell them systems. Furthermore, one retired official was very open about the

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<sup>79</sup> Subsidy dependence means that PV systems will not get cheaper as their consumption is subsidised and industry has no incentives to increase sales through lowering prices.



inclusion of private actors into the SPP from the beginning of the 1990s onwards. In his view, the Indian government had realised that the diffusion/rural electrification part was “a complete disaster” because the administration was not able to implement PV programs effectively. As a consequence, the government had decided to allow private business participation. The other retired government official pointed out that part of the problem was that the government had never understood “village life” and user needs.

Interviewees also noted that the absolute size of the existing government program would be very small compared to the overall size of demand for subsidised systems. Secondly, the government programs were considered inefficient in implementation as parts of the annual budget to support PV were not spent. Another weakness mentioned was the applied tendering system which favoured the lowest bids and therefore prohibited any innovation in PV systems while supporting low-quality systems.

### **6.2.3 Conclusions: Markets**

This short review indicates that the driving force for rural diffusion of SHS has been, and currently is, the SPP. This is reflected in the growing number of installed SHS systems over time. The results for the three states indicate that the implementation at the state level plays a significant role. More detailed analysis within this context is not possible. Interviews indicate that the government subsidy is the most important element in the SPP, especially as private companies stated that no sales in rural areas were possible without it. The subsidised market is also, in the view of all industry representatives, by far the largest in India.<sup>80</sup> They also pointed out that SPP had created an awareness among the Indian population that now serves as a basis for the slowly growing unsubsidised sales in semi-urban and urban areas.

Interviews also revealed that a number of weaknesses of the program still continue to exist. Implementation depended strongly on the state agencies, which are still, to various degrees, not able to spend the whole dedicated budget. The whole subsidy regime is still not transparent or coherent, and lacks effective marketing. Furthermore, the retired government officials stated quite openly that corruption and misappropriation of the money were common among officials in charge of the SPP. The private market was, in their perspective, not a result of awareness created by the SPP, but rather of its ineffectiveness and corrupt rules which left no choice to some end-users but to buy a system without subsidy.

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<sup>80</sup> Chaurey et al. report from a case study on remote villages in the state of Rajasthan that the state program suffered from a lack of funds, and sent out unclear signals to consumers concerning the future rates of subsidies. Additionally, despite the subsidy, the poorest parts of the rural population were not able to afford SHS (Chaurey, Ranganathan, and Mohanty 2004).

## 6.3 PVMTI project

### 6.3.1 The PVMTI – goals and project design

The main goal of PVMTI is to “stimulate PV business activity in selected countries and to demonstrate that quasi-commercial financing can accelerate its sustainable commercialization and financial viability in the developing world” (IFC 1998: 5). A further goal is the replication of such business activity by other investors without receiving PVMTI funding (IFC 1998: 15).

To achieve both goals, PVMTI lowers the cost and risk for private businesses to develop necessary market infrastructure as a basis for increased sales through subsidised finance in the form of equity, soft-loans, and bank default guarantees. Offered finance should be used as working capital for the development of sales and distribution systems or to subsidise downstream, end-user finance. It was further hoped the subprojects would be commercially viable by the end of the project period and in the position to repay parts of the IFC/GEF capital.

Companies receiving PVMTI finance will herein be referred to as PVMTI subprojects or investee companies. PVMTI addresses GEF Operational Program #6: “Promoting the Adoption of Renewable Energy by Removing Barriers and Reducing Implementation Cost” as listed in the chapter on the GEF section 5.1.

The project document assumes that 66 MW<sup>81</sup> of PV applications will be installed over the ten years’ lifetime of the project (between 1998 and 2008) in India, Kenya and Morocco as a minimum. This would be roughly the equivalent of 1,350,000 50W systems (IFC 1998:15).

Calculating CO<sub>2</sub> emission reduction, IFC assumes that a 50W system in theory could substitute the equivalent of 1.83 tons of carbon (C) (the project document does not mention over which period of time) by replacing kerosene use and diesel-based battery charging. In practice, it assumes that only half of the savings will be achieved as consumers will use PV applications partly in addition to other energy sources, and partly in order to replace kerosene. Based on the assumptions made, the IFC further assumes that total avoided carbon emissions would be 1,207,800 tonnes C.<sup>82</sup> This aggregate figure for expected environmental benefits was not broken down for India, Kenya, and Morocco.

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<sup>81</sup> The document does not reveal how this figure is calculated.

<sup>82</sup> Although the calculation of (1,350,000 x 1.83): 2 results in 1,235,250 tons of carbon.

### 6.3.1.1 Specific project impacts for India

US \$15 million (representing 50 per cent of the overall PVMTI budget) funding (including technical assistance and cost for project execution) were allocated to PVMTI India. The IFC expected that 11 subprojects (four of them with a low probability) would receive funding in response to the PVMTI request for proposals. The number of possible investments was actually expected to exceed PVMTI funds (IFC 1998). IFC further expected that PVMTI-funded projects (plus those companies imitating PVMTI-funded business models) would install a total of 10MW PV generation capacity from 1998 to 2003 in addition to all other Indian PV installations (see Table 13).

**Table 13: Expected project outcomes in India**

Current Annual Sales (MW)	Sales Expected in 2003 without PVMTI (MW)	Sales Expected in 2003 with PVMTI (MW)	% Increase with PVMTI	PVMTI Investment	Expected Minimum Leverage	Co-financing Likely Over Life of Project (US \$ million)	Total Investment in PVMTI Projects (US \$ million)
11.0	18.0	28.0	55%	15	3:1	45-60	60-75

Source: IFC 1998

The expectations related to PVMTI India were based on market research carried out by IT Power and IMPAX in 1997 (Derrick 1998). According to IT power India, performance goals were agreed to for each investment as part of the contractual arrangements between the subproject and the IFC. These differed from subproject to subproject and included a number of established sales outlets, co-financing, and system sales. Individual performance goals were declared confidential by IT Power. While no effects on the direct cost of PV were expected,<sup>83</sup> PVMTI is thought to “indirectly encourage additional investment in manufacturing” (ICF 1998: 16).

The ruling out of any PVMTI investment in PV production was, as one interviewee explained, a reaction of the perceived lack of commercial finance for activities at the lower end of the PV value chain by the IFC. Finance for the investment in production technology was, according to the IFC argument, sufficiently available by the time of the project development.

<sup>83</sup> The project document states explicitly that the barrier of high technology cost is not addressed through PVMTI, although “a background paper for PVMTI refers to a progress ratio of 0.80 for PV in order to project business-as-usual (BAU) scenario price trends (World Bank 1996) based on an experience curve approach” (Duke and Kammen 1999).

### **6.3.1.2 Technology transfer and environmental benefits**

International technology transfer is not a goal of the PVMTI. However, as it follows the logic of the GEF market transformation approach (in which technology transfer might take place not because it is directly supported but as an indirect result from the project success), it is valid to evaluate PVMTI with regard to its achievements in technology transfer.

The project document envisions “global environmental benefits” in the form of the reduction of carbon emissions by substituting kerosene-based lighting with PV technology. In the PVMTI rationale, any environmental benefit is strictly seen as a result of a supported business activity. The aim of supporting the global environment was combined, in the words of the IFC, as “appropriate risk management in the interests of cost-effectiveness, financial sustainability, and future replicability” (IFC 1998: Appendix 2).

### **6.3.1.3 Project cycle**

The project is divided into four steps: the solicitation of PVMTI subproject proposals, project selection, loan disbursement, and the repayment period. The first call for proposals was published in 1998, the deadline for project proposal submissions was set to 2002. 2007 was set as the end-date for all repayments. Private investors or existing private companies selling PV applications apply for PVMTI funds through business plans solicited through a call for tenders. Selected investments are called PVMTI subprojects.

### **6.3.1.4 Types of funded projects/ investments**

Funded projects should expand or set-up distribution and sales networks for PV applications. Projects had to include partnerships with finance institutions in order to provide end-consumer loans for the purchase of PV systems. PVMTI might include finance for the manufacture of Balance of Systems (BoS) and systems integration, as well as PV-related ventures including battery companies. “Financing of free-standing PV manufacturing efforts not explicitly tied to a parallel market development effort will be considered outside the scope of PVMTI” IFC 1998: 17).

Funding administered through PVMTI to individual subprojects ranged from a minimum of US \$500,000 to a maximum of US \$5 million. Each subproject had to achieve a certain number of sales of PV applications to receive the subsequent disbursement of the loan. Loans were paid in four instalments. The capital received in the form of the loans was to be used as operating capital, or to temporarily subsidise the consumer loans. It was not allowed to subsidise PV systems directly.

The targeted end-users of PV applications sold through subprojects are private and commercial end users.<sup>84</sup> As one interviewee explained, PVMTI was never intended to support a special market segment (e.g. the rural market) but to support marketing efforts more generally which could include any market segment or niche if the business plans was viable.

#### **6.3.1.5 Institutional setup**

The IFC designed and developed the PVMTI. The GEF provided the necessary financial means of US \$30 million. The international renewable energy project development company IT Power was chosen to implement the project in India, Kenya, and Morocco. The UK capital management firm IMPAX administered and distributed the funds for subprojects on behalf of the IFC. PVMTI India was implemented by IT Power India. All decisions on investments were made by the IFC. IMPAX preselected and suggested investments and administered the funds. The Indian government approved the project but held no formal role.

#### **6.3.2 PVMTI results**

The following section will present an overview of the PVMTI India results. As both CO<sub>2</sub> reductions as well as technology transfer depend on the aggregate sales of PVMTI funded projects, I will, in the following, summarise the business results of PVMTI funded business activities. I will then try to explain the results based on the interviews conducted and discuss CO<sub>2</sub> reduction and technology transfer afterwards.

PVMTI made investments in four companies. Their achievements are summarised in Table 14.<sup>85</sup>

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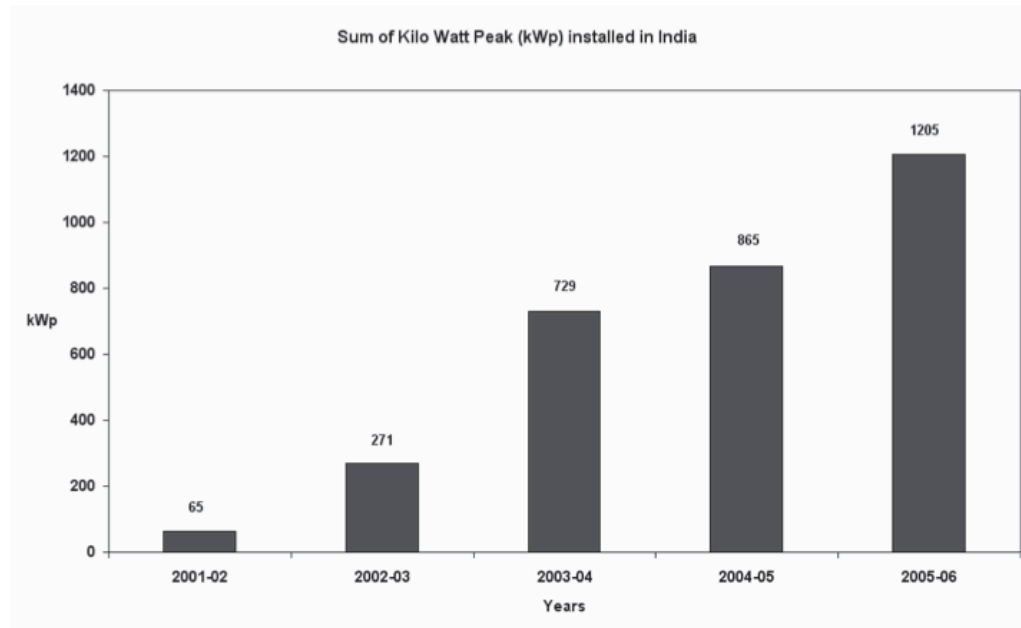
<sup>84</sup> The following applications could be sold through PVMTI-funded companies: PV applications for households, applications in agriculture, commercial SHS applications in the 20-500 Wp range, agricultural water pumping, small power plants serving commercial end users, municipalities and villages, in the 10 kW to 500 kW range and possibly hybrid, grid inter-connection, such as rooftop installations for semi-urban housing or commercial captive power applications to provide reliable power and/or relieve peak loads.

<sup>85</sup> According to interview sources, sales figures were verified through certified audits by IT Power India. "Certified audit" means an accredited auditor would verify the sales receipts of sold PV applications. According to IT Power India, irregular and unsystematic field visits to inspect installations were also carried out. A number of interview sources expressed doubt about the reliability of figures as auditors were not in the position to establish whether PV systems were sold with PVMTI support or within other PV support programs.

**Table 14: Achievements of subprojects by July 07**

<b>Investee Company</b>	<b>Investment</b>	<b>Project Summary</b>	<b>System sales</b>	<b>Infrastructure</b>	<b>Status</b>
<b>Company A</b>	US \$2.2 m.	Expansion of a network of “energy stores” in Southern India, selling PV and other alternative energy products	8,000 lanterns (24 kW) 2,000 other solar gadgets (27.6 kW) 3 power plants (4.5; 4.5; 3.0 kW)	8 energy stores.	Economically unstable, hardly selling solar PV applications IFC repayment not secured
<b>Company B</b>	US \$3.5 m. of 12.5 m <sup>86</sup>	Introduction of a credit scheme for PV customers in West Bengal	12,000 to 13,000 SHS up to 75 W 1000 street lights, 40 kW power plants	Operating through sales and dealer network	Economically stable, selling solar PV applications with government subsidies IFC payment secured
<b>Company C</b>	US \$4.0 m.	Expansion of a network of Solar Centres in southern India and establishment of a credit scheme for end users in partnership with local financial institutions	30.000 SHS	25 energy stores	Terminated operations in 2006 IFC repayment not secured
<b>Company D</b>	US \$1.1 m. of 14.7 m <sup>87</sup>	Expansion of energy stores in southern India with consumer credit.	24,000 to 26,000 SHS of 10, 20 and 40 W	25 Energy Service Centres	Economically unstable, repayment delayed
<b>Total</b>			70,000 SHS 8,000 lanterns 1,000 street lights		

Source: Interviews<sup>88</sup><sup>86</sup> Based on (TERI 2001)<sup>87</sup> Based on (TERI 2001)<sup>88</sup> Specifications of the subprojects partly differ from official IFC figures. The IFC has published the following figures: Company D 15,000 systems, company C 26,000 systems, company A 2,000 systems, and company B 15,000 systems leading to a total of 58,000 systems (no date specified) (IFC 2007).

**Figure 6: Development of installed PV systems in India in kWp**

Source: (PVMTI 2006)

System sales and installed capacity were well below initial expectations. The accumulated overall installed capacity resulting from PVMTI India of 1.2 MW by the end of 2007 was just above 10 per cent of what was expected to be the yearly sales generated through PVMTI in 2003 (10 MW) (see figure 6). To understand and explain PVMTI results, one has to understand why fewer projects than envisioned were funded, the individual project experience and why replication was not achieved.

A number of interviewees pointed out the initial market PVMTI market research was flawed and the initial number of systems to be sold overestimated. However, as the IFC declared initial market research as confidential, it is impossible to reconstruct the characteristics of the envisioned market or the assumptions made, e.g. about the influence of PV system prices and prices of other energy sources.

### **6.3.3 Call for proposals and subproject selection**

IT Power India published the call for tenders/ proposals for PVMTI subprojects in 1998 and received around 22 proposals for subprojects. Proposals included solar-powered cash machines, internet centres, and phone booths (Gunning 2003, interview sources).

According to IT Power India, PVMTI India had considerable problems in selecting investments as the proposals did not match the quality expected. Other interviewees gave several explanations for the disappointing turnout. One interviewee explained that the situation in the Indian market had changed between the period of initial market research and when the call for proposals had changed. In 1998, Indian companies were much more interested in export than in

the Indian market, as demand in developed countries was picking up. Numerous interviewees underlined that successful PV businesses in India were from the late 1990s onwards built on module manufacturing for export as demand abroad was considerably higher and less difficult to meet. As PVMTI did neither finance manufacturing nor export activities the project was of no interest to their business goals. Furthermore, several interviewees pointed out the minimum investment size of US \$500,000 was too large for the Indian market as most sales companies could handle only smaller sums for investments. At the same time, most interviewees considered the overall IFC/GEF investment sum of US \$15 m as far too small to transform a market as large as India's.

Six investments were preselected. From among these, one company withdrew, according to a senior manager, because the administrative procedures and funding disbursement worked, in his opinion, too slowly to establish a profitable business. According to PVMTI, the investment was abandoned because it was not considered financially viable. The reason for the withdrawal of the second company could not be established as no representative of the consortium could be contacted. Only four (those listed in Table 14 above) received funding. Preconditions were the extension of the sales of infrastructure and the partnering with commercial finance institutions to provide end-consumer loans. Investee companies were not allowed to use PVMTI funds to subsidise the systems they sold directly (funds were to be used as operating capital, for sales infrastructure investment, and to subsidise end-consumer loans to a certain extent).

Officially, all available Indian PVMTI funds are now committed. It is unclear how much of the committed funds have been disbursed to the subprojects. According to interview sources not all of them have been disbursed yet. IT Power India declared the absolute level of disbursement as confidential.<sup>89</sup>

### **6.3.4 Subproject performance**

Four companies received PVMTI finance. The business models of all investee companies are similar. The investee company assembles PV lighting systems and markets them either with their own sales infrastructure or through cooperation with a dealer network. The investee company also cooperates with a bank to offer finance solutions to the PV end-consumer, since they are usually not able to pay for the PV system up-front. Three of them were operating prior to PVMTI in the Indian market. Only Shell entered the Indian market when PVMTI funds became available.

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<sup>89</sup> Rogers et al. report that in 2004 PVMTI India had committed all of its available funds but not all of them were disbursed. According to several interviewees, this situation had not changed in 2007. The exact level of disbursement for India was declared confidential by IT Power India (Rogers, Hansen, and Graham 2006).



All company representatives interviewed had solicited PVMTI funds for similar reasons. They had applied because PVMTI was offering terms and instruments unavailable through IREDA or commercial banks at the time. By the time of soliciting funding, subprojects considered PVMTI as superior to government funding because it seemed to offer more flexibility, innovative finance instruments and better support. IREDA, the government bank in charge of financing PV in India, concentrated on end-consumer finance but not was investing directly into companies. One interviewee pointed out that the Indian government program was, in his view, not doing very well at the time and a stronger focus on marketing seemed sensible.

Interviewees explained that their sales were mainly based on the fact that end-consumers willing to purchase systems did not have to rely on the Indian government program which operates with different success in different Indian federal states. In addition, one of their main selling points was after-sales services, which other vendors could not offer to the same extent. Because it is impossible to state whether investee companies would have been able to pursue similar sales without PVMTI funding, we have to assume that PVMTI sales are additional to other sales and would not have taken place otherwise.

It turned out that, until 2007, those companies receiving funding were not necessarily sustainable. Only one company claimed to be profitable, but admitted openly that this was because almost all of their sales were executed with government subsidies.<sup>90</sup> One of the companies supported through PVMTI ceased operations.<sup>91</sup> No information regarding its involvement in Indian subsidy programs could be obtained but the company also sold systems within other donor solar programs.<sup>92</sup> One company is, according to its CEO, in an economically uncertain position. It0 successfully stayed and continues to stay out of the government program but has also been selling systems within other multilateral donor programs. One company never managed to sell a substantial amount of PV applications.

***Individual company experiences (for extended descriptions see appendix G)***

**Company A** never achieved its original goals of setting up 300 energy stores. The company abandoned the initial idea of the stores after the eight stores it set up to sell exclusively SPV applications proved commercially unviable. As an alternative, Company A changed their originally proposed business model and aimed to use their existing dealer network for other products to also market their SPV applications. The existing vendors could, however, not be

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<sup>90</sup> The company bids in government tenders and claims a subsidy from the state government for each solar home system sold.

<sup>91</sup> No representative of company C wanted to comment on the reasons.

<sup>92</sup> One project report of a project in which Shell Solar participated with three other vendors claimed that the project had triggered 50 per cent of all SHS sales within the states the project operates. Although this claim is not substantiated and therefore questionable, it underlines that sales resulting from other donor programs might contribute significantly to the overall business of a PVMTI investment (Painuly 2005).

convinced to sell PV applications as they thought their value proposition was not strong enough to actually make sales. In reaction, Company A changed their business model again and partnered with two other major Indian energy companies to sell liquid natural gas products as well as SPV applications through the 2000 existing sales outlets of the energy companies. The energy companies cancelled this agreement after the Indian government changed their subsidy policy on liquid natural gas and the partners started losing money on the products.

Another reason for the low success within the SPV business was, according to the interviewed company representative, that the company was not allowed through PVMTI rules to invest in PV module manufacturing although it would have made, in their opinion, economic sense. The company, therefore, lost two government contracts for the supply of PV systems as the government favours suppliers with a manufacturing backbone and thus missed opportunities in exporting PV systems overseas. Company A is selling very few SPV applications and is struggling to repay the PVMTI loan.

**Company B** is successfully selling SPV applications (mostly SHS) with the subsidised funding from the PVMTI project. Company B's success is based on two factors. When first negotiating for funding, Company B and PVMTI agreed that business activity encompassed the setting up of a new sales network in form of "one-stop PV shops" where customers could acquire SHS, spare parts, and have access to finance. These stores were however never set up because Company B decided they were financially unviable because the price for modules was slowly increasing due to rising demand in Europe. Furthermore, Company B was hesitant to take the risk of offering end-consumer finance. Consequently, the business goals were changed to system integration, sales through an existing dealer network and the provision of end-consumer finance through bank partnerships. Opposed to the experience of Companies C and D, banks in the area of operational activity of Company B were already giving out loans for the purchase of SHS. Hence, ties between Company B and commercial banks either already existed or were easily established. The second reason for the good performance of Company B is that for every SHS sold, the company also could claim the Indian government subsidy. According to a company representative, it is difficult to sell SHS without the state subsidy. Company B had estimated to sell 40,000 SHS but only managed to sell 13,000. Company B is in a commercially stable position and repaying the PVMTI loan.

**Company C** refused to be interviewed about their PVMTI experience because it ceased operations during fieldwork. However, two former employees contributed to our understanding of the performance of the company. Company C started operating in India with PVMTI funds to establish 25 energy stores and sold the highest number of SHS. The reasons for the termination of operations are not entirely clear, but the mother company of Company C, one of the largest oil companies in the world, drew out of the PV business completely because profits were lower

then expected. Company B in India had faced considerable problems reaching profitability as their business model focused exclusively on solar home systems which had small profit margins. Company C suffered from the rules PVMTI had established regarding bank partnerships. As banks, the geographic area in which Company C operated had not yet integrated loans for SHS, Company C had to negotiate partnerships. Commercial banks in India tend not to be interested in giving loans for SHS as transaction costs are high in relation to the overall loan sum and the default risk is considered high. To mitigate the banks' concerns, PVMTI had allowed some of the loan to be used as a premium to be paid to the banks to downstream the cost of the loan and PVMTI-provided default guarantees. The bank lowered interest rates for end-consumers buying a solar PV application, and the difference between the standard and the lowered rates was paid as a premium from the PVMTI subproject to the bank. As a result, a loan became cheaper to the customer and the bank became compensated for the resulting loss directly by subprojects.

However, Company C still encountered considerable difficulties in partnering with banks as the premium to the banks had to be reduced over time. In addition, in order to obtain the default guarantees, the banks would have had to go through a rigorous screening process by the IFC for which the banks felt they would have had to give away too much confidential information. The default guarantees were therefore never applied and partnerships with banks considerably delayed.

**Company D** had been in the Indian market for three years prior to soliciting PVMTI funds and used the loan as working capital for ongoing operations. Company D sold a considerable number of SPV applications but suffered from the implementation of the PVMTI project.

The main problems the company encountered were protracted and delayed payments of the loan instalments resulting in the inability to react to changes in the market. Company D received the first instalment of their loan five years after submitting a proposal in 1998. Furthermore, the company missed support from PVMTI when prices for PV modules increased 50 per cent due to demand in Europe which threatened the existence of the company. Additionally, the company suffered a working capital crunch when the final disbursement of the loan was delayed due to problems external to Company D. Company D faced similar problems in forging partnerships with banks as Company C. The company is still operational. It is the only company completely outside the Indian government scheme but it also operates with concessional finance from multilateral donors other than the GEF.

### ***Discussion***

As seen in the short summaries above, a number of factors emerged that influenced sales and, in the final analysis, the commercial success of PVMTI subprojects. These are: project

implementation factors, the chosen project approach, market factors and management decisions. They will be summarised individually in the following sections.

### ***Project Implementation Factors***

All interviewees from investee companies agreed that business operations were constrained by time-consuming procedures and slow decision-making processes within PVMTI. In the first instance, it took from 1998 to 2001 to put first investments in place. In some cases, it took six months to approve a project by the IFC and then another year for companies to provide the required documentation as IFC requested 100-page business plans. In addition, loans were paid out in four instalments and each instalment required again extensive due to diligence procedures by the investee companies. Even when required documentation was available, decisions were protracted due to the institutional set-up of the project. The split between IFC in Washington, IMPAX in London and IT Power India led to inefficient communication and considerable misunderstandings between funding bodies and funding recipients. All interviewees also underlined the fact that the IFC lacked ownership of the project over long periods of time despite its role as the final decision making body.

Long decision-making procedures, the protracted disbursement of loans and the slicing-up of loans into various instalments constrained all recipients. These factors limited the ability to close deals and react to the market. As one interviewee put it: “If I have talked to banks at one point in time and GEF does not give money, a year later everything is different because I can’t close deals.” Process efficiency was closely related to the ability to quickly finalise investments. As another interviewee put it: “You need an efficient process: in emerging markets things change quickly. If you can strike a deal you need to close it quickly.” Furthermore, the same interviewees pointed out that the slow payout of funds created frictions between project partners, e.g. systems were installed but the supplier could not be paid.

IT Power India and IMPAX confirmed their view by admitting retrospectively it was a mistake to slice up the PVMTI loans in four instalments and to require 100-page business plans “in a country where business are still sealed by a handshake” (interview source).

When asked why the donor side had not reacted to the problems of process efficiency, documentation requirements, or the changing macro-environment during the project span, one interviewee stated that, although they were learning along the way, it was too late to change procedures and rules. Additionally, there was a strong pressure from the IFC side to carry out the PVMTI project according to initial rules since it was more successful than many other IFC projects despite its much less than average size.

Interviewees from the PVMTI subproject also criticised the limited flexibility of the IFC. The IFC was flexible regarding subproject goals and business models and, because during the course

of the project investee companies could not reach their initial targets, these were modified. The IFC however insisted on the initial rule of not funding investments in PV manufacturing, although it turned out during the project that it may have made economic sense due to increasing demand in industrialised countries and the price increase for modules on the world market. Interviewees from the donor sides stated that retrospectively it would have made sense to allow subprojects to invest in module manufacturing. By the time of the increase of prices for PV modules, the institutional division between IT Power India, IMPSX and IFC had not been able to assess the situation properly and IFC had hence insisted on the exclusion of manufacturing although subprojects had asked to change their business plans and invest in manufacturing.

Furthermore, one interviewee from a subproject stated that the IFC did not support him when his business activity became endangered due to the price increase of PV modules in the world market and he would have needed extra support in terms of changed finance modalities.

### ***Project design and approach***

Another set of factors relates to the design of the project and the chosen project approach. Several interviewees from the Indian government and local experts pointed out that PVMTI was not aiming at reducing the cost of PV systems. The cost of systems was seen as the main bottleneck in system diffusion as most un-electrified rural households were very poor. While this aspect is of no concern to the investee companies (as they obviously have a market for their business model) it points to the overall size of the market which seems to have been overestimated by PVMTI.

A second factor relates to the decision of the IFC not to allow investment in manufacturing. While investments in manufacturing would have supported the sustainability of investee companies, it is less clear whether investment in manufacturing would have led to increased PV sales in India. Interviewees stated quite clearly that manufacturing was deemed for exporting.

PVMTI stakeholders also agreed that the modalities regarding bank partnerships hampered the progress of business activities. Investee companies were allowed to use PVMTI funds to subsidise end-consumer loans in order to make partnerships attractive for banks. PVMTI would pay a premium to the bank which would allow the bank to lower the interest rate for its end-consumer credit. PVMTI companies welcomed the opportunity to establish bank linkages as the availability of end-consumer loans decreased the dependency on the government subsidy.

However, the premium had to be phased out over time as the notion of PVMTI was that the PV market in India should function without subsidies. Two subproject interviewees criticised that available modalities to design end-consumer loans were not attractive for banks and delayed the partnerships with banks considerably. Banks were not used to giving out loans for PV systems

especially in southern India where the sums involved (around 20,000 rupees) seemed too small to actually bear the transaction cost of giving out loans. Furthermore, in order to obtain loan default guarantees, the banks had to undergo a rigorous screening process which, according to the three interviewees, made partnering with PVMTI subprojects unattractive.

### ***International and national market factors***

Another set of factors influencing the sales of PVMTI subprojects were the changes in the market environment beyond subprojects. Firstly, market prices for modules increased which were influenced by rising demand in Europe. One interviewee stated that the years 2005 and 2006 were very difficult years for the subprojects because module prices had increased, and no cheap, high quality modules were available on the market. A second interviewee stated that the initial plan to set up an own dealer network was abandoned as it turned out to be financially too risky because of slowly increasing prices for PV modules. The third investee suffered from changes in the market for liquefied gas. It had planned to market PV application in partnership with two large Indian liquefied gas suppliers, which already owned a large Indian dealer network. During the course of the project, the Indian government changed its subsidy policy on liquefied gas and the partnership collapsed. Additionally, interviewees stated that their products stood in competition to the government subsidy market.

### ***Company management decisions***

Interviewees from IMPAX/ IT Power India stated that reasons for the sub-optimal performance of PVMTI subprojects were also to be found in management decisions by PVMTI subprojects. Although interviewees of PVMTI subprojects did not raise this particular issue, it is likely that some management decisions had a negative effect on company performance. Poor management decisions cannot be ruled within market-based approaches. At the same time, interviewees from subprojects openly recounted management decisions that were appropriate from the perspective of the investee company but were contrary to the goals of PVMTI. Company B had an initial target of a 40,000 PV system sales and the establishment of its own sales infrastructure. The idea of the sales infrastructure was abandoned as it turned out that other forms of distribution were more profitable. Additionally, Company B states to be in a financially stable position, having sold 13,000 instead of 40,000 systems and was not aiming at 40,000 systems anymore. Although more sales might be desirable from the perspective of Company B, they were not a business necessity. Likewise, Company A abandoned the idea of setting up its own dealer network with 300 outlets when this initial goal turned out to be unprofitable. In the same manner, the closing down of company C was a business decision that were contrary to the goals of PVMTI.

#### **6.3.4.1 Replicability**

All subproject interviewees stated that they were not aware of companies operating on a similar business model due to PVMTI. Interviews revealed two explanations for lacking replicability. Firstly, the relatively small PV industry did notice that PVMTI-funded subprojects were struggling to sell PV systems. Secondly, all interviewees stated that it was virtually impossible to sell PV systems without the government subsidy. PV professionals, believing that companies might be profitable in serving the private market despite the IFC funding, seemed to have been in a minority.

Two system integrators interviewed started serving the private market without PVMTI money after PVMTI India had commenced. Their target groups were wealthy customers in urban areas that needed PV as reliable backup systems due to the numerous blackouts of the public grid. They expressed the view that the Indian private market was now “ripe” to be addressed in their business activity. This “ripeness” was felt through increased consumer awareness of the technology as well as increased recognition by banks. The driving force of this development was mainly seen in the government program. Although both companies had taken over staff from Shell Solar, they felt that their businesses were considerably different. Both were targeting wealthy urban customers and sold PV as back-up systems for already grid-connected households. Their business model was, however, the same as they sold small-scale off-grid PV systems and arranged for loans to purchase such systems. Both were part of larger international companies and declined to comment on their commercial progress.

#### **6.3.4.2 Comparison**

Compared with the regional achievements of the Indian government program’s (SPP) result for the subsidised sale of SHS, PVMTI results look better than compared with initial PVMTI expectations (see Table 15).

**Table 15: Comparison of solar home system sales in selected Indian states from 2001-2006**

State	PVMTI Subproject	Solar Photovoltaic Programme (SPP)
West Bengal	Company A: 13,000	45,557 <sup>93</sup>
Andhra Pradesh	Company B: 0	814 <sup>94</sup>
Andhra Pradesh, Karnataka and Kerala <sup>95</sup>	Company C: 30,000 Company D: 24,000	18,575 <sup>96</sup>

Source: Author

In the state of West Bengal, one PVMTI subproject alone sold almost one-third of the number of systems as the government program sold in total. Two further PVMTI subprojects, C and D, sold considerably more systems than the SPP in their respective areas of operation, and only one subproject did not sell any SHSs. I could not undertake a full comparison of PVMTI and the SPP. However, the interviewees give some indication why PMVTI has “outperformed” the SPP in two cases. As stated before, Company A was selling (against the original PMVTI intentions) with the government subsidy. As interviewees noted, the PV program in West-Bengal is comparatively well-implemented and the head of the West Bengal renewable energy agency strongly supported rural electrification via PV technology. At the same time, the PV programs in the other states were not considered to be well-designed or pursued with vigour by their state governments. The head of the Karnataka state renewable energy agency stated openly that “PV had not been the focus of his activities.” So one possible explanation for the relative success of Companies C and D is that private- sector initiatives may work “better” despite all limitations in cases in which state institutions are weak or fraught with the bureaucratic inefficiencies discussed in section 6.2.2 of this chapter. Company C and D managed to sell systems with PVMTI and additional donor funding. The fact that Company C terminated operations and D was financially unstable when fieldwork for this thesis ended, might actually not be due to a general weakness of business focused approaches but caused by the way they are funded. One major difference between SPP and PVMTI is the underlying assumption in how far subsidies are needed for successful PV systems diffusion. The Indian government has, on various occasions, changed the geographical availability and level of the subsidy, but so far has not

<sup>93</sup> No figures were available for the years 2001, 2002, 2003. Reflecting the trend in the figures for overall Indian installations, I have assumed these figures to be equal to the year 2000 for 2001 and 2002 and the double figure of 2000 for 2003.

<sup>94</sup> There are no figures for the years 2002 and 2001 but only the cumulative figure of all installations until 2002 of 1,016 systems. I have therefore assumed that the figure for 2002 equals the figure of 2003 and the figure for 2001 is half the figure of 2003. This is a somewhat arbitrary figure but is based on the trend of overall SPP instalments as represented in Table 15.

<sup>95</sup> The PVMTI subprojects C and D India were active in these three regions.

<sup>96</sup> The cumulative figure for Karnataka is 13,811. There are no annual figures available for SHS installations in Kerala. The cumulative figure is 7,900 systems over the whole running time of the SPP (anert.gov.in). I assumed that half of the installations took place between 2001 and 2006 as this roughly reflects the trend of the overall Indian installation figures (3950).



questioned the necessity of the subsidy for solar home systems. The PVMTI project, in line with the market transformation approach, assumes that any form of subsidy will become unnecessary after the subsidised project intervention. The economic position of the PVMTI subprojects indicates that at current cost for PV technology a subsidy is needed beyond the project intervention to sell PV technology successfully. This is underlined by the economically good situation of Company A which claims the government subsidy additional to PVMTI funding and the agreement between all interviewees that the government subsidy is necessary to sell PV profitably in rural areas.

### ***The customer base of the project***

Another issue relevant in explaining the better performance of Company C and D compared to the government program emerged during the interviews. According to the representative of PVMTI India, customers of the PVMTI subprojects are predominantly rural. Her statement was allegedly based on information given by the respective subprojects. However, this statement is contradicted by the information subproject representatives and experts were giving me (see the section on individual projects). Several interviewees criticised that PVMTI was not serving rural customers but rather wealthy customers in urban areas. Considering the customer base of the different subprojects, it turns out that only company A sells its systems almost exclusively to customers in rural areas but also claiming the government subsidies. One company stated it had sold to urban and rural customers, but rural customers had been from the wealthier strata. One company did not comment about its customer base but company marketing publications clearly indicate that it targets rural and urban customers. In other words, Companies C and D have also sold more systems because they could tap into the semi-urban and urban market which is not covered by the Indian government program.

### **6.3.4.3 Effects on CO<sub>2</sub> substitution and technology transfer**

As the installed capacity resulting from PVMTI is only a fraction of the assumed overall installations over the project life cycle, carbon substitution goals are likewise not met. According to IT Power India, the amount of kerosene replaced is estimated by the respective subprojects. It was assumed that average system size was 50 Wp, and each system replaced six litres of kerosene a month.<sup>97</sup> If this calculation represents the real replacement, PVMTI achieved a reduction of roughly 55,000 t CO<sub>2e</sub> from 1998 to 2006. PVMTI India estimated in 2007 that until 2009 92,503.2 t CO<sub>2e</sub> would be replaced. The estimation procedure is, however, not

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<sup>97</sup> However, there are conflicting accounts of the calculation from one subproject claiming to have calculated kerosene displacement to be 0.2 tons a year for his 10 Wp systems (8.3 litres monthly) and 0.35 tons for his 30 and 40 Wp systems (14.6 litres monthly). While it is possible that the relatively low figure of 6 l monthly kerosene displacements was chosen to reflect the different periods of operation of the individual systems, the figures are pretty useless until the methods of calculating carbon displacement are revealed. Without access to the method and underlying assumptions, the figures have to be treated with caution.

transparent and figures have to be considered with caution.<sup>98</sup> Although PMVTI was more successful in selling SHS than the Indian government, we cannot be equally certain that PMVTI is the better approach to support CO<sub>2</sub> emissions. The technology is the same but there is no information on the operation of systems although PMVTI subprojects claimed that after-sales services are one source of their competitive advantage. As we have seen, both SPP and PMVTI seem to have different customer groups as some PMVTI subprojects also sell to urban customers.

There is some evidence that serving the urban market has implications for the actual amount of carbon displacement. As discussed briefly in section 6.2, the acquisition of SHS in rural areas leads to a relatively high rate of kerosene displacement. The underlying assumption is that rural dwellers are relatively poor and unable to afford both kerosene and SHS. Relatively wealthy households in semi-urban and urban areas might have coal power plant-based grid connections and only use SHS in cases of a power outage. Although using costly PV systems only as back-up systems does not make sense financially, as one would expect frequent usage to save money on the electricity bill, it is a form of usage in urban areas that has been identified through market research (TERI 2004). In addition, two of the system integrators interviewed as part of the PV industry study confirmed that their wealthy urban customers use PV systems predominantly as back-ups. The system integrators market their products accordingly as back-ups rather than as money-saving devices.<sup>99</sup> While a broad customer base in urban areas is desirable from the perspective of the companies it also indicates that the assumptions about kerosene displacement have to be treated with care because the PV system usage pattern of urban customers might need further investigation.

### *Technology transfer*

As the PMVTI investee companies are system integrators/vendors and do not manufacture themselves, any investment in production/manufacturing would have been made by the suppliers to the subprojects. All interviewees from suppliers and subprojects stated that no company had made any investment in production technology due to the demand created through PMVTI. Their first and foremost explanation was that the demand created through PMVTI sales was too small to stimulate further investment in production technology which might have included international technology transfer to India. Although not all PV manufacturers interviewed were familiar with PMVTI, almost all remaining manufacturers agreed that PMVTI had no impact on the industry's development.

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<sup>98</sup> A more detailed breakdown of the figures can be found in appendix E.

<sup>99</sup> Although one may only speculate about the reasons for this kind of usage. The generally low price for electricity in India as well as the relative wealth of urban PV customers might be part of an explanation.

All investments made by cell and module manufacturers, which included in many cases the acquisition of production technology from abroad, were made because of the booming export markets in Germany, Japan, Spain, Italy etc. Representatives from the government, the PVMTI stakeholders as well as the local experts shared this view.

We can, however, assume that technology could have been transferred to India if the demand created through PVMTI was larger. There are several arguments supporting this assumption. Firstly, no Indian manufacturer of PV production technology exists and only one manufacturer stated that they were able to build production technology himself. Secondly, interviews revealed that foreign companies did enter the market through joint ventures with Indian firms when the market in India seemed to expand significantly in the beginning of the 1990s. The first was the oil company BP forming a joint venture for the manufacture of PV cells and modules with the Indian company Tata. The second is the company Webel Solar that was founded at the same time as a joint venture with an Italian PV company. Interviewees from both companies stated that they had benefited (as the joint venture of Webel does not exist any longer) and still benefit (in the case of Tata BP) from knowledge transferred from abroad through the joint venture. Thirdly, technology is currently imported as demand abroad is growing. There is no reason why PV systems should not be imported in the case that demand in the Indian market would be growing.

However, based on the investigation undertaken for this thesis it seems unlikely that imported technology would significantly improve the technological capabilities of Indian manufacturers. This assumption is based on several observations. Firstly, Indian manufacturers lack significantly technological capabilities in relation to technology leaders. They are not able to produce cells of the highest efficiency nor those with the latest material designs (thin-film, nano). Secondly, the Indian market requires, under its current demand, mainly subsidised low-cost modules for rural applications and unsubsidised low-cost modules for urban applications, which can be manufactured with existing technological capabilities. In other words, the Indian market currently offers no incentives for domestic manufacturers to transfer PV technology that would significantly expand their technological capabilities and add to the innovative capabilities they would need to successfully compete with PV manufacturers operating at the current technological frontier. Thirdly, Indian manufacturers stated quite clearly that they saw no reason to add to their technological capabilities and did not plan to do so. This was mainly because they considered their capabilities and knowledge links sufficient for their current business models. The only exception was Moser Baer, who intended to actually reach the state of the art in PV technology production. Representatives of the company underlined, however, that this was done purely for export markets.

### 6.3.5 Theoretical discussion

In the following, the results of the PVMTI project with regard to technology transfer and environmental and economic benefits will be discussed from the perspective of the theoretical framework.

In line with the specifications from the market transformation approach PVMTI aims to support the relevant institutions for a market for small scale PV units. The main measure to support market infrastructure is finance for companies that will sell small-scale solar PV applications. The main measure to increase end-consumer demand is end-consumer finance. The transformative aim is for funded sales companies to be able to successfully operate after PVMTI funding has ended. This is also in accordance with the market transformation approach..

**Supply:** As the project did not support supply directly, all technology supply from abroad would have taken place in relation to growing demand. As the results discussed in chapter 6.3.2 show, no investment was taken that would have led to technology supply in form of international technology transfer. The PV units sold were produced within India. Existing PV manufacturers did not import any PV systems or systems components and did not make any investment that would have increased their technological capabilities with knowledge imported from abroad. Foreign manufactures did not enter the Indian market.

**Technological capabilities:** The PVMTI project did not support technological capabilities of Indian PV manufactures directly. All investments would have been undertaken in relation to growing Indian demand. As seen in chapter 6.3.4, no investment was undertaken that would have been deemed appropriate to augment technological capabilities in reaction to PVMTI. The reasons were that demand created through PVMTI compared less favourable to demand from abroad. Furthermore, the technologies sold under PVMTI could be produced with the existing level of technological capabilities

**Institutional aspects of technological capability-building:** No investments in institutional aspects of technological capability-building were made due to growing demand.

**Demand policy:** The implementation of PVMTI shows that that the market transformation approach is suited to achieve environmental goals. Although numerous problems occurred throughout the project implementation and the institutional structure (GEF/IFC in Washington, Impax Capital Management in London, and local management in India) does not seem to be ideal too, the demand side approach of the project achieved a larger diffusion of individual PV system than the government approach.

The theoretical discussion of the market transformation approach already suggested that projects modelled after the market transformation approach are more likely to support environmental rather than economic benefits as it exclusively supports demand side measures. This assumption

has been confirmed through the implementation of the PVMTI project in India. The project worked better with regard to environmental benefits than government measures that also aimed at the diffusion of similar PV systems (see chapter 6.3). Since PMVTI left economic benefits from technology transfer to the market, any effects from PVMTI would result from the demand it created. The theoretical discussions suggested that - for the demand side, measures to stipulate international technology transfer depend on the existence of relevant industries and their capabilities, but also on the size and the quality of the demand created. This assumption was also confirmed through the PVMTI project. PV manufacturers instigated investments in production technology and their technological capabilities due to large overseas markets, not as a result of PVMTI India. The implementation of PVMTI therefore suggests that the market transformation approach in its current form is not suited to support international technology transfer for economic benefits.

The results of the PVMTI projects gives evidence to the assumption that the GEF market transformation approach does not adequately support the interests of developed and developing countries with regard to international technology transfer. The analysis of the PV industry has also shown that only a very small portion of the Indian PV industry aims to increase its technological capabilities to research and manufacture at the technological frontier. This position is in contrast to the Indian government position on technology transfer under the UNFCCC, which states quite clearly that they aim to have access to the latest PV technologies (see chapter 2.2.4). The Indian PV industry actually welcomed PVMTI initially and its focus on diffusion of PV systems (aka environmental benefits), as they hoped that it would increase demand for PV substantially and become a commercially viable alternative to the Indian government program on PV.

In order to better understand which crucial aspects the market transformation approach tends to underplay, the next section will reflect more deeply the strategies found within the Indian model in relation to the literature on technological capabilities.

### **6.3.6 Indian PV manufacturer strategies**

At the time of conducting the thesis, the Indian PV industry was growing due to demand from abroad. Cells and modules produced were of average efficiency (14 to 16 %). The innovative capabilities of the Indian PV industry are not sufficient to be internationally competitive regarding production cost. As many interviewees have stated, Chinese firms are able to produce cheaper rendering the same quality. Further, capabilities were insufficient to produce cells of highest efficiencies or thin film cells. They were also insufficient to undertake R&D at the technological frontier.

The manufacturers simply had or were planning to expand their production capacities. However, they clearly stated that they did not plan to significantly augment their technological capacities through the acquisition of relevant production technologies or invest in R&D facilities that would lead to firm endogenous development of such capabilities.

Although investing in new production capacities all but one firm stated that they aimed for producing current state-of-the-art technology (cells of 18 to 20 per cent efficiency and thin film cells) in an even more distant future than the next investment in production capacity. In the understanding of those manufacturers, the necessary production technology would be at that time available on the market and their technological capabilities were sufficient to adapt this technology to their needs. These findings show that current strategies of the Indian PV technology industry do not aim at developing capabilities to innovate at the technological frontier. By the time Indian manufacturers invest in current state of the art technology, the state of the art will have progressed through research and development activities elsewhere.

Augmenting technological capabilities are of secondary importance to most of the companies interviewed, as business models currently work fine. The Indian government seems to assign significantly more importance to international technology transfer as expressed in relation to the UNFCCC (see chapter 2.2.4) than the majority of the representatives of the Indian PV industry.

At the same time, Indian manufacturers have expressed dissatisfaction with Indian government-sponsored R&D activities in the field of solar photovoltaic technology.

Whether or not the Indian PV industry will be economically successful with ongoing strategies therefore depends on the existence of sufficient demand for mature products in the future.

Whether this is the case is an open question as no one can reliably forecast future demand. Also, the Indian PV manufacturing industry is facing low-cost competition from China.

If projects like PVMTI aim for the long-term development of an industry, they must not only support markets but also give incentives and support to industries to significantly expand their technological capabilities. This includes supporting alternative company strategies, facilitating access to relevant knowledge, the improvement of the coordination with relevant institutional aspects of technological capability building, but also the co-ordination with national governments, which are obviously more long-term in their planning than industry.

### **6.3.7 Summary and discussion**

The PVMTI project in India aimed at a certain transformation of the Indian market for PV applications. The transformation as envisioned by the World Bank/IFC consisted of a transformation of the distribution system for technology (from government to private actors), the finance modalities (from direct end-consumer loans state subsidy to unsubsidised

transactions with end-consumer loans) and the establishment of a market for PV technology that would be functional without further public financial intervention. The result of this investigation suggests that this goal was not achieved until 2007, the time of my fieldwork in India. The aim of this chapter was to give an evaluation of the PVMTI program towards two goals that linked to the result of PVMTI India: the reduction of CO<sub>2</sub> emissions and international technology transfer. In the following, the main findings regarding both aspects will be summarised.

### ***CO<sub>2</sub> reduction***

As discussed in the theory chapter, CO<sub>2</sub> reduction is a function of technology diffusion and its effective operation. In the case of PVMTI India, diffusion is achieved through sales of small scale off-grid PV applications, and effective operation is determined by private end-consumers. The results of PVMTI regarding PV system sales are far below initial IFC/GEF expectations but higher in relation to the SPP of the Indian government. It was not possible to explain why results were lower than initial expectations as initial market research underlying expectations and other official documents were declared confidential. We can assume that initial estimations significantly overestimated the demand for unsubsidised systems. All interviewees stated that it is impossible to sell PV technology in a profitable manner in India without the government subsidy as demand in rural areas depended on the subsidy. If there were opportunities outside the direct subsidy program, they were small and had to be backed up and developed through adequate additional policy in order to grow. In other words, one factor severely limiting the sales of PMVTI is the notion that demand must only be temporarily subsidised although the product is not yet cost competitive.

My research has found explanations for the actual results. PVMTI subproject sought PVMTI funding as no other source with comparable conditions was available in India. The factors limiting the success of the PVMTI subprojects, on the one hand, are mainly in the time-consuming project execution through the IFC, the ruling out of investment in manufacturing, and the rules to establish partnerships with banks. On the other hand, the performance of companies was limited by factors beyond the control of IFC. These are primarily changes in other markets as experienced by Company A (subsidy for liquefied gas) and Company C (the increase of module prices through increasing demand of Europe), and low demand for systems not subsidised by the government. Further, management decisions of subprojects were not necessarily taken with regard to strict sales maximisation and the availability of end-consumer finance does not necessarily serve as a sufficient incentive to purchase a system especially if consumers can hope for government subsidised systems.

While the problem of slow project execution and investment rules could, in theory, be improved in future market-based projects, the vulnerability of companies regarding changes in

international markets, prices, and demand cannot be controlled within the market transformation approach because it does not include mechanisms and resources to do so (e.g. financial support in case prices for factor inputs increase). This is unsurprising because it is the core idea of the market transformation approach to create markets but not to intervene once they are created. The main weakness emerging here is that the barrier of PV system price is not addressed and the extra costs of PV systems are not controlled (as in a subsidy approach) but rather shifted to the consumer (in this case through micro-loans). If prices would, for any reason, increase and companies find no alternative revenue streams (like investing in manufacturing or claiming subsidies), costs would have to be passed on to the consumer which lowers demand.

At the same time, I found that PVMTI subprojects performed in two cases better than the solar photovoltaic programme of the Indian government. This indicates that, under certain conditions, approaches supporting private market transformation may achieve more system sales than state subsidy approaches. A number of factors emerged that explain the relative better performance in terms of installed system in relation to SPP. These include: less institutional inefficiencies, access to additional sources of finance, independence of government planning and a broadened customer base as those companies not claiming additional Indian government subsidies also sell systems in urban areas. As this thesis is not focusing on the comparison of both approaches, this aspect needs further investigation to come to a more reliable and refined explanation.

Effective operation of sold PV systems (the second factor determining CO<sub>2</sub> reductions) has to be achieved by the end-users of a sold system. How end-users operate PV systems sold through PVMTI subprojects could not be investigated within this thesis. We therefore have to assume for rural areas that system sales (plus the offering of after-sales maintenance services) through PVMTI subprojects will lead to substitution rates and related CO<sub>2</sub> reductions similar to those described in previous research. These are also the basis for the calculations by IT Power India presented in above.

However, it emerged during my fieldwork that PVMTI subprojects also sell to semi-urban and urban customers in grid-connected households that use PV technology systems as back-up systems in case of power black-outs. It could not be established how many of the overall sales fall into these categories. There is, to my knowledge, no research on the PV system usage pattern of grid-connected households and related CO<sub>2</sub> reductions in India. This leads to two problems in estimating CO<sub>2</sub> substitution. Firstly, PV system use in grid-connected households leads to the substitution of electricity generated from coal-based power plants. Hence, displacement calculations are different for rural households relying on kerosene. It appears that such calculations have not been undertaken for India. Furthermore, usage patterns within rural households are, for the most part, unknown. Initial research by TERI suggests that grid-connected households use PV systems as back-up for power failure rather than as a substitute



for electricity from the grid. These findings were confirmed through the statements from interviews from my research. The relation between system installation of private companies serving rural, semi-urban, and urban customers and CO<sub>2</sub> savings might, therefore, be different than in government programs serving purely rural households. This question is inevitably tied to the question of system cost and the duration of subsidies. If costs do not decrease and subsidies are limited as in PVMTI, private actors inevitably will seek wealthier customers in urban areas who already live in electrified households. More research on the different customer segments and their technology usage patterns of private PV sales companies has to be undertaken to provide a more differentiated evaluation of their CO<sub>2</sub> reduction potential. My research may only suggest that the relation is different, then, for entities selling purely to poor households in rural areas.

### *Technology transfer*

As established in the theory chapter, technology transfer in the context of this thesis is related to a process of industrial learning that contributes to additional technological capabilities on the side of the technology recipient.

Interviews with industry representatives revealed that demand created through PVMTI was too small to justify additional investments in production technology and any technology transfer additional to the ongoing transfer activities did not take place. The market transformation approach in its current form seems to be inadequate to support technology transfer. The development of the Indian PV industry indicates firstly that the demand created to give incentives for international technology transfer must be much larger and more stable than with the sums attributed to PVMTI.

PV applications sold by PVMTI subprojects are bought in India and carry cells with an efficiency between 12 and 14 per cent. In other words, Indian demand can be met with the existing level of technological capabilities. The market for PVMTI subprojects is very cost competitive because they face competition from the subsidised SPP, and most non-electrified households are poor. As a result, there is no incentive to import more advanced production technology to allow firms to produce cells with efficiencies higher than the existing ones.

Regardless of the Indian market, Indian manufacturers seemed, at the time of my investigation, inclined to develop and increase their technological capabilities. Most manufacturers had no intention to immediately upgrade their production technology through technology transfer. Only one manufacturer is actively pursuing the goal of achieving production with state-of-the-art technology but is doing so because of markets abroad and not because of the Indian market.

If we assume that PVMTI would have created much larger demand, we can therefore assume that any imported technology would not have added to the existing levels of technological

capabilities. Learning necessary for diffusion of systems would then have been limited in contrast to learning for export and long-term competitiveness.

The Indian PV industry is engaged in international technology transfer through R&D links abroad and import of production technology, etc., but these learning activities and investment in production capacities have taken place due to demand abroad which is reflected in the increasing export shares of the industry.

Historically, the first companies producing PV cells and modules were state companies. They built most of their production capacity indigenously but with the help of some international technology transfer. Once private firms were allowed to produce PV cells and modules, international technology transfer became more important as most firms had to rely on acquisition of technology from abroad as well as joint ventures (supported by the foundation of testing facilities and Indian government funded R&D) to develop their technological capabilities.

Currently, the Indian PV industry depends strongly on international technology transfer as still no Indian manufacturer of cell production technology exists and only a minority of state companies has built production technology by themselves. However, in the perspective of the industry, this international technology transfer is currently not an issue since most manufacturers plan to increase production capacity in the future and consider their in-house technological capabilities not only as the most important source of (incremental) innovation but also as sufficient to operate profitably with their current business models.

The only exception is one cell manufacturer aiming to produce State-of-the-art PV in the shortest time possible. This particular company is relying heavily on technology transfer to build up relevant production capacities and innovative capabilities. This example shows that the needs of companies regarding technology transfer differ.

Most cell manufacturers state that their technological capabilities are sufficient to undertake adaptation and incremental innovation but insufficient to undertake breakthrough innovation, meaning the production of either thin-film cells or cells with an efficiency of 20 per cent and more. Most companies acknowledge that the access to thin-film and 20 per cent efficiency cells is not immediately possible but have hardly expressed any access restrictions. They perceive the concentration of breakthrough technology in Western firms as unproblematic because they either consider their capabilities to be sufficient to develop the relevant capabilities themselves, or because they are certain that this technology will be accessible at one point in time. However, most cell manufacturers see no reason to actually undertake such innovations as their business models currently work well. From their perspective, it does not seem to matter whether or not

projects like PMVTI deliver technology transfer as they have other routes for technology acquisition.

## **7 Summary empirical findings and overall conclusions**

In the following chapter, I will summarise the findings of my empirical chapters and discuss them in relation to each other, and, in hindsight, to theories of technology transfer and diffusion. I will conclude the chapter by reconsidering my initial research question, drawing general conclusions of my findings and outlining areas for future research.

### **7.1 Technology transfer under the UNFCCC**

The main goals of the first empirical chapter were to understand how the notion of technology transfer is framed under the UNFCCC, to develop a normative framework for the discussion of the GEF technology transfer approach based on UNFCCC material as well as on developed and developing country positions.

As seen in chapter four, the Conference of the Parties (COP) to the UNFCCC has not made any decision concerning how to conceptualise technology transfer with the exception of the technology transfer framework. It reflects the requirements regarding policy that should support the diffusion of technology for achieving environmental goals, as well as for the technological learning of the recipient for development goals in a general manner; it does not contain normative elements and lacks references to direct technology transfer. Any specific goals of technology transfer, beyond the overarching goal of preventing dangerous climate change, have not been formulated.

The theoretical part of this thesis distinguished between policy that directly supports technology transfer through increasing direct access to technology, policy that supports technology transfer indirectly through increasing absorptive capacities via support of technological learning and policies that support technology transfer through market creation. The technology transfer framework is an integrated framework that addresses policy to support absorptive capacities and markets but does not include policy for direct transfer.

The level of abstractness of the technology transfer framework does not allow one to draw any conclusions concerning what level of technological learning is at least theoretically (regardless of the specific technology in question) supported, nor to what extent innovative capabilities are supported. In general, no aspect of the framework is mandatory and the framework leaves enormous leverage to design specific technology transfer programs or projects. As the framework does not contain any goals but is merely a list of aspects that should be addressed

when implementing technology transfer, it could not be used as a normative framework to evaluate the ensuing empirical parts of the thesis.

The COP has, furthermore, made a number of decisions leading to action that could involve the transfer of technologies under the UNFCCC. These are Activities Jointly Implemented, the Clean Development Mechanism, and three funds to be operated under the GEF. Although all these involve technology transfer in practice, these mechanisms do not have an explicit technology transfer mandate. Therefore, no technology transfer goals or criteria to measure progress towards technology transfer goals were developed, either of which could have served the purpose of developing a normative framework used for this research project.

In conclusion, one can say that the UNFCCC has not only failed in implementing technology transfer, but has not advanced very far in conceptualising the issues. In the language of public policy analysis, the COP succeeded only to a very limited extent in policy design despite the prominence of technology transfer in the UNFCCC agenda (Jann and Wegrich 2005).

### **7.1.1 Country positions on technology transfer**

As seen in chapter two, developed countries stress the importance of enabling environments, markets, policy frameworks and, generally, improving the investment conditions for private actors. Some, especially the USA, speak quite openly about improving the conditions for diffusion rather than transfer. Establishing markets and policy frameworks, from a theoretical perspective, are measures that, in the first instance, support the diffusion of technology and only thereafter would support technology transfer by giving incentives to private investors. This thesis has found that the positions of developed countries on technology transfer indicate that technology transfer shall primarily support the diffusion of technology and environmental goals. Hence, the transfer of technology becomes a function of the protection of the environment.

Developing countries do not dismiss the roles of markets and policy frameworks for diffusion, but insist on additional, government-led, direct technology transfer activities in order to ensure the transfer of selected technologies. Developing countries favour measures that directly support technology transfer by underscoring publicly organised transfer, weakening of IPR etc. This gives evidence to the assumption that they prioritise access to technology and the increase of technological capabilities over diffusion. Measures supporting diffusion are not dismissed but are of lesser importance. Environmental protection hinges in their perspective on the transfer of technologies. They rank development higher than finding solutions to environmental problems. Former UNFCCC negotiators for the government of India supported this view for the Indian position under the UNFCCC. We can, therefore, state that the positions of developing countries on technology transfer indicate that technology transfer shall primarily support access to technology and are therefore oriented towards broader development goals.

The analysis of county positions demonstrated that developed and developing countries have considerably different ideas about how to implement technology transfer reflecting differing goals to be achieved with technology transfer (environmental goals on the one hand and development goals on the other). Theoretically speaking, developed countries are actually aiming for the diffusion of technology while developing countries aim for technology transfer as described in the academic discourses on industrial development. The positions of developed and developing countries mirror older conflicts between developed and developing countries over technology and development although they have been reframed in the context of global environmental problems.

Both positions represent selected aspects of the much more complex theoretical discussions on technology transfer reviewed in chapter two. Developed countries support policies for the diffusion of technology and leave the actual transfer of the technology to the market. From a theoretical perspective, this position has a number of drawbacks in relation to development and environmental goals. While supporting policy environments are necessary for the diffusion of low-carbon technology as long as they are not cost-competitive and other barriers for diffusion exist, the literature has also shown that successful diffusion requires a certain degree of technological learning related to the technology in question. The degree of learning required is related to the complexity of the technology. To completely neglect this aspect means also to decrease the chances of successful diffusion. The developed country position reflects the neo-classical economic assumption that the transfer of technology is effortless and that learning does not involve additional costs for learning (chapter 2.3.6). Leaving technology transfer predominantly to the market means effectively leaving environmental and developmental goals to the goals of business firms. Even if there is public intervention in those markets (e.g. through-feed in tariffs, carbon taxes, etc.) the behaviour of companies is not necessarily a mechanistic reaction to the incentives. As seen in chapter 2.3.9, firms have a Schumpeterian interest in safeguarding knowledge related to innovative capabilities and core technologies but do transfer substantial amounts of technology to recipient firms in developing countries in practice according to their business interests and the level of capabilities of the recipient firm. Increasing demand for low-carbon technologies through adequate policy increases the likelihood of technology transfer but does not guarantee that the recipient's learning is sufficient for mitigation effects through technology diffusion or economic development effects through the formation of innovative capabilities. While we can expect that market signals might lead to the transfer technology, it is unlikely that it will be sufficient alone to build the institutions that support technological learning in developing countries as a prerequisite for the formation of absorptive capacities in cases in which they do not exist. The "technology transfer paradox" discussed in section 2.3.13 suggests that leaving technology transfer to markets will tend to

favour those developing countries (and also specific sectors within them) that are already relatively technologically strong. It is likely that the technology transfer paradox may also be relevant for low-carbon technology. Lewis and Wiser, for example, find that European firms transferred wind energy technology to China at a time when the technological capabilities of Chinese wind technology manufacturers were low because of the large Chinese market *and* the industrial policy measures of the Chinese government (Lewis and Wiser 2007). This thesis indirectly supports this assumption as no evidence was found for actual or planned technology transfer to India beyond the existing level of technological capabilities of the Indian PV industry due to the Indian market.

Developing countries take, theoretically speaking, the other side of the academic discourse. They support access to technology and list measures that aim to increase the chances of technological learning through technology transfer. While developed countries emphasise access through publicly supported technology transfer, they also seem to address the aspect of absorptive capacities by underlining that technology transfer must be country-need specific, public intervention must also remove barriers, and technology must be absorbed. However, the latter aspect features less prominently than calls for unspecified public support of technology transfer and weakening or modification of the IPR regime. As seen in the theoretical chapter, direct access to technology is no guarantee for successful technology transfer since knowledge inflows should be matched to existing technological efforts and complemented with learning efforts on the side of the technology recipient (chapter 2.3.7). Their position seems to underplay the fact that domestic markets for low-carbon technologies need to be created to actually achieve emission reduction. While demanding technology access, developed and developing countries place considerably less emphasis on the diffusion of technology by neglecting the role of relevant policy measures and domestic conditions. Currently, policy intervention that is different from policy supporting technological learning is needed in developing countries.

My findings concerning the positions of developed and developing countries are in line with the existing empirical literature that, for a long time, has pointed out that developed countries primarily pursue environmental goals in international environmental policy while developed countries work to avoid jeopardising their economic development for the sake of environmental problems caused by industrialised nations (Najam, Huq, and Sokona 2003; Barton 1997). The results of my research, however, draw attention to an aspect that is underemphasised in the literature directly related to technology transfer under the UNFCCC. This set usually points out that technology transfers is, firstly, essential and, secondly, has to comprise “hard and soft technology” or “technology and know-how” (Forsyth 1998; IPCC 2000; International Energy Agency 2001; Ockwell, Watson, MacKerron et al. 2008; Newell 2008). This literature has, however, so far neglected the implications of the choice of mechanisms and its effects on the

outcomes of technology transfer. It does not consider the extent to which political goals like environmental protection or technology transfer interact with the political shaping of technology transfer mechanisms, but seem to imply that the goal of technology transfer is achieved once technology is internationally relocated. My research suggests that developed and developing countries relate to very different things when talking about technology transfer under the UNFCCC, a fact reflected in the instruments they suggest with which to achieve their “version” of technology transfer. In other words, the process is politically value-laden and, once associated with a goal like “environmental protection” or “development”, different requirements result than the actual implementation of any transfer. My research underlines the fact that, if certain measures concerning how to implement technology transfer are likely to support one goal more than another one, then the selection of measures is not only about effectiveness but also political.

As it is not possible to derive any normative framework based on UNFCCC activity, the GEF approach to technology transfer as well as the PVMTI project were evaluated according to the positions on technology transfer of developed and developing countries. Doing so meant that any GEF measure must lead to the diffusion of low-carbon technology but also to the transfer of previously non-existing technological capabilities within the recipient country to satisfy both sides in the debate.

## **7.2 The GEF approach to technology transfer and its relation to the UNFCCC**

The chapter on the GEF aimed at gaining a better understanding of the GEF approach to technology transfer. It reconstructed the historical evolution of the approach, identified the responsible drivers, and clarified the role of technology transfer within GEF activities. It also analyzed the relation between the GEF and the UNFCCC, especially with hindsight to guidance on technology transfer, in how far the UNFCCC shaped the GEF technology transfer approach and in how far the approach reflected developed and developing country positions under the UNFCCC. This chapter is to be seen as a link between the requirements regarding technology transfer formulated within the UNFCCC arena and the implementation through the PVMTI project.

### **7.2.1 The GEF approach to technology transfer**

One of the main findings is that the GEF includes technology transfer as an indirect or secondary goal of their market transformation approach.

The overall aim of the market transformation (MT) approach is to establish or facilitate markets for certain environmental technologies in developing countries by removing barriers to market



development. A central goal is that markets will function beyond the time of project intervention. Once these markets are set to work, it is assumed that private investments will serve the markets including the transfer of technology.

In its current form, the market transformation (MT) approach supports the framework conditions and markets for technologies rather than the transfer itself. As seen in the theoretical chapter, it directly supports some aspects that are necessary for the diffusion of low-carbon technologies. It is also central to increase the incentives for business to become involved GEF projects. Despite its conceptual vagueness, it is obvious that it stands in sharp contrast to approaches that support transfer directly, e.g. in the form of a fund financing technology acquisitions.

The analysis of the MT approach in chapter five revealed that the “market” aimed for is not a market for attracting investment in technology production but a market for the end use of low-carbon technologies that aims at the diffusion of technology.

From a theoretical perspective, the GEF approach supports diffusion by increasing demand, lowering-transaction cost and supporting entrepreneurial activity. It does not consider the necessity of technological learning either for the diffusion of technology, to achieve environmental goals, or for technology transfer and the formation of technological capacities.

The GEF approach supports diffusion under the assumption that technological learning is not necessary for diffusion or that additional policy support is not required for learning. According to theory, quite the opposite might be the case. Not supporting technological learning at all might diminish diffusion because the knowledge to positively modify and adapt a technology influences diffusion and hence its positive environmental effects.

The theoretical review also suggests that companies do invest in technology transfer if profitable markets in the recipient country exist. The existence and size of markets is, however, only one of several factors related to the decision whether to transfer technology or not. Other factors include absorptive capacities of recipients, competitive threats and local cost for input factors. Transfer is determined by business goals which might not necessarily coincide with environmental or development goals.

Of key importance is the distinction between technology transfer for environmental goals and technology transfer for development goals. Measures to support the diffusion of low-carbon technology for environmental purposes should support both demand and limited technological learning by the recipient. International technology transfer for industrial development should support both technology supply and the technological learning of the recipient. Technology supply that depends on private firm strategies cannot be taken for granted, especially if the

technology holder will perceive the learning process within a recipient country as a competitive threat.

Considering the market transformation approach and its focus on demand-side measures, it seems unlikely that it will achieve technology supply and technological learning. However, whether or not the market transformation approach will support technology transfer and whether or not technology transfer can be sufficient for industrial development is exemplified in the case of PVMTI in India.

### **7.2.2 UNFCCC guidance on technology transfer**

In the section on UNFCCC guidance to the GEF, I demonstrated that the COP never decided upon guidance on direct technology transfer, that the GEF developed its market transformation approach without any influence of the COP and that the GEF operates relatively independently with regard to technology transfer of the COP. In the interpretation of GEF staff, the GEF is following UNFCCC guidance. They consider the technology transfer framework and the GEF pillars of market transformation to be similar. This is only partly true. Firstly, the technology transfer framework at least lists “mechanisms for technology transfer” and formally includes direct technology transfer (although no further qualification regarding mechanisms is made). Secondly, the technology transfer framework includes elements that could serve to support technological learning and the formation of absorptive capacities. Activities to directly support technological learning and absorptive capacities are clearly not part of the market transformation approach. The technology transfer framework and the GEF Market Transformation approach are similar as they both support demand-side measures like policy for the diffusion as well as improvement of investment conditions. The GEF is, hence, even more limited in supporting technology transfer than some industrialized countries under the UNFCCC.

The GEF market transformation approach is by far more similar to the ideas of developed countries on how to transfer technology, reflecting the core GEF goals of preserving the global commons. The GEF approach differs conceptually very strongly from developing country ideas. At the same time, the GEF maintains that technology transfer will occur.

This means in practice that the “implementation deadlock” regarding technology transfer on the UNFCCC level is broken by the GEF as the GEF does finance projects designed according to an approach that claims to support technology transfer to developing countries. Despite its effective mandate as a financial mechanism to the UNFCCC, the GEF, in practice, finances projects that support the technology transfer according to goals and measures proposed by developed countries.

The theoretical literature so far has no answer to the question of how far the increase of demand for low-carbon technology through intervention by a multilateral finance organisation like the GEF will stimulate private international technology transfer that will contribute to technological learning and the reduction of carbon-dioxide emissions within developing countries. The following third empirical part tried to give an explorative answer by investigating the implementation of the GEF PVMTI project in India.

The empirical findings on the GEF also draw attention to technology transfer as a political process that is not only shaped by supplier, recipient, and institutions supporting technological learning, but is also politically shaped by institutions selecting and designing the projects and instruments that shall facilitate knowledge flows but have no direct influence on the knowledge flow as such.

In other words, investigating more closely how the GEF translates the general UNFCCC mandate of technology transfer into instruments and project design underlines that both selecting and designing effect technology transfer – and not only in terms of whether a policy instrument is applied well or a project successfully implemented. The GEF acts effectively as the executive to the UNFCCC and is a form of international bureaucracy (Andler 2007). Within the literature of policy analysis, the distinction between the legislative and the executive has been challenged for many decades now and the influence of the executive, not only on policy implementation but also on policy shaping, has been shown empirically in numerous ways (Lasswell 1956). It is therefore no surprise that the GEF has managed to formulate and implement its own policy on technology transfer especially since the UNFCCC was not able to develop policy on its own.

### **7.3 The PVMTI project in India**

The third empirical part of the thesis evaluated a GEF project based on the market transformation approach: the Photovoltaic Market Transformation Initiative (PVMTI) in India. The aim was to understand the extent to which the approach yielded results regarding the achievement of environmental and development goals.

As seen in chapter six, the PVMTI project works relatively well in relation to PV system sales although it has not been able to substantially increase the market for small off-grid solar PV applications in India. The success can be considered mixed as the results regarding PV system sales (and hence carbon dioxide emissions prevented) are disappointing in relation to initial project goals. However, in comparison to the Indian government program on PV technology, PVMTI was a success insofar as PV system diffusion was better than that of the weakly implemented government program in areas where PVMTI supported companies operated. The

project did not achieve the establishment of functioning markets for PV technology beyond the project duration.

As seen in chapter six, a number of factors are responsible for the results of the PVMTI project. Purely relying on business and markets introduced a range of factors beyond the control of IFC. These are primarily changes in other markets as experienced by two PVMTI-funded companies, and the low demand for systems not subsidised by the government. While the encountered problems of slow project execution and investment rules could be improved in future market-based projects, the vulnerability of companies regarding changes in markets, prices, and demand cannot be controlled in the current approach design.

The availability of end-consumer finance does not necessarily serve as a sufficient incentive to purchase a system especially if consumers can hope for government subsidised systems. The main weakness emerging here is that cost barrier is not addressed as the prices of the PV applications are not controlled (as through a subsidy approach) but rather shifted to the consumer. If prices, for any reason, increase and companies find no alternative revenue streams (like investing in manufacturing or claiming subsidies), the costs have to be passed on to the consumer which lowers demand. Selco needed additional funding from other donor sources in order to successfully operate to maintain its policy of not claiming Indian government subsidies.

As seen, choosing a market-based approach and supporting firms also meant that control over both goals is given over to firms. Firms decided to change business strategy and lowered their PV system sales goals according to their needs and interests once they received funding. Especially telling is the experience of SREI, which received PVMTI funding but additionally claimed government subsidies for each PV system sold. It effectively received subsidies from two sources for every system sold but still scaled down system sales ambitions and abandoned the idea of developing sales infrastructure when it did not suit the business strategy. In the language of environmental policy, a market-based instrument like PVMTI can control the price of the policy intervention (as the amount of funding is limited) but not the environmental outcome as it is left to firms.

In the theoretical part, it was pointed out that some technological learning is necessary to support diffusion. In the case of India, not including elements for technological learning by recipient countries had no effect on diffusion as an Indian PV industry already existed that had sufficient technological knowledge to cater for the demand created by PVMTI.

PVMTI sources quantified the total (not annual) CO<sub>2</sub> replacements with 92,503 t CO<sub>2e</sub> from 1998 to 2009. The estimation procedure is, however, not transparent and figures have to be considered with caution. This is relatively little compared to the 412 million metric tons of carbon annual emissions of India in 2006 (one ton of carbon amounts to approx. 3.7 tonnes of

CO<sub>2</sub>.<sup>100</sup> This means that PV projects of the size and focus of PVMTI will be insufficient to contribute significantly to Indian CO<sub>2</sub> reductions. As CO<sub>2</sub> reductions are in the context very roughly measured by system sales, we can, however, state that PVMTI is more successful than the SPP approach of the government in meeting this goal. In other words, market-based approaches can play a certain role in broader CO<sub>2</sub> emission reduction efforts if they are improved with regard to the cost of PV technology.

### 7.3.1 Technology transfer

This thesis found that PVMTI did not play any role in industry development and the formation of technological capacity building. The recent growth of the Indian PV industry was mainly driven by demand in Europe and elsewhere abroad. This result does not reflect the expectations of developing countries but is actually in line with the GEF conceptualisation of market transformation approach. In the GEF understanding, technology transfer is left to private actors. If they do not undertake technology transfer it is primarily not the fault of the GEF project as long as GEF-supported markets work.

The technology transfer results can be discussed with hindsight to the market transformation approach and also with regard to the study of the Indian PV industry. With regard to the approach, the lack of technology transfer suggests that programs following a market transformation approach probably need to “create” much larger markets than through PVMTI to create sufficient incentives for industrial investments that might include technology transfer. This would be in line with the logic of the market transformation approach but this still does not guarantee transfers. As seen, PV manufacturers have significant overcapacities and the market would have to grow substantially to justify investments in new production technology.

A second option would be to actually combine market transformation with direct technology transfer. As interviewees pointed out, sustainable PV business models in India currently include cell and module manufacturing for export as the Indian market is, despite its importance, much more difficult to succeed in than the export market.

Supporting PV production through PVMTI is more likely to have led to international technology transfer if new entrants to the PV industry would have received finance through PVMTI. As no dedicated cell production equipment manufacturer exists in India, PVMTI subprojects would have had to import production technology from abroad. Manufacturers pointed out that finance and not access is the most important barrier to technology transfer; IMPAX could have also operated funds for subsidised finance.

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<sup>100</sup> [http://cdiac.ornl.gov/trends/emis/tre\\_ind.html](http://cdiac.ornl.gov/trends/emis/tre_ind.html).

Interviewees from the GEF and World Bank brought up two arguments against supporting technology transfer directly. Firstly, they stated that the GEF's implementing agencies had no competencies in providing technology. Secondly, they stated that PVMTI was designed to overcome a lack of finance for PV sales as it was assumed that sufficient finance was available for investments in PV manufacturing. Both arguments seem of little plausibility in the light of the PVMTI project. Indian companies could have chosen technology themselves and IMPAX (or a similar finance firm) could have managed funds for technology transfer. The general availability of finance is not, *per se*, an argument against subsidised finance in case investments in production technology and related technology are considered political goals.

Increasing demand and/or including technology transfer would require an increase in project funds as the underlying concept of replicability has not functioned and the Indian PV sales industry that is independent of the government program is far from growing.

With hindsight to policy, the PVMTI project underlines that "environments" and "markets" not only need to be "in place" and "operational", they also need to be designed to support industrial development. Almost all industry representatives pointed out that India would need policy for grid-connected PV applications to actually promote industrial development as grid-connected applications would increase demand far beyond rural electrification. While the decision about grid-connected PV is a decision of the Indian government, the interview statements indicate that the GEF could refine their market transformation approach towards what kinds of policies and institutions actually support industrial development and technology transfer more than others. The EU, for example, has seen a debate related to the better renewable energy policy (feed-in tariffs vs. quotas) with regard to the share of energy from renewable energy sources but as well regarding industrial development.

Interpreting the results of PVMTI for technology transfer with regard to the PV industry study adds another perspective to the issue. As seen, the importance of technology transfer changed over time for the Indian PV industry. Historically, acquisition of technology as well as joint ventures supported by the institution building and state-funded R&D seemed to be the most important mechanisms of technology transfer. Now that the industry is relatively well developed, international technology transfer is of secondary importance to the Indian PV industry. International knowledge is accessed through international R&D co-operation or international supplier relations. The reasons for the "loss" of importance are the achieved levels of capabilities that are sufficient for the current business models of the PV cell and module manufacture. All but one company is considering an expansion of production, increasing cell efficiency and/or the moving up in the value chain (for which they would need to import technology to India). However, as these are considered future activities and access is mostly considered unproblematic, technology transfer currently is not considered to be a pressing issue.

The exception is one cell manufacturer aiming to produce state-of-the-art PV in the shortest time possible but even this company has expressed restrictions to technology access. These results not only underline the fact that needs of companies regarding technology transfer differ. More importantly in this context, technology transfer is of secondary importance to most companies interviewed as business models currently work well. The importance assigned by the PV industry seems to far less then compared to the Indian government perspective as expressed towards the UNFCCC and within the interviews conducted for this thesis. The implication is that, to the Indian PV, it seems of little concern whether projects like PVMTI support technology transfer or not.

Indian cell manufacturers are not competitive regarding the latest levels of efficiency but have so far successfully exported modules. Whether or not this is a successful strategy in the long-term is an open question. Increasing cell-efficiency would mean increasing technological capabilities and/or the import of advanced production technology as demanded by the Indian government. However, having these demands implemented under the UNFCCC does not only depend on developed countries and their support of technology transfer but also on the goals and motivations of the Indian PV industry.

## **7.4 Overall conclusions**

### **7.4.1 Initial research question**

The initial research question was:

To what extent does the GEF approach to technology transfer support the goals of developed and developing countries on technology transfer under the UNFCCC?

The research question is of considerable political relevance because, as I've developed in the empirical chapters, the GEF operates not only the largest single climate change project program in the world but is also supporting technology transfer on behalf of the UNFCCC, despite the disagreement between developed and developing countries on the subject at the UNFCCC level. The question is also of considerable academic relevance as only very limited research on market-based approaches to deliver technology transfer of low-carbon technologies for developing countries exists.

Although all parties to the convention speak of technology transfer as a seemingly easily identifiable and neutral process, the analyses of UNFCCC party positions revealed that developed and developing countries have considerably different understandings of the process. As a first result we saw that developed countries' governments primarily seek to achieve

environmental benefits through international technology transfer. Developing countries' governments primarily seek to achieve economic benefits. As the analysis in chapter four showed, elements that aimed to achieve both goals were integrated in to the technology transfer framework, although the question of technology supply was not addressed, neither in form of market nor in form of direct market interventions.

In relation to the research question we can conclude that the GEF market transformation approach in its current form seems better suited to achieve the goals of developed countries in form of environmental benefits. In the following, I will summarise the findings that support this answer.

Although the UNFCCC technology transfer framework integrates elements that support both environmental and economic benefits and it is relevant guidance for the GEF, the GEF managed to develop its approach to international technology transfer independent of the UNFCCC.

On a conceptual level, the GEF market transformation approach supports markets for end-use low carbon technology in order to increase the number of adoptions of such technology. As such it supports primarily environmental benefits. Economic benefits through technology transfer that accrue from different levels of technological assimilation are left to private companies in reaction to growing demand and not supported. It is not an integrated approach that supports both goals separately with dedicated measures. The design of the approach follows the position of developing country' governments under the UNFCCC.

The investigation of the PVMTI project has shown that the market transformation approach is, despite its limitations and implementation problems, capable of achieving a reduction in CO<sub>2</sub> emissions. In the case of India, it is more successful than the Indian government program supporting similar technologies and similar goals with respect to diffusion. However, in its current form, it may work more successfully than the Indian government program but it will have to be modified in order to significantly contribute to CO<sub>2</sub> reductions. While supporting business seems to be a good opportunity in light of the inefficiencies of public administration encountered in relation to the SPP, my research found out that PVMTI was constrained (irrespective of implementation deficits) by the limited duration of the subsidy and difficulties in developing a substantial amount of business models. This indicates that market transformation approaches need more financial support but also depend much more strongly on the market context factors (capacities) they aim to support.

Furthermore, even when business activity is successful, the absolute amount of CO<sub>2</sub> reduction will depend on business goals of the funding recipient as seen in the PVMTI example. In order to increase or better control the amount of CO<sub>2</sub>, reductions would either mean to increase



incentives for funding recipients (and hope that funded companies will make business decisions accordingly) or to think about additional CO<sub>2</sub> reduction measures.

The PVMTI project was much less successful with regard to goals advocated by developing countries under the UNFCCC: economic benefits through technology access and development of additional technological capabilities. The market transformation approach as implemented by the GEF gives insufficient incentives for international technology transfer as such and even less incentives for the transfer of cutting-edge technology as the markets effectively “established” through the program are by far too small to give sufficient incentives for private investment. Furthermore, it is doubtful that even larger demand in India would substantially add to the existing level of technological capabilities of the Indian PV industry. Under the given political context, demand is off-grid rural (in niche applications urban) and consisting of cheap PV applications that can be met at the current level of technological capabilities. If rural off-grid demand in its existing form would increase through PMVTI or other measures, PV manufacturers might expand their existing production capacities but are unlikely to upgrade their technological capabilities as demand excluded more efficient modules that are more expensive. Most cell manufacturers do not see a business case for purchasing cutting-edge technology for the Indian market. The situation might change if a different kind of demand was created (for example through renewable energy policy) that would support grid-connected PV applications. The PV industry analysis showed at the same time that manufacturers saw no need for technology transfer as they considered access sufficient in relation to their business models and current levels of technological capabilities. In other words, markets must create not any but very specific demand in order to give incentives for the expansion of technological capabilities. By placing the GEF market transformation approach, and its application through the PVMTI project in India in relation to the UNFCCC, it allows us to draw conclusions in relation to developed and developing country decisions.

Thus, my conclusion for developed country positions is that market-based approaches for supporting low-carbon technologies are important. The PVMTI project demonstrated that they can work relatively well regarding technology diffusion as long as they are sufficiently funded. Constructing markets beyond the project duration requires, however, a much larger effort and corresponding resources as long as low-carbon technologies are relatively more expensive than competing fossil-based technologies. In other words, constructing markets is not a cheap option to support emission reduction if they go beyond small diffusion projects like PVMTI. The size of PVMTI is obviously unsuitable under the UNFCCC considering the amount of emission that needs to be reduced in Non-Annex II countries.

The main conclusion for developing country positions is that the GEF market transformation approach is unlikely to trigger technology transfer if the investments to create demand are as small as PVMTI funding. However, even if the absolute sum of investment increases and the demand expands sufficiently to give incentives for international technology transfer, it does not necessarily increase access to new technology leading to additional technological capabilities. Assuring that technology transfer will lead to increased technological capabilities is likely to need a much more complex market scenario that requires sophisticated demand for state-of-the-art technologies as well as institutions that support technology transfer. Furthermore, even though such a scenario can be imagined, it can hardly be implemented successfully against the goals and strategies of existing industries in the recipient countries. The GEF case, therefore, underlines the case that supply of relevant technological knowledge for low-carbon technology cannot be left entirely to the market.

Taking a step from my research question, my findings cast doubt on the assumption that the GEF is able to successfully implement policy on behalf of the UNFCCC in general within the current top-down setting. As we have seen, differing positions of developed and developing countries on the subject of international technology transfer on the UNFCCC level lead to very vague guidance for the GEF. At the same time, the GEF showed substantial leverage in following the vague UNFCCC guidance and used that leverage to develop a technology transfer approach that reflected its own experience as well as the external political specifications from its funding governments. At the PVMTI project level, I also found that firms do not necessarily adhere to project goals. This relates to PVMTI subprojects but also to the Indian PV industry. The Indian government position on access to technology diverges from current PV industry dynamics and industry needs. Even if PVMTI would have otherwise included measures to directly supply technology or support the technological capabilities of the Indian PV industry, it is uncertain whether the Indian PV industry would have adopted them. In other words, the three levels of investigation seem currently much more loosely integrated than necessary for the effective achievement of the environmental-end economic benefits which could prevent dangerous climate change and support sustainable development. This calls for tighter integration of the three levels through clearer goals articulated at the UNFCCC level, better UNFCCC – GEF co-ordination and better interaction with stake-holders in the country of implementation. It remains an open question for further research as to whether this form of integration could be achieved.

#### **7.4.2 Generalisability of findings**

The multi-level approach for this thesis gives a route to generalisation as it allowed an in-depth understanding of both the UNFCCC debates and the GEF market transformation approach.

Findings should, therefore, have some validity to other GEF projects and other technology-transfer activity under the UNFCCC.

Generalisation of my empirical results relates to two additional dimensions: other forms of similar policy and other low-carbon technologies. In my argument, generalisability can be claimed for both dimensions. A number of multilateral and national mechanisms are currently operating or developing programs following similar principles as the GEF market transformation approach. One example is the renewable energy and efficiency partnership (REEEP) that also aims to “catalyse markets” for low-carbon technology.<sup>101</sup> Also on the national levels, industrialised countries support projects in developing countries according to market transformation principles. Already in the late nineties, the US, EU and other OECD members started to finance government programs in relation to the UNFCCC with the aim of “establishing which technologies and modalities each developing country partner sees as most beneficial and continued by working with these countries to implement actions to attract investment in these technologies” (Kline et al 2004: 7).

The World Bank has been promoting the implementation of similar approaches. As they are also situated along the North-South axis and touch upon the same conflict between achieving environmental and development goals, results from my case study should, in general, also apply to similar mechanisms. One example is the Lighting Africa, a joint World Bank – IFC program to support African markets for off-grid lighting.

Further international environmental conventions include provisions for technology transfer in which developed countries place a similar emphasis on the importance of the private sector in technology transfer. Examples are the Convention on Biological Diversity (UNCBD) and the Convention to Combat Desertification (UNCCD) (Wagner 2007).

The rural PV systems supported by PVMTI are small end-use technologies. As the crucial component is the PV cell, similar problems would apply to larger systems as they hold the PV cell as the core technological component. In general, I would argue my findings are also relevant to more complex technologies like clean coal technology or more efficient steel smelting ovens. These technologies would require different demand-side policies to create effective markets for such technologies. For example, the installation of more efficient steel

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<sup>101</sup> REEEP initiates and funds projects; targeted interventions in two specific areas that offer the greatest potential for developing the market for sustainable energy:

- assisting governments in creating favourable regulatory and policy frameworks,
- promoting innovative finance and business models to activate the private sector.

REEEP is supported primarily by governments (Australia, Austria, Canada, the European Union, Germany, Ireland, Italy, Netherlands, New Zealand, Norway, Spain, the US and the United Kingdom) and by contributions from the private sector. Robust governance and monitoring structures ensure that all contributions are spent transparently and effectively ([www.reep.org](http://www.reep.org)).

smelting ovens could be directly subsidised. Due to the complexity of these technologies, we can assume that their adoption would have to be accompanied by much more sophisticated knowledge flows and would require much more technological learning on the side of the recipient even than for purely environmental goals. However, the difference in knowledge between efficiently operating a smelting oven (including the knowledge for adaptations and minor improvements) and actually replicating and substantially improving a more energy-efficient oven might be considerable. Hence, the distinction between knowledge necessary to achieve environmental benefits (including incremental innovation) and the knowledge necessary for increased economic benefits still applies. The other generalisable aspect is that, within demand-side driven market creation, the actual decision to transfer technology (or import it) is left to firms and their strategies rather than to political goals and corresponding intervention.

### **7.4.3 Theoretical conclusions**

In my current theoretical framework, I have included two related sets of theories. The first includes theories of international technology transfer. This set explains how international technology transfer may lead to economic benefits through industrial development on the side of the technology recipient. This theory, however, does not explain how international technology transfer will lead to significant environmental benefits. I therefore included a second set of theories into my theoretical framework. Theories of the diffusion of environmental technologies explain how technology may achieve environmental benefits like the reduction of carbon dioxide emissions.

According to theories of international technology transfer, economic effects on the side of the technology recipient depend largely on the degree of assimilation of the technology and the development of innovative capabilities through a process of technological learning. Theory differentiates between operative, adaptive, replicative, and innovative assimilation. The formation of innovative capabilities through technology transfer depends on the availability and quality (supply) of knowledge (which is, in most cases, determined by the technology transfer strategy of a private firm), the existing technological capabilities of the recipient, and the active learning effort of the recipient by capitalising on links with institutions offering additional knowledge.

The diffusion of environmental technology (including low-carbon technology) depends on the availability of such technology, the learning process of the adopter to efficiently use such technology and the successful implementation of policy creating demand for such environmental technology. Both processes are in practice not separate from each other.

A comparison of both theories suggested that, although learning is central to both concepts, the achievement of economic benefits through international technology transfer requires a much

deeper and more intense learning process as it must lead to improved innovative capabilities within firms. The adoption of technology to achieve environmental benefits requires less learning but requires, due to market failure, policy intervention to initiate a widespread adoption process. Potential adopters often have weak economic incentives to adopt low-carbon technology without further support through policy.

As a result, I distinguished broadly between two transfer processes, which are differentiated through their motivation or goal: international technology transfer for economic benefits and international technology transfer for environmental benefits.

My theoretical contribution lies in clarifying the relationship between the notions of technology transfer for industrial development and technology transfer for the protection of the environment. As I focussed on the discussion policy to support international technology transfer, my theoretical contribution primarily lies in better understanding how to design policy. Also, the distinction between four different learning processes leading to different levels of technological assimilation on the one hand and demand policy at the other proved to be a useful matrix to draw out some of the differences between different policies.

As we have seen, the market transformation approach of the GEF supports markets, but does not directly support any form of technological learning beyond operative assimilation by the recipient and aims mainly at the diffusion of low-carbon end-use technology it. It is modelled on a neo-classical understanding of international technology transfer.

The empirical analysis revealed that it works well with regard to the diffusion of environmental technology, although continuous financial support is needed to sustain diffusion as PV technology is not yet cost-competitive. The analysis also revealed, that demand must fulfil certain criteria to support international technology transfer in form technological capability development. Demand must be large enough to make investments in additional production capacity profitable and it must require products that exceed the existing level of technological capabilities of domestic manufacturers. But even if these conditions are met, manufacturers might still not be able to improve their technological capabilities. Manufacturers might not have sufficient access to relevant knowledge as they might lack internal R&D capacities or lack linkages to relevant knowledge institutions such as universities or research laboratories abroad. From that perspective, demand side measures alone may not lead directly to international technology transfer for economic benefits. If international policy to support international technology transfer were to lead to economic benefits, it should include measures to support supply, technological capabilities of recipients, and linkages to knowledge institutions. There is no set rule concerning which of these elements would be best to support. The theoretical discussion of the thesis pointed out that innovative assimilation of a technology may be

achieved by supporting only one, all or a selection of these elements. This means policy to support development of technological capabilities should be coordinated with the relevant recipient industry in order to meet firms' needs. This assumption is however based on little evidence as India, de facto, has a PV industry; thus, further research in countries without PV industries would be needed to validate this claim.

My findings suggest that any policy measure supporting environmental and economic goals should either apply several different instruments addressing both goals specifically or find integrated instruments that address both goals simultaneously. But within a political discussion that abounds with references to win-win situations in relation to climate change, it reminds us that these are very difficult to identify and even harder to politically achieve.

#### **7.4.4 Strength and limitations of research**

The following paragraph will briefly discuss the conceptual, empirical, and practical strengths and limitations of this research. Conceptually, the three-level approach allowed an in-depth understanding of the important relation between selected aspects of international environmental policy (UNFCCC), its operationalisation within a multilateral organisation (GEF), and its practical implementation (PVMTI, India). The strength of this approach is a holistic, longitudinal view on three different policy arenas that are interconnected through the task of supporting international technology transfer. By focusing on how different policies and actors at each level conceptualised and implemented international technology transfer, I was able to understand the extent to which there was congruence in goals as well as actions and in how far the GEF policy is suitable to achieve the goals of the UNFCCC, which is theoretically the institution guiding the GEF. Also, I could explain why the GEF approach to international technology in its current form does not seem to be suitable to achieve economic and environmental benefits as articulated under the UNFCCC. I was able to do so because I grounded the implementation of the PVMTI project in an in-depth analysis of the Indian PV industry and the Indian government program supporting PV technology. The conceptual weakness of this longitudinal approach is that on the UNFCCC level I was not able to explain why certain actor positions are found and why policy had developed in certain way. At the GEF level, I included a partial explanation. A proper explanation of how and why the GEF market transformation approach has taken a particular form at the time of my research would however have required a different theoretical framework (e.g. a theory that explains change in policy processes) and a different case study set up. Another limitation results from my use of theory. I have used theory as a means to map actor positions and to evaluate policy. The results of my research contribute to a better understanding of the design and implementation of policy for

international technology transfer but not to test or refine the theories used in my theoretical framework.

Empirically, the strengths of my thesis are that I have conducted a single, in-depth case study that is innovative in its three-level design. International technology transfer projects and GEF projects have been investigated before, but their results have – to my knowledge – so far not been related to any other layer of international environmental policy. The weakness of my approach is that little comparable work exists and, despite my identified possibilities for generalisability (see 7.4.2), more case studies would need to be undertaken to refine my findings.

Practically, the strengths of my approach emerge in its mixture of figures, documents and expert interviews as empirical sources. These, however, are also the practical limitations of my case study. Figures were not only hard to determine, they were in my case not necessarily 100 per cent reliable. I have not been allowed to access any official GEF files on the PVMTI and the sales figures I received are still unofficial. Also, PVMTI sales figures given to me from PV-funded subprojects do not fully match the figures I received from PVMTI management. The same holds for figures related to the Indian government program on PV as well as the PV industry. Although figures from government sources for the former exist, various Indian experts pointed out that they might be not fully correct. Likewise, hardly any official or coherent records of the Indian PV industry existed. In other words, I had to rely on interviews for much of my empirical findings. Interview results could only partly be backed by reliable documents and figures. The reliability of my interviews comes mainly from the fact that I conducted a large number of them with experts from a large variety of backgrounds (NGO representatives, local experts, government officials on various levels, etc.) and their accounts did severely contradict each other.

#### **7.4.5 Outlook and future research**

In order to increase the understanding of the GEF market transformation approach, more comparative work is necessary. This relates to the institutional context necessary to successfully fund private investments. As seen in the Indian case, PMVMTI achieved much lower results than expected. Interviewees pointed out that almost no investments were made in Morocco and Kenya, and no PV sales were made. Their explanation was the “insufficient business environment” in both countries. This points to the necessity of a certain level of existing market development before market support approaches can actually work. A comparison of the PVMTI experience in Kenya, India, and Morocco could help us to better understand what level of market development is necessary to successfully implement PVMTI. Furthermore, research in India indicated that private companies sell PV applications to urban customers. In order to

better understand the effects of PV sales to urban customers on CO<sub>2</sub> substitution, research on the way these customers use PV applications is necessary.

More cross-country comparative research is also necessary with regard to technology transfer. The market transformation approach is unlikely to add new technological capabilities in countries with existing industries by expanding without changing demand. This might be different in countries with little or no technological capabilities in the specific technology supported. Furthermore, in terms of other environmental conventions, there is much fruitful comparative work to be done to explore how technology transfer can be framed and implemented in manifold settings.

New institutions are currently employing market-based approaches with similar features as the GEF market transformation approach. The new climate investment funds (Clean Technology Fund and Strategic Climate fund), set up by developed countries, pursue “low-carbon growth and climate resilient development in developing countries” by financing relevant projects. The goal of the Clean Technology Fund is to “finance demonstration, deployment and transfer of low-carbon technologies with significant potential for GHG emissions savings” (CIF 2009). The Clean Technology Fund explicitly relates to the UNFCCC and the GEF in its self-description (World Bank 2008). From that perspective, it could be fruitful to investigate the Clean Technology Fund with a method similar to the one chosen in this thesis to understand how technology transfer is framed and implemented in a different multilateral finance institution.



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1	A/AC.237/88	Matters relating to arrangements for the financial mechanism. Implementation of Article 11 (financial mechanism), paras. 1-4. Transfer of technology. Note by the interim secretariat.	United Nations
2	FCCC/CP/1997/MISC.1	Review of the implementation of the Convention. Financial mechanism. Report of the Global Environment Facility to the Conference of the Parties at its third session. Note by the secretariat.	United Nations Framework Convention on Climate Change (UNFCCC)
3	FCCC/CP/1998/12	Review of the implementation of commitments and of other provisions of the Convention. Financial mechanism. Report of the Global Environment Facility to the Conference of the Parties at its fourth session. Note by the secretariat.	United Nations Framework Convention on Climate Change (UNFCCC)
4	FCCC/CP 1995/7	Report of the Conference of the Parties on its first session, held at Berlin from 28 March to 7 April 1995. Part one: Proceedings	United Nations Framework Convention on Climate Change (UNFCCC)
5	FCCC/CP/1995/7add1	Report of the Conference of the Parties on its first session, held at Berlin from 28 March to 7 April 1995. Part one: Proceedings.	United Nations Framework Convention on Climate Change (UNFCCC)
6	FCCC/CP/1996/12	Review of the implementation of the Convention and of decisions of the first session of the Conference of the Parties. Commitments in Article 4. Second compilation and synthesis of first national communications from Annex I Parties. Executive summary by the secretariat.	United Nations Framework Convention on Climate Change (UNFCCC)
7	FCCC/CP/1996/15/Add.1	Report of the Conference of the Parties on its second session, held at Geneva from 8 to 19 July 1996. Addendum. Part two: Action taken by the Conference of the Parties at its second session.	United Nations Framework Convention on Climate Change (UNFCCC)
8	FCCC/CP/1996/8	Decisions to promote the effective implementation of the Convention. Financial mechanism. Report of the Global Environment Facility to the Conference of the Parties. Note by the secretariat.	United Nations Framework Convention on Climate Change (UNFCCC)
9	FCCC/CP/1996/9	Decisions to promote the effective implementation of the Convention. Financial mechanism. Draft Memorandum of Understanding between the Conference of the Parties and the Council of the Global Environment Facility. Annex on the determination of funding necessary and available for the implementation of the Convention. Note by the secretariat.	United Nations Framework Convention on Climate Change (UNFCCC)
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11	FCCC/CP/1998/16/Add	Report of the Conference of the Parties on its fourth session, held at	United Nations Framework

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12	FCCC/CP/1998/MISC.5 Development and transfer of technologies (decision 13/CP.1). Submissions by Parties. Note by the secretariat.	United Nations Framework Convention on Climate Change (UNFCCC)	<a href="http://unfccc.int/resource/docs/cop4/misc05.pdf">http://unfccc.int/resource/docs/cop4/misc05.pdf</a>	Bonn
13	FCCC/CP/1999/6/Add.1 Report of the Conference of the Parties on its fifth session, held at Bonn from 25 October to 5 November 1999. Addendum. Part two: Action taken by the Conference of the Parties at its fifth session.	United Nations Framework Convention on Climate Change (UNFCCC)	<a href="http://unfccc.int/resource/docs/cop5/06a01.pdf">http://unfccc.int/resource/docs/cop5/06a01.pdf</a>	Bonn
14	FCCC/CP/2000/3 Review of the implementation of commitments and of other provisions of the convention: Report of the Global Environment Facility to the conference. Note by the secretariat.	United Nations Framework Convention on Climate Change (UNFCCC)	<a href="http://unfccc.int/resource/docs/cop6/03.pdf">http://unfccc.int/resource/docs/cop6/03.pdf</a>	Bonn
15	FCCC/CP/2001/13/Add.1 Report of the Conference of the Parties on its seventh session, held at Marrakesh from 29 October to 10 November 2001. Addendum. Part two: Action taken by the Conference of the Parties. Volume I.	United Nations Framework Convention on Climate Change (UNFCCC)	<a href="http://unfccc.int/resource/docs/cop7/13a01.pdf">http://unfccc.int/resource/docs/cop7/13a01.pdf</a>	Bonn
16	FCCC/CP/2001/13/Add.4 Report of the Conference of the Parties on its seventh session, held at Marrakesh from 29 October to 10 November 2001. Addendum. Part two: Action taken by the Conference of the Parties. Volume IV.	United Nations Framework Convention on Climate Change (UNFCCC)	<a href="http://unfccc.int/resource/docs/cop7/13a04.pdf">http://unfccc.int/resource/docs/cop7/13a04.pdf</a>	Bonn
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19	FCCC/CP/2002/4 Review of the implementation of commitments and of other provisions of the Convention. Financial mechanism. Report of the Global Environment Facility. Note by the secretariat.	United Nations Framework Convention on Climate Change (UNFCCC)	<a href="http://unfccc.int/resource/docs/cop8/04.pdf">http://unfccc.int/resource/docs/cop8/04.pdf</a>	Bonn
20	FCCC/CP/2002/7/Add.1 Report of the Conference of the Parties on its eighth session, held at New Delhi from 23 October to 1 November 2002. Addendum 1. Part two. Action taken by the Conference of the Parties.	United Nations Framework Convention on Climate Change (UNFCCC)	<a href="http://unfccc.int/resource/docs/cop8/07a01.pdf">http://unfccc.int/resource/docs/cop8/07a01.pdf</a>	Bonn
21	FCCC/CP/2003/6/Add.1 Report of the Conference of the Parties on its ninth session, held at Milan from 1 to 12 December 2003. Addendum. Part two: Action taken by the Conference of the Parties at its ninth session.	United Nations Framework Convention on Climate Change (UNFCCC)	<a href="http://unfccc.int/resource/docs/cop9/06a01.pdf">http://unfccc.int/resource/docs/cop9/06a01.pdf</a>	Bonn
22	FCCC/CP/2003/6/Add.2 Report of the Conference of the Parties on its ninth session, held at Milan from 1 to 12 December 2003. Addendum. Part two: Action taken by the Conference of the Parties at its ninth session.	United Nations Framework Convention on Climate Change (UNFCCC)	<a href="http://unfccc.int/resource/docs/cop9/06a02.pdf">http://unfccc.int/resource/docs/cop9/06a02.pdf</a>	Bonn
23	FCCC/CP/2003/CRP.1 Round-table discussions among ministers and other heads of delegation. Summary by the President of the Conference of the Parties at its ninth session.	United Nations Framework Convention on Climate Change (UNFCCC)	<a href="http://unfccc.int/resource/docs/cop9/crp01.pdf">http://unfccc.int/resource/docs/cop9/crp01.pdf</a>	Bonn

24	FCCC/CP/2004/10/Add.1	Report of the Conference of the Parties on its tenth session, held at Buenos Aires from 6 to 18 December 2004. Addendum. Part Two: Action taken by the Conference of the Parties at its tenth session.	United Nations Framework Convention on Climate Change (UNFCCC)	19.04.2005	<a href="http://unfccc.int/resource/docs/cop10/10a01.pdf">http://unfccc.int/resource/docs/cop10/10a01.pdf</a>	Bonn
25	FCCC/CP/2004/6	Report of the Global Environment Facility to the Conference of the Parties. Note by the secretariat.	United Nations Framework Convention on Climate Change (UNFCCC)	22. Nov 04	<a href="http://unfccc.int/resource/docs/cop10/06.pdf">http://unfccc.int/resource/docs/cop10/06.pdf</a>	Bonn
26	FCCC/CP/2005/3	Report of the Global Environment Facility to the Conference of the Parties. Note by the secretariat.	United Nations Framework Convention on Climate Change (UNFCCC)	20.10.2005	<a href="http://unfccc.int/resource/docs/2005/cop11/eng/03.pdf">http://unfccc.int/resource/docs/2005/cop11/eng/03.pdf</a>	Bonn
27	FCCC/CP/2005/5/Add.1	Report of the Conference of the Parties on its eleventh session, held at Montreal from 28 November to 10 December 2005. Addendum. Part Two: Action taken by the Conference of the Parties at its eleventh session.	United Nations Framework Convention on Climate Change (UNFCCC)	30.03.2006	<a href="http://unfccc.int/resource/docs/2005/cop11/eng/05a01.pdf">http://unfccc.int/resource/docs/2005/cop11/eng/05a01.pdf</a>	Bonn
28	FCCC/CP/2006/3	Report of the Global Environment Facility to the Conference of the Parties. Note by the secretariat.	United Nations Framework Convention on Climate Change (UNFCCC)	17.10.2006	<a href="http://unfccc.int/resource/docs/2006/cop12/eng/03.pdf">http://unfccc.int/resource/docs/2006/cop12/eng/03.pdf</a>	Bonn
29	FCCC/CP/2006/5/Add.1	Report of the Conference of the Parties on its twelfth session, held at Nairobi from 6 to 17 November 2006. Addendum. Part Two: Action taken by the Conference of the Parties at its twelfth session.	United Nations Framework Convention on Climate Change (UNFCCC)	26.01.2007	<a href="http://unfccc.int/resource/docs/2006/cop12/eng/05a01.pdf">http://unfccc.int/resource/docs/2006/cop12/eng/05a01.pdf</a>	Bonn
30	FCCC/CP/2007/6/Add.1	Report of the Conference of the Parties on its thirteenth session, held in Bali from 3 to 15 December 2007. Addendum. Part Two: Action taken by the Conference of the Parties at its thirteenth session.	United Nations Framework Convention on Climate Change (UNFCCC)	14.03.2008	<a href="http://unfccc.int/resource/docs/2007/cop13/eng/06a01.pdf">http://unfccc.int/resource/docs/2007/cop13/eng/06a01.pdf</a>	Bonn
31	FCCC/CP/2008/7/Add.1	Report of the Conference of the Parties on its fourteenth session, held in Poznan from 1 to 12 December 2008. Addendum. Part Two: Action taken by the Conference of the Parties at its fourteenth session.	United Nations Framework Convention on Climate Change (UNFCCC)	18.03.2009	<a href="http://maindb.unfccc.int/library/view_pdf.pl?url=http://unfccc.int/resource/docs/2008/cop14/eng/07a01.pdf">http://maindb.unfccc.int/library/view_pdf.pl?url=http://unfccc.int/resource/docs/2008/cop14/eng/07a01.pdf</a>	Bonn
32	FCCC/KP/CMP/2005/8/Add.4	Report of the Conference of the Parties serving as the meeting of the Parties to the Kyoto Protocol on its first session, held at Montreal from 28 November to 10 December 2005. Addendum. Part Two: Action taken by the Conference of the Parties serving as the meeting of the Parties to the Kyoto Protocol at its first session.	United Nations Framework Convention on Climate Change (UNFCCC)	30.03.2006	<a href="http://unfccc.int/resource/docs/2005/cmp1/eng/08a04.pdf">http://unfccc.int/resource/docs/2005/cmp1/eng/08a04.pdf</a>	Bonn
33	FCCC/SB/1997/1	Progress report on technology and technology transfer. Note by the secretariat.	United Nations Framework Convention on Climate Change (UNFCCC)	17.02.1997	<a href="http://unfccc.int/resource/docs/1997/sb/01.pdf">http://unfccc.int/resource/docs/1997/sb/01.pdf</a>	Bonn
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35	FCCC/SB/1997/4	Development and transfer of technologies. Update to progress report. Note by the secretariat.	United Nations Framework Convention on Climate Change (UNFCCC)	25.07.1997	<a href="http://unfccc.int/resource/docs/1997/sb/04.pdf">http://unfccc.int/resource/docs/1997/sb/04.pdf</a>	Bonn

36	FCCC/SBI/1996/10	Financial and technical cooperation. Secretariat activities relating to technical and financial support to Parties. Progress report. Note by the secretariat.	Change (UNFCCC)	United Nations Framework Convention on Climate Change (UNFCCC)	03.07.1996	<a href="http://unfccc.int/resource/docs/1996/sbi/10.pdf">http://unfccc.int/resource/docs/1996/sbi/10.pdf</a>	Bonn
37	FCCC/SBI/1996/5	Transfer of technology. Note by the secretariat.	United Nations Framework Convention on Climate Change (UNFCCC)	United Nations Framework Convention on Climate Change (UNFCCC)	02.02.1996	<a href="http://unfccc.int/resource/docs/1996/sbi/05.pdf">http://unfccc.int/resource/docs/1996/sbi/05.pdf</a>	Bonn
38	FCCC/SBI/1997/8	Financial and technical cooperation. Financial mechanism. Review process referred to in Decision 9/CP.1. Synthesis report.	United Nations Framework Convention on Climate Change (UNFCCC)	United Nations Framework Convention on Climate Change (UNFCCC)	20.06.1997	<a href="http://unfccc.int/resource/docs/1997/sbi/08.pdf">http://unfccc.int/resource/docs/1997/sbi/08.pdf</a>	Bonn
39	FCCC/SBI/2002/14	Financial mechanism. Review of the financial mechanism. Synthesis report. Note by the secretariat.	United Nations Framework Convention on Climate Change (UNFCCC)	United Nations Framework Convention on Climate Change (UNFCCC)	11.09.2002	<a href="http://unfccc.int/resource/docs/2002/sbi/14.pdf">http://unfccc.int/resource/docs/2002/sbi/14.pdf</a>	Bonn
40	FCCC/SBI/2002/MISC.2	Financial mechanism. Review of the financial mechanism. Compilation of submissions on the review of the financial mechanism.	United Nations Framework Convention on Climate Change (UNFCCC)	United Nations Framework Convention on Climate Change (UNFCCC)	05.09.2002	<a href="http://unfccc.int/document/2002/02/02/misc2.htm">http://unfccc.int/document/2002/02/02/misc2.htm</a>	Bonn
41	FCCC/SBI/2004/18	Report on the assessment of funding necessary to assist developing countries in fulfilling their commitments under the Convention prepared in the context of the Memorandum of Understanding between the Conference of the Parties and the Council of the Global Environment Facility. Note by the secretariat.	United Nations Framework Convention on Climate Change (UNFCCC)	United Nations Framework Convention on Climate Change (UNFCCC)	21.10.2004	<a href="http://unfccc.int/resource/docs/2004/sbi/18.pdf">http://unfccc.int/resource/docs/2004/sbi/18.pdf</a>	Bonn
42	FCCC/SBI/2006/7	Synthesis report on the financial mechanism. Note by the secretariat.	United Nations Framework Convention on Climate Change (UNFCCC)	United Nations Framework Convention on Climate Change (UNFCCC)	16.05.2006	<a href="http://unfccc.int/resource/docs/2006/sbi/eng/07.pdf">http://unfccc.int/resource/docs/2006/sbi/eng/07.pdf</a>	Bonn
43	FCCC/SBI/2006/L.18	Adaptation Fund. Draft conclusions proposed by the Chair	United Nations Framework Convention on Climate Change (UNFCCC)	United Nations Framework Convention on Climate Change (UNFCCC)	25.05.2006	<a href="http://unfccc.int/resource/docs/2006/sbi/eng/l18.pdf">http://unfccc.int/resource/docs/2006/sbi/eng/l18.pdf</a>	Bonn
44	FCCC/SBSTA/1997/10	Development and transfer of technologies. Progress report.	United Nations Framework Convention on Climate Change (UNFCCC)	United Nations Framework Convention on Climate Change (UNFCCC)	30.09.1997	<a href="http://unfccc.int/resource/docs/1997/sbsta/10.pdf">http://unfccc.int/resource/docs/1997/sbsta/10.pdf</a>	Bonn
45	FCCC/SBSTA/1997/13	Second communications from Parties included in Annex I to the Convention: Activities of Parties included in Annex II related to transfer of technology.	United Nations Framework Convention on Climate Change (UNFCCC)	United Nations Framework Convention on Climate Change (UNFCCC)	24.09.1997	<a href="http://unfccc.int/resource/docs/1997/sbsta/13.pdf">http://unfccc.int/resource/docs/1997/sbsta/13.pdf</a>	Bonn
46	FCCC/SBSTA/1998/MI-SC.3	National communications. National communications from Parties included in Annex I to the Convention. Information submitted by	United Nations Framework Convention on Climate Change (UNFCCC)	United Nations Framework Convention on Climate Change (UNFCCC)	17.04.1998	<a href="http://unfccc.int/resource/docs/1998/sbsta/misc03.htm">http://unfccc.int/resource/docs/1998/sbsta/misc03.htm</a>	Bonn

		Parties on reporting of information on finance and transfer of technology. Submissions by Parties. Development and transfer of technologies. Projects and programmes incorporating cooperative approaches to the transfer of technologies and responses on how the issues and questions listed in the annex to decision 4/CP.4 should be addressed, as well as suggestions for additional issues and questions. Submissions from Parties: Part One. Note by the secretariat. Development and transfer of technologies. Report of the Expert Group on Technology Transfer for 2003. Note by the Chair of the EGTT.	Change (UNFCCC)	pdf		
47	FCCC/SBSTA/1999/MI SC.5		United Nations Framework Convention on Climate Change (UNFCCC)	19.04.1999	<a href="http://unfccc.int/resource/docs/1999/sbsta/misc05.pdf">http://unfccc.int/resource/docs/1999/sbsta/misc05.pdf</a>	Bonn
48	FCCC/SBSTA/2003/12		United Nations Framework Convention on Climate Change (UNFCCC)	18.09.2003	<a href="http://unfccc.int/resource/docs/2003/sbsta/12.pdf">http://unfccc.int/resource/docs/2003/sbsta/12.pdf</a>	Bonn
49	FCCC/SBSTA/2004/IN F.17	Report of the Expert Group on Technology Transfer for 2004. Note by the Chair of the Expert Group on Technology Transfer.	United Nations Framework Convention on Climate Change (UNFCCC)	06.12.2004	<a href="http://unfccc.int/resource/docs/2004/sbsta/inf17.pdf">http://unfccc.int/resource/docs/2004/sbsta/inf17.pdf</a>	Bonn
50	FCCC/SBSTA/2005/IN F.10	Annual report of the Expert Group on Technology Transfer for 2005. Note by the Chair of the Expert Group on Technology Transfer.	United Nations Framework Convention on Climate Change (UNFCCC)	28.11.2005	<a href="http://unfccc.int/resource/docs/2005/sbsta/eng/inf10.pdf">http://unfccc.int/resource/docs/2005/sbsta/eng/inf10.pdf</a>	Bonn
51	FCCC/SBSTA/2006/8	Activities implemented jointly under the pilot phase. Seventh synthesis report. Note by the secretariat. Recommendations of the Expert Group on Technology Transfer for enhancing the implementation of the framework for meaningful and effective actions to enhance the implementation of Article 4, paragraph 5, of the Convention. Note by the Chair of the Expert Group on Technology Transfer.	United Nations Framework Convention on Climate Change (UNFCCC)	13.09.2006	<a href="http://unfccc.int/resource/docs/2006/sbsta/eng/08.pdf">http://unfccc.int/resource/docs/2006/sbsta/eng/08.pdf</a>	Bonn
52	FCCC/SBSTA/2006/IN F.4		United Nations Framework Convention on Climate Change (UNFCCC)	17.05.2006	<a href="http://unfccc.int/resource/docs/2006/sbsta/eng/inf04.pdf">http://unfccc.int/resource/docs/2006/sbsta/eng/inf04.pdf</a>	Bonn
53	FCCC/SBSTA/2006/MI SC.10	Views and suggestions relating to the review of the Expert Group on Technology Transfer by the Conference of the Parties at its twelfth session. Submissions from Parties Proposed terms of reference for a report on performance indicators and for a report on future financing options for enhancing technology transfer. Note by the Chair of the Expert Group on Technology Transfer.	United Nations Framework Convention on Climate Change (UNFCCC)	21.08.2006	<a href="http://unfccc.int/resource/docs/2006/sbsta/eng/misc10.pdf">http://unfccc.int/resource/docs/2006/sbsta/eng/misc10.pdf</a>	Bonn
54	FCCC/SBSTA/2008/IN F.2		United Nations Framework Convention on Climate Change (UNFCCC)	20.05.2008	<a href="http://unfccc.int/resource/docs/2008/sbsta/eng/inf02.pdf">http://unfccc.int/resource/docs/2008/sbsta/eng/inf02.pdf</a>	Bonn
55	FCCC/TP/1998/1	Technical paper on terms of transfer of technology and know-how. Barriers and opportunities related to the transfer of technology.	United Nations Framework Convention on Climate Change (UNFCCC)	13.10.1998	<a href="http://unfccc.int/resource/docs/tp0198.pdf">http://unfccc.int/resource/docs/tp0198.pdf</a>	Bonn
56	FCCC/TP/2006/1	Innovative options for financing the development and transfer of technologies.	United Nations Framework Convention on Climate Change (UNFCCC)	28.08.2006	<a href="http://unfccc.int/resource/docs/2006/tp01.pdf">http://unfccc.int/resource/docs/2006/tp01.pdf</a>	Bonn
57	GEF/C.2/11	Response to Decision 10/3 of the Intergovernmental Negotiating Committee for a Framework Convention on Climate Change at its Tenth Session	Global Environment Facility (GEF)	03.11.1994	<a href="http://www.gefweb.org/COUNCIL/GEF_C2/GEF.C.2.11.pdf">http://www.gefweb.org/COUNCIL/GEF_C2/GEF.C.2.11.pdf</a>	Washington

58	GEF/C.3/10	Report by the GEF to the First Conference of the Parties of the Framework Convention on Climate Change	Global Environment Facility (GEF)	24.02.1995	<a href="http://www.gefweb.org/COUNCIL/GEF_C3/GEF.C.3.10.pdf">http://www.gefweb.org/COUNCIL/GEF_C3/GEF.C.3.10.pdf</a>	Washington
59	GEF/C.13/Inf.5	Engaging the Private Sector in GEF Activities	Global Environment Facility (GEF)	22.04.1999	<a href="http://www.pebids.org/files/Publications/GEF/GEF_-_Engaging_the_private_sector_in_GEFactivities.pdf">http://www.pebids.org/files/Publications/GEF/GEF_-_Engaging_the_private_sector_in_GEFactivities.pdf</a>	Washington
60	GEF/C.17/Inf.5	Program study on Climate Change	Global Environment Facility (GEF)	26.04.2001	<a href="http://gefweb.org/C.17.Inf.5.pdf">http://gefweb.org/C.17.Inf.5.pdf</a>	Washington
61	GEF/C.2/5	Guidance for Programming GEF Resources in 1995	Global Environment Facility (GEF)	03.11.1994	<a href="http://www.gefweb.org/COUNCIL/GEF_C2/GEF.C.2.5.pdf">http://www.gefweb.org/COUNCIL/GEF_C2/GEF.C.2.5.pdf</a>	Washington
62	GEF/C.21/Inf.11	Strategic Business Planning: Directions and Targets	Global Environment Facility (GEF)	17.04.2003	<a href="http://www.gefweb.org/COUNCIL/GEF_C21/C21.Inf.11.pdf">http://www.gefweb.org/COUNCIL/GEF_C21/C21.Inf.11.pdf</a>	Washington
63	GEF/C.33/7	Elaborating a Strategic Program to Scale-up the Level of Investment in the Transfer of Environmentally-friendly Technologies	Global Environment Facility (GEF)	24.03.2008	<a href="http://www.gefweb.org/uploadedFiles/Documents/Council_Documents/_%28PDF_DOC%29/GEF_33/C.33.7%20Technology%20Transfer.pdf">http://www.gefweb.org/uploadedFiles/Documents/Council_Documents/_%28PDF_DOC%29/GEF_33/C.33.7%20Technology%20Transfer.pdf</a>	Washington

## 9 Appendices

### Appendix A: Quotations from UNFCCC country submissions in relation to technology transfer 1998-2000

#### Annex I Countries

**Australia:** “the private sector (is R.H.) playing the key role in technology development, diffusion and transfer; the public sector, however, has a significant role in designing the legal, institutional and policy frameworks to facilitate private sector investments and in ensuring that adequate education, training and research and development frameworks exist and are enhanced” (FCCC/SBSTA/1999/MISC.5: 3).

**Canada:** “In order to create an effective flow and interface for the development and transfer of technologies, it is necessary to establish an enabling environment that maximizes the opportunity for the full participation of key government and private sector players in both recipient and supplier countries. .... Facilitating the establishment of such an enabling environment for the transfer of technologies should be the principal objective for governments in developing countries and economies in transition as well as for developed countries” (FCCC/SBSTA/1999/MISC.5: 12-13).

**Norway:** “While it is industry that ultimately must implement environmentally-friendly and energy efficient measures, the role of the government is to develop, design and implement an appropriate mix of instruments that will accelerate the process and encourage the industry to initiate its own improvement programmes” (FCCC/SBSTA/1999/MISC.5: 30).

**USA:** “country-specific, market-based technology transfer programs will be most effective in achieving the goals of the UNFCCC. The public sector, however, can play a pivotal role in promoting market-based technology transfer by assisting in the removal of market barriers and building human capacity” (FCCC/SBSTA/1999/MISC.5: 50). “The private sector is the main vehicle for technology transfer” (FCCC/SBSTA/1999/MISC.5: 69).

“In our view, technology will flow most quickly and easily to those countries with the proper enabling environment to attract private sector technologies. Promoting such an environment thus becomes the primary objective of government-to-government cooperation; success will be marked by a better identification and implementation of innovative enabling activities that can lead to increased technology diffusion and that encourage the replication of similar projects in other countries. Actions may be technology and sector-specific, and may also include efforts to



create stable macroeconomic conditions, transparent laws, and open trade and investment policies” (FCCC/CP/1998/MISC.5: 17).

**Austria (on behalf of the EU):** “We must recognise that the private sector is the primary agent for technology transfer within and between countries” (FCCC/CP/1998/MISC.5: 3). “The EU welcomes the existing trends towards greater public participation, resulting in more demand-driven efforts at capacity building and the transfer of environmentally sound technology. Public - private partnerships can offer a means of increasing access to, and transfer of, environmentally sound technologies. The EU stresses the need for legal and policy frameworks that would facilitate the transfer of environmentally sound technology and are conducive to technology-related private sector investments” (FCCC/CP/1998/MISC.5: 4).

**Switzerland:** “the private sector should be the driving force of the initiatives of technology transfer” (FCCC/CP/1998/MISC.5: 16).

#### Non-Annex I Countries

**China:** “Such kind of technology transfer is on a grant or concessional basis (Article 11.1 of UNFCCC), namely on non-commercial terms. ....The roles of the governments, particularly the governments of the developed country Parties, are crucial, even though the technology transfer activities may involve other actors” (FCCC/SBSTA/2000/MISC.2: 6).

**Columbia:** Technology transfer projects should “make an appreciable impact both on environmental and socio-economic terms, facilitate transfer of technology on concessional and preferential terms, encourage the direct participation of governments, with a view to promoting the development and use of the technologies on the part of the private sectors over the short term, take into consideration market factors which would make future participation by private enterprises in the use of transferred technologies an economic proposition” (A/AC.237/Misc. 41: 33).

**Egypt:** Developed countries must take practical steps to promote, facilitate, and finance the transfer of environmentally sound technologies and know-how to developing countries (FCCC/SBSTA/1999/MISC.5: 20).

**South Africa:** “A process needs to be established to address the direct information and technology transfer needs of individual developing nations. Particular attention should be given to matching specific local needs with technologies and relevant mechanisms to effect transfer and full diffusion into the mainstream of recipient nations. .... As such the focus should not be on public or private ownership, but rather on identification of technologies, identifying areas of application and then defining means of overcoming hurdles. .... For specific technologies to become fully integrated into the mainstream of a nation's economy and culture, a holistic

strategy needs to be established – specific to a particular nation and often to a particular technology (FCCC/SBSTA/1999/MISC.5: 41-44).

South Africa quite clearly underlines that technology transfer shall lead to “development of a local technology base” and also points out that technology transfer must go along with the development of a corresponding skill base to make productive use of the technology (FCCC/SBSTA/1998/MISC.3).

**Uzbekistan:** “For the improvement of the effectiveness of the transfer mechanisms the chain of the executory bodies is required: from the national information and technology centres analysing the country demands up to the specialized agencies responsible for the technology introduction, personnel training and technical maintenance” (FCCC/SBSTA/1999/MISC.5: 80). “In the process of technology transfer the private sector can participate, as well as with crediting of target oriented programs, in the independent assessment of technological needs, market transparency of the legislation basis sufficiency and effectiveness of the financial procedures (FCCC/SBSTA/1999/MISC.5: 81).

**Lebanon:** “A country like Lebanon will need full funding on adoption of environmentally sound technology. Therefore, we would appreciate your emphasis regarding the financial contribution of developed countries, related to this matter as stated in Articles 4.3 and 4.5 of the convention” (FCCC/SBSTA/1998/MISC.3: 3).

**Mauritius:** “During transfer of technologies between donor and recipient countries the following measures have to be taken into consideration:

- Objective and purpose of the transfer;
- Adaptability of the transferred technology;
- Modifications and innovations to enhance its efficiency;
- Capacity building available in recipient countries to absorb the technology in the national system;
- Transfer mechanism;
- Priority of maximizing profits; and
- Form of assistance to strengthen local capacity needs to integrate such technology”

(FCCC/CP/1998/MISC.5: 9).

**Philippines:** “In order to facilitate this transfer, including through financial assistance on grant and concessional terms, the Philippines also supports the establishment of a Technology Transfer Mechanism (TTM), as proposed by the Group of 77 and China at the June sessions” (FCCC/CP/1998/MISC.5: 12).

**Samoa** (on behalf of the Alliance of Small Island States): “There is evidence to suggest the basic position to be that a proportion of technology is held or owned by Governments and public institutions and that Governments exercise significant control and influence over the technological knowledge produced in publicly-funded research and development institutions. In short, there is potential for the generation of publicly-owned technologies which could be made accessible to developing countries. .... the incorporation of publicly-funded technologies in transfer and funding arrangements under multilateral environment agreements, especially with the Montreal Protocol experience in mind, would be of great potential value.” (FCCC/CP/1998/MISC.5: 13).

**China** (on behalf of G77): “The purpose of Technology Transfer Mechanism TTM shall be to assist developing country Parties to obtain their needed environmentally sound technologies and know-how conducive to addressing climate change on non-commercial, preferential terms and thus contribute to the ultimate objective of the convention” (FCCC/SBSTA/1998/CRP.1). China has submitted the most upfront proposition on behalf the G77 on how to implement technology transfer under the UNFCCC. It includes the suggestion that Annex II parties compile a list with relevant technologies while non-Annex II parties assess their needs. All parties then create enabling environments to stimulate private investment while simultaneously setting up technology transfer mechanism which assists developing countries in receiving environmentally sound technology at preferential terms (FCCC/SBSTA/1998/CRP.1).

## **Appendix B: Quotations from UNFCCC country submissions in relation to technology transfer 2006 – 2008**

### **Annex I Countries**

#### **Australia**

„achieved through market driven investment supported by sound legal, economic and social frameworks that are appropriate to national circumstances.“ FCCC/SBSTA/2006/MISC.10: 4 (Document on review of the EGTT)

The UNFCCC Secretariat has noted that the private sector is, and will continue to be, the overwhelmingly dominant driver of technology development and deployment. The dispersion of technologies globally is put to effect by the private sector. Intellectual property, in particular, is the domain of the private sector. The attractiveness and efficiency of global and national markets will determine the success of technology cooperation. To date, the private sector has been under-represented in discussions and should be given a greater role.

The key to enhancing investment flows is the creation of appropriate and stable enabling environments, economic incentives and supportive national policy frameworks. Targeted public sector investment in technology cooperation can play an important role, particularly in areas with no market or where the market has failed.

Countries with a capacity to develop and deploy clean technologies should focus their efforts on cooperative research, development and the deployment of new clean technologies with others.

International efforts to facilitate the deployment of clean technologies should prioritise those countries in particular the least developed countries – that will benefit most.

In order to make the most of our resources, we should use these existing processes and mechanisms rather than create new ones.

Below are a broad set of factors that could guide Parties' discussions on technology cooperation. We propose that actions should:

- Enhance the global development and uptake of mitigation and adaptation related technologies, particularly through improved trade and investment flows
- Be cost effective, by using markets to the fullest extent possible
- Address clearly demonstrated needs, market failures and/or other identified policy/regulatory barriers
- Promote or enhance sustainable market-based outcomes where appropriate.
- Complement existing activities, processes and mechanisms both inside and outside the UNFCCC to maximise benefits, use existing resources and avoid creating unnecessary overheads.

Ownership of intellectual property (IP) rights is not a significant barrier to technology cooperation or use. However, poor IP protection can deter investment and innovation. Work could be undertaken by the EGTT, in conjunction with relevant financial experts, to develop template models for IP licensing arrangements for use by Parties. Appropriate and accessible IP licensing models may improve IP protection and reduce project development costs (FCCC/AWGLCA/2008/MISC.5/Add.2\_I)

### **Canada**

Parties should cooperate to review and strengthen existing international technology mechanisms to support the global development and deployment of the clean technologies needed to achieve our shared vision of a low-carbon economy. Strengthened domestic enabling environments, including appropriate policy, legal and regulatory frameworks, should provide the foundation for increased flows on financial resources and investment in support of mitigation and adaptation.

Mobilizing and leveraging private sector investment will be paramount in achieving our shared vision of a low-carbon economy. The global carbon market should play a key role, provided that existing and new market mechanisms meet a high standard of environmental integrity.

FCCC/AWGLCA/2008/MISC.5/Add.2\_I

### **Iceland**

Technology development and cooperation are crucial for mitigation efforts and adaptation. Iceland shares such views as expressed by AOSIS, that invigorated efforts to develop and diffuse the use of renewable energy, energy efficiency and other related clean technologies are a priority. In considering such actions, cooperative sectoral approaches and sector-specific actions hold much promise. Towards that end, possible technology development and cooperation arrangements and transnational market-based instruments in specific sectors need to be developed. Financing is a necessary element in a strengthened regime for technology transfer and development. Private financing is a crucial element for climate friendly investment and actions, and ways must be found for the UNFCCC to leverage an increase in clean investment by the private sector FCCC/AWGLCA/2008/MISC.5/Add.2\_I

### **USA**

Fostering Domestic Enabling Environments. We would suggest reflecting the view that a key focus of the UNFCCC on technology could be to facilitate the creation of effective domestic environments for innovation and dissemination of environmentally sound technologies in the broader context of mitigation and adaptation strategies. The document might best reflect the notion that it is important to build and focus on existing frameworks and institutions.

Treatment of Intellectual Property Rights. The document should reflect the view that protection by countries of intellectual property rights is an essential component of an overall strategy to promote technology innovation, diffusion and transfer.

We also suggest reflecting the view that “we acknowledge the essential role of private sector investments in technology innovation and diffusion.”

On an individual basis, Parties can strengthen legal and economic institutions to promote the protection and enforcement of IPR, promote competitive and open markets for ESTs, and provide a well-defined, efficient and transparent system of contract enforcement.

we suggest adding the concept that we consider “encouraging cooperative partnership between governments and industry to promote the development, diffusion and transfer of technologies.”

FCCC/AWGLCA/2008/MISC.5/Add.2 \_II

### **Japan**

In order to achieve the long-term target, developed countries, along with developing countries that are willing to take part, should accelerate innovative technology development in cooperation with the relevant international organizations, through expanding investment in research and development, sharing technology roadmaps, and strengthening international cooperation.

The private sector owns most climate-friendly/environmentally-sound technologies, and technology transfer is already well under way on a commercial basis in various forms such as product exports, joint ventures, and licensing. In some sectors, developing countries such as China and India have already reached an advanced stage to lead the world.

- Intellectual property rights (IPRs) and their associated profits contribute to recoup research and development (R&D) investments, provide strong incentives for further technology development and transfer, and also create sources of business competitiveness.
- Therefore, the improvement of such an enabling environment for the private sector is the key for encouraging the involvement of more businesses, which leads to further promotion of technology transfer.

In order to accelerate technology transfer, analysis on the actual conditions and barriers in each sector is necessary. Based on this analysis, comprehensive solutions to accelerate measurable, reportable and verifiable (MRV) actions by both the public and the private sector on the supply and demand sides based on the principle of “common but differentiated responsibilities and the respective capabilities” should be formulated. For this purpose, enhancing the enabling environment for businesses in host countries including development of legal systems and intellectual property protection is crucial.

In order to achieve the long-term goal, it is essential not only to quickly deploy practically available technologies but also to develop innovative technologies. For this purpose, it is important for the UNFCCC to review the current progress of innovative technology R&D, and to encourage further efforts. It is important to encourage each government to make further efforts on an expansion of investment in the development of energy technologies, to develop and share technology roadmaps and to strengthen international cooperation by utilizing the reports from knowledgeable organizations such as IEA. FCCC/AWGLCA/2008/MISC.5/Add.2

## II

“It is necessary to share the view that climate-friendly technologies are owned by the private companies. The major task of the government in relation to technology transfer is to play a role as a catalyst to increase the incentives for the private companies to transfer their technologies” (FCCC/SBSTA/2006/MISC.10: 30)

## **EU**

The existing technology transfer framework (4/CP.7) and the additional set of actions to enhance implementation of Article 4.1c and 4.5 of the Convention (3/CP.13 and 4/CP.13) provide a sound foundation for future action.

An enhanced Framework on technology for mitigation and adaptation should include agreement by:

- Developed country Parties to scale-up both their RD& D efforts and support related to technology through assistance to support developing countries efforts for technology needs assessments, human and institutional capacity building, design of national deployment schemes, and participation in voluntary cooperative technology-oriented agreements;

EU on enabling environments:

All parties are required to improve enabling environments for technology diffusion through the identification and removal of barriers that can serve to expand commercial and public technology transfer to developing countries

For a future climate change agreement the EU proposes that:

Technology-specific policies and measures (PAMs) should be defined/strengthened and implemented.

These PAMs should include deployment schemes for low-carbon technologies and national energy and climate policies (e.g. standards for energy efficiency and emissions limitations, abolishment of perverse incentives for carbon intensive technologies, IPR protection regulation, public procurement).

Additional actions to strengthen technology development and transfer: Technology oriented agreements (TOAs)

Cooperative actions and partnerships outside the UNFCCC play an important role at contributing to the development, transfer and deployment of technologies relevant to mitigation and adaptation. Several of these activities are also engaging the private sector and civil society organisations.

To this end, the EU proposes:

The establishment and recognition under the UNFCCC of focused voluntary TOAs. Such cooperative TOAs would include, inter alia cooperative R&D and large scale demonstration projects (e.g. energy, transport, infrastructures, CCS, concentrated solar power, adaptation-related technologies ), technology deployment projects (e.g. on energy efficiency, renewable energy), cooperation on specific sectors or gases, such as F-gases, cooperation on climate observation and warning systems for enhancing resilience.

## 2.3 Means of implementation

### Finance

Scaled-up finance related to technology should include assistance to support developing countries efforts for technology needs assessments, human and institutional capacity building, design and implementation of national deployment schemes, and participation in voluntary cooperative technology-oriented agreements. There will be a central role for national governments to implement regulatory and market based incentives to attract public and orient private finance towards the deployment of low carbon technologies. Public finance should, wherever possible, spur and catalyse the involvement of the private sector to provide leverage on private flows as private investment will be the bulk of the scaled-up finance, particularly for mitigation, and will play a major role in driving economic and technological changes. The EU notes there are many existing significant funds and bodies financing activities related to climate-friendly technologies. Public financing for technology should focus on market “gaps” identified along stages of technology innovation chain. The EU supports the ongoing work of the EGTT regarding the identification and analysis of existing and potential new financing resources and vehicles.

### Institutional arrangements

Finally, with regard to institutional arrangements, the EU believes there is a need to support the delivery of the technology provisions of the Convention in the future climate change agreement. These arrangements will need to help guide, support, verify and monitor the activities and commitments related to technology within the Convention. They will also monitor the activities



related to technology beyond the Convention since many organisations are undertaking and will undertake important work on technology. These arrangements would also be useful in providing a “home” for technology information dissemination. The formal aspects of these arrangements should also be finalised by taking into account the possible institutional needs raised in the other building blocks of the negotiation. FCCC/AWGLCA/2008/MISC.5/Add.1a

### **New Zealand**

Creating “enabling environments” is very important for research and development (R&D) and commercial deployment of current, new and innovative technologies. When creating enabling environments, governments need to recognise the important role of the investment/business community in developing and deploying technology, and make full use of the range of policy support measures available to them.

2. For R&D and deployment of mitigation technologies the investment community needs clear incentives. New Zealand considers that a carbon price signal and removal of environmentally harmful subsidies are critical foundations. To maximise incentives and to minimise leakage, this carbon price signal needs to apply as broadly as possible. There may be a need for transitional financial incentives to supplement the carbon price signal, as well as other policy measures to overcome non-price barriers.

The most important contribution that the UNFCCC can make is the development of an effective global agreement on climate change that establishes a price on carbon to apply as broadly as possible, and sends a clear signal to the global investment community to set up and direct resources to towards technology development and innovation”

New Zealand is committed to international cooperation on research and development of technologies in the livestock agriculture sector and we are seeking other countries to actively cooperate with us in this effort.

New Zealand is committed to international cooperation on research and development of technologies in the energy sector, and we are always seeking new opportunities to enhance our existing cooperative relationships with other countries in this respect.

17. The key focus of our international energy technology research and development effort is our work under a number of IEA Implementing Agreements.

Enabling environments are fundamental to the research and development of technologies and to the successful deployment of new technologies. A carbon price signal and removal of environmentally harmful subsidies are critical foundations. To maximise incentives and to minimise leakage, this carbon price signal needs to apply as broadly as possible. There may also be a need for transitional financial incentives to supplement carbon price signals, as well as

other policy measures to overcome non-price barriers. We should look to strengthen the catalytic role of the Convention to promote and facilitate multilateral technology cooperation inside and outside of the Convention, and build upon existing initiatives/institutions. Parties could make an explicit political commitment to actively promote and resource global technology cooperation

### **Turkey**

Turkey believes that a technology transfer fund will be very supportive for developing country Parties

Turkey proposes that a new technology transfer mechanism financed by a fund/body under the Convention should be formed with contributions of Annex–II countries as per Article 4, paragraphs 3, 4 and 5 of the UNFCCC. In this mechanism, concessionary loans, export loans or tax incentives could be used to attract investment in technology development and transfer as well. The Mechanism should be tailored to the needs of all Non-Annex–II Parties of the Convention.

Without any differentiation between developed and developing countries, the support should be determined by taking into account GHG reduction and technology diffusion potentials of the countries. Furthermore, irrespective of the status of the project hosting country, a reduction credits trading system to be established among sectors and/or countries would shift the technology transfer from one-way mechanism to a bilateral arrangement.

FCCC/AWGLCA/2008/MISC.5/Add.2 \_II

### **Non-Annex I countries**

#### **Antigua and Baruda (on behalf of AOSIS)**

Ways to accelerate deployment, diffusion, and transfer of affordable Environmentally Sound Technologies:

immediate and urgent delivery of technology to developing countries requires suitable responses, including a continued emphasis by all Parties, in particular developed country Parties to the Convention,

- on enhancement of enabling environments

- facilitating access to technology information and capacity-building,

- identification of technology needs and

- innovative financing that mobilises the vast resources of the private sector to supplement public finance sources where appropriate.

Provision of adequate financial resources to facilitate the transfer of technologies to developing countries for mitigation and adaptation. Such financing should be made available to defray and/or pay for the cost of Intellectual Property Rights or pay for alternative access regimes.

On ways to accelerate deployment, diffusion and transfer of technologies, specific proposals on capacity-building include: The establishment and provision of support to national and regional academia and Centres of Excellence the promotion of South – South co-operation

Co-operation on research and development of current, new and innovative technology, including win-win solutions FCCC/AWGLCA/2008/MISC.5/Add.2\_I

### **Argentina**

Argentina fully supports the proposal made by the G77 & China on an institutional structure under the Convention to enhance technology development, deployment and transfer and associated enabling activities such as capacity building at institutional level, technical training among private and public stakeholders, and bilateral and multilateral research and development cooperation.

Further enabling activities for technology development and transfer should include activities at all stages of the technology development cycle, i.e. research and development (R&D), institutional capacity building and technical training, technology demonstration, deployment and diffusion. In fact, transfer of technology involves the pursuing all these issues and not simply the technology trading and post-sale services. Transfer of technologies should also be supported by appropriate domestic policies, regulations and standards, and institutional arrangements in the recipient countries. FCCC/AWGLCA/2008/MISC.5

### **Bolivia**

Developed countries cannot treat knowledge and innovation crucial for survival as private property through the existing intellectual property system, and as something "sacred" that has to be preserved at any cost.

Technology related to climate changes must be fully within the public domain, not under any private monopolistic patent regime that obstructs and makes technology transfer more expensive to developing countries.

In-depth study of issues and proposals through an UNFCCC Commission on Innovation and Access to Climate Technologies and a follow-up working group and action plan, including a global strategy and global initiatives (along the lines of the WHO Commission) and the G77 and China proposal for an enhanced technology mechanism under the UNFCCC.

- Clarification and possible expansion of flexibilities in the intellectual property rights system on compulsory licensing, parallel imports and a waiver of the requirement that production be

"predominantly for domestic market" to allow diffusion of technologies in developing countries with insufficient manufacturing capacity.

- Clarification or expansion of exemptions for climate-friendly technologies, using existing or new provisions in the intellectual property system including the use of exemptions and implementation periods in developing countries vis-a-vis developed countries.
- Non-voluntary and mandatory/voluntary licensing such as those used by some developed countries which empower courts to compel patent holders to provide licenses to other technology users or producers at a specified royalty for technologies that prevent/reduce air pollution (e.g. components in cars).
- Patent pooling, for example, through one-stop centers for obtaining licenses for technologies at specified and discounted rates to facilitate cheaper and easier licensing for products that either reflect multiple patents or for which there are multiple users especially in developing countries.
- Expansion of public domain for technologies that have been publicly funded by governments or through international cooperation or agencies.

Technologies must be in the public domain and available to all people without monopolistic requirements that inhibit access and undermine efforts to tackle climate change. To promote access to and transfer of technologies, we also call for so-called enabling environments to promote the transfer of technologies from developed countries to be improved, in order to ensure the availability of full funding for the transfer of all relevant technologies and know how to developing countries. FCCC/AWGLCA/2008/MISC.5/Add.2\_I

### **Brazil**

“increase the contracting of technological research in developing countries .... consider new approaches that combine intellectual property rights protection and facilitated technological sharing, bearing in mind the example set by decisions in other relevant international fora related to intellectual property rights, such as the Doha Declaration on the TRIPS Agreement and Public Health ..... consider incentives to stimulate technology transfer within companies, with a view to strengthening capacity in subsidiary companies located in developing countries; ..... foster the establishment of national/regional technology excellence centers to promote technology development, deployment and transfer, stimulate capacity building, improve access to information, support an innovation culture and establish an appropriate international cooperation environment ..... establish new financing mechanisms and tools for scaling up the development, deployment and transfer of technology, in particular privately owned technology, to support action on both mitigation and adaptation to climate change in accordance with Article

4 paragraph 3. .... Brazil believes that a new mechanism under the Convention should be created to address these issues” FCCC/AWGLCA/2008/MISC.5

### **China and G 77, India**

China submitted in 2008 another proposal related to technology transfer on behalf of the G 77. The same proposal was submitted by India. The proposal asks for a new mechanism to support “development, deployment, adoption, diffusion and transfer of environmentally sound technologies” (FCCC/AWGLCA/2008/MISC.5). The fund shall support research, development, transfer and diffusion of technology. Transfer and diffusion shall be realised through the provision of finance. The fund shall also ensure that technologies in the public domain are transferred to developing country decisions and adapted to local conditions. Patented technologies shall be made available on an affordable or no cost basis. Activities supported by the mechanism shall include:

- Promotion, facilitation and implementation of activities along the entire technology cycle to enable the accelerated adoption of ESTs;
- Support for research, development, manufacture, commercialization, deployment and diffusion of technologies for adaptation and mitigation in accordance with Decision 1/CP.13.
- adaptation technologies to address the adverse effects of climate change and finance the removal of barriers to the large-scale transfer of technologies for adaptation;
- technologies to address the adverse impact of response measures, and finance the removal of barriers to the large-scale transfer of technologies for reducing the adverse impact of response measures;
- capacity-building to manage and generate technological change, enhance absorptive capacity, create enabling conditions in developing countries, inter alia, costs of:
  - Research, development and demonstration of new technologies;
  - Enhancing human and institutional capacity;
  - Guarantees on foreign direct investment for environmentally sound technologies.
- Commercialization of new and emerging technologies, inter alia:
  - Venture capital, with public investment leveraging private capital markets for emerging technologies;
  - Research, development, and demonstration of new technologies, financed by venture capital and other sources;
  - Joint technology development.

- Creation of manufacturing facilities for EST, including low-GHG emission technologies, inter alia, costs of:
  - Compulsory licensing, cost associated with patents, designs, and royalties;
  - Conversion of existing manufacturing facilities or of establishing new facilities;
  - Research and development activities, including joint research, development, design, and demonstration;
  - Technology adaptation;
  - Retraining and dissemination of know-how;
  - Operation; and
  - Monitoring and verification.
- Procurement of low-GHG emission technologies, including software and hardware, inter alia:
  - Cost of premature modification or of replacement of existing equipment, as well as the cost of new equipment;
  - Cost of retraining and dissemination of know-how;
  - Cost of technical assistance for the design, installation, and stable operation of the technology;
  - Cost of fuel and other operational costs;
  - Cost of technologies for fuel switching;
  - Cost of monitoring and verification.

### **Pakistan**

The key concern that has been and should be at the center of discussion and future actions is to make technology accessible to all those affected. We must bring about flexibilities in the intellectual property rights regime. Approaches include:

- a) An international system or an agreement or declaration on compulsory licensing for climate friendly technologies along the lines of that undertaken in the health sector;
- b) Joint technological or patent pools providing and transferring technologies to the developing countries at low cost, an idea which earlier guided the discussion on health and TRIPS;
- c) Limited time patents. This body could consider calling for reducing the life of patents on climate friendly technologies, so that they could be commercialized quickly;

d) And most importantly, the provision of Incentives (tax exemption, subsidies etc) for the owner of technology for differential pricing;

e) Along the lines of World Health Organizations (WHO), an in-depth study of issues and proposals through an UNFCCC led Commission on Innovation, Intellectual Property Rights and Access to Climate Technologies and a follow-up working group and action plan, including a global strategy and global initiatives (along the lines of the WHO Commission) and the G77 and China proposal for an enhanced technology mechanism under the UNFCCC.

**Panama on behalf of Costa Rica, El Salvador, Honduras, Nicaragua,**

1- Developed countries should agree to a quota of technological and financial transfer to sustain voluntary mitigation actions in developing countries.

2- Developing countries could establish a list of possible mitigation options each associated with a cost.

3- The developed countries could then bid or select from the developing country proposals therefore allowing countries to cooperate to reach this common mitigation goal.

4- The technological and financial support pledged by the developed countries should be verified by an independent body to ensure that countries meet this new commitment.

Whether this strategy of long-term cooperation or another one is retained, the countries of Central America feel that it is essential that developed countries commit to a target of financial aid and technology transfer to sustain the effort of developing countries to reduce their greenhouse gas emissions. Without a clear, transparent and sustained new financial flow, mitigation efforts will not succeed

**Trinidad and Tobago**

The “technology target” or “technology objective” will be met in technology terms by Annex I Parties as provided for under the UNFCCC, and can be effected through the public, private or both sectors, as will be determined by Annex I Parties through appropriate domestic policy.

FCCC/AWGLCA/2008/MISC.5/Add.2 \_II

**South Africa**

Mitigation actions by developing countries must be supported and enabled by developed countries through the provision of the means of implementation (technology, financing and capacity-building) to developing countries in a measurable, reportable and verifiable manner, including:

i. Financing and incentives for pledged mitigation actions by developing countries will be essential. Incentives could come from different categories of funding sources, including

(1) public funding (e.g. grant finance, subsidies); (2) market-linked sources of funding (e.g. revenues from auctioning of allowances); (3) carbon market (e.g. CDM, ETS, no-loss sectoral crediting baselines); (4) market finance (e.g. loans on preferential terms, revolving credit, venture capital); and others.

ii. Technology development, application and diffusion, including transfer, should be supported across the technology life-cycle, including support in the form of different categories of costs (full, incremental) and support for the practices and processes to enhance the absorptive capacity for technologies in developing countries.

iii. Technical assistance and capacity building to ensure the widespread absorption and rollout of the mitigation measures, such as the need to build local production, installation, operation and maintenance capacity. FCCC/AWGLCA/2008/MISC.5

### **South Korea**

Proposal: To recognize carbon credit for the verifiable mitigations arising from the NAMAs (Nationally Appropriate Mitigation Actions) of the Bali Action Plan Decision 1 Para.1(b)(ii) as a sustainable source of finance and technology transfer for mitigation actions of developing countries. Carbon credit for NAMAs could be established under the UNFCCC as one of the means of finance and technology transfer mechanism for the Bali Action Plan while the CDM under the Kyoto Protocol is primarily a compliance mechanism for Annex 1. Revenue from the sales of the credits will channel financial resources and technologies necessary for the NAMAs of developing countries.

Rationale: Mitigation actions of developing countries have to be supported by financial flow and technology transfer. However, most of the financial resources and technologies are in the hands of private sector and the governments of the Annex 1 Parties can only play a limited role in transferring financial resources and technologies.

A new climate regime needs a sustainable source of finance and technology for the mitigation actions of developing countries. Public funds which are being proposed by the public sector such as governments and development financing institutions are limited in scope and size. Public funds will not be large enough to sufficiently cover all the financing and technology transfer needs of developing countries. FCCC/AWGLCA/2008/MISC.5

ANTIGUA AND BARBUDA ON BEHALF OF THE GROUP OF 77 AND CHINA

### **Venezuela**

La propiedad intelectual es un concepto que no ha permitido la necesaria transferencia tecnológica que requieren los países en desarrollo. Los países desarrollados tienen una gran



deuda en esta materia, y se les debe instar a que cumplan con la misma pero a través de métodos razonables y justos, en contraposición a los MDL. FCCC/AWGLCA/2008/MISC.5/Add.2 \_II

### **Indonesia**

Such cooperation entails an iterative process involving government, the private sector, and research and development facilities to ensure the best possible results from transfer of technology. Successful longterm partnerships in technology cooperation require continuing systematic training and capacity-building at all levels over an extended period of time.

A large body of useful technological knowledge lies in the public domain. There is a need to secure access of the developing countries to patented technologies as well as those in the public domain.

Substantial consideration must be given in dealing with patent protection and intellectual property rights in the context of access to and transfer of environmentally sound technology.

FCCC/AWGLCA/2008/MISC.5/Add.2 \_II

## Appendix C: List of Interviewees

### 1) Chapter 5: The Global Environment Facility

Charles Feinstein Sector Manager Infrastructure The World Bank Washington, DC, USA	Christine Wörten Programme Manager Climate Change Global Environment Facility Washington, DC, USA	Alan Miller Coordinator GEF International Finance Corporation Washington, DC, USA
Richard Hosier Team Leader Climate and Energy Global Environment Facility Washington, DC, USA	Luis Gomez-Echeverez Director Public-Private Partnerships Programme UNDP New York, USA	Mark Radka Energy Programme Coordinator UNEP Paris, France

### 2) Chapter 6: PVMTI Project in India

Indian Government (in service and retired)

S.P. Gon Chaudhuri Special Secretary, Power Govt. of West Bengal Colcata, India	Dr. J. Gururaja Renewable Energy Advocacy Forum, former UNFCCC negotiator Bangalore, India	Prodipto Gosh Prime Minister's Council Climate Change New Delhi, India
Nagappa K. Payannavar Deputy General Manager Karnataka Renewable Energy Dev. Bangalore, India	T.C. Tripathi Group Head Solar Photovoltaic Programme Ministry of New and Renewable Energy New Delhi, India	Bargavah Head Division Solar Photovoltaic Development Ministry of New and Renewable Energy New Delhi, India
P.V Sastry Professor Renewable Energy Osmania University Hyderabad, India		

## PVMTI Stakeholders

Jyoti Poddar Director Environ Energy Tech Kolkata India	Harish Hande Chief Operating Officer Selco Solar India Bangalore, India	N.P. Ramesh CEO ORB Energy (Formerly Shell India) Bangalore, India
Jonathan Forster Investment Manager IMPAX Asset Managemen London, UK	Kumar Director Shri Shakti Alternative Energy Hyderabad, India	Antil Nair CEO Sunwatt Technologies
Deviany Hari Chief Financial Officer IT Power India Pondy cherry, India		

## Indian PV Experts

B.D. Sharma Senior Advisor Integrated Action for Research and Development New Delhi, India	Ackancha Chaury TERI-The Energy and Resources Institute New Delhi, India	
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## Indian PV Industry

N.P. Ramesh Chief Operating Officer ORB Energy Bangalore, India	M.B. Mathur General Manager Rajahstan Electronics Jaipur, India	Amitabh Kumar Gupta Managing Director Synergy Kolkata, India
Pawan Kulshreshtha Manager Marketing Maharishi Solar Technology New Delhi, India	Ranajit Sinha Director Sigma Solar Kolkata, India	Chiranjeev Sulav Managing Director Premier Solar Systems Hyderabad, India
S. Vasanthi	Mohan Murali	K. Subramanya

Director - Technical and Marketing Webel – SL Energy Systems Kolkata, India	DGM – Sales and Marketing Sun Technics Bangalore, India	Chief Executive Officer Tata BP Solar Bangalore, India
Srinath T. Director Technical EMVEE Glas and Photovoltaics Bangalore, India	N. Ramakrishna Director Access Solar Limited Hyderabad, India	K. Srinivas Kumar CEO Kotak Urja Bangalore, India
Dr. G Rajeswaran President and CTO MoserBaer Photovoltaics New Delhi, India	Pampapathy Anchala Chief Operating Officer Titian Energy Systems Secunderabad, India	Ashok Ramakrishna Sr. Deputy General Manager Bharat Heavy Electricals Bangalore, India
Ashok, CEO and Founder UPV Solar		

## **Appendix D: Development of Subsidy for Solar Home Systems within SPP**

The state renewable energy agencies designed projects within which end-users purchase PV systems with a 50 per cent subsidy on ex-work cost (cost without installation), and initially limited to the selected states.<sup>102</sup> Furthermore, the subsidy scheme was extended to cover all Indian states. The regents covered previously were designated as special regions with higher subsidy rates (MNES 1997). In 1988, the subsidy for solar home systems was capped at 6000 Rupees (MNES 1999). In 2000, the number of special regions was reduced to two (the North-Eastern Region and Sikkim), for which the subsidy was increased to 10,000 Rupees, or 90 per cent of ex-work costs (MNES 2001). In 2001, the subsidy for solar home systems in the other regions was reduced to 5,500 Rupees or 50 per cent of ex-work costs as a reaction to decreasing prices (MNES 2002).

In 2003, the subsidy scheme became more differentiated. It distinguished from then on between five different solar home system types in the price range from 2,400 to 9,840 Rupees, depending on the size (from 18 to 74 Watt module) and duration of warranty (two, five, or ten years) or 50 per cent of work costs. A similar differentiation was introduced for the special regions where subsidy ranged from 4,300 to 9,840 Rupees or 90 per cent of ex-work costs. As a reaction to further price decreases, MNES reviewed manufacturing prices and set new maximum prices for PV including SHS. The number of special areas was extended to the North Eastern Territories, Sikkim, Jammu and Kashmir, Himachal Pradesh, Uttaranchal, and non-electrified islands (MNES 2004). In 2004, the subsidy for the largest system (74 W) was reduced to the subsidy of 37 W systems as it was felt that only well-off people bought those systems (MNES 2005).

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<sup>102</sup> Assam, Arunachal Pradesh, Manipur, Meghalaya, Mizoram, Nagaland, Tripura, Sikkim, Himachal Pradesh, Jammu and Kashmir, Andaman and Nicobar Islands, Lakshadweep, and Hill districts of Uttar Pradesh and West Bengal.

### Appendix E: CO<sub>2</sub> displacement through PVMTI India

Variable	Units		
	Till end March 2006	Till end PVMTI (December 2009)	
<b>Shell Solar India</b>			
Kerosene replacement (Litres)	10,021,762.37	17,550,439.74	litres
CO2 emission factor of Kerosene (tCO2/litre of kerosene)	0.002	0.002	tCO2/litre
Estimated annual net Electricity Generation by the project activity (MWh)	1,114	1,950	MWh
Baseline Emission Factor Electricity	0.93	0.93	tCO2e/MWh
Emissions Saving tCO2e	26,019.0	45,565.3	tCO2e
<b>SELCO</b>			
Kerosene Replacement (Litres)	4,945,896	8,397,810	litres
CO2 emission factor of Kerosene (tCO2/litre of kerosene)	0.002	0.002	tCO2/litre
Estimated annual net Electricity Generation by the project activity (MWh)	123.65	809.46	MWh
Baseline Emission Factor Electricity	0.93	0.93	tCO2e/MWh
Emissions Saving tCO2e	12,444.9	21,687.9	tCO2e
<b>SREI (EETS)</b>			
Kerosene Replacement (Litres)	5,499,790.8	9,631,414.464	litres
CO2 emission factor of Kerosene (tCO2/litre of kerosene)	0.002	0.002	tCO2/litre
Emissions Saving	13,710.8	24,010.9	tCO2e

<b>Shri Shakti</b>			
Estimated annual net Electricity Generation by the project activity (MWh)	761.24	1,333.12	MWh
Baseline Emission Factor Electricity	0.93	0.93	tCO2e/MWh
Emissions Saving tCO2e	707.6	1,239.1	tCO2e
<b>Total PVMTI India Savings</b>	<b>52,882.3</b>	<b>92,503.2</b>	<b>tCO2e</b>

Source: IT Power India

## Appendix F: Background information on Indian PV Industry

Table 1: Sample of Indian PV manufacturers interviewed

Type of Business according to integration along value chain	No. of firms	No. of interviews
Manufacturers of wafers, cells and modules, systems	1	1
Manufacturers of cells, modules and systems	5	2
Manufacturers of cells and modules	3	3
Manufacturers of modules	3	1
Manufacturers of modules and systems	7 <sup>103</sup>	6 <sup>104</sup>
Total	19	13

Source: Author

Table 2: The ten largest PV cell manufacturers in 2005

Company	Share %	Origin	Production plants
Sharp	23.5	Japan	UK, Japan
Kyocera	7.8	Japan	Czech. Rep., China, Mexico, Japan
Q-Cells	9.1	Germany	Germany
Sanyo	6.9	Japan	Hungary, Mexico, Japan
Schott Solar	5.2	Germany	Germany
Mitsubishi Electric	5.5	Japan	Japan
BP Solar	4.7	UK	Spain, USA, China, India, Australia
Suntech Power	4.5	China	China
Shell Solar	3.2	US	Germany, Portugal, USA
Motech	3.3	Taiwan	Taiwan
Others	26.3		

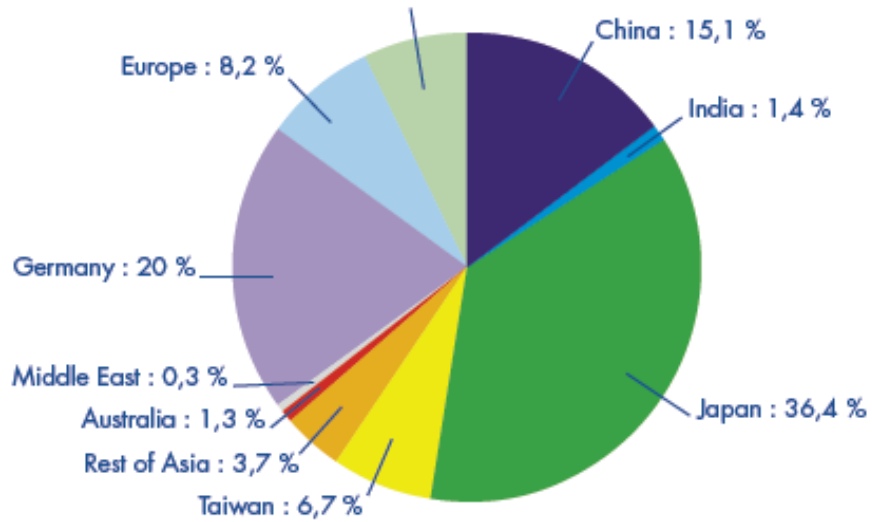
Source: (TERI 2006; Schmela 2006)

<sup>103</sup> One module producer was not taken into account as part of the population of this study since it produced modules only of 5Wp used for applications such as solar toys. It procures no modules for applications relevant to this study.

<sup>104</sup> The interview with Photonsolar did not yield any insights regarding innovation tech access as the representative declined to comment on the subject.

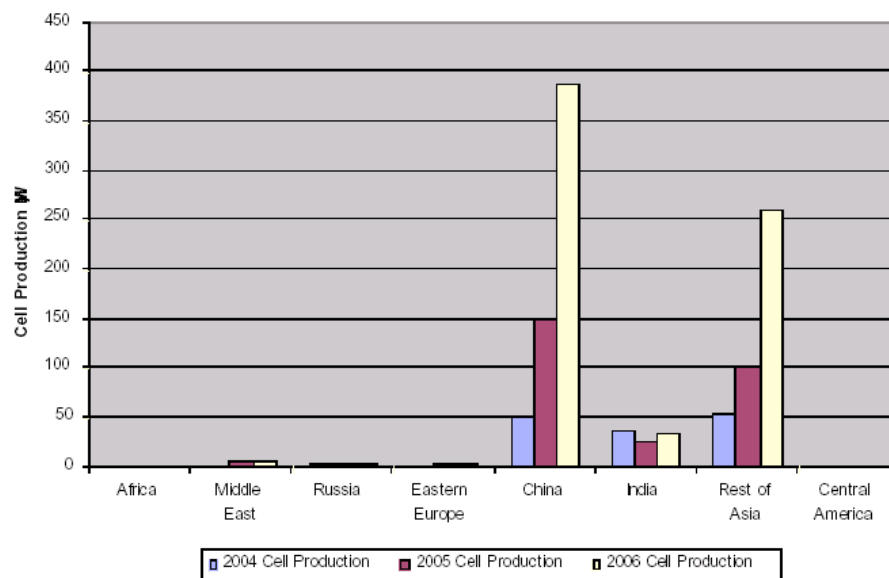


Figure F1: regional share in cell production in 2006



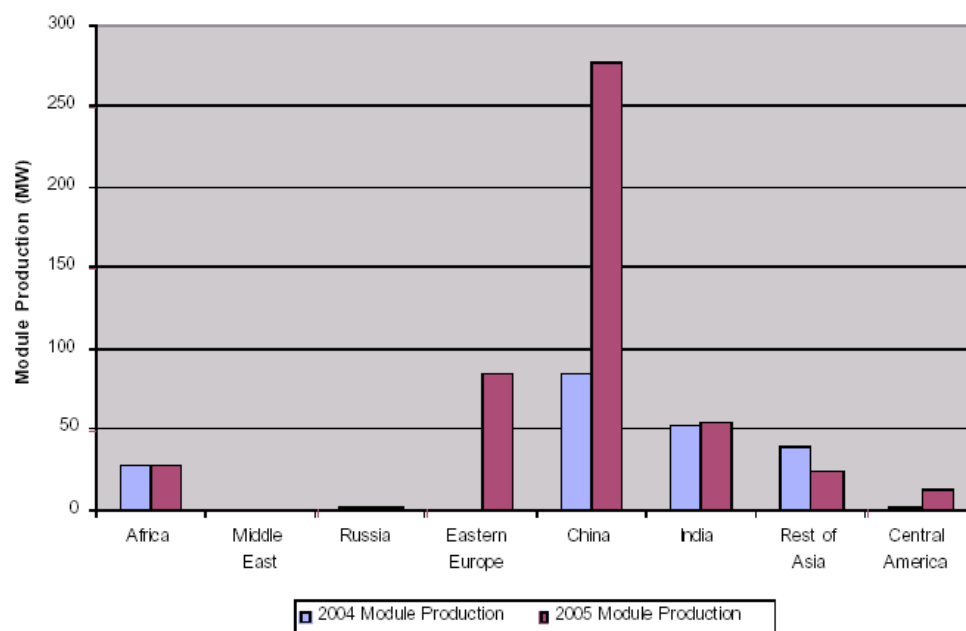
Source: European Photovoltaic Technology Platform 2007

Figure F2: PV cell production in developing countries 2004-2006



Source: Hirschman et al 2007, Schmela 2005, 2006

Figure F3: Module production in developing countries



Source: Schmela 2005, 2006

Table F1: Basic data of Indian PV cell manufactures

Company	Prod Cap Cell MW	Efficiency	Prod Cap Module MW	Export Share	Foundation	Ownership
BHEL	?	13	?	50	1975	Government
Moser Baer	40	12 to 16	40	100	2006	Private
Webel	10 Mono	12 to 14	Integrated	90	1991	Government Private
Maharishi	3,5 Mono, Poly	12 to 16	Intergrated	60 - 80	1999	Private
Tata BP	52 Poly	12 to 16	105	70 - 80	1989	Private Int. JV
UPV	?	12 to 13.5	?	80	2004	Private
CEL	?	?	?	50	1974	Government
BEL	Mono	?	?	30	1994	Government

Source: interviews, company websites, TERI 2006

## **Appendix G: Extended summaries of PVMTI subproject experiences**

### **Shri Shakti Alternative Energy**

**Business model:** Shri Shakti Alternative Energy sought initially to market PV consumer applications by establishing 300 energy stores. The setup was supposed to benefit through the existence of a franchise dealer network selling liquefied petroleum gas (LPG) products of the Shri Shakti Group (Gunning 2003). Shri Shakti received a grant and a loan through PVMTI funds. IFC also acquired a 26 per cent equity stake in Shri Shakti.

**Experience:** Soon after starting operations, SSAEE changed its business model. The company set up eight energy stores with PVMTI funds but decided against further expansion as they were not considered to be profitable on a stand-alone basis, and more stores were considered too risky.

As a result, SSAE decided to use their existing dealer network selling other Shri Shakti Group products to market PV systems. However, the dealers could not be convinced to sell them as the PV products could not carve out a niche for themselves and suffered from a higher price when compared to the equivalent consumer products. The value proposition of selling PV products was not attractive enough to traders in the existing distribution channels.

Consequently, SSAE changed its business model from marketing PV consumer appliances (including SHS) towards sales of LPG products and small PV power plants. To market LPG, SSAE tied up with Indian Oil and Hindustan Petroleum to market gas appliances through their network of nearly 4,000 gas dealers all over India. However, this model suffered a serious setback as Indian Oil and Hindustan Petroleum both cancelled the agreement after two years. They did not want to promote sales of gas appliances as these companies were losing money on LPG sales due to government subsidized prices to domestic customers.

SSAE also faced problems regarding the sale of small solar PV power plants. The underlying market largely consists of government projects. The government favours companies with a module manufacturing backbone to supply these projects, so SSAE was structurally disadvantaged since they could not use PVMTI funds to expand into manufacturing. Two contracts, e.g. which had already been awarded, were cancelled by the government and re-issued to competitors with module manufacturing capacities.

Currently, Shri Shakti Alternative Energy caters to the private market through retail. PV products offered are small-scale products (lanterns, etc.) and small power plants. It also sells smaller solar power plants (grid and stand-alone), street lighting and pumping systems as well as home lighting systems through government programs. According to Shri Shakti, sales

documents, sales to government programs are higher than direct sales to private customers regarding installed generation capacity (77.28 kW government vs. 63 kW private).

**Achievements:** Shri Shakti Energy Alternative has made the lowest sales in solar PV of all PVMTI investments. The reason is mainly that the initial business idea was abandoned in favour of the marketing of LPG. The interviewee stated quite clearly that “the project was not a success”.

**Reasons:** Interviewees mentioned a number of reasons for the poor performance of the PVMTI investment. Shri Shakti had misjudged the market potential for PV consumer applications as envisioned in the original business model. The following idea to market LPG through partnerships with established oil companies failed because of unpredictable LPG subsidy policy to state-owned companies by the government effectively harming private players<sup>105</sup>. The business is further hampered by the government’s preference for suppliers with a manufacturing base regarding procured small-scale PV power plants.

In addition to the management and market related explanations, interviewees also identified constraints through PVMTI. While on the one hand being flexible to allow for a complete change in the business model, on the other hand, SSAE regretted not having been able to invest in manufacturing as other sustainable business models in PV outside the government subsidy scheme are based on manufacturing. Business operations were further hampered through the spread of the funding over five years entailing transaction costs through recurring due diligence in order to receive disbursements and reduced flexibility to react to changes in the market. If the money would have been disbursed in fewer instalments, SSAE felt it could have improved market development.

Another severe constraint resulted in the perspective of SSAE from the institutional setup of an external management team in form of IMPAX and IFC. It had led to procedures and decision-making processes which were too long to effectively manage a company.

On a more general level, the SSAE representative criticized that PVMTI had completely overestimated the market beyond the government-subsidised share and had consequently neglected an alignment with the government program. If that would have been sought, policies beyond the rural market could have been developed and PVMTI activities could have been integrated within the existing government programs. Furthermore, the interviewee missed efforts and funds from the PVMTI side to undertake action-oriented research and policy pilots in order to increase the reflexivity of the program.

### **Selco India**

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<sup>105</sup> The government announced removing subsidies for LPG but, in the end, did not.

**Business Model:** Selco India was founded in 1995 with initial funding from the Rockefeller Foundation and the Solar Energy Light Fund. In 1997, it became a 90 per cent-owned subsidiary of Solar Electric Light Company Inc., a US-based photovoltaic company. Subsequently, Selco received equity investments from Selco US, accessed World Bank/GEF dollars for lending to end-users through IREDA, and received a conditional grant from Winrock International (WI), provided under the USAID Renewable Energy Commercialization project.

Selco operates mainly in the state of Karnataka, but also in Kerala and Andhra Pradesh. The business model of Selco consists of the integration, sale and service of solar systems for domestic use and larger applications for commercial or institutional purposes. Selco's offer included the provision of end-consumer finance through partnerships with banks. Selco sells PV applications through its own sales and service centres and independent dealers. It operates outside the Indian government programs but up to now sells systems within PV programs of international donors.<sup>106</sup>

Selco received a loan and a grant through PVMTI funds but its equity has been exclusively from its US affiliate. The PVMTI loan represents the largest loan taken out by Selco. The money was used as working capital inventory and as guarantee to back an expansion of PV consumer finance through the banking system.

Selco submitted an initial proposal in 1998 and received the first disbursement of the PVMTI loan in 2003 and the third and last disbursement in 2005. The loan repayment period started in 2006. With the PVMTI funds, Selco planned to expand existing sales infrastructure offering PV applications as well as end-consumer loans through partnerships with rural banks in southern India.

**Experience:** Since its foundation, the business model of Selco has not changed. Their customer base is rural, and grid-connected private households from the middle class to below the poverty line and small enterprises as well as public institutions. By the time of the interview and according to a SELCO representative, the company has been in an economically unstable position and went through a severe crisis since the acceptance of PVMTI funding.

**Achievements:** Currently, the company owns and operates 25 sales and service centres in the states of Karnataka, Kerala and Andhra Pradesh. PVMTI funds contributed positively to Selco's operations. Revenues increased steadily, and the company became profitable in 2005.

Selco has, according to the interviewed company representative, no contractually-fixed goals in relation to PVMTI. Initially agreed goals were abandoned by the IFC/GEF due to the late and

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<sup>106</sup> Most recently within the UNEP Loan Program for Solar Home Systems.

protracted payout of PVMTI funds. Selco has sold considerably more systems than other recipients of PVMTI funds though less than Shell.

**Reasons:** A number of reasons contributed to the difficult commercial experience since the receipt of PVMTI funding. These relate to delays in forging partnerships, a dramatic rise in module prices due to demand in Europe and design as well as implementation of the PVMTI.

One of the major constraints was that Selco received the first loan instalment five years after the submission of their proposal. The reason for the delay lies in an initial rejection of the proposal, comprehensiveness of documentation requirements, the long decision-making procedures within the external management team built by IMPAX and the IFC and also difficulties in forging partnerships with banks Selco had not worked with before.

IFC rejected Selco's initial proposal as its business model was not considered viable. When rewritten, revisited and finally accepted, Selco felt constrained by the inflexibility of the IFC as well as the organisational setup. Managing the funds in the UK seemed too remote for timely and effective operations. In the eyes of the interviewee, an Indian bank would have been more effective. The Selco representative also felt that a lack of commitment and shifting responsibility within the IFC hindered effective procedures. Furthermore, due diligence was too time-consuming to solicit funds in a way that allowed seizing opportunities and reacting to market demands. Selco suffered severe business setbacks as the disbursement of the PVMTI loan took too long to close deals and to react to a changing market environment.

Additionally, Selco had difficulties in closing deals with banks as they were particularly hesitant to venture into rural PV finance if they had not worked with Selco before. Likewise, PVMTI initially did not accept cooperation with rural micro finance institutions. The problem of closing bank partnerships delayed the payment of the first disbursement for three years, according to an interviewee from the donor side.

Selco ran into its first serious crisis when the macro-environment changed. As European, and especially the German, governments increased their policy support for PV, demand for modules increased sharply and prices rose almost 50 per cent. Selco felt abandoned by PVMTI expecting the extension of loans and the lowering of interest rates. Selco also suffered severe business setbacks as the disbursement of the PVMTI loan took too long to close deals and to react to a changing market environment.

PVMTI directly caused another financial crisis to Selco India, leading to a working capital crunch and disrupted operations, when the final tranche of the loan was delayed due to

commercial problems of the parent company (Selco International) and another Selco daughter company<sup>107</sup>.

### **Shell Solar India**

**Business Model:** Shell Solar India is a 100 per cent subsidiary of Shell Overseas Investments BV. Shell's business model consisted of developing a marketing, retail and service network for the sale of solar home systems, shop lighting, and other solar PV products. Shell India partnered financial intermediaries offering loans and/or hire-purchase schemes. Target groups were customers in non-electrified areas as well as grid-connected customers in need of backup systems.

Shell also partnered Udhaya Electronics for the local manufacture of PV modules as high import duties disfavoured imports of complete modules. Shell provided the material and paid Udhaya a fee for assembling the modules.

Shell India received an unspecified grant and a loan of US \$2.6 million and a partial guarantee for default on consumer loans (provided by partner financial institutions) of up to US \$1.4 million from PVMTI funds. Shell India was founded with help of the PVMTI money and was not operating in India before this time. The only target Shell had in this scheme was the sale of a certain number of systems in order to qualify for subsequent disbursements of PVMTI grants.

**Experience:** Shell India was the only company declining to be questioned about its PVMTI experience as the company was in the end phase of closing down. Two former employees offered insights into the PVMTI experience. Shell Solar India stopped sales operations in 2006 and was sold to SREI during in the autumn of 2007. The reasons for the termination of operations are unclear. One interviewee stated that the complete withdrawal of Shell International from the solar business and low profitability of Shell India was the reason for the termination of sales activities in India. One interviewee stated that the former director of Shell India had misappropriated the PVMTI money and therefore severely threatened operations. One interviewee stated that Shell India was a successful company judged by the number of sales but that it was difficult to become profitable by focusing solely on solar home systems as margins were small. A broader portfolio (including street lighting, small power plants, etc.) would have had more chances of long-term success.

**Achievements:** During the course of the project, Shell established 25 energy stores and sold around 30,000 SHS. According to one interviewee, Shell was asking IFC for a cancellation of the loan repayments as sales were not sufficient to recover operational costs. This claim was neither confirmed nor contradicted by IT Power India.

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<sup>107</sup> According to IFC rules there are limitations on loan towards companies and company groups

**Reasons:** While the Shell business model seems to be a success and Shell India has benefited from the PVMTI capital, interviewees pointed to two major restraints incurred through the PVMTI relationship. The first restraint is the already mentioned time consuming procedures on the IFC side. Secondly, Shell encountered difficulties in establishing the required partnerships with banks because of the rules imposed by the IFC.

Banks were discouraged because, in order to qualify for the loan default guarantees offered by the IFC, IFC required a rigorous rating and screening process which banks refused to undertake as they felt they would have to give away too much confidential information. Without the loan default guarantees, it turned out to be difficult to convince banks to provide PV end-consumer finance. Furthermore, financial benefits allowed to banks were considered too small to serve as a real cooperation incentive.

PVMTI subprojects were allowed to use some of the PVMTI funds as a buy down of interest rates of end-consumer loans. The bank thus lowered interest rates for end consumers buying a solar PV application and the difference between standard and lowered rates were paid as a premium from the PVMTI subproject to the bank. As a result, a loan was cheaper to the customer and the bank was compensated for the loss in return. This premium was to be decreased over time by PVMTI rules making partnerships with Shell effectively less attractive for banks.

### **SREI International Finance**

**Business Model:** SREI International Finance is owned 50.6 per cent by a business family from Kolkata, 9.6 per cent by two EU development agencies, 16.4 per cent by private shareholders, 14.3 per cent by Indian financial institutions and 9.1 per cent by the IFC. In addition, SREI received a US \$10 million IFC grant (IFC 2007).<sup>108</sup> SREI's core business is the finance of heavy construction equipment and infrastructure.

In 1999, SREI funded the SREI Renewable Energy Unit (SREU) to expand its activities into the renewable energy market and started supplying PV applications to the government rural electrification programs discussed above.

The business model consists of selling solar home systems to end-consumers in cooperation with banks providing end-consumer loans. The specific implementation of the SREI business model changed considerably over time. SREI was awarded US \$3.5 million in loans, grants and guarantees through PVMTI in 2001.

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<sup>108</sup> [www.ifc.org/ifcext/southasia.nsf/Content/SelectedProject?OpenDocument&UNID=6E4148A69D6A243E852568B00063CCE8](http://www.ifc.org/ifcext/southasia.nsf/Content/SelectedProject?OpenDocument&UNID=6E4148A69D6A243E852568B00063CCE8)



**Achievements:** SREI has sold 12,000 to 13,000 SHS, 1,000 street lights, and a 40 kW power plant since receiving PVMTI funds. Initially, SREU aimed at “42,000 Solar Photovoltaic systems (excepting solar power plant) over 6 years; resulting in the creation of about 3 MWp of power generating capacity” in relation to the PVMTI project (SREI undated)<sup>109</sup>.

According to the company representative interviewed, the solar business was a success and operations went well. In addition, the company reached the sales figures necessary to qualify for the disbursement of the subsequent loan instalments and is currently repaying the PVMTI loan.

**Experience:** SREI applied for PVMTI funding in partnership with Tata BP Solar as PV systems supplier.<sup>110</sup> The initially agreed goals between PVMTI and SREI encompassed the development of a rural sales network in the form of a “one-stop shop” where customers could acquire PV systems and spare parts and have access to finance via partnership banks. These goals were changed as SREI reconsidered the establishment of the planned rural sales network as commercially too risky. The main reason was the slowly increasing price for modules. Furthermore, SREI was hesitant to take on rural consumer credit risks. Sales through the initial years were slow and mostly on a cash and carry basis. The provision of consumer loans through partnerships emerged slowly.

In 2002, the goals in relation to PVMTI were re-negotiated because of the slow business development. The goal of an own sales network was abandoned and the role of SREI was reduced to system integration, marketing and building co-operations with banks. In 2004, SREI founded the electrification service provider Envirotech which focuses on marketing solar home systems. Currently, Envirotech sells PV applications to the private market through an external dealer network and arranges for loans through banks. It also supplies to government PV programs.

**Reasons:** The company representative interviewed underlined the fact that SREI success depended on changing project goals in 2002. Furthermore, the interviewee stated that SREI customers for solar home systems also benefited from the Indian Government photovoltaic subsidy program for [?]. SREI customers received a discount on the amount of the government subsidy and SREI claims the subsidy directly from the West Bengal government for each system sold. SREI customers were, according to the interviewee, 99 per cent from rural areas

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<sup>109</sup> SREI International Finance (undated): SREI Renewable Energy Unit (SREU) Bio. Available at [www.srei.com/sreu/SREU\\_BIO\\_Website.doc](http://www.srei.com/sreu/SREU_BIO_Website.doc)

<sup>110</sup> SREI initially solicited PVMTI funds as part of a consortium with PV manufacturer Tata BP Solar, the NGO Ramakrishna Mission, and The Energy and Resources Institute (TERI). The consortium fell apart and SREI went ahead with a supplier relationship solely with Tata BP. Two competing accounts exist as to why the consortium fell apart. According to the IFC, it fell apart due to internal conflicts. According to one interviewee, IT Power India did not want an NGO and a research institute as partners in a PVMTI investment as they would have represented a “critical voice”.

and “too poor to buy without the government subsidy”. One interviewee from the donor side admitted that SREI was operating within an “easy environment”.

## Appendix H: Questionnaire chapter 4 and 5

Name:		Institution:	
Position		Date:	

### Part A: The GEF technology transfer approach

The first part of this questionnaire relates to the way the GEF supports technology transfer projects within its climate change project portfolio. According to GEF publications, the idea of “market transformation” seems to have special importance.

- 1) How would you characterise the GEF market transformation approach?
- 2) Are there other/different approaches to technology transfer within the GEF?

- 3) The operational strategy of the GEF reads:

“in cases in which substantial cost reduction can be achieved through greater use of local manufacturing capacity, the GEF will pursue technology transfer, local procurement, and the development of appropriate industrial infrastructure”.

Is this aspect still central to the GEF? In which projects?

### Part B: The GEF-UNFCCC relation

The GEF acts as the financial mechanism of to the UNFCCC. According to Article 11 of the Convention, technology transfer is one of the tasks of the GEF.

- 1) How would you evaluate the relation between the GEF and the UNFCCC?
- 2) To what extent does the GEF implement guidance given by UNFCCC??
- 3) Do all GEF climate change projects designed by GEF meet UNFCCC criteria?

### Part C: Technology transfer within the UNFCCC

Technology Transfer seems to be a controversial issue between developed and developing countries.

- 1) To what extent have parties to the UNFCCC, especially developed and developing countries, reached an agreement on how to implement technology transfer?
- 2) To what extent does the GEF approach to technology transfer do justice to the expectations of developed and developing countries?
- 3) What are possible solutions to meet the requirements of Article 4.5 UNFCCC for technology transfer by Annex I countries?

**Appendix I: Questionnaire Chapter 6**

Company:	Name:
Date:	Place:

Interviews are confidential and results presented in form of publications or presentations will not be related to the interviewee

**9.1.1.1.1 Part A: PVMTI Project**

- 1) What are, in your opinion, the most important goals of PVMTI?
- 2) How far have these goals been achieved?
- 3) What have, in your opinion, been the largest obstacles to achieving project goals?

**9.1.1.1.2 Part B: PVMTI subprojects in India**

- 1) How would you describe the company experience under PVMTI?
- 2) To what extent have PVMTI subprojects contributed to “market transformation”?
- 3) Which of the PVMTI investments in India would you consider a success/a failure?

**9.1.1.1.3 Part C: Organisational set-up (only asked to direct stakeholders)**

- 1) How effective do you consider the institutional division IFC/Impax/IT Power India?
- 2) What are, in your opinion, the reasons for the protracted implementation of PVMTI in India?
- 3) To what extent have the IFC/GEF and IMPAX learnt from the PVMTI experience?

**Part D: Indian PV markets and industry**

- 1) What are the main drivers of the Indian PV market?
- 2) What are the specific strengths/weaknesses of the government PV program?
- 3) Has PVMTI contributed to increased technological capabilities within the PV industry?

## Appendix J: Questionnaire Chapter 6: The Indian PV Industry

Company:	Name:
Date:	Place:

Interviews are confidential and results presented in the form of publications or presentations will not be related to the interviewee.

The main aim of my research is to understand the contribution of the Photovoltaic Market Transformation Initiative (PVMTI) to the development of the Indian PV market and the Indian PV industry. To achieve this aim, I have selected a number of PV manufacturers in India with and without a direct supplier relationship to the PVMTI project. Interviewing the PV manufacturers with no relationship to the project will help me identify any differences being linked to PVMTI might have made.

### 9.1.1.1.1.4 Part A: Development of the Indian PV market

- 1) What are the main drivers/constraints for the development of the Indian PV market?
- 2) How important is the Indian market for the company you represent?
- 3) Which share of your sales goes to government programs?
- 4) Which share of your sales goes to the Indian private market?
- 5) Since when have you been selling to the private market and what is your sales model?

### 9.1.1.1.1.5 Part B: Development of the Indian PV industry

- 1) What are the main drivers of the development of the Indian PV industry?
- 2) What role do export markets play in the development of the Indian PV industry?
- 3) What role has the PVMTI project played in developing the Indian PV industry?

### 9.1.1.1.1.6 Part B: Drivers of innovation and technological change

- 1) What are the barriers to innovation in the company you represent?
- 2) What were the most important sources of innovation for the company you represent?
- 3) What role does foreign technology transfer (import) play in innovation?
- 4) Do you feel any restraint in getting access to technology?
- 5) Are you able to adapt and improve production technology you have bought?
- 6) Would you be able to build production technology yourself?