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Energy Security, Rural Electrification, and Market-based Climate Change Intervention by the Global Environment Facility in India: the Limits of Transformation

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Abstract – *This paper investigates the effects of market-based projects supporting rural electrification through small scale solar photovoltaic applications on climate change mitigation and energy security in developing countries It is based on a case study investigating a Global Environment Facility project in India. It concludes that market based approaches have the advantage of providing support for private actors that is otherwise not available and serve well to complement similar government activities. From that perspective, they may have a positive impact on mitigation through reduction of CO_2 emissions and on energy security of rural populations. At the same time, this research suggests that market based approaches are limited considerably through the business goals of the private actors they aim to support as well as lack of mechanism to effectively compensate the additional cost of solar photovoltaic technology.*

Keywords – Global Environment Facility, India, rural electrification.

1. INTRODUCTION

The diffusion of small-scale solar photovoltaic (SPV) applications like solar home systems, solar lanterns, *etc.* through governments and official development assistance (ODA) projects in developing countries have increased energy security for rural populations by decreasing dependency on fossil fuels as well as biomass (diesel, wood) and grid-electrification programs for more than 50 years. The traditional mechanism to support the diffusion of these technologies has been an end-user subsidy as SPV applications are more expensive than competing energy sources like kerosene lanterns. But during the 1990s, two changes took place with regard to publicly supported SPV based rural electrification programs.

Firstly, they became intertwined with the environmental problem of climate change when the Global Environment Facility (GEF) chose to support SPV technology as an instrument to combat climate change in the early 1990s. The World Bank, one of the GEF implementing agencies and ideological father of the GEF SPV support program, considers "large-scale use of photovoltaics as one of the best long-term strategies for reducing greenhouse gas emissions in developing countries" (World Bank undated). Secondly, market-based approaches started to replace the subsidies as mechanisms to support the diffusion of SPV applications in developing countries.

The paper proposes an analysis of these changes on two levels: it will firstly reflect on how the application of market-based approaches to reduce carbon dioxide emissions in rural areas relate to common barriers of PV-based solar electrification. It will secondly reflect on the implications of market-based approaches to the goals of climate change and energy security.

The paper discusses the specific market-based approach designed by the GEF to increase the share of SPV applications in rural areas in developing countries. The paper also reflects on the potential and the limitations of the GEF approach regarding climate protection and energy security by analyzing the results of a GEF project designed according to market-based principles in India. It is based on a case study of the Photovoltaic Market Transformation Initiative (PVMTI) in India.

It is one of the earliest projects financed through the GEF following market based principles. The case study is based on literature reviews, official document analysis as well as 18 in depth interviews with relevant stakeholders in the US, UK, and India.

This paper will argue that the mode of delivery of such systems has strong implications for both climate protection and energy security, which must be understood when designing future rural PV-based electrification projects under the Clean Development Mechanism (CDM), GEF programs or future United Nations Framework Convention on Climate Change (UNFCCC) funds aimed at the diffusion of renewable energy technologies in developing countries. Two main weaknesses emerge on the basis of this research. Firstly, the barrier of cost is not addressed sufficiently as the extra cost of the solar photovoltaic application is not controlled (as through a subsidy approach) but rather shifted to the consumer, which lowers demand even further. If prices for productive inputs for any reasons increase and companies find no alternative revenue streams (like investing in manufacturing or claiming subsidies) additional costs have to be passed onto the consumer which lowers demand. Secondly, the business

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goals of companies might coincide with the goals of funding bodies at the time of fund disbursement but not necessarily over time. Both these weaknesses have negative effects on climate change mitigation and energy security of rural populations.

2. GOALS OF PUBLIC RURAL ELECTRIFICATION PROGRAMS

SPV technologies convert solar radiation into electricity. Rural electrification through solar photovoltaic technology is one option to increase energy security for rural populations in developing countries and to reduce CO_2 emissions from rural households [1]. Relevant applications include solar powered water pumps and streetlights, small power stations serving hospital or hamlets, or small lighting systems to electrify households. Small household systems (SHS) typically comprise a photovoltaic array of one or two modules (40 to 80 Wp) to charge a battery from which fluorescent lights and other small household appliances (television, radio, fan) can be powered [2], [3].

The diffusion of SPV technology increases energy security at the national level by decreasing import dependence on fossil fuels and alleviating strains on foreign currency reserves and balance of payments. SPV increase the relative energy security of rural populations by reducing the dependency on wood and other fossil fuels as well as government grid connection programs. Furthermore, even when a grid connection to a household is established, electricity is often cut due to black outs and/ or limited generation capacity, and SPV applications can serve a back-up systems [1], [4], [5].

Rural electrification through SPV is currently pursued by the GEF, which serves as the primary financial mechanism for the UNFCCC. In 1991, the foundation of the GEF and its assignment to address climate change marked the international intertwinement of SPV applications, rural electrification and mitigating climate change. The GEF selected PV technology as one of the “GEF set of technologies”, which comprised a range or renewable energy and energy efficiency technologies, which would not diffuse to developing countries without interventions [6], [7]. From a climate change perspective, rural electrification through SPV opens the possibility to displace or avoid CO_2 emissions as rural households typically use kerosene lanterns, batteries charged through diesel generators, or paraffin lamps to satisfy their lighting needs. If SHS are used as an alternative to a grid connection they also avoid CO_2 emissions as almost all electricity supplied through the grid is based on fossil fuel power stations [8]-[11].

Barriers to Rural Electrification with SPV and Diffusion Approaches

In most developing countries SPV diffused through both purely private markets and government/ international donor support [12]. However, private markets have been and are still limited to niche markets. Government intervention is needed as the diffusion of SPV technology for rural electrification faces a number of barriers. There is no consensus on which barriers frustrate the diffusion of renewable energy technologies, including SHS. Barriers and their relative importance are highly context dependent, varying with the specific approach through which SPV are supported [13]-[15]. Yet in most cases a key barrier to SPV diffusion is cost. Two types of costs barriers are relevant: the capital cost for SHS; and the relative cost for the generation of one unit of energy. The capital cost for SHS are substantially higher than the costs for competing lighting sources like kerosene lamps [16], [17]. Relative costs refer to the costs for producing one kilowatt hour of electricity for SHS and competing technologies. Although the average costs of PV units have declined substantially over the past 25 years, SHS provide one unit of energy for relatively higher cost in relation to grid connections and portable diesel generators even if calculated over a 30 year running period in the developing world [13][2], [18].

International donors and governments of developing supporting the diffusion of SHS have traditionally focussed on overcoming the cost barriers by reducing the system cost for the end-user by fully or partly subsidising these technologies. SHS and other SPV applications were either provided for free, for a subsidised price, or a subsidy was paid to the end user to purchase such systems. The subsidy approach was complemented within multilateral development institutions, including the World Bank and development aid from the early 1990s onwards by attempts to build markets for SPV technology rather than supplying them at subsidised rates [23].

The GEF approach, which will be discussed in more detail below, is based on the World Bank approach to rural SPV. The World Bank was dissatisfied with subsidy projects as they allegedly had no effects beyond the lifetime of the project, were assumed to hinder local industrial development, and were not suitable to decrease the cost of technology. The Bank therefore did not support widespread application of SPV through subsidies [6], [24]-[27]. As a reaction, the Bank remodelled their SPV support programs according to market-based principles [25]. Market-based approaches for the deployment of SHS and other SPV applications in developing countries do not supply subsidised SPV but support the development and modification of institutions necessary to put the end-user in a position to purchase such systems despite their high capital cost. Projects based on market principles consequently do not focus on the provision and distribution of technologies but on the support of private sales and service

[2] Relative costs are highly context specific. They vary from country to country [19] and there are circumstances, usually related to geographical location of application, when SHS systems are more cost-effective then e.g. grid connections [20]-[22]. Wamukonya (2007) warns critically that the cost-effectiveness calculations in favour of SPV usually do not account for the severe limitation of SHS in relation to grid connections from a user perspective: limitations regarding the duration of applications (usually four hours a day), restriction regarding the powered applications (restricted to light, fans, radios and TV sets), and the need for new high capital investments in form of additional systems if demand increases.

companies, the availability of end-consumer finance, a favourable tax and duty structure in case such systems are imported, publicity, and workforce training [16]. As we will see in the following, market based approaches have also specific limitations.

The Global Environment Facility and Climate Change

The GEF was founded in 1991 and currently serves as the financial mechanism to four international environmental conventions (biological diversity, climate change, desertification, and persistent organic pollutants).

In order to service those agreements the GEF operates "the largest and most comprehensive global portfolio of investments in energy efficiency, renewable energy and other climate-friendly projects" [28]. This portfolio consists of 207 projects (144 full size) for which it has allocated $1.63 billion between 1991 and 2004. The projects are spread among 143 countries. Officially, the GEF estimates the avoided direct and indirect emissions to be 224 million metric tons CO_2 at an incremental cost of $194 million [28].

In the context of energy policy, market transformation programs are an umbrella term describing a range of different policy instruments that aim at increasing the diffusion of clean or cleaner energy technologies by increasing demand for such technologies. A significant feature of market transformation projects is that they aim to transform the market in such a way that the transformation achieved through the intervention lasts beyond the end of the intervention and no further intervention will be required. In the case of energy efficiency, the intended transformation is to replace the volume of purchases for a certain product by the purchase of the same product with higher energy efficiency [29], [30].

A second feature associated with market transformation programs is their potential to reduce the cost of specific clean or cleaner technologies. The underlying assumption is that production cost are reduced through learning and experience curves if the volume of production is increased as a reaction to increased demand [10], [31]. Krause (1996) defines market transformation policies as all the policy instruments that increase demand other then changes in energy prices. Relevant instruments include standards, labels, end-user subsidies, voluntary agreements, procurement incentives, *etc.* [32], [33].

The evolution of the GEF approach to market transformation cannot be separated from the development of the approach within the World Bank. The GEF financed market-based World Bank projects from early on and the same World Bank staff who developed the World Bank approach shaped the GEF approach during the first years of its operation (interview sources). The integration of the approach started within the GEF around 1997.

The GEF definitions of market transformation are short on details, change slightly over time, and can be confusing. For instance, the term is used interchangeably as a project goal and as an indicator to measure project results. An early document describes the aim of GEF projects as "accelerated replication and adoption of technology applications than would otherwise occur" [34]. An early 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" [35].

A more recent document frames transformed markets as "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" [36]. Essential to the GEF notion of market transformation is the idea of replicability. Replicability means that project measures shall be replicated by actors not directly involved in GEF projects leading to project outcomes beyond the actual GEF project [37].

The practical implication of the adoption of the market transformation approach is that the GEF is not supplying technology in any form but removing the barriers to its diffusion.[3] Technology shall be supplied by the private sector as a reaction to growing demands. GEF market transformation projects try to address the following barriers: lack of an established market, lack of successful business models, lack of business finance and skills, unwillingness of utilities to provide off-grid electricity services, high transactions costs, high first cost and affordability, lack of consumer financing, uncertain technological track record, uncertain or unrealistic grid expansion plans, and other policy constraints like subsidies, tariff structures, and import duties [38]. Projects usually address some of the barriers in accordance to the perceived need of the targeted market.

All SHS are supplied and sold by private companies for non-subsidised prices. The under underlying rationale is that private companies will start to invest in SHS when their initial investment risk is reduced and market infrastructure in the form of finance, etc emerges. As markets shall be working without external financial support in the long run, financial support is phased out over time. Aiming to establish markets and increasing the role of the private sector includes the hope of donors that the increased uptake of SHS will not depend on subsidies. Also, market-based projects for rural electrification with SHS seek lasting effects beyond the duration of the project intervention [6].

If markets are the solution to delivering SPV applications, barriers to their diffusion are then the lack of institutions considered necessary for the constitution of a market. The important "barriers" are from a market-based perspective lack of end-consumer finance, lack of business models, lack of trained work-force with managerial as well as technical skills, lack of awareness

[3]Some early projects did supply technology and supported its application, but this approach was abandoned (interview source).

within end-consumers, and lack of a supportive policy environment (import taxes for systems, subsidies for other fuel sources *etc.*) [25].

3. THE PVMTI PROJECT

The Photovoltaic Market Transformation Initiative (PVMTI) project is one of the earliest projects financed through the GEF and follows the market transformation approach. PVMTI was implemented in Kenya, Morocco and India. In the following, the results of PVMTI India will be presented. The GEF bore the $30 million cost of the project and the International Finance Corporation (IFC) served as the implementing agency. The IFC's part of the World Bank group and provides finance for private sector investment in developing countries.

The overall aim of PVMTI is to support private business to increase the installed SPV generating capacity. PVMTI offered finance (between $0.5 and $5 million) in form of equity or soft loans for new or existing companies, which would integrate, market and sell small-scale SPV applications in India. The project document clarifies the aims are 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" [39].

Companies apply with business plans and are called in case IFC decides in favour of an investment PVMTI subprojects. The first call for tenders was published in 1998; the deadline for project submission was set as 2002 and the end-date for all repayments was set as 2007 and later extended to 2009.

PVMTI aims to lower the cost and risk for private investors to develop necessary market infrastructure as a basis for increased sales. PVMTI required no particular business model and was open to existing and new application of SPV. Investments in manufacturing system components (PV cells, modules, *etc.*) were ruled out as IFC considered commercial finance for manufacturing as sufficiently available from private finance institutions in India. Importantly, the finance offered by PVMTI was not meant to directly subsidise the price of the systems sold.

If companies chose to sell SPV in the form of SHS to households as their business model, they were expected to partner with commercial banks in order to provide end-consumer finance. To increase the attractiveness of partnerships for banks, PVMTI finance could be used as a default guarantee for the banks and as a premium to reduce end-consumer loan cost. This premium had however to be reduced over time as GEF/IFC aimed at business models working without any financial support at non-market rates after PVMTI funding.

IFC/GEF assumed that the PVMTI funded companies contribute to the formation of a larger domestic PV market, stimulate in increased sale of PV applications, and animate additional investors / companies to adapt similar business models to those financed by PVMTI without direct PVMTI support. It was further hoped the sub-projects will be commercially viable by then end of the project period and had repaid their loans [39].

GEF/ IFC chose this approach as a reaction to five perceived constraints on the diffusion of SPV applications in developing countries: the absence of successful business models, the lack of finance for business, the lack of relevant know-how and service support, the absence of private commercial actors of a size which would have an interest in business activities for commercial rural PV [40]. Finance is however considered to be the main bottleneck, as lack of commercial finance hinders any business activity and lack of end-user finance restricts purchases of PV systems [41].

The targeted beneficiaries are private end users who are able to afford electricity but unlikely to receive a grid-connection and commercial users in need of non-grid energy sources.[4]

IMPAX Capital Management in London managed PVMTI funds, the Indian part was implemented by IT Power India and all final decisions about investments were made by the IFC in Washington.

Implications for Climate Change and Energy Security

The World Bank project fact sheet states PVMTI will prove "large-scale use of photovoltaic as one of the best long-term strategies for reducing greenhouse gas emissions in developing countries" (World Bank undated).[5] The displacement of CO_2 is listed as a secondary goal of the PVMTI project [39]. As PVMTI shifts the responsibility of diffusing SPV to private actors, any environmental benefit is a result of the supported business activity. The amount of CO_2 displaced depends on the number of absolute system sales, the duration of operability and the change in energy usage patterns resulting from the acquisition. In this context, system sales and carbon displacements as calculated by PVMTI India will be used as rough proxies. The IFC assumed that total avoided CO_2 emissions would be 1,207,800 tons. Assuming incremental cost to be $17.25 million for the whole project (under the assumption that loans are partly repaid) the price for per ton avoided carbon would be $14.30 dollars [39].

Similar to the environmental benefits, effects on energy security are a function of the business activity of the funded companies. Rural households decrease their dependence on fossil fuels if the acquisition of a SHS leads to a decline in kerosene consumption. Grid connected households will receive a backup system during black outs and power-cuts. An analysis of the

[4] households, applications in agriculture, commercial applications SHS 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 peri-urban housing or commercial captive power applications to provide reliable power and/or relieve peak loads).

[5] http://www.gefweb.org/Outreach/outreach-PUblications/Project_factsheet/Global-phot-9-cc-wb-eng.pdf

customer base of the project will give a more specific indication of energy security effects.

PVMTI Goals in India

PVMTI goals are not linked to fixed, quantified output targets but the project document lists a number of impact estimations on the national markets as project outcomes. These estimated impacts are based pre-project consultation and market research which was undertaken prior to the project by IT Power and Impax Capital Management, both being later responsible for the management of the project [41].

The IFC expected that 11 sub-projects (four of them with a low probability) worth $214 million (including non-PVMTI co-finance) would be developed in response to the request for proposals. The number of possible investments was actually expected to exceed PVMTI funds. IFC further expected annual sales to rise from 11.0 MW in 1998 to be 28.0 MW in 2003 as a result of PVMTI. Without PVMTI sales were assumed to rise to 18.0 MW. In other words, the IFC expected 10.0 MW of sales of PVMTI installations for the year of 2003 in India, which would represent a 55 per cent increase of the share of PVTMI of the market (IFC calls it a transformation). Fifteen million US dollars of funding, including technical assistance and cost for project execution, were allocated to India to achieve this goal [39].

The Indian Context

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, of which 92 percent are located in rural areas [42], [43]. The Indian government has classified almost 89 percent of the 587 or 556 Indian villages as electrified through the conventional grid. However, the Indian government's definition of "electrified" is that one line of electricity leads to a village, irrespective of how many village households are able to draw electricity from that line. The central government has furthermore classified nearly 24,500 un-electrified villages as "remote villages", which will not be connected to the conventional grid in the near future [22].

The Indian government maintains a large rural electrification program, which generally consists of the expansion of the main electricity grids and a program supporting the development and diffusion of renewable energy technologies including SPV. In 1975, the Department of Science and Technology initiated the Solar Photovoltaic Program. The program aimed at developing commercially viable PV applications, the creation of a strong manufacturing base, and the diffusion of PV applications to remote and rural areas of India. The program covers different SPV applications like solar streetlights, solar home systems, solar water pumping, solar lanterns, and PV power plants.

The government entrusted public sector electronics companies with developing PV products and assigning research and development programs on solar cells to some of the states' research institutions. It also initiated a large technology demonstration and diffusion program and increased its research efforts from 1980 onwards. In contrast to the World Bank program, the main instruments of India's domestic SPV program for the diffusion of technology including SHS were capital subsidies, fiscal as well as financial incentives, and demonstration projects[44], [45].

With state level agencies designating villages to be electrified with SHS, the SHS diffusion program initially appeared to be working on a purely project basis. Villagers were then offered to buy such systems and receive a subsidy of between 55 and 90 percent depending on location. Over time, the Indian government opened stores selling SHS and other small-scale SPV applications directly to consumers without any subsidies and allowed private companies to sell directly to end-consumers with the state subsidy (interview sources). Until March 2008, roughly 403.000 SHS were installed under the government program (MNRE 2008).[6]

An overall review of the government SHS program does not exist. But it does seem that high technology cost, commercial fuel subsidies, inadequate budgetary allocation for renewable technologies, and inadequate research and development for the rural sector limited its effectiveness. Product development according to the needs of the different rural users in PV was stagnating due to lacking interaction between users and developers and the subsidy approach. Implementation was weak as the focus of the program was on installation targets rather than saving funds to ensure proper service and maintenance. The program also struggled because different signals were sent to consumers over future rates of subsidies and sales infrastructure and service structures were notably lacking (TERI 1994 cited in [21], [46]).

When PVMTI India was launched in 1998, the initial IFC assumptions about the Indian market can be summarized as follows: On the one hand, PVMTI market research showed poor quality of PV systems, no service, and no user commitment to the government program. It also assumed lacking private initiative in PV sales due government's "suppression" of such activity and "dependence" on government program. On the other hand, stood the assumption of "underdeveloped consumer finance which is crucial to make SHS affordable", a "strong" market side, and an abundance of experience and competences [47].

Project Results

PVMTI project results can be viewed from two closely related perspectives. Firstly, the results of the project are linked to the strengths and its weaknesses of market-based approach. This will be done by considering the reactions to the call for tender and the performance of the PVMTI subprojects. Secondly, the effects on CO_2

[6] Ministry of New and Renewable Energy Website http://mnes.nic.in/

displacement and energy security must be considered. This will be done by considering the number of systems sold, avoided CO_2 emissions, and the customer groups of PVMTI subprojects. The discussion is based on PVMTI documentation and 18 interviews with representatives of IFC, IMPAX, IT Power India, PVMTI subprojects, external consultants to PVMTI, and Indian government officials.

Response the PVMTI India Tendered and Investment Selection

PVMTI India published the call for tenders/ proposals for subprojects in 1998. Following the call, 22 proposals were received. Proposals included solar powered cash machines, internet centres, and phone booths [47]. The opportunities to invest resulting from the proposal were considered weak (interview sources). The number of proposals and the number of investment pre-selected did not match the number established from market research.

IFC authorised investments for India three years after the initial call in 2001. According to the donor side, the long period was needed to establish the robustness of the business model (interview sources). PVMTI subprojects claimed that the period took so long due to institutional arrangements that slowed decision making processes, the low priority accorded to the project within the IFC/GEF, and unnecessarily burdensome documentation requirements (100 pages business plan).

After these considerable delays, six proposals were pre-selected and eventually four investments were made. The four selected investments relied on a similar business model. They aimed to expand sales infrastructure and to enlist commercial banking institutions for the sale of SHS and small-scale SPV applications. The more innovative business models received no funding. One company withdrew its proposal because management felt that the decision making process was too long (interview source). The reason funding for the second company was withdrawn could not be firmly established, though those involved in the PVMTI suggested its business model was insufficiently robust (interview sources).

Table 1. PVMTI Investments in India.

Investee Company	Investment	Project Summary
Company A	US$ 2.2 M.	Expansion of a network of 300 “Energy Stores”, selling PV and other alternative energy products.
Company B	US$ 3.5 M.	Introduction of a credit scheme for PV customers.
Company C	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.
Company D	US$ 1.1 M.	Expansion of energy stores coupled with consumer credit scheme.
Company E	US$ 0.0 M.	Development and marketing of PV-powered streetlights with space for advertisement The investment was announced but never took place.
Company F	US$ 0.0 M.	Selling PV powered Water Pumping and Purification Stations The investment was announced but never took place

Source: PVMTI Website/ interviews

Company Experience

Supporting sustainable business models meant in the IFC/ GEF understanding that PVMTI subprojects would sell SPV systems, repay their loans, and operate without further non-commercial funding after end of the project. Preconditions were the extension of the sales infrastructure and the partnering with commercial finance institutions to provide end-consumer loans.

On a general level, the main strength of PVMTI was that it provided capital, which was otherwise not available in India. All funding recipients pointed out that commercial banks and the Indian Energy Development Agency (responsible for financing renewable energy technologies) did not offer finance on similar conditions. Also, 90 percent of all systems sold were considered to be working as after sales services were one of the main selling points of companies. Furthermore, end-consumers willing to purchase systems did not have to rely on Indian government program, which had varying success rates in different Indian federal states.

The chief weaknesses of the PVMTI’s design were that it had a small overall IFC investment sum of $15 million and it focused on the demand side. In the opinion of most interviewees, much more money was needed to “transform” the Indian market away from a subsidised SPV market to a commercially viable market. Also, the focus on demand was criticised as PV systems were considered far too expensive to reach the bulk of the Indian rural population. More investment in research and development in the PV technology and PV production technology were considered necessary to bring down costs.

Weaknesses encountered during the PVMTI’s implementation of the project included long decision making processes, considerable misunderstandings between funding bodies and funding recipients, extensive documentation requirements, and the fact that loans were paid out over multiple instalments (each instalment required new application and documentation procedures).

Company A has never achieved its original goals of setting up 300 energy stores. The company abandoned the initial idea of the stores as it turned out after having set up eight outlets that the stores selling exclusively SPV applications were not commercially viable. 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 convinced to sell PV applications as they thought demand was insufficient. 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 rate in the SPV business was, according to an interviewed company representative, that the company was not allowed through PVMTI rules to invest in PV module manufacturing although it would have made economic sense in their opinion. The company therefore lost two government contracts for the supply of PV systems as the government favours suppliers with a manufacturing backbone and 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 negotiating for funding, company B and PVMTI agreed that business activity would consist of building a sales network with "one-stop PV shops" where customers could acquire both SHS and spare parts as well as finance. These stores were however never set up because company B decided they were financially not viable as the price for modules was slowly increasing due to rising demand in Europe. Also, company B was hesitant to risk offering end-consumers 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. In contrast 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 claims the Indian government subsidy. According to a company representative, it is difficult to sell SHS without the state subsidy. Company B had hoped to sell 40,000 SHS but only sold 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 provided some insights into 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 operation are not entirely clear, but the mother company of company C, one of the largest oil companies in the world, decided to leave the PV business completely as profits were lower than 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 in 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 to be uninterested in giving loans for SHS as transaction cost are high relative to the overall loan sum and default risk is high. To mitigate the bank's 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 provide 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 were paid as a premium from the PVMTI sub-project to the bank. As a result, a loan was cheaper to the customer and the bank was compensated for the resulting loss directly by subprojects.

Company C however still encountered considerable difficulties in partnering with banks as the premium to the banks had to be reduced over time. Also, 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 stalled accordingly.

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. Also, the company missed support from PVMTI when prices for PV modules increased 50 percent due to demand in Europe which threatened the existence of the company. Also, 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 also operates with concessional finance from multilateral donors other then the GEF.

The absolute achievement of the four companies in terms of system sales and the installed capacity is summarized in the Table 2.

The increase in overall SPV generation capacity as a result from PVMTI India activity is represented in Figure 1.

Table 2. Achievements of PVMTI subprojects as of July 2007.

Investee Company	Infrastructure	System Sales	Status
Company A	8 Energy stores.	8.000 Lanterns (24 Kw) 2.000 other solar gadgets (27.6 KW) 3 power plants (4.5, 4,5, 3.0 KW)	Economically unstable, hardly selling solar PV applications IFC repayment not secured
Company B	Operating through sales and dealer network	12.000 to 13.000 SHS 8 to 75 W. 1000 Streetlights, 40 Kw Power plant	Economically stable, selling solar PV applications with government subsidies IFC payment secured
Company C	25 Energy Stores	30.000 SHS	Terminated operations in 2006. IFC repayment not secured
Company D	25 Energy Service Centres	24.000 to 26.000 SHS of 10, 20 and 40 W	Economically unstable, IFC repayment delayed
Total		70.000 SHS 8000 Lanterns 1000 Streetlight	

Source: interviews

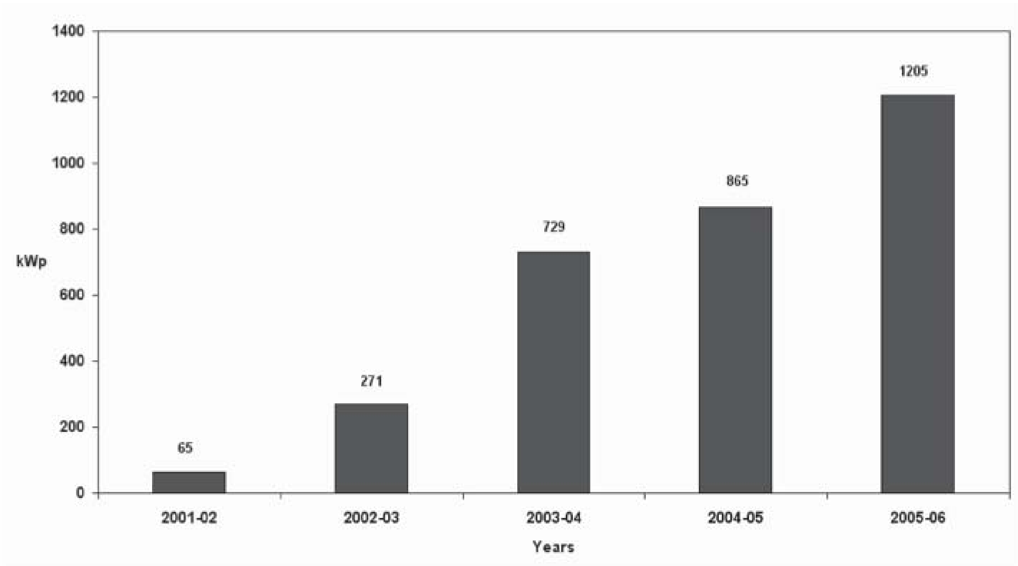

Fig. 1. Sum of KW generating capacity installed in India [48].

4. CONCLUSIONS

Discussion of Market Based Approach

It is obvious that the results regarding the support of viable business models are below initial IFC/GEF expectations.[7] The number and quality of business proposals did not match the expectations of prior market research. Whether or not the majority of the investments made resulted in sustainable business models is doubtful. One of the companies ceased operations despite a considerable number of sales. One company is, according to its CEO, in an economically uncertain position and relies on other international donor funded projects to remain solvent. One company never managed to sell a substantial amount of SPV applications. Only one company claimed to be profitable but admitted openly that this is because almost all of their sales were executed with government subsidies. Interviewees from the donor side considered the identification and funding four subprojects was already a success as results in India were better than in Kenya and Morocco.

The factors limiting the success of the PVMTI subprojects lie, on the one hand, in the slow and time consuming project execution through the IFC, the decision to rule out of investments in manufacturing, and requirements 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 D (increase

[7]Considering that the companies that had undertaken the market research later on managed the project in India suggests that their might be some intrinsic optimism regarding project outcome. This is however an unsubstantiated assumption which might be wrong. IFC declared all project documents as confidential.

of module prices through increasing demand of Europe) and the low demand for systems not subsidised by the government. While the problem of slow project execution and investment rules could be in theory improved in future market-based projects, the vulnerability of companies to exogenous shifts in markets, prices, and demand cannot be controlled. Also, the availability of end-consumer finance does not necessarily serve as a sufficient incentive to purchase a SHS especially if consumers can hope on government subsidised systems. The main weakness emerging here is that the barrier of cost is not addressed as the prices of the SPV is not controlled (as through a subsidy approach) but rather shifted to the consumer. If prices for any reasons increase and companies find no alternative revenue streams (like investing in manufacturing or claiming subsidies) costs have to be passed onto the consumer which lowers demand.

Carbon Dioxide Displacement

The number of systems sold does not match the initial expectations of the IFC. The overall installed capacity is currently (after nine years of project operations) just over 10 percent of what the IFC thought would be installed annually from 2003 onwards.

As the installed capacity resulting from PVMTI is only a fraction the assumed overall installations over the project life cycle carbon displacement goals are also not met. IFC did not list country specific targets but hoped to achieve overall emission reductions to be 1,207,800 tons of carbon equivalent over ten years. According to IT Power India, a proper calculation of CO_2 emission reduction has not been carried out so far. However, IT Power India undertook a very rough calculation themselves leading to 92.503, tCO_2e saved over the project life cycle of 11 years.

The number of installed systems is influenced clearly by company performance and the factors limiting company performance as explained in the previous paragraph. But the number of system sales is influenced by yet another factor beyond the control of IFC/ GEF. As we have seen, companies A and B changed their business models as they found out that their initial models (in line with the IFC expectations) were not commercially viable and considerably reduced their targets regarding system sales and sales infrastructure. Company C ceased operations before they achieved a fraction of the sales hoped for by the IFC. In other words, one severe limitation is that the business goals of companies might coincide with the goals of funding bodies at the time of fund disbursement but not necessarily over time. Companies might even just decide that their operations are a success as in the case of company B but may be not willing to achieve secondary aims of donors like mitigating CO_2 through increasing their business activity beyond what they consider commercially satisfactory. In the language of market based environmental policy instruments, market based approaches like PVMTI can control cost as they determine the amount of funding given to companies but have no control regarding the environmental outcome even in case the funded company is commercially successful. Apart from that, the contribution of rural electrification through SHS will mitigate very little of overall India GHG emissions.

Energy Security

In India, 83.12 million rural households used kerosene as a primary source for lighting in 2001. Assuming that each household operates one kerosene lamp, the weekly consumption averages according to estimations carried out by TERI-The Energy and Resource Institute 0.435 l per week and 22.66l a year leading to a overall annual consumption of 1880.2 million per year [49].

Although the overall reduction of oil imports saved through replacing kerosene lamps would only by a fraction of the 2.098 million bbl/day of crude oil imports (for 2004) the Indian government could save a substantial fraction of its annual $390 million spending on kerosene subsides for rural lighting [42].

Energy security depends on the number of systems sold and is hence limited by the same factors as mitigating CO_2. Relevant in this context is whose energy security is addressed. Considering the customer base of the four subprojects, it turns out that only one company sells its system almost exclusively to costumers in rural areas but is 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 on its customer base but publications clearly indicate that it had rural and urban customers. One company hardly sells at all. While a broad customer base in urban and rural areas is desirable from the perspective of the companies it also indicates that these companies cannot cater for all target groups in need of energy supply. The subsidy based government program focuses, at least in theory, on the lower income groups in rural areas, which are not addressed to the same extend by the PVMTI investee companies. In other words, if subsidies are reduced, companies have to sell to urban areas, where wealthier clients use PV systems as back-up systems. This has implications for mitigating CO_2. There is no systematic research in how far PV backup systems for grid connections displace carbon dioxide emissions. One can assume however that these depend on the number and duration of black outs, and a simplifying assumption is that displacement rates are different and potentially smaller than in rural areas. The reduction of subsidies has also social implications. The argument for state intervention in delivering off-grid solutions for rural electrification has usually been that the targeted population is either completely outside the market economy or shows only very low purchasing power [5]. Poor rural customers are not the primary target group of PVMTI companies (unless co-claiming state subsidies) and their energy security needs neglected.

The findings of the paper suggest that the integration of energy security aspects in efforts to reduce carbon emission in rural areas is feasible. However, in order to address energy poverty and climate change, pure market-based approaches will not be sufficient as the cost for renewable energy technologies is still too high to consider them cost-competitive with other rural energy sources. Until cost competitiveness is achieved, market-based projects should aim to integrate some subsidy aspect to expand the target groups of supported companies. This finding also calls for a more nuanced interpretation of additionality for small scale renewable projects. The restriction that companies, however, might not follow the aims of carbon dioxide replacement and energy security beyond their business goals cannot be overcome within market-based approaches.

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