Microfinance Intervention for Financing Solar Cooking Technologies – Financing with Savings

by
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I. Background

The United Nations Framework Convention on Climate Change (UNFCCC) Article 4.5 mandates the developed country parties to 'promote, facilitate and finance, as appropriate, the transfer of or access to, environmentally sound technologies and know how to the developing country party (UNFCCC, 1992). Sustainable energy technologies are captured by the broad environmentally sustainable technologies spectrum of the convention. Sustainable energy technologies directly and indirectly relate to the first seven Millennium Development Goals (MDG) (Aalst, 2004). Article 4.5 of UNFCCC creates the environment for integrating energy technologies in the Global Partnership for Development (MDG Eight). Innovative financing has been recognized as a key component of the technology transfer framework of UNFCCC under mechanisms for technology transfer (FCCC/SBSTA, 2006). Microfinance institutions (MFI) have been reported as an innovative financing mechanism for transferring energy technologies in several studies(Allderdice, Winiecki, & Morris, 2007; Hilman, Gidwani, Morris, Subedi, & Chowdhary, 2007; Kabutha, Sengendo, Winiecki, & Morris, 2007; Linden & Gautam, 2009; Rao, Miller, Wang, & Byrne, 2009). This paper will investigate the role of microfinance institutions in the distribution and acquisition of solar cookers, a particular passive solar thermal technology.

A. Rationale for Microfinance Intervention

Thomas Malthus suggested the possibility of the vicious cycle of poverty and environmental degradation. Implied was the relation between myopic mindset of the vulnerable poor and their likelihood of engaging in environmentally deleterious behavior to sustain immediate consumption. Gray and Moseley(2005) provide a detailed account of literature on poverty-environment interactions. Recently, along with the negotiations on climate change, the issue of vulnerable poor has taken center stage. The objective of adapting with uncertainties from climate change is intrinsically tied with the objective of mitigating carbon emission. The World Development Report 2010 warns that 'unless developing countries also transform their energy systems as they grow limiting warming to 2° C will not be achievable. That transformation requires transfers of substantial financial resources and low carbon technologies from developed to developing countries (World-Bank, 2010).'

In their most recent World Energy Outlook (WEO) report, the International Energy Agency (IEA) estimates that the population of people relying on traditional use of biomass will rise from 2.7 billion, at present, to 2.8 billion by 2030. The use of biomass in inefficient stoves and the resultant indoor air pollution is expected to cause 1.5 million premature deaths per year (IEA, 2010). Solar cooking technologies are one of the environmentally sustainable technologies that can contribute to mitigating the dependency on biomass fuels. Further, solar cooking technologies do not require any form of fossil fuel for operation.

The universal access to clean cooking technologies could be achieved though additional cumulative investment of $56 billion between 2010 and 2030 (IEA, 2010). Of this investment, 51% would have to be spent in biogas systems in rural areas, 23% in advanced biomass cookstoves in rural areas, and 26% in LPG cookstoves in both rural and urban areas (ibid). IEA claims to use LPG cookstoves only as a proxy for modern cooking technologies. Solar thermal technologies are among the most mature environmentally sustainable technologies. It is also obvious that solar cooking technologies perform more sustainably than both biomass and fossil fuel based technologies. IEA explicitly mentions microfinance among the financial intermediaries to disburse funds for improving access to clean cooking technologies (ibid). If the case of solar cooking technologies is investigated, can the microfinance institutions as financial intermediaries promote their wider adoption?

II. Literature Review

A. Solar Cooking Technologies

Solar cooking technologies have been considered as cheap and robust technologies for the developing countries for quite some time. Tabor(1966) was of the view that though parabolic solar cookers are not the most inexpensive technologies, their durability compensates for the initial investment. Telkes(1959) through her experiments on solar ovens remarks on the cost effectiveness of solar box cookers and on their applicability in preparing a wide range of food –'…practically all types of foods can be prepared….We conclude that all types of food can be prepared in solar ovens of the types described (triangular solar oven, pot stove, and the cylindrical oven (ibid).' Löf carried out a study on food processing ability of 7 solar cookers. He established the principle requirements for successful adoption of solar cookers as:

(i) Unit must cook foods effectively. Unit must be capable of providing a sufficient energy rate, at desired temperature, and to desired quantity of food.
(ii) It must be sturdy to withstand rough handling and natural hazards.
(iii) It must be sociologically acceptable and fit in with the cooking and eating habits of the people.
(iv) It must be economically possible for the user to obtain the cooker at a cost that gives him gain by its use (ibid).

More recent studies provide adequate basis for examining the technology of solar cookers. Schwarzer and da Silva (2008) provide a generic framework for classifying solar cookers. The four general categories (i) flat plate collector with direct use, (ii) flat plate collector with indirect use, (iii) parabolic reflector with direct use and (iv)parabolic reflector with indirect use. Reflectors are used in tracking and focusing the sun's energy with concave surfaces. In indirect systems heat is transported via a medium to cooking pots. This reduces the limitation of size. A more elaborate discussion on types of solar cookers is provided in S. K. Sharma (2004). See Annex 1 for details. Parabolic concentrators perform better than box type cookers when food has to be fried, roasted, or grilled. Box type cookers are most appropriate for boiling and baking. Sharma (2004) recommends consideration of (i) cost, (ii) safety, (iii) heating and cooking capacity, (iv) convenience (v) durability, (vi) ease of maintenance, (vii) stability in wind, (viii) operating instructions on the use of the cooker along with thermal performance for rating solar cookers.

Several studies converging on particular type of solar cookers further establish the potential of solar cookers as a complete alternative to traditional technologies. A flat plate collector cooker (2 m^2 collector area, two 10 liter cooking pots) with oil as heat transfer fluid can produce 210°C rise in temperature at 25°C ambient temperature and global solar flux of $1000W/m^2$ (Schwarzer & Vieira da Silva, 2003). Kalbande and Kothari, et al. (2008) on the basis of their experiments with parabolic solar cookers (1.3 m aperture diameter, 0.3 m depth, 0.35 m focal length) conclude that these cookers can be used for boiling, baking, and frying food. Some innovations in solar cooking technologies are represented in designs with vacuum tube collectors(Balzar, Stumpf, Eckhoff, Ackermann, & Grupp) and in designs with vacuum tubes and phase change materials which make solar cooking possible throughout day and night(S. D. Sharma, Iwata, Kitano, & Sagara, 2005).

B. Socio-economic Implications of Solar Cooking Technologies

Having ascertained the technical competence of solar cooking technologies, it is equally important to understand the social and economic implications of using these technologies. The application of solar cookers has been studied in diverse social contexts – in communal dining center for children (Franco, Cadena, & Saravia, 2004), urban communities (Ahmad), rural communities (Biermann, Grupp, & Palmer, 1999), etc. The studies also stretch across countries and regions. The acceptability of solar cooking technologies across communities is found to be encouragingly high. Dennery (2007) reports successful promotion of panel solar cookers, CooKit, in Kenya. Toonen (2009) found the same technology, CooKit, to complement cooking with use rate of 31% in Burkina Faso. The perception of CooKit in urban communities of Burkina-Faso relate with capacity of CooKit and with how the time spent on cooking food was valued by men and women(ibid). This study found that women were satisfied with the time saved by the use of solar cookers. A comprehensive study by Biermann (1999) in South Africa found families to use solar cookers on 32% of all days and for 38% of all meals. Ninety-three percent of these families were satisfied with the performance of solar cookers. This study observed that families use their solar cookers as much as or more than other cooking options. Ahmad recommends that solar cooker promoters should develop better understanding of the potential users.

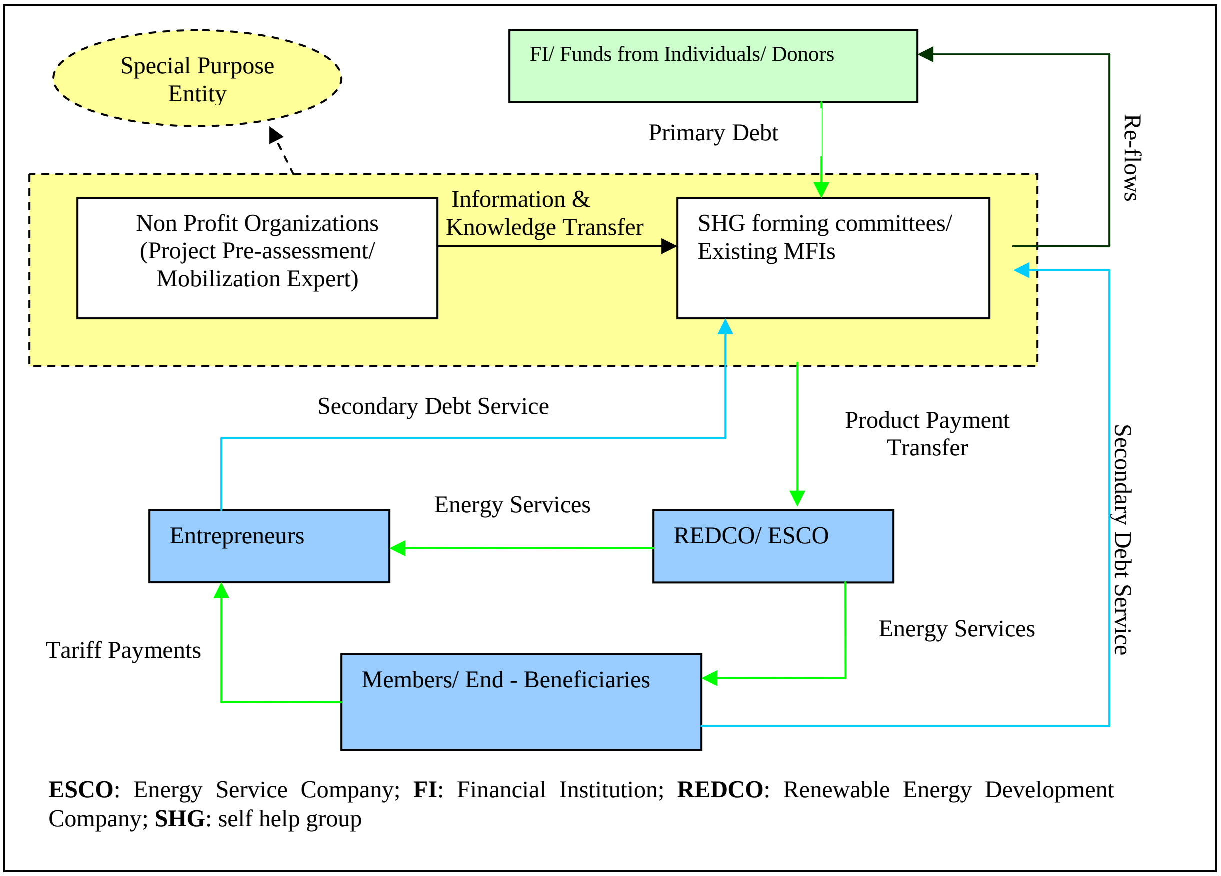
Economic impacts of solar cookers have been studied by several scholars(Biermann, et al., 1999; Carmody & Sarkar, 1997; Kandpal & Mathur, 1986; Nandwani, 1996; Wentzel & Pouris, 2007). Kandpal & Mathur (1986) analyzed net present value and performed break-even analysis to relate cost of solar cookers with savings from solar cookers. Savings from solar cookers is a function of meals cooked with solar cookers and price of the fuel saved. In such analysis, the price of conventional fuel per meal, initial cost of solar cookers, and frequency of solar cooker use are key parameters. Carmody & Sarkar (1997) discussed the roles that solar cookers can play in boosting indigenous economies and the national economy at large. Solar cookers can foster household savings while spurring growth in indigenous industries. Solar cookers can decrease drudgery for women and children in collecting firewood, incidence of acute respiratory infection and dependency on imported fuels (ibid). Nandwani(1996) estimated payback period for Costa Rican consumers using solar cookers along with possible CO2 reductions from use of solar cookers. Biermann(1999) carried out a similar analysis and came to the conclusion that financing solar cookers solely from monthly fuel savings would be a plausible strategy. In his analysis of seven solar cookers, the five least expensive cookers gave the consumers with use rate of 35% the opportunity to payoff the capital investment in 8 months to 5 years even when interest rates were as high as 30%. The variation in payback period was found to be the function of initial cost. Studying the same project, Wentzel and Pouris(2007) found solar cookers to offer savings in terms of (i) fuel saving, (ii) monetary saving, and (iii) time savings. Solar cookers had a positive impact on alleviating household poverty and on development at the household level (ibid).

Several studies on solar cookers have found the initial cost of these technologies as a binding constraint to widespread adoption. Initial cost can prohibit use of solar cookers (Biermann, et al., 1999; Carmody & Sarkar, 1997; Dennery, 2007; Kandpal & Mathur, 1986; Wentzel & Pouris, 2007). Kandpal and Mathur(1986) recommended subsidizing access to credit for solar cooker consumers. (Löf) made an interesting comment on the financial criterion. He recommended extending credits to potential consumers of developing countries who otherwise would not be able to pay the initial cost of solar cookers. Carmody and Sarkar (1997) and Wentzel and Pouris (2007) recommend using microfinance institutions for promoting solar cookers.

B. Microfinance Institutes (MFI) and Energy Technologies

Until the recent economic turmoil in South Indian microfinance industry, MFIs have been widely revered as an effective instrument for providing the poor with access to credit. In general, scholars appear to have reached consensus on the effectiveness of MFIs in reaching and serving the poor. The biggest contribution of MFIs has been showing that the poor are bankable(Hamada, 2010). Economics of MFIs have been discussed at length by several authors (Beatriz Armendariz de Aghion & Morduch, 2005; Gine, Jakiela, Karlan, & Morduch, 2010; Goddard, 2009; Kono & Takahashi, 2010; Morduch, 1999). Microfinance agencies use group lending, peer monitoring, and dynamic incentives to reduce risks that can be ascribed to lack of collateral and information asymmetry. Group lending lessens adverse selection and dynamic incentives are effective against moral hazard. Group lending can also alleviate moral hazard if peers can coordinate and if returns are sufficiently high (Kono & Takahashi, 2010). The returns on loans and strategic behavior of the borrowers are elaborated in (Beatriz Armendariz de Aghion & Morduch, 2005). Borrowers will find it strategically prudent to repay as long as payoff from default is less than payoff from compliance.

Several studies have focused on energy and microfinance link. Hall and Collins, et al. (2008) have argued that MFIs should be supportive of environmentally sustainable initiatives. MFIs concerned about scale (more clients), risks (more profit), regulation, access to funding, competition, and ethical considerations should work closely with microenterprises and promote environmentally friendly technologies (ibid). Rao, et al. (2009) proposed an ‘energy/microfinance framework’ for fulfilling the cooking and lighting energy requirements of low income households through microfinance intermediation. The framework envisions two agencies, one with energy expertise (a partner organization (PO)) and the other with financial expertise (MFI), to actualize energy projects. The PO identifies energy service companies that would design, service, and install clean energy technologies. It also selects the technology by studying the attributes of the households. Further, it identifies potential entrepreneurs to commercialize the technology. MFI independently assesses the credit worthiness of such potential entrepreneurs. PO provides training to these entrepreneurs and MFI provides credits to its clients to invest in products offered by the clean energy entrepreneur and to the entrepreneurs themselves. In this framework, all beneficiaries are members of MFI. Also, in this framework MFI and PO can be either a single or independent special purpose entities (figure 1).

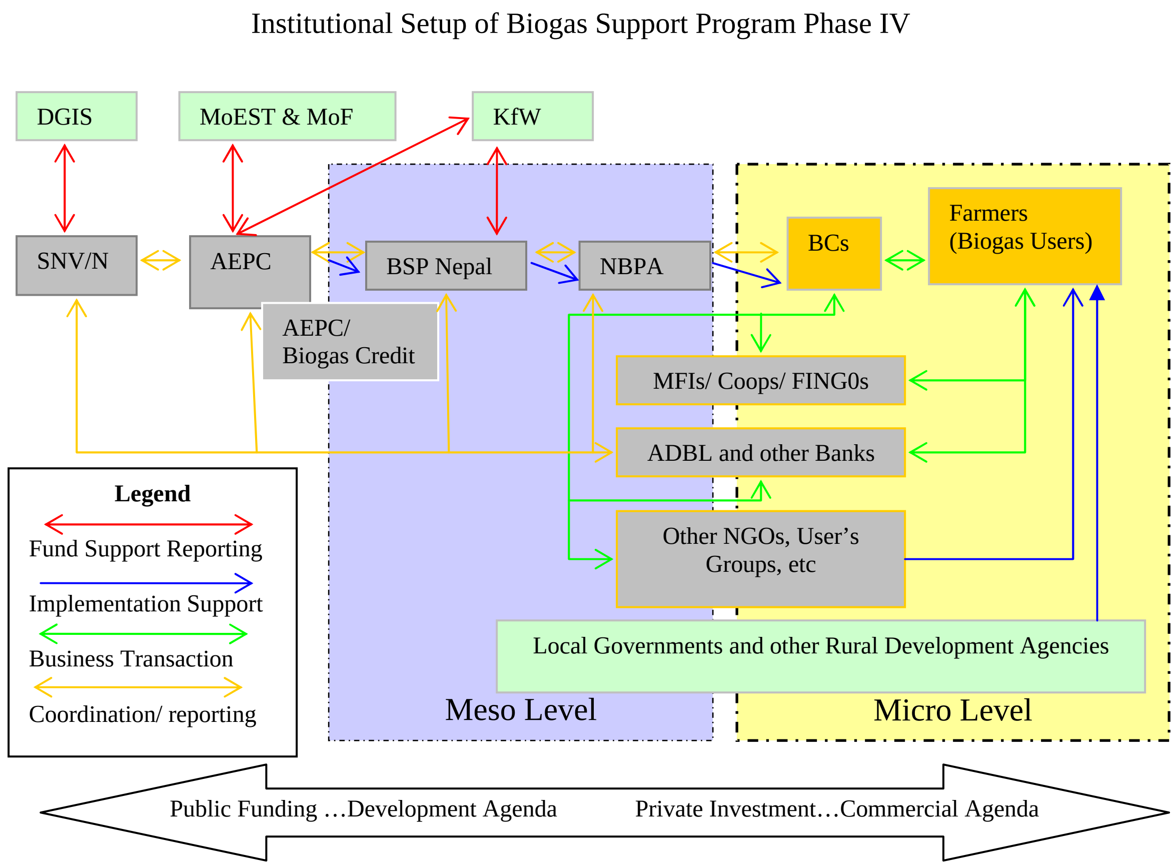


ESCO: Energy Service Company; **FI**: Financial Institution; **REDCO**: Renewable Energy Development Company; **SHG**: self help group

Figure 1: Energy/Microfinance Framework

Source: Rao, et al. (2009)

A model with specialized entities is practiced by the Biogas Support Program in Nepal. In this case there are no transactions between MFIs and companies that design, install, and service biogas systems (BSP, 2010). A single entity model for renewable energy – microfinance interaction is practiced at Grameen Shakti in Bangladesh for dissemination of photovoltaic lamp(Grameen-Shakti, 2010).Grameen Shakti assembles, installs, finances, and provides after sales services to promote photovoltaic solar home systems. Figures 2 and 3 depict the strategies of BSP and Grameen Shakti respectively.



DGIS: Ministry of Foreign Affairs of the Netherlands; **SNV/N**: Netherlands Development Organization Nepal; **KfW**: Kreditanstalt Für Wiederaufbau; **MoEST**: Ministry of Environment, Science & Technology, Nepal; **MoF**: Ministry of Finance, Nepal; **AEPC**: Alternate Energy Promotion Center; **BSP**: Biogas Support Program; **NBPA**: Nepal Biogas Promotion Association; **BC**: Biogas Companies; **FINGO**: Financial International Non Government Organizations; **ADBL**: Agriculture Development Bank Limited

Figure 2: Microfinance and Renewable Energy Financing –Biogas Support Program

Source: BSP(2010)

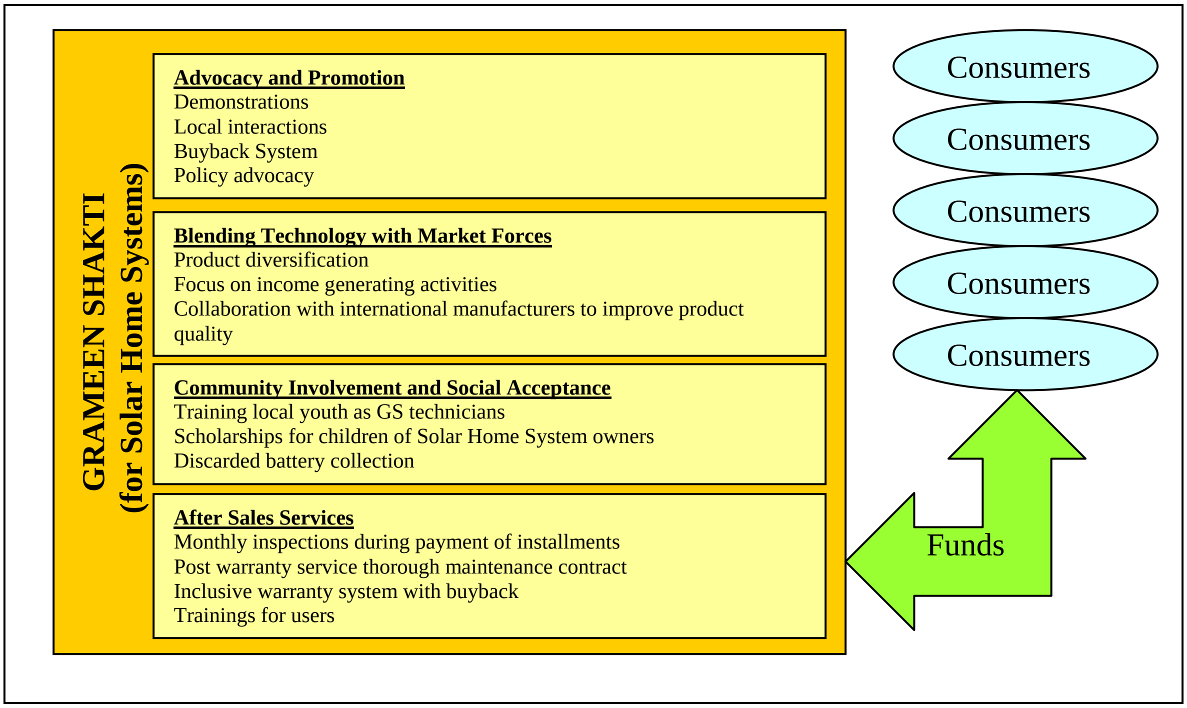


Figure 3: MFI and Renewable Energy Financing – A case of Grameen Shakti
Source: Grameen-Shakti(2010)

An extensive analysis of nexus between microfinance and access to energy is discussed in the series of studies by (Allderdice, et al., 2007; Hilman, et al., 2007; Kabutha, et al., 2007). These studies have reviewed MFI intervention for promoting energy technologies across Asia, Africa, and Latin America. The following table lists some of the microfinance institutes examined in these studies.

Microfinance	Energy Products
Self Employed Women's Association Bank (SEWA), India	Photovoltaic Solar Home System (PV SHS)/battery charging, solar lantern, improved cookstoves, sarai cooker
Sarvodaya Economic Enterprise Development Services (SEEDS), Sri Lanka	PV SHS, gird connection, village hydro scheme
Nirdan Utthan Bank Limited (NUBL), Nepal	Domestic biogas plant
Faulu Kenya, Kenya	Liquefied petroleum gas, PV SHS, biogas
Kenya Union of Savings and Credit Cooperatives(KUSCCO), Kenya	Liquefied petroleum gas, PV SHS, biogas
Mamoncito, San Jose, General Directorate of Community Development (DGCD), Dominican Republic	PV SHS
Fundación para Alternativas de Desarrollo (FADES), Bolivia	PV SHS

Table 1: Microfinance institutions and energy products compiled from Allderdice, et al. (2007); Hilman, et al. (2007) and Kabutha, et al. (2007)

In most cases, the interactions between MFI and energy products have been successful and financially acceptable. Summarizing the findings of these studies SEEP(2008) underscored the importance of well defined partnerships between the MFIs and energy enterprises. Further, SEEP(2008) have provided a set of tips for MFIs and a set of tips for energy enterprises. These tips were endorsed by 53 MFIs, energy companies, and investors representing 19 countries in a 2007 workshop in Ahemdabad, India (ibid).

Tips for MFIs looking for energy enterprises	Tips for energy enterprises looking for MFIs
Common development vision - energy enterprise like MFI should view lower income population as a potential market	***Flexibility in lending models*** - MFI should be flexible in designing lending and risk mitigation products such as repayment schedules, collateral requirements, loan tenure, and eligibility criteria
Reputable and reliable -energy enterprise should have good reputation and an acceptable history of operations	***Extensive and diverse reach*** - MFI should have broad, loyal, and diverse client base and it should be willing to attract new clients to support energy company. This will enable energy company to reap benefits of economies of scale.
Local market presence - energy enterprise should have presence in local market and it should be aware of local business environment	***Readiness to introduce energy lending*** - MFI should be willing to offer unconventional products and have the capacity to bear risks.
After sales services -energy company should be willing to provide after sales services such as service contracts, warranties, buy back deals in case of default	***Creditworthy and Sustainable*** - MFI should be transparent and be in good financial health. It should have strong client retention, realistic business plan, solid loan tracking and monitoring system, and disciplined management.
Strong business principles - energy enterprise should operate under sound business principles that are reflected in pricing, credit terms, product quality, and flexibility in product offerings	***Demand for energy*** - MFI should be informed and stay updated on demand for energy and household income situation.
Capacity to meet clients' needs - energy enterprise should be able to provide tailored products to suit client demands and have the capacity to scale up	***Top management buy-in and internal champion of energy*** - energy agenda should be ingrained internally and in top management of MFI
Technical trainings - energy enterprise must be willing to provide trainings to both MFI representatives and clients	***Internal capacity to support energy lending program*** - MFI should be able to allocate sufficient human and financial resources to start and to sustainably manage energy lending. Further, it should make efforts to institutionalize energy lending.

Table 2: Tips from field for MFIs and energy enterprises (SEEP, 2008)

A similar extensive cross country case study by Morris and Kirubi (2009) has investigated the role of the government in fostering nexus between financial agencies and energy enterprises. The study arrived at the conclusion that (i) access to modern energy services for the poor can be improved with interventions from small scale financial agencies (ii) outcomes are significantly affected by the design of small scale finance programs, (iii) energy financing is good business for financial institutions serving the poor and (iv) convergence between the policies pertaining to energy services and small scale finance improves access to affordable and modern energy services for the poor. The study rationalized proactive government support for fostering linkages between energy and small scale finance as these linkages helps in attaining the broader goals of poverty alleviation, rural development, job creation, and improvements in health, education, and gender equity. The study recommended that governments should (i) understand the existing situation on small scale financing for energy products and services, (ii) employ national rural energy policies and programs to create conducive environment for small scale financing, (iii) facilitate partnerships to support energy enterprises and financial agencies serving the poor and (iv) support and strengthen monitoring, evaluation, and disclosure of energy lending portfolio performance, impact, and growth (ibid).

The existing literature supports MFI intervention for accelerated and sustainable transfer of energy technologies. This research will examine the case of solar cooking technology and investigate whether the technology endows its consumers with benefits which would in turn enable them to borrow from MFIs. The questions are

(i) Would consumers of solar cooking technologies accrue adequate benefits to justify the cost of borrowing for adoption for these technologies?
(ii) Can MFIs lending for adoption of solar cookers expect sustainable repayment rates?

The findings of this inquiry, when viewed from the MFI perspective, would inform the MFIs on financial viability of solar cooking technologies and therefore help them in making prudent lending decisions.

III. Methodology

The investigation will proceed by developing an analytic framework for evaluation of financial viability of solar cooking technologies when these technologies are financed through MFIs. The analytic framework will be applied on four unique country cases with a solar cooking technology and the results will be discussed.

A. Analytic Framework

The objective of the analytic framework is
(i) to estimate the returns from use of solar cooking technologies
(ii) to integrate the redeemable estimate of returns as payoffs for lenders and borrowers involved in generic MFI lending contract
(iii) to observe whether it is strategically prudent for MFIs to invest in solar cooking technologies

This study will use ‘returns management’ scheme recommended by Aalst (2006). There are ample opportunities for policy makers and project developers working in climate change arena to reevaluate and improve returns from environmentally sustainable technologies. The five categories for evaluating returns are from financing projects that transfer sustainable technologies are
(i) Financial returns: Profits, interests, and other typical payments expected by the financier.
(ii) Economic returns: Economic benefits created by the project such as job creation, economic development.
(iii) Environmental returns: Value added or preserved in the natural environment as the result of project implementation such as mitigation of GHG.
(iv) Social returns: Benefits to society in form of improvements in health and education.
(v) Emotional returns: Human interest of project partners such as donors, philanthropists.

This scheme will produce a comprehensive understanding of returns from transferring solar cooking technologies and estimate all possible returns for the consumers and society at large. However, assuming that everything within the comprehensive returns may not align with decision models of MFIs, only those returns that are tangible will be integrated in the MFI decision model. The tangible returns are financial returns from the solar cooker to consumers, interest payments to the MFIs, and possible benefits to either consumers or MFIs from secondary markets such as carbon markets.

Kandpal and Mathur(1986) propose a method for estimating the financial returns from solar cookers based on cost of solar cookers, use rate, and price of substituted fuels.

$$NPV \approx \left(\frac{np-\alpha C_o}{d}\right)\left(\frac{(1+d)^t-1}{(1+d)t}\right)-C_o;\; N_m \approx \left(\frac{C_o}{p}\right)\left(\alpha+\frac{d(1+d)t}{(1+d)^t-1}\right);\text{ and}$$

$$PP_0 = \frac{C_o}{(np-\alpha C_o)}$$

Here,

C_0 is the initial cost of a solar cooker

NPV is the net present value of purchase to solar cooker user

α is the fraction of initial investment spent on maintenance of cooker each year

n is the number of meals cooked with solar cookers

p is the price of the fuel substituted

d is the discount rate for a time-period

t is the useful lifetime of solar cooker in periods

N_m is the number of meals that have to be cooked for breakeven or for NPV to be zero.

PP_0 is the payback period

This calculation will also work if *n* is the use rate and *p* is the total money spent on substituted fuels per period. This method is advantageous as using savings, *np*, based solely on frequency of use and price of substituted fuels as dependent variable makes the approach applicable to all solar cooking technologies.

It should also be noted that if payback period suggested by Kandpal and Mathur (1986) does not account for the interest on the loan that may be levied by the lending MFI. An alternate calculation of payback period as *'PP'* is adopted in this study. For an interest rate of *'I'* and monthly repayment amounts are $n_k * p_k$, which is simply the product of the use rate and price of substituted fuel for any month *k*, *PP* is the month when the total debt reduces to zero. Further *I* is compounded monthly such that *' i_c '* is the monthly interest rate levied by the MFIs on the borrowers. With such formulation, debt for any month *k+1* is $(D_k - n_k * p_k)(1+(i_c/100))$ where 'D_k', 'n_k', and 'p_k' are debt, use rate, and price of substituted fuels of the previous month respectively.

A simple analysis of dynamic incentives in the contract between MFI and borrowers investing in solar cookers will help in understanding the strategy for MFIs. Assuming that loans are made to individuals and the penalty of a default is confiscation of solar cookers, incentive compatibility constraint as described in Aghion and Morduch (2005) can be applied to observe the strategic position of borrowers. The incentive compatibility constraint for a MFI is the maximum gross interest rate that it can charge a borrower without incentivizing strategic default. The constraint is such that it ensures the borrower receives greater payoff from compliance that from default. In presence of dynamic incentives, a borrower will not default in any period '*k*' as long as $y_k + vdy_{k+1} \leq y_k - R + dy_{k+1}$ where y_k is the gross return from loan in period k , v is the probability that MFI will finance a loan to produce gross return y_{k+1} in the next period *k+1*, *R* is the periodic payment (interest and principle) payable to MFI, and *d* is the discount rate.

For any period *i* the gross return for the user of a solar cooker is savings from unused fuels for cooking, '*np*'. Here, *np* is the product of number of uses and price of the substituted fuels. Equivalently, it is product of use rate and total amount that would have been spent on fuels without solar cookers.

Hence, in the MFI's incentive compatibility constraint will be a function of $(n_k p_k)$ for any period *k.* The objective would be to find the *R* that fulfills the constraint. Calculations with savings as payoffs show $R_{max} = dy_{k+1}(1-v)$ *or* $R_{max}= dn_{k+1}\ p_{k+1}(1-v)$. The periodic payment that MFIs can charge a consumer is always less than or equal to the expected savings for unused fuels in the next period.

This analytic framework will be applied on 3 country cases for a test case solar cooker. Further, the other benefits discussed in returns management scheme Aalst(2006) will be evaluated in the discussion section.

B. Country Cases

For the purpose of this study, projects in Bangladesh, South Africa, and Mexico will be used as cases. These countries represent the major developing regions. Major rural populations in all of these countries depend significantly on fuelwood for cooking.

C. Test Solar Cooker

For this study, the HotPot, a solar cooker distributed by Solar Household Energy (SHE) Inc, a non profit based in United States, will be used as test case solar cooker. The HotPot is a panel oven. The Hot Pot is comprised of a black enamel pot fitted inside a covered glass bowl and a foldable panel reflector of cardboard or aluminum. This simple device can boil and pasteurize water and cook food using only passive solar thermal energy and producing zero emissions or pollution. The technology was developed by the efforts of SHE, Florida Solar Energy Center, and Mr. Glen Newman of Energy Laboratories Inc. HotPot closely resembles CooKit. As in the case with CooKit, it has been socially accepted in projects implemented in Burkina Faso, Senegal, and the Gambia. The price of HotPot for this study is estimated at US$ 60 for all countries.

IV. Findings

Price of substituted fuels is determined from literature. In all cases, the price of the substituted fuels is approximated with the assumption that these prices will represent market prices or the opportunity cost of time and labor spent in collecting fuel. For simplifying the estimations the probability, '*v*', is assumed to be zero. The borrowers will not have access to the solar cookers or to credit in the case of default. It is important to understand that '*v*', depends on the procedures practiced by microfinance sectors in any given country. In practice, '*v*' is often non-zero. Implications of non zero probability will be discussed in the discussion section.

For each country case, three scenarios are considered. In the first analysis, discount rate is varied between 0.01 percent per month and 0.02 percent per month while price of the substituted fuels and use rate are kept constant. In the second analysis, discount rate is kept constant along with use rate while price of substituted fuels is varied at monthly rates between 0.99 and 1.01. In the third analysis, use rates are varied between 20% and 40% while discount rate and price of substituted fuels are kept constant.

While estimating net present value (NPV) after five and ten years of solar cooker use, it is assumed that the household is liable for repayment of entire debt.

Case I: Bangladesh

The rural energy survey carried out by Bangladesh Institute of Development Studies (BIDS) in 2004 depicts the following pattern of energy consumption in the sample households.

Energy Source	HH using source	Energy Used	Energy Cost (Tk)	Share of total Energy content (%)	Share of Total Energy Expenditure (%)
Fuelwood	84.3	37.14	169.73	38.81	36.80
Non-fuelwood biomass*	15.2	53.01	171.13	55.38	37.11
Kerosene	97.2	1.98	54.76	2.07	11.87
Grid electricity	29.0	2.17	47.09	2.27	10.21
Other sources	70.6	1.41	18.48	1.47	4.01
All energy sources	100.0	95.71	461.19	100	100
Sample size = 2388					
* includes leaves, crop residue, dung, and sawdust ** includes candles, dry cell batteries, LPG and LNG					

Table C.1: Energy Consumption by Rural Household in Bangladesh

(Barnes, Khandker, & Samad, 2011) remark that most of the energy for cooking comes from use of fuelwood and other sources of biomass for energy poor households. In such case, the net expenditure by energy poor household for cooking can be approximated at Tk 340 or approximately U.S. $ 4.82. This estimation is close to findings in (Miah, Kabir, Koike, Akther, & Yong Shin, 2010) that looks at a different set of 120 Bangladeshi households and finds expenditure of U.S. $ 3.02 by a household on biomass fuel.

The maximum compound interest rate that can be levied on the Bangladeshi households when price of substituted fuel is $4.81 and use rate is thirty percent is 26.52%. Compound interest rate of 20% is considered to estimate the breakeven payment period. When compound interest rate is 20.0%, use rate is 30.0% and price of substituted fuel is $ 4.81; a Bangladeshi household that expends its total savings from use of solar cookers on debt repayment can pay the debt in 85 months.

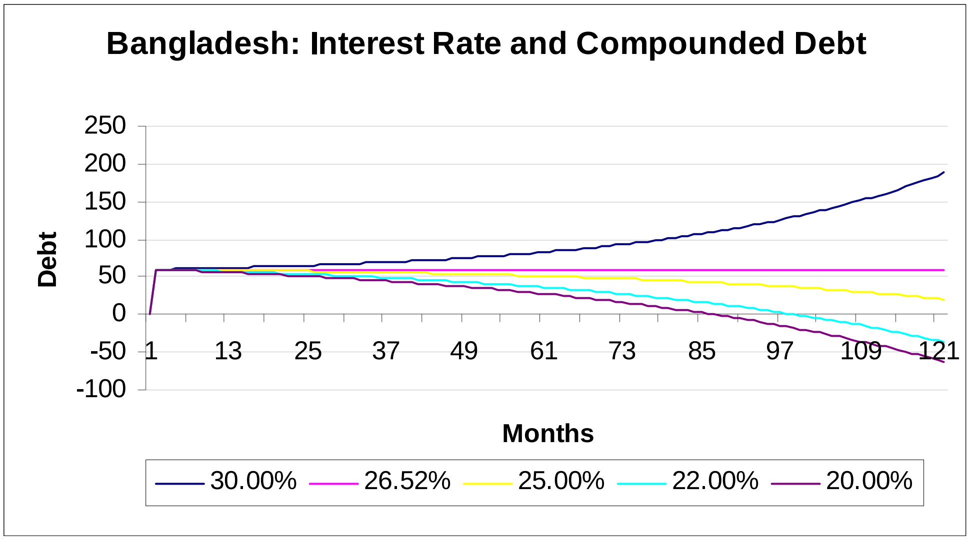


Figure C1: Compounded Debt at Different Interest Rates for Bangladeshi Household

NPV in 5 years is negative in such case regardless of discount rate. Table R.1 and figure R.1 show the net present values for solar cookers lasting five and ten years at various discount rates. With these assumptions the incentive compatibility constraint for MFIs is in the range of US$ 1.31 to US$ 1.30.

Monthly Discount Rates	0.01	0.012	.0.014	0.016	0.018	0.02
NPV : lifetime = 5 Years	-17.40	-15.25	-13.40	-11.80	-10.41	-9.22
NPV : lifetime = 10 Years	15.01	12.04	9.62	7.64	6.03	4.71
ICC on 85th month	1.31	1.31	1.31	1.30	1.30	1.30

Table R.1. Bangladesh-Net Present Value at different discount rates

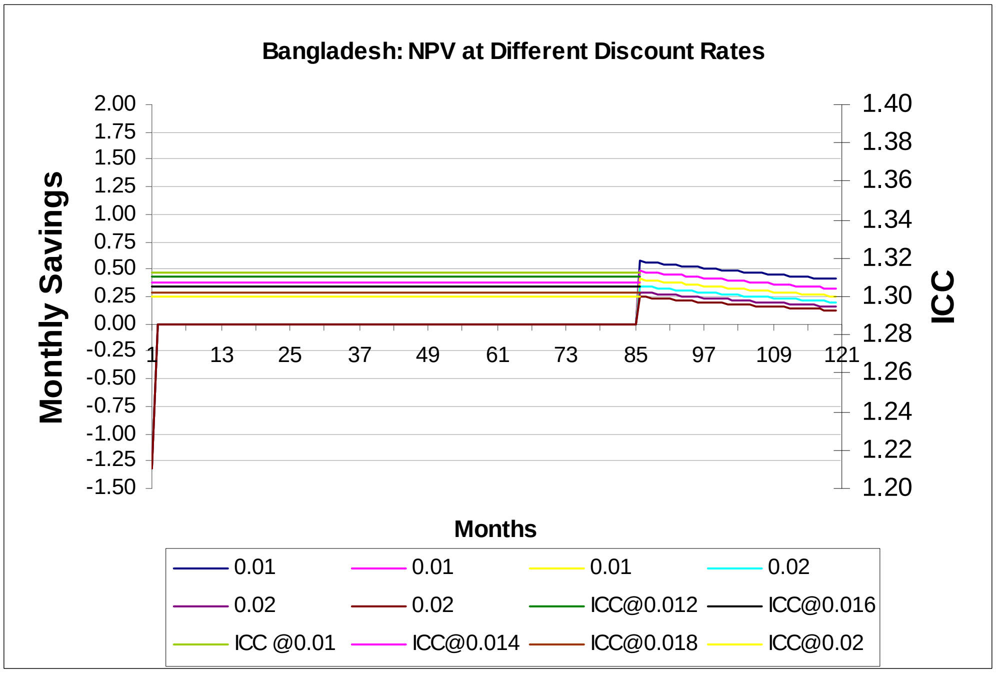


Figure R.1 Bangladesh – Net Present Values at different discount rates

Monthly savings change significantly when the price of substituted fuels changes. Table R.2 and figure R.2 show NPV when the price of substituted fuels increases or decreases at constant rates. A Bangladeshi household will never be able to pay off the debt with savings alone if fuel prices change at the monthly rate of 0.99%. If the rate of change is 0.995%, the household will need more than ten years to repay the debt with savings. The incentive compatibility constraint when price of the substituted fuels is increasing has a positive slope. The highest incentive compatibility constraint is US$ 3.455 at one percent monthly increase in price of substituted fuels while the lowest at one percent monthly decrease is US$ 0.447. Households subjected to increases in price of traditional fuels have incentives to comply with payment schedules of the MFIs.

Rate of change In price of substituted fuels	0.99	0.995	1	1.005	1.01
NPV : lifetime = 5 Years	-35.68	-28.87	-20.70	-10.86	1.06
NPV : lifetime = 10 Years	-23.59	-8.68	12.11	41.75	84.85
Breakeven payback period (months)	Never	>10 Years	85.00	65.00	54.00
ICC on 85th month	0.48	0.81	1.31	2.08	3.25

Table R.2. Bangladesh-Net Present Value at different price change rates

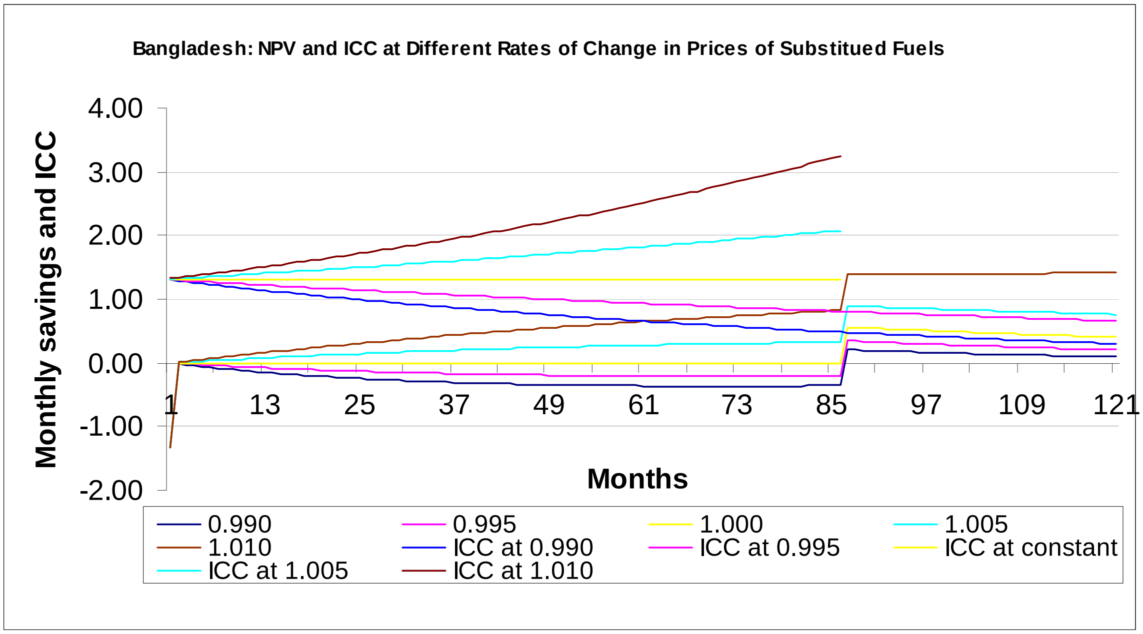


Figure R.2 Bangladesh – Monthly savings and incentive constraint at different rates of change in price of substituted fuels.

The other important factor influencing the savings from solar cookers is the use rate or frequency of use in the household. The savings are directly proportional to use rates. Table R.3 and figure R.3 show results for different use rates. ICC and breakeven payback periods also change with use rate.

Use Rate	**0.2**	**0.25**	**0.3**	**0.35**	**0.4**
NPV : lifetime = 5 Years	-39.07	-28.23	-17.40	-6.57	4.27
NPV : lifetime = 10 Years	-18.18	-1.39	15.41	32.21	49.01
Breakeven payback period (months)	Never	>10 Years	85.00	62.00	49.00
ICC on 85th month	0.836	1.074	1.313	1.551	1.790

Table R.3. Bangladesh-Net Present Value at different use rates

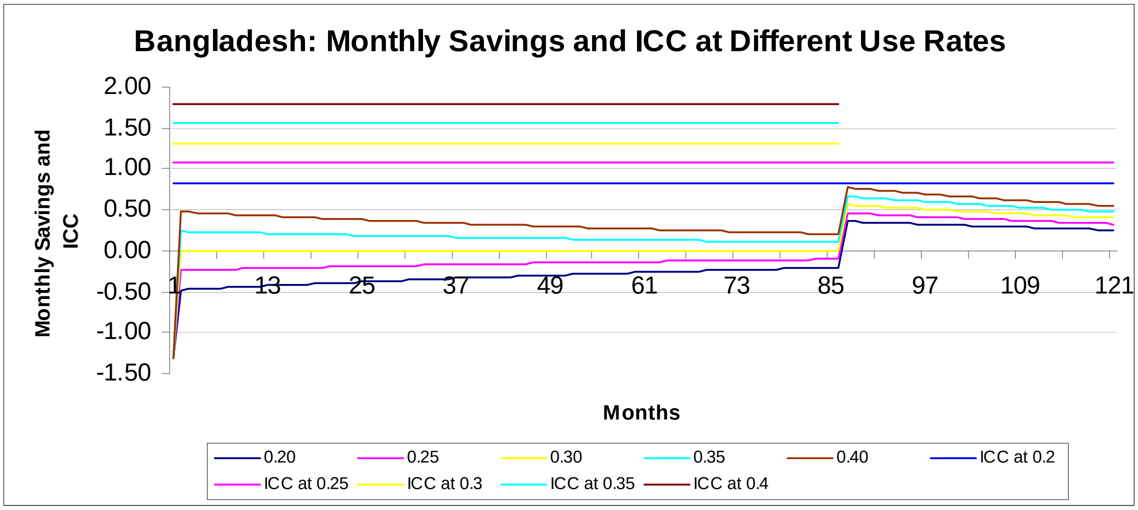


Figure R.3 Bangladesh - Monthly Savings and Incentive Constraints at Different Use Rates

Case II: South Africa

(Wentzel & Pouris, 2007), in examining five studies from 1997 to 2003, find the use rate of solar cookers to be greater than thirty percent among the adopting households. These studies were carried out in deep rural (Onseepkans on the Namibian border), urban (Pniel near Barkly-west), and peri-urban (Huhudi near Vryburg) areas. Average savings for all fuels using solar cookers were as follows. The savings were highest in test areas where electricity was accessible and fuel had to be bought and lowest in areas where wood was collected for fuel. In average, the reported monthly savings from use of solar cookers using the 2002 exchange rate can be approximated at U.S. $ 6.00.

Indicator	Pniel	Onseepkans	Huhudi
Weighted average all fuel savings (%)	36	34	39
Average monthly fuel expense (ZAR)	46	31	66
Average monthly fuel savings (ZAR)	17	12	26

Table CII : Average monetary savings by households using solar cooker in South Africa

Source: GTZ and DME (2002) in (Wentzel & Pouris, 2007)

A longitudinal study by (Madubansi & Shackleton, 2006) reports average fuelwood expenditure in households of five villages in Bushbuckridge, South Africa to be ZAR 65 in 1991 and 96.8 in 2002. The approximated savings of U.S.$ 6.00 is more conservative than the fuelwood expenditures observed in (Madubansi & Shackleton, 2006).

A South African household with use rate of 30.00% and paying $6.00 every month on substituted fuel can pay only the interest and not the principle from savings if solar cooker is financed at 33.6%. To calculate the breakeven payment period, compound interest rate of 30.00% is used. In such case, South African household can repay the loan with savings in 91 months (when use rate is 30.00% and fuel price is $6.00).

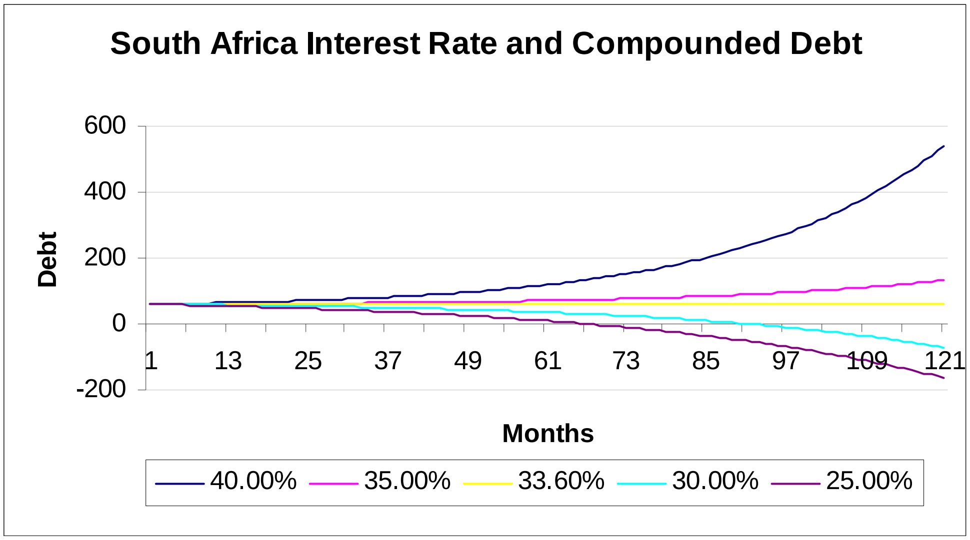


Figure CII: Compounded Debt at Different Interest Rates for South African Household

As in the case of Bangladesh, the South African households get monthly positive savings from solar cookers after the end of breakeven payment period of 91 months when the price of substituted fuel is constant. South African households are subjected to higher interest rate in this analysis and thus NPV after five years remains negative regardless of discount rates. Table R4 and Figure R4 show the results for different discount rates when use rate is 0.3 and price of substituted fuel is constant. Incentive compatibility constraint for MFIs is in the range of US$ 1.66 to US$ 1.64 in this case.

Monthly Discount Rates	0.01	0.012	.0.014	0.016	0.018	0.02
NPV : lifetime = 5 Years	-26.23	-22.84	-19.92	-17.42	-15.27	-13.42
NPV : lifetime = 10 Years	14.84	11.75	9.24	7.21	5.56	4.22
ICC on 91st month	1.66	1.66	1.65	1.65	1.65	1.64

Table R.4. South Africa-Net Present Value at different discount rates

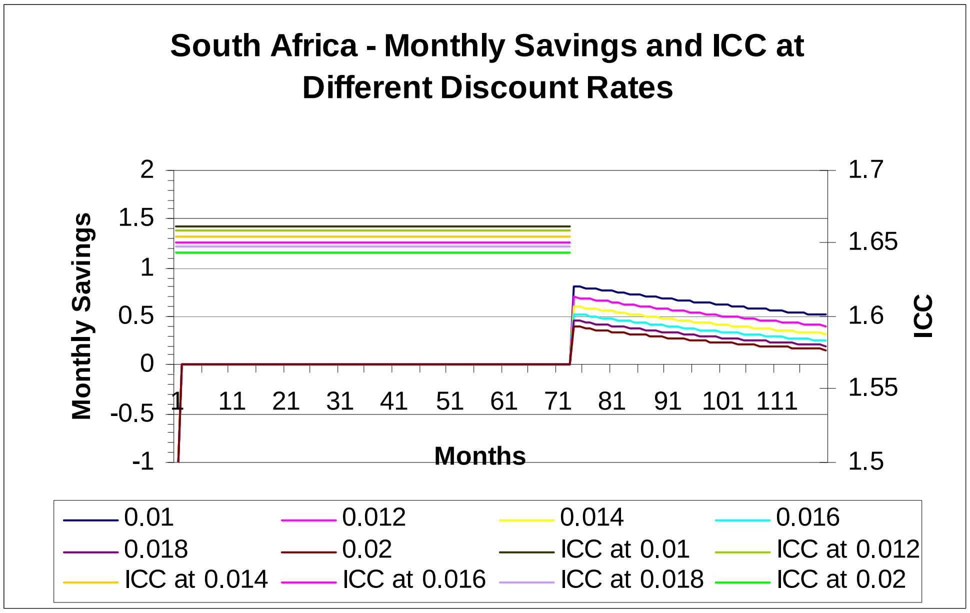


Figure R.4 South Africa – Net Present Values at different discount rates

At 30.00% compound interest rate, South African households will never be able to pay off the loan only with savings when price of the substituted fuels change at monthly rates of 0.99 and 0.995. The highest incentive compatibility constraint for MFIs financing solar cookers in South Africa is US$ 4.33 when fuel prices are increasing at the monthly rate of one percent. Table R5 and Figure R.5 show the NPV for changes in fuel price.

Rate of change In price of substituted fuels	0.99	0.995	1	1.005	1.01
NPV : lifetime = 5 Years	-44.88	-36.40	-26.23	-13.97	0.86
NPV : lifetime = 10 Years	-29.10	-10.54	15.35	52.24	105.89
Breakeven payback period (months)	Never	Never	91	63	52
ICC on 91st month	0.59	1.00	1.66	2.70	4.33

Table R.5. South Africa-Net Present Value at different price change rates

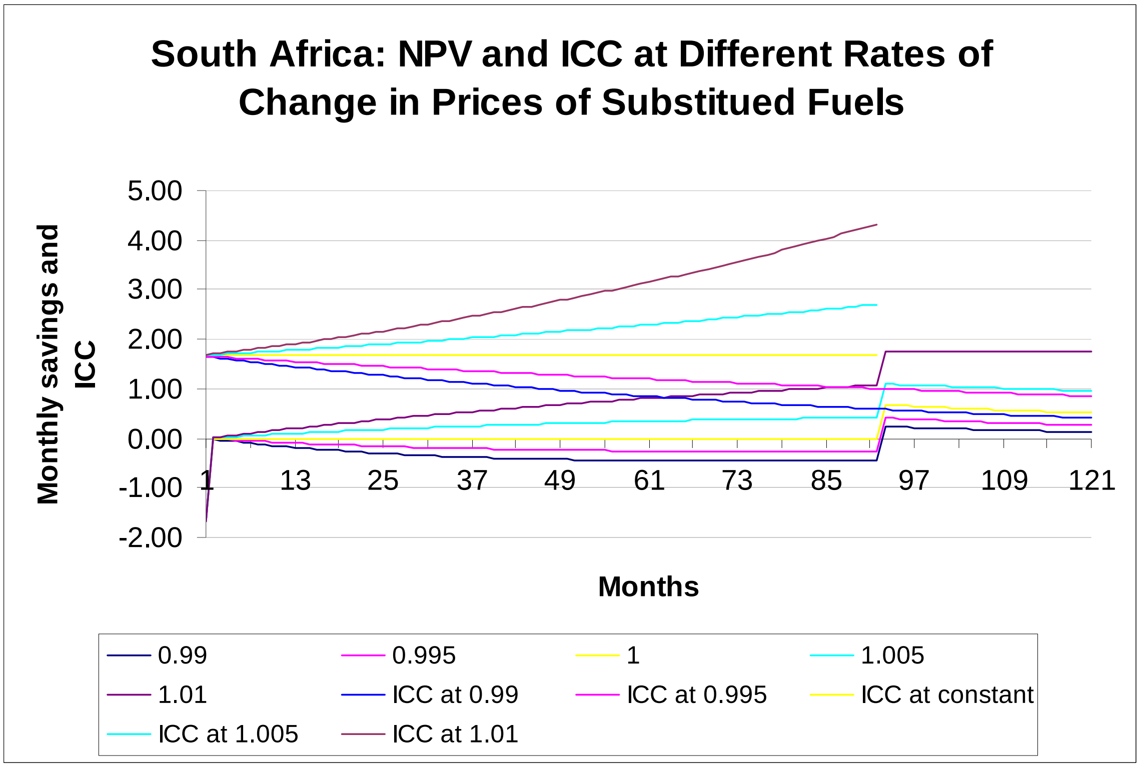


Figure R.5 South Africa – Monthly savings and incentive constraint at different rates of change in price of substituted fuels

A South African household with use rate of less than 30.00% will never be able to pay off the loan with savings as long as fuel prices remain unchanged. The NPV is negative even after 10 years for South African households that use solar cookers less than thirty percent cooking. Table R5 and Figure R5 show the results for different use rates. The highest incentive constraint for MFIs in this case in US$ 2.26 at forty percent use rate.

Use Rates	**0.2**	**0.25**	**0.3**	**0.35**	**0.4**
NPV : lifetime = 5 Years	-53.20	-39.71	-26.23	-12.74	0.75
NPV : lifetime = 10 Years	-26.47	-5.56	15.35	36.26	57.17
Breakeven payback period (months)	Never	Never	91	58	44
ICC on 91st month	1.07	1.37	1.66	1.96	2.26

Figure R.6 South Africa - Monthly Savings and Incentive Constraints at Different Use Rates

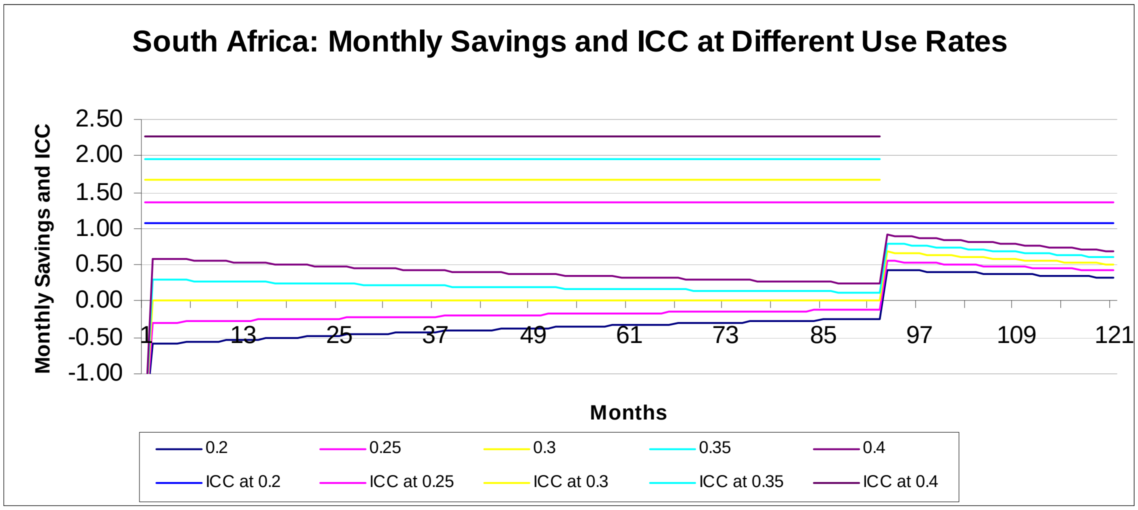


Figure R.6 South Africa - Monthly Savings and Incentive Constraints at Different Use Rates

Case III: Mexico

(Berrueta, Edwards, & Masera, 2008) studying the households in Michoacan, Mexico found per capita per day consumption of fuelwood to be lowest in households using improved cookstoves (in this case improved cookstoves called Patsari cookstoves) and a mix of fuels. (García-Frapolli et al., 2010) assumed price of fuelwood to be US$ 0.12 per kg to carry out a cost benefit analysis with data from (Berrueta, et al., 2008). Assuming all households collect fifty percent of the fuelwood at no cost and buy the remainder at US$ 0.12, the monthly cost of fuelwood for household that uses only fuelwood is approximately between US$ 31.8 and US$ 6.6. The following table computes monthly expenditure on fuelwood with findings from (Berrueta, et al., 2008)with price of fuelwood used by (García-Frapolli, et al., 2010).

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	Household characteristics	Sample size	Household size	Wood consumed (kg/capita/day	Fuelwood cost U.S.$ (excluding collected)
Traditional cookstoves	Exclusively fuelwood	23	5.2±0.3	3.4±0.8	31.824
	Mixed fuels	20	4.7±0.5	2.3±1.1	19.458
Improved cookstoves	Exclusively fuelwood	8	4.6±0.6	1.1±0.4	9.108
	Mixed fuels	6	4.6±0.6	0.8±0.3	6.624
Fuelwood priced at US$ 0.12 per kg					

Table CIII: Expenditure on fuelwood in Michoacan, Mexico

Source: (García-Frapolli, et al., 2010) and (Berrueta, et al., 2008)

The estimated expenditure of US$ 6.624 is the most conservative approximation and represents the households that have improved cookstoves and use a mix of fuels.

A Mexican household with use rate of 30.00% intending to pay the loans with savings from application of solar cookers cannot bear more than compound interest rate of 37.34% when fuel prices remain constant at $6.624. Payback period at compound interest rate of 30.00% is sixty-six months.

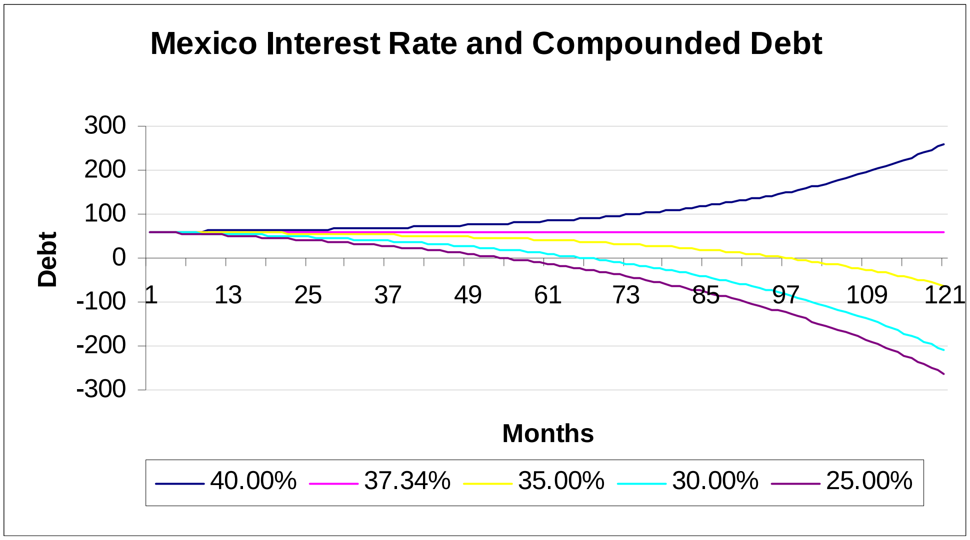

Figure CIII: Compounded Debt at Different Interest Rates for Mexican Household

For constant price of substituted fuels and constant use rate, monthly savings start from 66th month, the payment period. NPV at the end of five years is negative whereas at the end of ten years it is as high as $ 37. Table R.7 and Figure R.7 show the results for Mexico.

Monthly Discount Rates	0.01	0.012	.0.014	0.016	0.018	0.02
NPV : lifetime = 5 Years	-7.82	-7.12	-6.50	-5.96	-5.48	-5.05
NPV : lifetime = 10 Years	37.82	31.31	25.91	21.42	17.68	14.55
ICC on 66th month	1.85	1.84	1.84	1.84	1.83	1.83

Table R.7. Mexico-Net Present Value at different discount rates

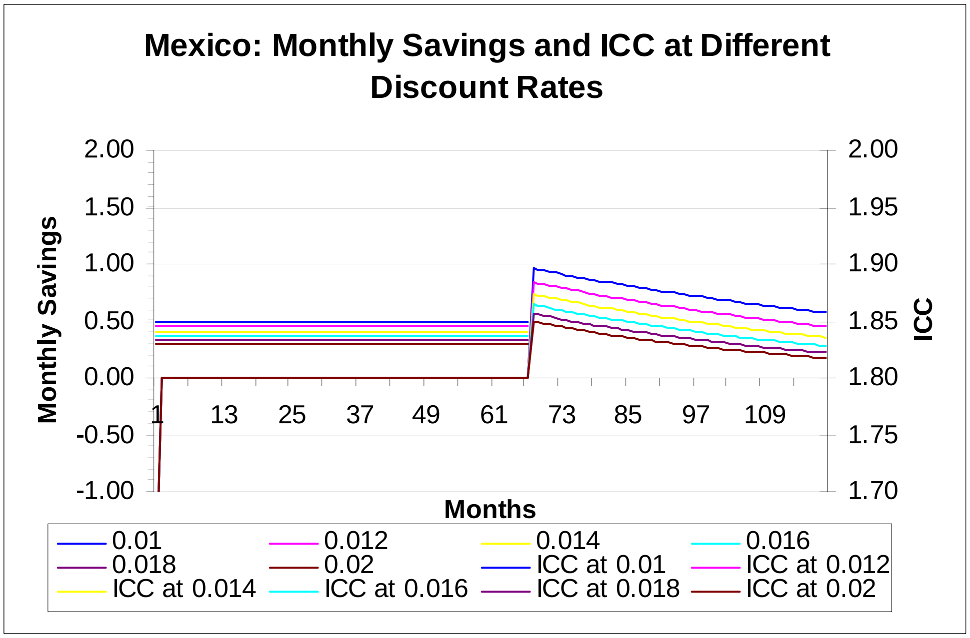

Figure R.7. Mexico-Monthly Savings and ICC at different Discount Rates

A Mexican household will never be able to payoff the loan with savings only if the price of substituted fuels decreases by 1.00% every month. Likewise, NPV in ten years is negative only when price rates are decreasing at monthly rate of one percent. The highest NVP for prices increasing at one percent is US$ 22.07 in five years and US$ 138.34 in ten years. The lowest investment constraint is US$ 0.88 and the highest is US$3.71 on sixty-sixth month. MFIs in Mexico should be comfortable financing solar cookers as long as savings from the cookers satisfy these investment constraints.

Rate of change In price of substituted fuels	0.99	0.995	1	1.005	1.01
NPV : lifetime = 5 Years	-28.42	-19.05	-7.82	5.70	22.07
NPV : lifetime = 10 Years	-10.68	9.80	38.38	79.11	138.34
Breakeven payback period (months)	Never	118	66	52	44
ICC on 66th month	0.88	1.29	1.85	2.63	3.71

Table R.8 Mexico-Net Present Value at different price change rates

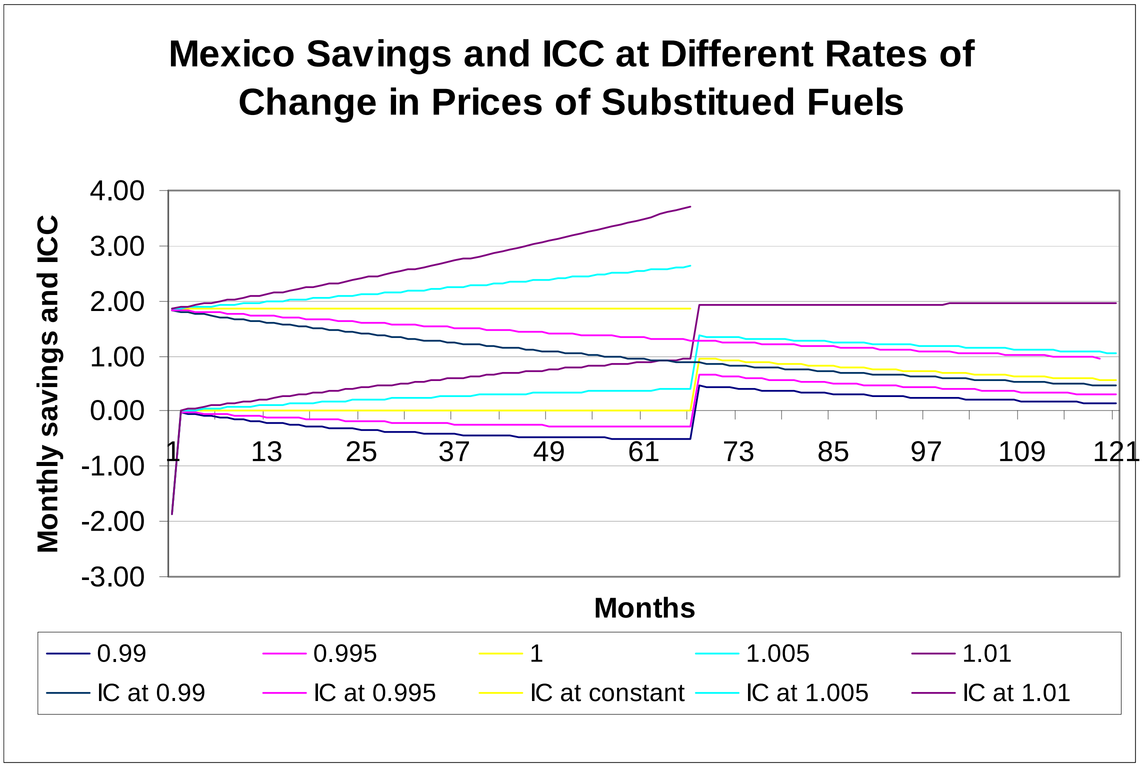

Figure R.8 Mexico – Monthly savings and incentive constraint at different rates of change in price of substituted fuels

In the ten year period, NPV is negative only when use rate is below 25.00%. At use rate of 20.00%, a Mexican household will never be able to pay off the loan with savings from use of solar cookers. Highest NPV is accrued by households that use solar cookers for cooking forty percent of their meals. The lowest incentive compatibility constraint is US$1.19, and the highest incentive constraint is US$ 2.50.

Use Rate	**0.2**	**0.25**	**0.3**	**0.35**	**0.4**
NPV : lifetime = 5 Years	-37.60	-22.71	-7.82	7.07	21.95
NPV : lifetime = 10 Years	-7.79	15.30	38.38	61.47	84.55
Breakeven payback period (months)	Never	>10 Years	66	47	37
ICC on 66th month	1.19	1.52	1.85	2.18	2.50

Figure R.9 Mexico - Monthly Savings and Incentive Constraints at Different Use Rates

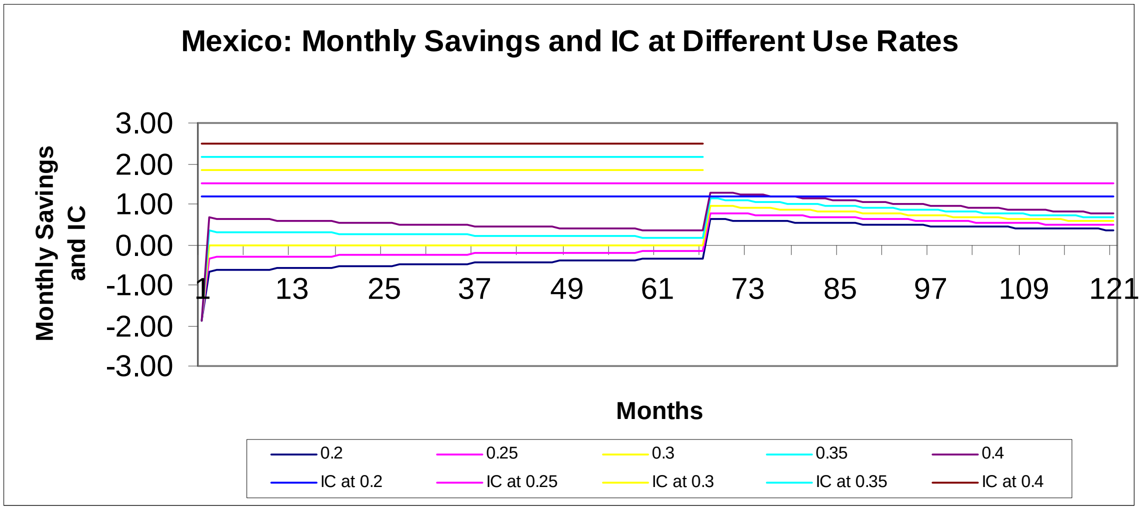

Figure R.9 Mexico - Monthly Savings and Incentive Constraints at Different Use Rates

V. Discussion

The interaction between the consumers of solar cookers and MFIs are to a large extent dependent on behavior of consumers, dynamics of MFI lending strategy, and price of cookers, credit, and substituted fuels. From the standpoint of MFIs, the probability of alternate access to credit also plays an important role in forecasting performance of loans. Finally, both consumers and MFIs would be affected by supplemental returns suggested by Aalst (2006).

Implications of Consumer Behavior

Consumer benefits are positively related with the use rate of solar cookers. Regardless of all other factors, the consumers that use solar cookers for most of their cooking needs develop the ability to payoff the loans at shorter periods.

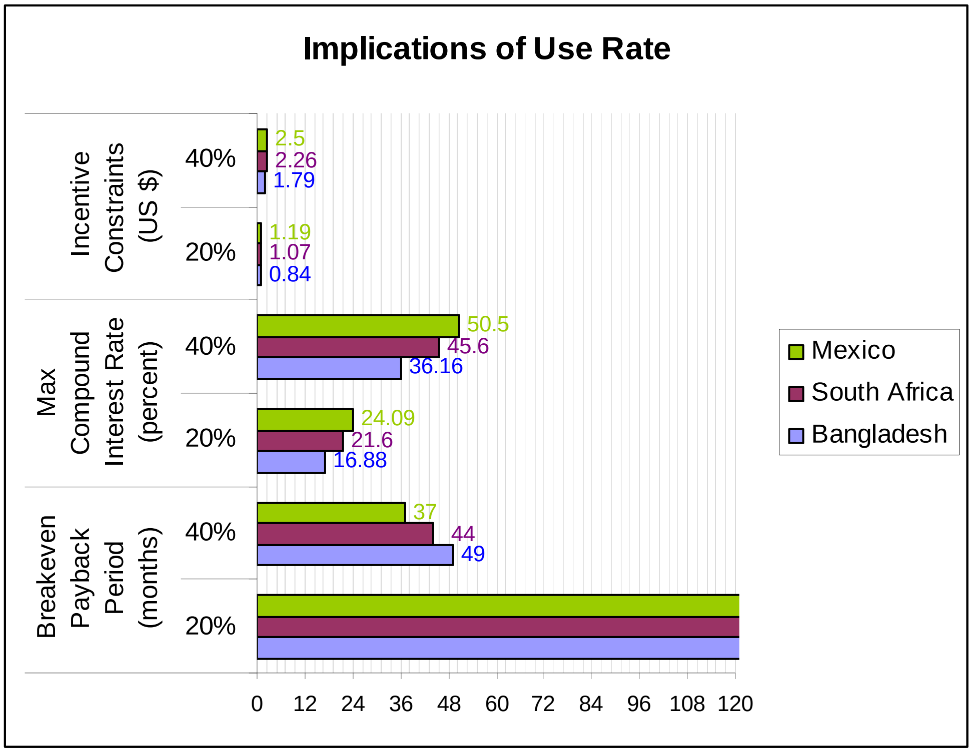

Figure D1: Implications of Use Rate on Payback Period, Interest Rate, and ICC

Implications of Dynamics of MFI Lending

Group lending, peer monitoring, and dynamic incentives are widely used by MFIs to reduce default by the borrowers. In group lending, either members of a borrower group are fully or partial (limited) liable for each other or transactions between the lender and borrowers take place in presence of peers. Peer monitoring within groups describes the ability of borrowers to observe and report each other efforts and returns. Dynamic incentives implemented by the lenders make future loans accessible to cooperating borrowers or borrower groups and inaccessible to defaulting borrowers or borrower groups. Kono and Takahashi (2010) observed (i) Group lending tackles the problem of adverse selection. It can also prevent moral hazard if peer monitoring is in place. If returns are sufficiently high group lending can help in securing higher repayment rates and if returns are low it can exacrebate defults. (ii) Dynamic incentives can prevent strategic default and moral hazard but do not affect the problem of adverse selection. (iii) Flexibility into dynamic incentives and group lending can lead to higher borrower welfare. Kono and Takashi (2010) in defining group lending have not differentiated it from group liability.

Group lending has the potential to mitigate adverse selection. Aghion and Morduch(2005) observed that if borrowers are well aware of each others type (safe with certain repayments or risky with uncertain repayments) assortative matching occurs among the borrowers. Safe borrowers pair with safer borrowers and risky borrowers with other risky borrowers. Assortative matching and joint liability incease the ability of risky borrower to payback and consequently bring down the interest rate for both safe and risky borrowers. Aghion and Gollier (2000) found that if limited liability is enforced in group contracts, risky borrowers subsidize the interest rate for safe borrowers and increase welfare.

Peer Monitoring was conied by Stiglitz(1990) to describe the incentive structure where borrowers as members of borrowing group monitor behavior of each other. Stiglitz (1990) observed that under joint liability, incentives for peer monitoring can be created and such structure would mitigate ex ante moral hazard and increase welfare. Aghion and Morduch (2005) have remarked that under joint liability, a borrower will choose to monitor her peer as long as the cost of monitoring is less than the expected gain from avoiding the need to assume responsibility for peers repayment. This reduces ex post moral hazard among borrowers.

Several important implications of group lending and peer monitoring in transfering solar cooking technologies are plausible. The returns from solar cookers are related positively with use rate of borrowers. Assortative matching allows users that have higher application and users that have lower application of solar cookers to assemble into different groups. Assortative matching can reduce interest rates for all groups. Further, for the lending MFIs it gives the opportunity to identify attributes of households most likely to adopt solar cookers. Groups of borrowers well informed of each other can not only help in resolving adverse selection and in benefiting the MFIs but can also assit in maintaining successful adoption(use) rate. This can help in creating positive perception of solar cookers.

In group lending scheme with joint liability, members of the groups can be expected to encourage each other to increase their use rate In group liability schemes without joint liability but with group (public) meetings, borrowers sensitive to their reputation may choose to increase their use rate and thus their savings (returns) from solar cookers. In either case, the increase in use rate among the borrowers increases the probability of success of the borrowers.Adoption of solar cookers would depend as much on behavioral changes as it may depend on economic benefits. Under group lending schemes, the borrowers have sufficient incentives to monitoor the cooking behavior of their peers such that their payoff and that of the group as a whole increases.Therefore concerns of economic benefits among the borrowers can induce behavioral changes after purchase of solar cookers.

On the contrary, however, the risks collusion among group members followed by collective rejection of solar cookers and of lower or partial repayments also exist. Laffont and Rey(2003) have shown that group contracts perform better than the alternatives regardless of collusion if the outcomes for the borrowers are corelated. Finally, Rai and Sjöström (2004) have proposed cross reporting to improve the terms of joint liability in the group lending contracts. MFIs financing solar cooking technologies can adopt cross reporting by users of solar cookers to adjust terms of repayments and liability.

Implications of Price of Solar Cookers

In this model, the price of Solar Cookers directly impacts the payment period at given interest rate, price of substitued fuels, use rate and discount rate. Repayment installments are affected by the base price (without interest) as monthly depriciation at 0.002% is cacluated on it. Payment period for higher base price exceeds the 10 years lifetime of the solar cookers. In practice, MFIs lend money for periods significantly shorter than 10 years. In such context, the base price of the solar cookers can be the binding constraint to the scheme of financing solar cookers without increasing financial burden of the borrowers. Figure D2 shows the changes required in interest rate (keeping use rate and prices of substituted fuels constant), use rate, and price of subsituted fuels at different base prices for payment within lifetime of solar cookers.

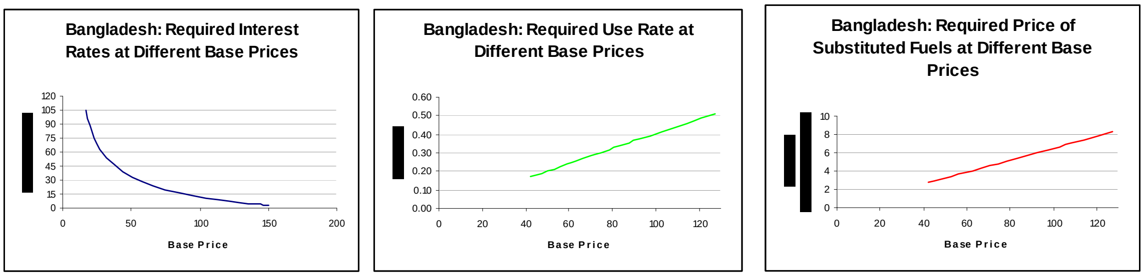

Figure D2: Implications of Different Base Prices for Repayment within 10 Years

If base prices are high – cetaris paribus – interest rate that can be levied on borrower should be low to ensure repayments within the lifetime of solar cookers. If base prices are high then everything else remaing the same use rate must be proportionally high to hold the constraint. Similar relation exists between base prices and price of substituted fuels.

Implications of Price of Substituted Fuels

The incentive compatibility constraint which determines the maximum amount the borrower will be willing to pay while preserving her benefits is consequence of savings from use of solar cookers. As saving is essentially a function of use rate and price of the substituted fuels, ICC changes significantly for change in the price of substituted fuels. Figure D3 shows that for a given interest rate, base price, discount rate and use rate, a borrower will never be able to payback the cost of solar cookers if prices of the substituted fuels are to decrease at a rate of 1%. However, the payback period improves significantly for increase in fuel prices at a rate of 1%. ICC fails to hold when the prices decrease and are significantly lower that the binding ICC (estimated at the time of lending). ICC improves significantly when prices increase.

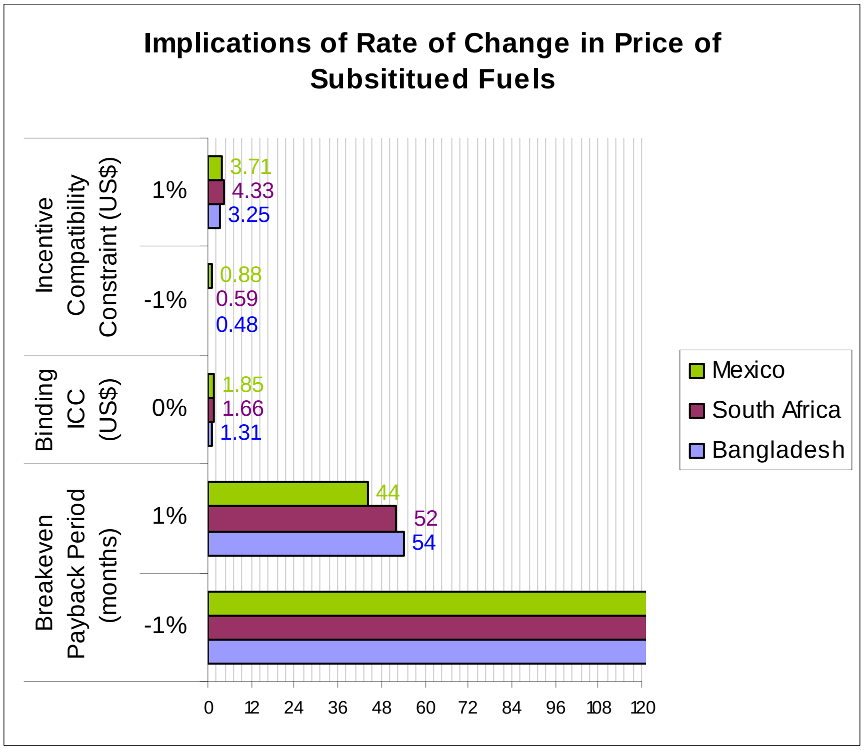

Figure D3: Implications of Change in Price of Substituted Fuels

A MFI financing solar cookers can anticipate lower default rates when prices of the substituted fuels are increasing. It can also expect to recover the loan within shorter periods. On the contrary, if fuel prices decrease, default is most likely.

Implications of Non Zero Probability

In estimating the ICC, assumption that the borrowers have zero probability of finding alternate financing in case of default has been used. This condition also implies that MFI would be able to seize the solar cooker if a monthly repayment is defaulted. However, in practice both the conditions might not hold. A borrower may use alternate avenues of financing when coordination and information sharing between competing MFIs are weak. Further, the ability of MFIs to enforce the contract and repossess the solar cooker may be limited. These conditions invalidate the assumption of zero probability and therefore decrease the ICC for MFIs. Figure D4 shows that non-zero probability can bring down ICC even in when price of the substituted fuels and when use rates are high.

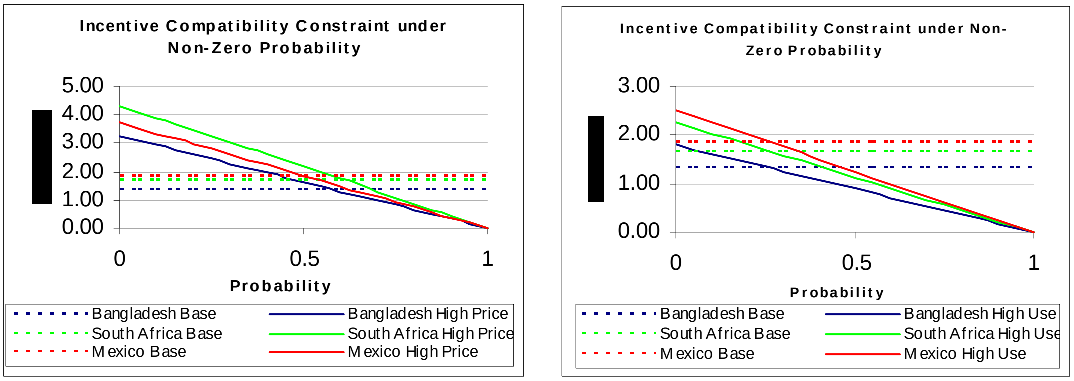

Figure D4: Implications of Non Zero Probability of Defaulter Financing

In absence of sufficient mechanism to enforce the contract or prevent lending to defaulter, MFIs will face difficulties in financing solar cookers regardless of other favorable conditions.

Indirect Benefits

(Pending…………)

VI. Conclusion

The analytic framework described above integrates the economics of solar cooking technologies proposed by Kandpal and Mathur(1986) with incentive compatibility constraints for MFI financing. The framework splits the capital cost of solar cookers equally over the payment periods based on the base price, interest rate, use rate and price of the substituted fuels. The scheme allows a borrowing household to pay the cost of solar cookers with saving from use of solar cookers.

The findings of this analysis are consistent with findings of Kandpal and Mathur(1986). The discount rate has insignificant effect on NPV. When estimations are carried out with interest rates reasonably below the critical interest rates, regardless of the discount rate the solar cooker generates positive NPV for the user. Use rate and price of the solar cookers significantly affect the NPV. For given interest rate, decrease in either of these parameters leads to negative NPV. Further, at lower user rates and prices the user would not be able to pay the loan with savings from use of solar cookers.

As in the case of the borrowers, the effect of discount rate for the lending MFIs is insignificant. However, changes in prices and in use rate have implications on determination of critical interest rate at the time of financing and on the incentive compatibility constraint at the time of payment collection. The decrease in use rate or in the price of the substituted fuels diminishes the savings for the borrowers and therefore reduces the maximum repayment that MFIs can collect. The outcomes can reverse however if the prices and use rates increase. When solar cookers are culturally suitable for local cooking, it would not be far fetched for MFIs to anticipate increase in user rate that would result from learning by doing. Further, where forest resources are unsustainably depleted over time, MFIs can expect the prices of fuel wood (the substituted fuel in this analysis) to increase. In all the analyzed cases, the prices of the substituted fuels have been conservatively underestimated. As fuelwood become more scarce and as consumer switch to more modern fuels, the financial benefits from solar cookers can be expected to increase. Such possibilities would improve the savings from solar cookers and ICC for MFIs. If all savings are expended for repayments, increase in use rate and price of substituted fuel can also result in shorter repayment periods.

Base price of solar cookers is also an important parameter in determining the feasibility of financing. MFIs levying high interest rates at lower use rates can finance only the relatively cheap solar cookers and expect full repayments over the lifetime of the cookers. Similarly, these MFIs would not find it prudent to finance expensive solar cookers when prices of the substituted fuels are low. Subsidy on base price would be necessary to incite any financing by MFIs under these circumstances. However, base price should not be a binding constraint where use rates and prices are sufficiently high. In case of Bangladesh, constraint of full repayment within the lifetime of solar cooker holds even for twice the base price and thrice the annual interest rate when use rate and prices are doubled.

Group lending commonly practiced by the MFIs can complement the transfer of solar cookers. With assortative matching, groups of borrowers well informed of each others cooking behavior and utility of solar cookers are most likely to seek financing. In the initial process of introducing the technology to the rural communities, adoption and adequate use of solar cookers can create a positive perception of the solar cookers. Further, solar cooking (at least with HotPot) can only be performed in open. Individuals can be incentivized by the joint liability in group lending to monitor behavior of each other. The requirement to cook in the open (sun) can make peer monitoring easy and less intrusive. These benefits inputed by group lending process might become particularly important in early stages of technology dissemination. In situations where use rates are undetermined, subsidy for reducing cultural barrier to technology transfer can be justified in MFI financed systems. Subsides can lure self selected borrowers who intrun monitor each others use rate and encourage more use of solar cookers. Experiments of these intial borrowers with solar cookers can help in ascertaining use rate and in promoting solar cookers to rest of the community.

The recent endorsement of the Global Alliance for Clean Cookstoves, a public private initiative led by the United Nations Foundation, by the Clinton Global Initiative and the American government is an encouraging development. A coalition of American public agencies which includes U.S. Department of State, U.S. Environmental Protection Agency (EPA), U.S. Department of Energy, U.S. Department of Health and Human Services – Centers for Disease Control and National Institutes of Health, and the U.S. Agency for International Development (USAID), has committed to "*unprecedented* *government effort to mobilize financial resources, top- level U.S. experts, and research and development tools to help the Alliance achieve its target of '100 by 20,' which calls for 100 million homes to adopt clean and efficient stoves and fuels by 2020.(State, 2010)"* United States has committed 50.82 millions dollars over the next five years to achieve the stipulated goal. Global Alliance for Clean Cookstoves anticipates mobilization of more than 60 million dollars to create a thriving global market for clean and efficient household cooking solutions. The initiative is expected to save lives, improve livelihoods, empower women and combat climate change. It is clear that benefits of using solar cookstoves are congruent with the agenda of the Alliance. Further the study establishes the viability of financing solar cookers with microfinance institutes. The commitment of the Global Alliance for Clean Cookstoves can be a historic opportunity for initiating projects that transfer solar cookers.

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