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Livelihood linked Clean Energy Models – Case Studies from India

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Abstract

Decentralised clean energy (DCE) systems are positioned to play key role in meeting the global targets of 100% energy access. However, there are certain aspects that need to be addressed for success of these technologies. Firstly, task of expanding energy access through these systems, to "energy poor" pose a formidable challenge to planners and development practitioners. However, economic development in several developing countries, increasing urbanisation, along with dynamic energy access programmes has played a crucial part. Secondly, for efficient delivery of services, selection of a right business model that suits its stakeholders is important. This aspect is usually paid less attention when success of any technology is discussed. Thirdly, these solutions require systematic analysis and research which need to be looked from the local perspective. Developing institutional, business or financial models for rural electricity supply could be a lot more complex and dynamic.

With aforementioned issues in mind, activity of preparing a detailed case study was undertaken. The aim of this activity was to assess cost-effectiveness of decentralised clean energy solutions and to analyse delivery models innovated by energy enterprises for commercial viability and sustainability purposes. This exercise also attempted to understand whether these technologies are socially acceptable, institutionally viable and environmentally desirable and whether various financial mechanisms act as uptake drivers. The projects selected for the study are *"Solar home lighting model in Gujarat on creating a link between energy service and income generation, using innovative financing as a catalyst implemented by SELCO and SEWA Bank, 2007"* and *"Pico-hydro model in Karnataka implemented by S3IDF and Prakruthi Hydro Labs (PHL) in 2009."* These two projects were supported by REEEP (Renewable Energy and Energy Efficiency Partnership) which is also the knowledge partner for the study.

Methodology included extensive literature survey including mainly REEEP evaluation reports, third party evaluation studies. This was followed by stakeholder discussions with implementing agencies and partners. On-site project visits, House-to-house visits for user feedback were also taken to validate the findings. Based on the information gathered, analysis and conclusion have been presented in the end of the paper.

In the two case studies, it was realised that though these system are accepted by the beneficiaries, but their level of acceptance may vary pertaining to different factors, which may or may not be local to the region. Further, for any business model to kick start there is essential requirement of seed funding, either in form or grant or soft loan. This is because in terms of investment it is still on a higher side for a rural stakeholder, be it an entrepreneur or beneficiary. Hence, an initial financial support plays a critical role. The impact of technologies cannot be quantified in every aspect however; one can clearly see improvement in quality of life.

Few key lessons that could be taken from these case studies are: first, grants are important and softest way for kick starting such ventures. However, a business model should have an inbuilt mechanism to guarantee long term viability. Secondly, extensive field survey is crucial, that includes all the parameters from resource availability to studying relevant demographic characteristics. Thirdly, people are differently impacted by energy access however, women and children have been found to benefit more, thus, they should be made part of decision-making. Last but not the least, implementation models that catalyze strong linkages energy services, income generation and appropriate financing may show better community acceptance.

Key words: business model, SELCO, S3IDF, solar, pico hydro

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1.0 Introduction

Decentralised clean energy systems are positioned to play a key role in meeting the global targets of 100% energy access primarily by delivering secure, locally sourced and environmentally benign energy solutions to urban and rural consumers. In developing and least developed countries where a large share of the population is not on the grid, decentralised clean energy systems bridge the energy access gap. It has been observed that most people in rural regions have simple lifestyles with basic livelihoods and electricity requirements. Domestic food preservation and processing such as milk chilling; ice making, grinding are also carried out, but at a relatively smaller scale. For these activities decentralised systems are, perhaps, currently the most suited option for meeting their electrical and mechanical energy demands, which when designed appropriately could serve well for many years to come, even when their demand increases, until connected permanently to grid.[1]

Moreover, the utility of electricity varies among users. For example, men tend to view the benefits of electricity in terms of leisure, improved quality of life and education for children; while women see it as a tool to assist in cooking, improve productivity, reduce workload, improve health and reduce expenditure (IANAS, 2011). Household electrification also increases the likelihood that women will read and earn income and possibly add to the overall productivity (ESMAP, 2004).

The task of expanding access of clean modern energy, for both domestic as well as productive uses, to the "energy poor" poses as a formidable challenge to planners as well as development practitioners. However, economic development in several developing countries, increasing urbanisation, along with dynamic energy access programmes have played a crucial part in helping hundreds of millions of people to attain modern energy access over the last two decades, especially in China and India. IEA 2011 report highlights that the number of people without access to electricity has reduced by 50 million while IEA 2012 reports that despite increase in world population sustainable energy access improvements have been seen in many countries, including India, Indonesia, Brazil, Thailand, South Africa and Ethiopia.

For efficient delivery of services, selection of a right business model that suits the end users as well as the players involved in its implementation is important. This is otherwise paid less attention when success of any technology is discussed. Bringing modern electricity services to more than 1200 million people across the world who do not have access to grid electricity yet will require a variety of innovative mechanisms. Majority of off-grid populations lack not only the ability to easily pay for electricity, but also the active

[1] In the discussed case studies it is seen that systems are sized of higher capacity than actual requirement of a household. This has been done considering in future the needs of households would increase. Further, two more suppositions could be considered in this case; a. progress of people would be gradual and secondly, in near future they would get access to grid power.

demand for electricity and this affects the financial viability of energy programs. Innovative strategies for rural electrification are crucial to success – whether through innovative financing programs, marketing strategies, or distribution channels (Krithika, and Palit 2011).

Decentralised energy projects are still more expensive to commission and difficult to operate and maintain. However, they are being recognized as the most viable options for long term energy supply and energy security. Hence in-order to achieve numbers and scales, entrepreneurs need to identify solutions that are techno-economically viable, institutionally feasible, socio-politically acceptable and environmentally sound. These solutions require systematic analysis and research, mainly because most of the issues need to be looked in the local perspective. Therefore developing institutional, business or financial models for rural electricity supply could be a lot more complex and dynamic.

The following project case studies have been developed with the aim to observe and analyse two separate energy delivery services in the South Asian region. The objective of this activity was to analyse the factors that determine the sustenance of the models. Both the case studies have used grant based funding to develop the business models to bring in investments and commercial viability in the long run. The cases studies analysed in this chapter are:

1. Solar home lighting model in Gujarat on creating a link between energy service and income generation, using innovative financing as a catalyst implemented by SELCO and SEWA Bank, 2007
2. Pico-hydro model in Karnataka implemented by S3IDF and Prakruthi Hydro Labs (PHL) in 2009.

In both these projects the REEEP[2] grant support was used to encourage enterprises and financial institutions to support micro-lending to small businesses in the Renewable Energy sector, to create pro-poor financing mechanisms, to develop appropriate risk mitigation instruments and to achieve scale[3], sustainability[4] and financial viability. The study also highlights the importance of donor funding in unlocking capital, giving business more breathing space and building leaderships. It was often observed that, such start-up grant funding when provided to the right enterprises at the right time improves the businesses success quotient and its speed to attain stability.

This paper would discuss whether these technologies were in fact socially acceptable, institutionally viable and environmentally desirable and how various financial mechanisms are deployed and act as uptake drivers.

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[2] Refer to section 3.2.3

[3] "Scale" in both the case studies essentially means attracting larger in-vestments to increase the capacity of the technology.

[4] "Sustainability" in this context refers to the capability of the project to attain commercial viability and earn profits on the long run by continuing to use the original base model

This paper has been prepared from post-implementation assessment of two projects. These two case studies have been specifically selected considering that the projects have been active on ground for over three years. This study aimed to assess the cost-effectiveness and energy security of off-grid clean energy supply solutions and analyse the various delivery models innovated by energy enterprises for commercial viability and sustainability purposes. Findings from the case studies are purely author's assessment of the projects and do not necessarily represent the views of the project implementers, parent institutions they are affiliated to or of the funding or supporting agencies.

2.0 Methodology followed

The study was done with an approach of analysing the existing situation of the project that has already been implemented with the help of REEEP grant support around 4-5 years ago. These selected projects had also undergone comprehensive monitoring and evaluation by REEEP South Asia Secretariat during their implementation and preliminary impact assessment phases. Several evaluation reports, third party assessment report and their finding were studied followed by stakeholder discussions with implementing agencies and partners.

The consultation covered interviews and structured questionnaire designed for different types of stakeholders.

Understanding the role of project beneficiaries who played a significant role during the project implementation phase is important. This is especially with regards to ownership, capacity building and long term sustainability. Hence the following activities were undertaken –

1. On-site project visits to understand the delivery model first hand
2. House-to-house visits for user feedback
3. In-depth analysis of the project deliverable and the actual execution process.
4. Assessing the portfolio of different partners
5. Identify if and what linkages were created in the process

Data collected was then analysed to understand the functioning and sustainability of business model. These projects have been analysed for their technical performance, financial viability, social impact, environmental impact, sustainability and government support.

A total of 17 households and commercial establishments in remote villages were visited and several levels of consultations were carried out with implementers, entrepreneurs, partners and financing organizations.

Each case study has been elaborated from the findings based on extensive discussions with stakeholders, their key roles, business model practiced in the region and post implementation impacts of the technologies. This has been covered through technical performance and maintenance of the system; financial impacts; social development; government support; health and environmental impacts. Business model has been separately studied through a SWOT analysis. Based on these factors lessons learnt have been discussed and could be useful in the replication and development of similar business model in other parts of the world. All figures have been expressed in Euros as well as Indian Rupees, following conversion rate of 1 Euro = 88.1 INR.

3.0 Solar home lighting model in Gujarat

This energy access project was implemented by SELCO India in partnership with SEWA bank[5], using Solar Home Lighting Systems (SHLS) in Kutch district of Gujarat[6] to create income generating mechanism for rural remote population deprived of electricity through energy services under a grant support from REEEP. The following sections will describe about how the model has been designed as well as analysis of the model and the key lessons learnt.

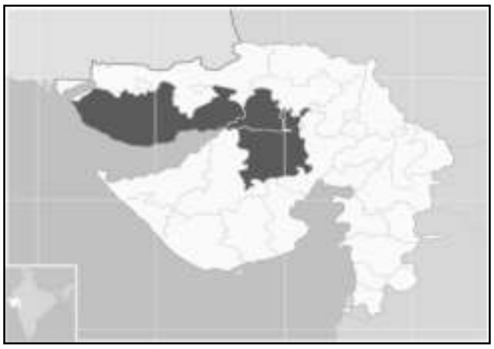

Fig 3.1: Map of Gujarat showing area of field study (Source: www.deshgujarat.com [Accessed 13 August 2013])

3.1 Location and geography

The project was conducted in Kutch district in the state of Gujarat (Figure 3.1). The sites record extreme climate and temperature ranges from 20°C in winter to 45°C in summer and annual solar insolation of about 5.8 - 6.0 kWh/m2. Rainfall is very limited - average annual rainfall - 14 inches (Punjokutch).

Fig 3.2: Lakhpat taluk where SELCO installations are done (Source: http://www.onefivenine.com/india/villag/Kachchh [Accessed 13 August 2013]

To understand the functioning of the model, 15 SELCO solar units installed in the Lakhapat taluk (sub district of Kutch District were studied, (Figure 3.2). These units included households and shops. This region is inhabited in a dispersed pattern. Although most of the area is partly connected to grid, these regions have highly interrupted and erratic power supply. Remote parts towards western border have no grid infrastructure. Also, some of the remote regions where the systems were installed, have very limited or no electricity. While some local population reside in permanent houses, most of the tribal communities lead a nomadic life.

[5] Self- employed women's association (SEWA)

[6] It was a part of a bigger, multi-state project implemented by SELCO through REEEP grant support. The other states covered in this project are Maharashtra and Karnataka.

3.2 Shareholders and their roles

3.2.1 Technology provider –SELCO

SELCO Solar Pvt Ltd was started in 1995 as a social enterprise[7] to provide sustainable energy solutions and services to the un-served and under-served households and businesses. It works with a bottom-up approach where the poor are not just beneficiaries or end-users but are clients and partners to its business. It helps in empowering its customer by providing a complete package of product, service and consumer financing through Grameen (Rural) banks, cooperative societies, regional rural banks[8] and micro-finance institutions and cooperative banks such as SEWA bank, Syndicate bank, Pragati Grameen bank, Karnataka Vikas bank, to mention a few.

Thus, SELCO operations deliver an energy service to its end user through provision of high quality products, installation, technical reliability, equipment maintenance, customer education and linkages to appropriate financial institutions. In this project, SELCO is the prime implementing organization and the technology providing agency.

Though its major presence is in Karnataka, SELCO has succeeded in replicating its models in states of Gujarat and Bihar through nodal partners and local organizations. So far, the organization has provided over 175,000 SHLS based technology packages and developed business and financial solutions benefiting more than 600,000 people. It is interesting to note that around 90% of SELCO's business generation is through word-of mouth and this in itself is interesting to learn.

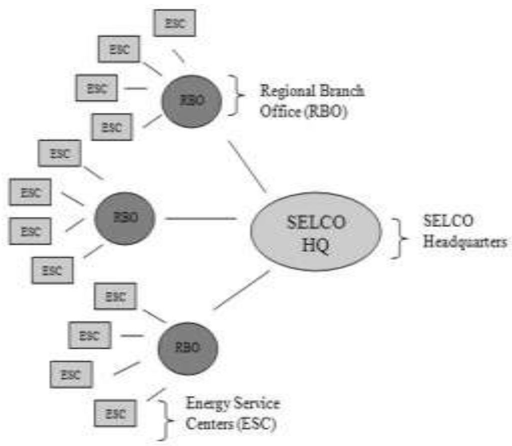

Fig 3.3: Schematic representation of SELCO operations and its business model (Source: http://www.selco-india.com/operations.html [Accessed 13 August 2013]

To understand the model it is important to understand the SELCO's delivery mechanism. SELCO mainly works on ground through a channel of three administrative strata (Figure 3.3):

(i) Energy Service Center (ESC): It is the basic building block of SELCO's rural operations. Each ESC has a service territory in which it markets, sells, installs, and services SELCO's energy services. Through these ESCs, SELCO reaches into the smallest and most

[7] A social enterprise is an organization that focuses in achieving social impact by applying commercial strategies to maximize improvements in human and environmental well-being. Social enterprises can be structured as a for-profit or non-profit, and may take the form of a co-operative, mutual organization, a disregarded entity, a social business, or a charity organization(EVAP) European Venture Philanthropy Association and web definition

[8] Regional Rural Banks are the banking organizations being operated in different states of India. They have been created to serve the rural areas with banking and financial service (Web definition)

remote communities.

(ii) Regional Branch Offices (RBO): SELCO operates Regional Branch Offices throughout its service territories to supply, administer, and manage its ESCs. The RBO provides on-going management and supply of SHLS components to these ESCs, and serve as contact point between SELCO central headquarters in Bangalore, and ESC offices.

(iii) Headquarters Office: SELCO Headquarters office is responsible for the overall management of SELCO operations. The head-quarters provides all accounting and managerial oversight.

The suitable financing partner is identified in the region which coordinates with RBO to provide the necessary financial support to the beneficiaries.

All the components of the SELCO PV systems are manufactured in India. PV modules are supplied by SELCO and any faults are reported to the SELCO head office, which keeps full details of all systems, so that problems with suppliers can be tracked quickly (Figure 3.4).

Fig 3.4: SELCO solar panels (Source: www.globalenvision.org [Accessed 13 August 2013])

The core business of SELCO is the design and sale of photovoltaic (PV) SHLS, principally to provide lighting, but also for radios, cassette players and fans.

In this case, SELCO with its combined ESC and RBO based in Ahmedabad, Gujarat, coordinates the activities of Kutch region. The technician based there is involved in the activity of installation, repair and maintenance of SELCO solar home lighting system in western region.

3.2.2 Local Partner – Self-employed women's association (SEWA) – Energy Cell, SEWA Bank

SEWA Bank is part of a larger organisation called SEWA - an organisation of self-employed women workers who earn a living through their own labour or small businesses. The Bank works with poor women workers engaged in the unorganized sector and provide them suitable financial services for socio-economic empowerment and self-development, through their own management and ownership. Energy cell, established in 2007, in SEWA Bank is specifically dedicated to providing energy access to its members, commonly called sisters (*behen* in singular or *behenein* in plural in Hindi); it started with linking household energy issues to their member's productivity and health. It works by identifying the challenges faced by women in the rural areas because of lack of energy or cleans sources of energy and develops loans or lending systems that would be sustainable and least risky to the bank.

3.2.3 REEEP – supporting agency

Renewable Energy and Energy Efficiency Partnership (REEEP) is an international organization which acts as a market catalyst for clean energy projects in developing countries. The main role of the partnership is to systematically focus on identifying viable business and financial models in renewable energy and energy efficiency in developing countries, in assisting their implementation, measuring the impact (direct and indirect) and facilitating their replication and scale-up. REEEP's role is also to act as a funder, information provider and connector of regional and global partners.

3.2.4 Solar entrepreneur and SEWA member

The most crucial component of this delivery model is the solar entrepreneur, who in this case is a local business woman, and a solar beneficiary working for the past 6 years. She is also a part of SEWA (Women self-help group) and has been working as a SEWA employee for last 13 years. She holds a diploma certificate in a business course. Her major earnings are through the following businesses:

- SEWA Bank with which she has been associated for 13 years now. There she has been marketing handicrafts, condiments and spices, prepared in the villages, earning around 60 Euros per month.
- She also works as a SELCO Solar Entrepreneur, through association with SELCO for over 5 years. During the five years she sold around 55 solar lantern and 30SHLS. As a SELCO entrepreneur she earns Rs. 3000-5000 (40 Euros) per month, mostly through loan installments collected from the existing end users and by selling new systems.
- Sale of fodder in her village which provides irregular earnings.

3.2.5 Village level business associate

In-order to improve the reach of the business, revenue collection efficiency and to reach out to a larger number of consumers, the SELCO solar entrepreneur employs a village level business associate (BA). BA's tasks are to identify stakeholders, do the initial basic marketing of the system to the potential consumer, conduct an informal due diligence or background check of the stakeholders, assess their willingness to pay, their affordability etc. and then link them up to solar entrepreneur. This set-up works well for solar entrepreneur. However, the solar entrepreneur has to gauge the reliability, authenticity and efficiency of the business associate.

3.2.6 The Maldhari community – the beneficiaries

Maldharis are nomadic tribal herdsmen based in the state of Gujarat, India. The literal meaning of Maldhari is "owner of animal stock". Maldharis are descendants of nomads who periodically came from Pakistan, Rajasthan and other parts of Gujarat. Being herdsmen, they mainly earn their living through animal rearing activities. However, with changing time and new settlements in the area they have also partly shifted to agricultural practices growing groundnut, castor, cotton, Psyllium (Isabgul), cumin and coriander, rape seeds and mustard seeds. In some families farming has become the chief source of income. While some farm on their own land, others work as hired labourers in other's field. The more affluent families have established small business of property dealing. Each family would have on an average 20 members, including both, adults and children.

While it is the men who mainly work outdoors or in the fields, women mostly take care of household activities. Some women help their husbands on the field. Many of them are also involved in famous Bharat (a type of embroidery and pattern design) work dress material which they prepare at home.

3.3 Business Model

Through one time REEEP grant, SELCO provided SHLS at a marginally low rate, at Rs.9700 (110 Euros) to Kutch villages, as against the market price of Rs.12, 000 (136 Euros). To purchase these subsidized systems, the solar entrepreneur takes a lump sum loan from SEWA Bank, based on the demand from the region which is sanctioned at a simple interest rate of 10% for 15 months. With this loan in hand she purchases SHLS at a fixed rate of 110 Euros/system. After adding the transportation cost and the interest on the loan the final cost of the SHLS the total amount may come to around Rs.10, 000 (120 Euros). This amount is mostly paid by the customer in installments designed around the user's income in-flow, with rare exceptions of complete payment made in one time. SEWA bank with their own initiative provides a 30% subsidy on the system cost (on subsidised cost of Rs.9700), which generally gets adjusted against the last installment of the loan taken by the SE. She passes some of this subsidy benefit to the customers by sharing at 50:50 bases hence further reducing the cost of the system. Once the total system cost has been paid by the beneficiary, he becomes the owner of the system.

The schematic representation of the business model is given in figure 3.5 and is described as below.

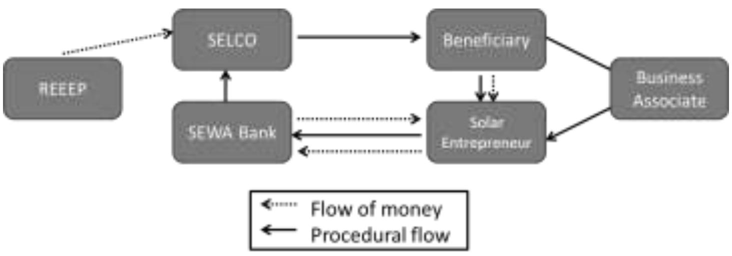

Fig 3.5: Schematic representation of SELCO business model in Gujarat

3.4 Understanding the system impacts and business model

3.4.1 Technical performance and maintenance of the system

The systems provided to them are non-fixated DC system. The critical factors are cleaning, maintaining the systems, the wiring and battery maintenance. All the systems provided in the region are of same configuration and specification. Details of the system are mentioned in Table 1. The batteries have 12 hours of storage life. However, the usage is done only for 6-8 hours, mainly before dawn and after dusk.

These systems have been designed in a customised way, keeping into consideration the nomadic nature of people. 2-3 community people are trained during the installation on how to manage basic technical issues that the systems may face. Thus, they were decently equipped with dismantling and re-installing the systems.

After 6 years of installation these systems continue to perform consistently. Additionally, the community people make sure that these systems are managed properly.

Table 1: System specifications of SELCO SHLS for Kutch region

Components	Features	Number of parts
Solar panel	20 W	1
Tubular Battery (12 V)	30 Ah	1
Charge Regulator (12 V)	30 Amps	1
LED light	3.6 W	1
LED light	2.4 W	1
Cables	2.5 sq. m., 2 core	15 meters

3.4.2 Financial assessment of system

Financial assessment of the system has been done at two levels, the solar entrepreneur and the end users. Several assumptions have been taken while assessing the benefits.

3.4.2.1 Solar entrepreneur

The SE's income depends on system cost, loan recovery time and the number of new customers. Based on these, on an average her monthly income would be anywhere between Rs. 3000 - Rs. 5000 (i.e. around 40 Euros). We assumed that she purchases 10 systems at subsidised rate (i.e. Rs. 9700 or 110 Euros) with loan amount of Rs.99000 (~ 1124 Euros) at a simple interest rate of 10% for 15 months. Additional cost that she incurs would include one-time documentation cost of loan at Rs.270[9] (306 Euros) and to and fro travelling expenses in Kutch villages. Since on an average the entrepreneur schedules once in a week visits, we assumed that she spends about Rs.200 (2.3 Euros) for each visit. So if she aims to pay the loan bank in 10 months she would end up spending about Rs.8000 (91 Euros) in her 10 months travel to collect the installments. Her direct earning would mainly be from the subsidy offered on her loan amount that she shares on 50:50 bases with the customer, therefore getting Rs.1500 (17 Euros). Accounting all this, it is seen that she would be able to

[9] Energy Cell, SEWA Bank loan documentation charges

generate a profit of Rs.7195 (~82 Euros) by marketing 10 SHLS. Actuals would vary considering the payments schedule of the different beneficiaries, installment amount of different beneficiaries, and frequency of visits to village and commission of village level agent. Details of the analysis are presented in table 2.

Table 2: Summary of net flows of the solar entrepreneur[10],[11]

Particulars	**Units**	**Values**
System Capacity	W	20
Number of systems		10
System Purchase Cost	Euros/system	**110.10**
Total Purchase cost	Euros	1101.02
Documentation charges	Euros	3.06
Travelling charges	Euros	91
Interest Repayment	Euros	32
Total Expenditure	Euros	**1223.67**
System Selling price	Euros/system	113.5
Total selling price	Euros	1135.07
Subsidy per system @30% of system cost	Euros/system	34.05
Saving from subsidy to the entrepreneur	Euros/system	17.03
Total savings from subsidy (10 systems)	Euros	170.3
Total Earnings	Euros	**1305.3**
Net Earnings	Euros	**6.8**
Net Earnings (per month)	Euros	**9.7**
Loan Amount	Euros	1223.8
Interest Rate (for 15 months)	%	10%
No of instalments for repayment	months	10
Instalment amount	Euros/system	11.4
Total amount repaid (loan+interest)	Euros	**1155.6**

[10] Please note: Loan amount taken is the actual figure of last loan amount taken by SE, as quoted by the Energy Cell In-charge. Figures other than starred are the actual figures quoted by either solar entrepreneur or energy cell In-charge during consultation

[11] Assumptions for these calculations are: 1. Whole loan taken is being utilised to purchase the SHLS 2. Considering the above statement, after 30% subsidy that is provided by the bank, and the SE would be purchasing about 10 systems. The balance amount may be used for meeting other expenses. 3. SE is receiving the installments timely so that she is able to pay back the loan amount in 10 months with interest. 4. No accounting is being done for Rs. 2000 (22.8 Euros) difference between the actual loan amount and total purchase cost.

3.4.2.2 Beneficiaries

Before the SELCO systems were installed, the locals purchased kerosene for lighting and sometimes for cooking purposes. However, their kerosene requirement go up to about 15–16 litres per month against their entitlement to 5 litre (Rs.15/L, 0.7Euro cents/L) in ration.[12] This situation compelled them to procure the difference from the unregulated market (referred to black market in India) at almost 5 times the original rate (Rs.40–60/L, 46-80 Euro cents/L) bringing their expenditure on kerosene alone to Rs.1080/month (12.25 Euros/L). Additionally, they would also incur some monthly transportation cost to travel to ration outlets and vendors shops.

After installing the SHLS they have been able to save on kerosene expenses. While Evaluating all these factors it is seen that the levelised cost of generation over the life span of module is Rs.29.29/kWh (0.33 Euro/kWh) and the payback of such sized system comes out to be 5.83 years. Many households have discontinued using kerosene, most SHLS users have drastically reduced their consumption and kerosene lasts for a longer time. Their onetime earning cum saving would be from the subsidy provided by the bank through the entrepreneur. Savings have also been seen in case of grid connected houses that have also installed SHLS (because of interrupted power supply). However, the users would have to incur annual service charge of Rs.250 (2.8 Euros) and battery replacement cost after every 6 years at the rate of Rs.4500 (51 Euros). This figure may vary with each beneficiary considering their income generation, expenses incurred in buying and transporting kerosene and their current kerosene consumption.

In practice, due to good quality systems, technicians have to rarely come for servicing, unless there is a need for component replacement of or some major technical issue arises. Those who are connected to grid and have also installed the SELCO systems save about Rs.700 (7.94 Euros) per monthly bill post installation of the system. Some users have even planned to increase the size of system. It was observed that people were willing to invest in the system though it cost 10 times more than the grid rates. However, system reduction would do wonders to the sale numbers and for the entrepreneur.

Women could work for longer hours at home. Each Bharat work earns them Rs.50 (~56 Euro cents). Post installation of the system, they are able to complete their work timely, producing at least 4-5 more dresses each month.[13],[14] This has boosted their self-

[12] Although 66th round of NSSO data published in January 2013 indicates that average kerosene consumption is an average of 4.49 L/ month for Gujarat, but in this case due to their large family size, the entitled amount did not suffice the need. In order to have sufficient lighting during dark hours, they would light lamps for longer duration, also spread in different rooms inside the house. Average number of rooms is 2, whether thatched huts or concrete house. It was also observed that females usually reside indoors during day time to carry out household activities under kerosene lit lamps which also added to increased kerosene consumption.

[13] Based on stakeholder discussion

[14] This has not been accounted in economic calculations, due to unclear figures.

confidence of making best out of indoor residing and zeal to work more and earn more to contribute to family. Summary of Beneficiary's financial assessment is given in table 3.

People are willing to pay higher cost for benefits from the system even when it is 10 times higher than the grid rates. However, reduced system cost would do wonders for entrepreneur itself. Cost reduction to Rs.5,000 (56 Euros) will make the systems aptly affordable for them. However, considering the benefits from the systems, the consumers are willingly paying the amount.

Table 3: Financial summary of beneficiary

Particulars	Sub head	Units	Value
Units Generation			
	Installed Capacity in first year	W	20
	Units Generated (per year)	kWh	29
	Useable Units (per year)	**kWh**	**20**
Earnings			
	Savings from replacement of kerosene in first year	Euros/year	10.2
	Savings from replacement of kerosene in second year	Euros/year	10.3
	Earning from electricity in first year	Euros	0.83
	Earning from electricity in second year	Euros	0.84
	Total expenditure in first year	Euros	0
	Total expenditure in second year	Euros	4.04
	Total Expenditure in 6th year	Euros	76.8
Expenditure			
	Service Charge in first year	Euros	0
	Service Charge from second year annually	Euros	2.9
	Battery Replacement cost (every 6th year)	Euros	73
Levelised Cost of Generation		**Euros/kWh**	**0.33**
Payback period		Years	3.83

3.4.5 Social development through system installation

The survey also found that the installation of these systems has also impacted the social life of people. People now work beyond sunshine hours on field and off the field near homes. They gather during evening and work under the common light, in case there is a community level installation. These systems even get shared among the families during occasions like marriage, child birth etc. Even the study hours of children has increased from 3-4 hours in the evening to 5-6 hours (during dark when lights are switched on). People are now also able to milk cows, before dawn, which was not the case earlier and do a timely delivery to the dairy. Even those who have installed it in their farm houses are able to work for longer duration, in early morning, evening and nights. Moreover, these systems have also helped women in economic development as well. Bharat[15] worker women, who stay at home, can now work for longer hours. They have started producing more Bharat works, thereby enhancing their income.

3.4.6 Government support to the system

In this whole business model, the central or the state government has no role to play whatsoever. There are no subsidy schemes for off-grid lighting being provided by the Gujarat government. This approach in a way is good as it reduces the financial dependency on the government and helps the market and makes the model sustainable in the long run.

3.4.7 Health and safety benefits

Major health benefits shared by the beneficiaries during survey are - reduced complaints of eye irritation and cataract problems which were most common among women, who used kerosene lamps for longer hours. Post installation of the system, women work under these SELCO lights with more brightness and less eye and breathing related issues[16]. Cases of tuberculosis complaint have also declined. Though the numbers could not be retrieved, yet cases of safe child births among SELCO light lit houses have also increased. The expecting mothers request for solar lights to aid the child delivery process.

Cases of scorpion sting which were common during the evenings and nights are reported to have drastically reduced, especially to children while playing or sleeping. These poisonous insects could now be easily spotted. Solar lighting systems have also helped in evading away wild animals that destroy nearby farms or hurt inhabitants and cattle in the dark.

3.4.8 Environmental benefits

As most of the studies as well as practices suggests, SHLS are environmentally benign, even in this case. They have caused no harm to the environment at the site in house and in the open area. Their soundless electricity production (as opposed to the case of diesel generators, used in nearby farms) along with pollution free operation unlike diesel generator and kerosene lamps has made them a suitable lighting choice in households and on farms.

3.5 SWOT analysis of business model

3.5.1 Strengths in the business model

One of the most important driving factors has been the enterprising nature of people. This has been an important tool for devising and implementation of business model.

[15] Embroidery pattern native to region and parts of Pakistan
[16] Relative figure of betterment could not be quoted by the consumer.

Despite being nomadic in nature, people have been able to maintain the systems quite well. They are decently equipped with dismantling and re-installing these non-fixated systems. Furthermore, considering that payment of system is being entirely done by the beneficiary, this has helped to create a sense of ownership and consequently more care of the system.

Efficient after sales service has proven to be a hit among the people, which has developed a trust for the product as well as the company. Though as per the norms, SELCO would charge Rs.250 (2.8 Euros) for any servicing visit after the first year of installation, the systems get often maintained freely when the technician visits the village for a new installation, thus bundling the installation and servicing trips.

One prominent and unique factor that is seen in this model is that it is not dependent on government subsidy. In case of India, for most of the decentralized energy systems, it is seen that a developer or the beneficiary is dependent on the central or state governments for subsidy to meet part of the capital cost. This procurement process is often lengthy and faces institutional delays. Gujarat is the only state in the country which doesn't provide any off-grid based state level subsidy. In such a situation, this business model has tried to look for an alternative solution in a way that it is being run entirely by the shareholders. People are willing to pay higher cost for benefits from the system even when it is 10 times higher than the grid rates for this service. Also the solar entrepreneur is taking substantially big loan with her minor earnings at her own risk to run this solar business in the Kutch region. However, to ease the burden of cost, SELCO through REEEP grant has reduced the cost by 19% and over this the SEWA bank is providing incentive to solar entrepreneur as 30 % on regular payments which in turn the entrepreneur shares with the beneficiary. This kind of arrangement does help us in realising that government subsidy may not be the only solution for mitigating the high capital cost.

The most important contribution in the value chain, which has been the driving factor of this model, is the role of solar entrepreneur in several ways. It is the zeal of the entrepreneur which has helped in sustaining of the model and up-scaling of the same. She, under guidance of SEWA, even undertook a diploma programme on skill development for running a business. Therefore, acknowledging the benefits of solar systems, she has been able to rightly market it to the customers with guidance from SEWA Bank. Identification of ideal entrepreneur for functioning of business model has been proven to be in favour of functioning of the model. It is this association and cordial working culture that the model has been able to successfully been implemented through least intrusion of SELCO or SEWA Bank, otherwise.

Women play a major role in the value chain. While the supportive bank, SEWA is all women bank for development and progress of women, the SE is also a woman. Besides this, in the beneficiary category it is the women who are not only benefitting health wise the most but also those engaged in Bharat work are able to generate income.

3.5.2 Weakness in the model

The system cost still remains as a deterrent among the beneficiaries. Since no subsidy is being taken from the government, the cost is borne by the different beneficiaries and by SEWA bank. Installments paid by the beneficiary depend on the income of the family. Discussion with the In-charge of SEWA Bank revealed that cost needs to come down to Rs.5500 (62.4 Euros) in order to become actually affordable and have much bigger market for SHLS.

3.5.3 Opportunities from the model

For this model to flourish and up-scale, there needs to be reduction in the cost and increase in the entrepreneur earnings. There exists a large untapped market in the region as well as outside it, if marketed correctly these areas could also be tapped. Moreover, since this technology helps Maldhari women become more financially strong, such entrepreneurship skills could be cultivated to have wider and planned spread of the market.

3.5.4 Threats in the model

The risk factor that may exist in long term is consistent cash flow through the value chain which is crucial to sustain the model. The beneficiaries who have very low to moderately low earnings cannot guarantee fixed installment amounts. The installments paid are depends on their earning. While some users have been regular in paying EMI with constant amounts, payments made by other users have not only been irregular in amount but also in maintaining the schedule of payments. This poses risk to the entrepreneur loan payback and securing a new loan to expand the business. This also affects the entrepreneur's earnings from the subsidy. Although due to her constant follow ups and visits, interaction and persuasion, she has been able to maintain her timely payments. Another significant point to be raised here is discounted cost of systems provided by SELCO to this community through the one grant provided by REEEP. This is important because such a discount price (which is still being considered relatively costly by the energy cell as well as the beneficiary) has been made affordable through this grant. Therefore, an initial financial support in form of a grant is crucial for making these systems affordable to the energy deprived community which could later be used to scale up the project.

4.0 Pico hydro business model in Karnataka

In Karnataka, many rural areas, especially in the hilly regions and some coastal regions have such geographical conditions that make it unsuitable for grid extension or reliable supply of power. Most of these areas are heavily forested where people make a living by farming of cash crops. Understanding these limitations, Prakruthi Hydro Labs (PHL),(now Prakruthi Renewable Power Private Limited - PRPPL) a technology supply company, in 2006, began developing pico-hydro systems that could be installed in regions having perennial water streams running for at-least 8 months in a year which could generate electricity sufficient enough to meet domestic energy demands at least. For better understanding of the site, PHL associated with a local company "Karavalli Renewable Energy" (KRE) to select the appropriate sites to install the hydro plants and maintain them.

Taking this further, S3IDF in partnership with PHL, using REEEP grant support implemented supply chain projects focused on improving access to clean energy technologies like pico-hydro and services, creating supply chains, linking these to consumer finance and generating awareness. Under this project S3IDF has facilitated 15 – 18 supply chain networks for various clean energy technologies one of which is pico hydro, to enable door-step access to RE products in villages in Karnataka. The technology provider and its associates facilitate the process of access to government subsidy through IWMS (Improved Watermills Programme)[17] and also provide post installation support such as servicing and maintenance of the system.

To facilitate the marketing, installations and servicing of the technology; local business associates were created to link the technology providers to local community. They commonly used Pico Hydro system for domestic usage which is a 1kW pico-hydro system that can operate on 10m-60m head and 4-60 l /s flow rate. Minimum head required is 5m. The total cost of installation, including system as well civil works is around Rs.150,000 (1704 Euros). Following the launch of the Improved Water Mill Scheme of Government of India (described below) in 2009, PHL and its partners attempted to link up with the scheme to reduce monetary burdens on the beneficiary. This has made systems more affordable to the beneficiaries, who otherwise would have to bear the entire cost.

4.1 About the technology and operation

The business model for this system focuses on developing a suitable supply chain linking technology provider and end users in remote villages. The information pertaining to demand for pico hydro system runs through three levels (Figure 9):

(i) Local Business Associate - LBA (Also referred as Trained Business Associate, TBA): Is the village or area level trained person who has the technology know-how. He works towards creating awareness about the system, collecting documents required for accessing the subsidy, working with the beneficiary on system installation and looking after basic repair and maintenance whenever required.

(ii) Dealer: Dealer conducts all the transaction work for the installation. This includes collecting beneficiary's information from the LBA and coordinates with the bank for intermediate loan, coordinate with PHL for technology and facilitating the required

[17] For the up-gradation of traditional watermill State Government is providing a subsidy of Rs. 6000/- per Watermill apart from the subsidy by MNRE i.e. Rs. 1.10 Lakhs for up-gradation for electrical/electromechanical output and Rs. 35,000/- for mechanical output.

documentation for the release of IWMS subsidy through Karnataka Renewable Energy Development Limited (KREDL).

(iii) Prakruthi Hydro Labs (PHL): They are the technology providers, who coordinate with the local company (KRE) and the dealer to understand the required system size and install it. They also provide servicing if required during emergency and serious cases.

4.2 Location and geography

The study was conducted in *Chembul* village, Kodagu district and forest area in the state of Karnataka (Figure 4.1). Only three households were covered for the study since the homes were located in dense forest area and miles apart.

Fig 4.1: Map of regions covered in Karnataka (Source: www.picstopin.com [Accessed 13 August 2013]

4.3 Shareholders and their roles

4.3.1 Technology provider - Prakruthi Hydro Labs

Created in 2006, its vision is to approach the sector in a business-like manner and generate economic value for all players in the chain of engineering, manufacture and delivery of the systems. The company is engaged with different players – the electronics, generator and mechanical engineering industries – to develop robust components for their products.

To generate power from streams it is necessary to divert the water from the stream and clean it from flowing matter like plant materials, sand etc. Then water is passed through a pipe to the power generating unit. This water after power generation has to be sent for use or back to the stream. The power generation unit consists of three main components. The turbine is the unit which converts the power of the water to rotation. It is coupled to the generator either directly or through a belt and pulley. The generator converts the energy into electricity. This electricity is conditioned through an electronic load controller with heating ballasts so that it can be used. The system is also connected to a load bank for dissipation of un-utilised excess load. The power generating unit is kept under a roof for safety reasons and in-order to stay dry. Some sites have installed small water tanks for rainwater collection, to be used during dry spells.

4.3.2 The Dealer

The dealer generally did all the transaction work. Dealer in this specific case was a former employee of PHL (the technology provider) and worked closely with three independent dealerships - Nisarga Environment Technologies, Canara Renewable Energy and Karavalli Renewable Energy – located separately in different parts of Karnataka; northern (Sirsi town, UK District, Karnataka), middle (Shimoga Town, Shimoga District Karnataka) and southern part (Belthangady, DK District, Karnataka) to carry out transaction work which included filing for loan and subsidy, documentation and collection of data for the same.

4.3.3 Trained business associate (TBA), entrepreneur and beneficiary

TBA in this project was a qualified electrical engineer and works as an electrical fitter in the village. In this project, he is the local focal point of Karavalli Renewable Energy, one of the Dealerships spawned by PHL, and most of his earnings are through commissions made from the selling the systems and facilitating end to end deals. His key task included identifying the beneficiary and act as a coordinator between the customer and the implementers. He did business development, documents collection from beneficiary for loan application, site civil works installation, commissioning. And critically he is a local point for after sales servicing.

4.3.4 Beneficiaries

They are native people in the region who reside in and around protected forest areas of Western Ghats. Most residents are farmers and grow *Arecanut*, cardamom and pepper in the forest, or on their own land making a living by selling it. While most women work at home, men work as paid labourers or in the field.

4.3.5 Credit banks

The two cooperative banks, Sharada Souharda and Siri Souharda Credit Cooperative Societies are involved providing initial loan for technology purchase, to the customers. These are regional rural cooperative banks, located in Shimoga district, and usually lend for agriculture and cement related work to the members and partly for gold. Lending for pico hydro systems began in 2009 and has extended this loan facility for non-members as well. As on date, 1/3rd of their loan amount is given for pico hydro systems.

4.3.6 S3IDF

S3IDF is a non-profit organization that was established in 2001 working towards reducing poverty in developing countries by supporting small-scale enterprises that meet basic infrastructure needs and provide opportunities for economic advancement.S3IDF uses its Social Merchant Bank Approach® (SMBA) to provide entrepreneurs with three bundled services: leveraged co-financing, technology access and knowledge, and business development support. It is a fund that helps in developing small scale environment-friendly enterprises which helps the poor to increase their earnings and well-being either as providers or users of infrastructure services- energy, water, communication and transport.

By tailoring the approach to local conditions and markets, S3IDF enables the poor access to employment, asset-creation and ownership opportunities, and basic services. The diverse project portfolio includes solar, biomass and biogas, water, and other technologies for small-scale industries The organization focuses on creating social merchant bank business model, providing financing, technology/know-how (with partners) for renewable energy and energy efficient systems (REES), for pro-poor infrastructure development, productive-use investments (e.g. irrigation pumping) and enterprises (e.g. REES owners, providers of REES technology). In this case study model S3IDF has provided a certain amount of working capital to the dealerships which connects each customer to these credit cooperative societies and enable a bridge loan from the society to cover the upfront capital costs of the electro mechanical machinery until they could recover this amount through subsidy provided by central government.

4.3.7 Karavalli Renewable Energy/Nisarga Technologies/Canara Renewable Energy

These organizations are independent dealerships and act as technical counterparts, providing technical support, from resource assessment until commissioning of the system. These three technical units are located at three different locations in Karnataka covering most of the potential sites around the state and supplying technology and support to the beneficiaries at the remotest of places.

4.3.8 REEEP (as described in the SELCO case study)

In this case study a part of REEEP support grant was used by S3IDF in identifying suitable local partners, undertaking workshops and training programs for Financial Institutions and creating supply chains for delivering suitable energy service solutions through pico hydro systems.

4.3.9 Karnataka Renewable Energy Development Limited, KREDL

KREDL, the designated nodal agency for the State of Karnataka is involved in sanctioning of the subsidy, under IWMS scheme. Their role is to analyse and authorize the projects that are eligible for subsidy from the MNRE after due diligence on site. For approving the eligibility of the projects, they take up the site visits to study the on field system.

4.3.10 Improved Water Mill Scheme

Very few users in the market can afford a good quality pico-hydro scheme because the technology, the pipes and reservoir are both resource intensive and costly. The MNRE therefore created a subsidy scheme for the technology. Under this scheme subsidy of about Rs.1, 10, 000 per watermill (1250 Euros) will be provided to consumers for installation of the system for either only electrical (up to 5 kW) or, both mechanical and electrical output (up to 5 kW). There is a state-wise cap on the number of consumers that can avail the subsidy through this scheme each year. Karnataka has a cap of 200 consumers/ year. Disbursement of subsidy in Karnataka is through the KREDL. Currently in the State of Karnataka around 500 pico-hydro projects have been installed through this scheme. Some key features of the model are:

- It is only applicable for development /Up-gradation of Watermills and setting up Micro Hydel Projects (up to 100 kW capacity).
- For any electrical output based water mill upto 5kW, a subsidy amount of Rs 1, 10, 000 per kW is provided.
- The scheme supports specialized studies / surveys, strengthening of data base, training and capacity building relating to watermills and micro hydel projects.
- Expenses beyond central finance assistance through subsidy to be borne by beneficiary/project owner.
- For watermills, 50% of subsidy release of Central Finance Assistance (CFA) on allocation of target as advance and the remaining after installation.

4.4 Business model

Generally when the end user shows interest in a pico hydro system; local business associate with the help of dealers applies for loan to one of the cooperative banks to purchase the hardware which costs around Rs. 90,000 (1022 Euros)[18] at a simple interest rate of 16%[19] per year as decided by cooperative banks[20]. The user needs to take the cost burden of the piping and civil work (like construction of the tank etc.) involved in the installation. Therefore cost of civil work and piping of around Rs. 40,000 – 60,000 (454 Euros – 681 Euros) is borne by the user. Once the loan is sanctioned, the dealer procures the PHL technology and piping work is done by both business associate and beneficiary. Meanwhile, all the documentation work required for claiming the subsidy from MNRE, which includes bank account creation, site registration with submission of legal documents, feasibility report, etc. is done by dealer with the help of business associate. Subsidy of Rs. 1.1 lakh (~ 1249 Euros) is provided by Government of India under IWMS scheme, as described in the above section. Once the system is installed and ready to be commissioned, KREDL visits the place for a site inspection. KREDL then submits a UC (Utilization Certificate) to MNRE for release of subsidy, along with other necessary documents. Only after it has been approved by MNRE, the subsidy is released to users or business associates account in the cooperative Bank. The loan amount plus interest[21] which sets to about Rs. 99000 (1124 Euros)[22] is kept by the bank, while rest (if any) goes to the consumer/players in the supply chain. It takes

[18] Turbine cost, shed for turbine, wiring, electrical heat exchanger

[19] The cooperative banks in this case are rural local bank based on local people's money pool thus, to have you high returns option, and they lend their money at higher interest rate.

[20] Which is raised to 19% from 2nd year

[21] Interest rate at 16% for first year and at 19% from 2nd year

[22] This varies from case to case depending upon the time in which subsidy is released. For the purpose of understanding we have assumed, based on the consultation with MNRE and cooperative banks, it takes about 6 months by MNRE to release the subsidy and reach the customer's bank.

around 6 – 12 months from the time the paperwork is filed to the time the beneficiaries receive their rebate. Schematic representation showing major steps in the model of is given in Figure 4.2.

The local two cooperative societies, *Sharada Souharda* and *Siri Souharda* Credit Cooperative Societies provide several bridge loans[23] at any instant of time. The subsidy available from the government has been in the order of around 200-250 systems a year. With this rate of subsidy provision, the dealerships manage to bridge the upfront capital requirements with the combination of their own finances, working capital provided by S3IDF and loans from the credit cooperative societies to end users. REEEP has provided onetime grant support of 100,000 Euros to S3IDF under an umbrella project on More Private Pro-Poor Small Scale Renewable Energy / Energy Efficiency Investments in South Asia[24]. This case study was part of latter. S3IDF used part of this grant as a revolving loan fund (RLF)[25] and provided loan at 12 % interest rate to the dealer. This amount provided by S3IDF is a credit guarantee and is used by the dealer to meet intermediate costs.

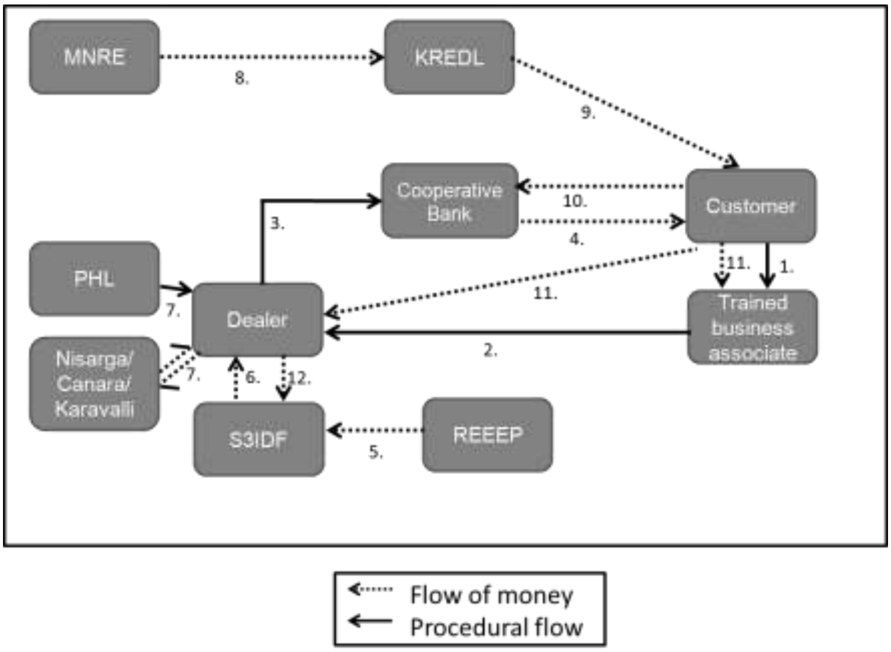

Fig 4.2: Schematic diagram of pico hydro business model

[23] It is short-term loan, typically taken out for a period of 2 weeks to 3 years pending the arrangement of larger or longer-term financing.

[24] Purpose of this project is to expand the investment portfolio and incorporate additional financing mechanisms into the S3IDF model to facilitate local finance and enterprise development for small REES projects with large pro-poor impacts, global and local environmental benefits, and the continued dissemination of the model's successes and lessons.

[25] A Revolving Loan Fund (RLF) is a source of money from which loans are made for multiple small business development projects. The fund gets its name from the revolving aspect of loan repayment, where the central fund is replenished as individual projects pay back their loans, creating the opportunity to issue other loans to new projects.

4.5 Understanding the system impacts and business model

The business model is essentially a subsidy based business model, where subsidy plays a major role in sustaining the whole model. Officially the subsidy amount of Rs. 1, 10, 000 (~1250 Euros) covers equipment amount (with electrical output). The most important driving factor of the business model is the trust relationship that the dealer shares with the cooperative banks and with LBAs. It is this relationship which sometimes guarantees loans to even the non-members of the bank for the hardware and installation of systems. Most of the times, the dealer himself is a member of the cooperative bank, has credit worthiness and is the guarantor for the loan. Hence the loan lending process to the beneficiary is based on Bank/lender – Dealer trust relationship, where the dealer takes guarantee of the amount being lent but without any mortgage. To reduce the civil work cost some of the beneficiaries try to avail the benefits under different schemes for tribal people.

Mostly 1 kW systems are installed which are utilized currently only for domestic purposes. Systems are installed on perennial water streams therefore it can generate power 24*7. It is provided with a valve that regulates the flow of river based on requirement of the household. Due to small requirements, small amount of energy is used, while rest gets lost as heat. Presently S3IDF and local organizations are working with the rural households in the area to scope out the possibilities of creating energy linked income opportunities such as Areca plate making to optimize the use of pico hydro systems in these settlements.

4.5.1 Technical performance and maintenance of the system

The systems provided by PHL are essentially 1 kW AC systems, specifications are mentioned in Table 4. These systems give an output of 24kWh per day and run on 90% efficiency[26]. A typical pico hydro supported house has load of about 100 to 150 units per month, 150 units if taken on the higher side. Since this technology is being set up in remote rural regions and is perhaps the only clean energy solutions to these households much work needs to be done to improve the productivity of the system. Over the past years the applicability of these systems has gradually expanded and these systems are being used for domestic application only to run, lights, bulbs, fans, TV, grinder and refrigerator.

Since most of these systems are single household owned, the onus of maintenance lies on the family. However, the local business associate is usually a help in case the issue is serious, which as reported, rarely is a case. There are not many issues with maintenance and operation. In case of any technical issue or rare instances (5 – 7% over the period of 6 months) where the system stops working on account of technical problems the local business associate (LBA) comes to help or contact the technical team in PHL. Periodic oiling and greasing is anyway done by them at a gap of 6 months. Removal of litter is done on regular basis from source end to maintain the continuous flow of the water.

[26] Based on stakeholder consultation

Table 4: System specifications of a typical pico hydro system in Karnataka

Heads	Value
Head range	1 – 100 m
Flow rate	4 - 10Lps
Electrical Output	22V AC output of 47 – 50 Hz
Energy output	24 kWh/day
Total length of the pipe	100 m
Water storage	Tank

4.5.2 Financial assessment of system for the beneficiary

Before the pico hydro systems were installed, the locals depended on kerosene for lighting and sometimes for cooking purposes. Therefore post installation their earnings be mainly from savings in kerosene which they were purchasing for Rs 125 (1.41 Euros) per month[27] and savings from electricity payment that they might incur it partly grid connected, the latter amount being Rs 6660 (75.6 Euros). There are few cases where savings from subsidy release after disbursement for other payments have also been seen, which again may vary from case to case. Most of their expenditure is mainly on O&M expenses, which is nil for at least first 10 years and then increasing at the rate of 5%[28]. Considering both these factors, their levelised cost of generation over the lifetime of the technology is Rs. 1.20/kWh (0.013/kWh Euro cents). Summary of the financial assessment is given in table 5.

4.5.3 Social development through system installation

The most important development socially is this technology has provided continued lighting and allowed running of electrical appliances giving the beneficiaries the comfort of continuous supply of power. Discussion with beneficiaries indicate that prior to installation of these systems, they relied completely on kerosene.

4.5.4 Government support to the system

The IWMS scheme under which finances are being met was launched in 2009, considering the improvement of existing water mill structure. It is the most important component for sustaining and driving the model. Without this subsidy the users would have had to pay a higher interest rate and for some the system would have been unaffordable. Under this scheme a capital subsidy of Rs.110000 is provided to the beneficiary for installing the system up to 5kW and for electrical or mechanical output. The 6 – 12 months of time between the filing of paperwork, assessing the installation and release of subsidy plays crucial role in determine the loan repayment and earnings of the various players. So far, they have been timely being released by the KREDL with only a few cases of delay.

[27] Estimated assumption based on stakeholder interaction
[28] As per CERC norms

Table 5: Financial summary of a beneficiary

Particulars	Sub head	Units	Value
Units Generation			
	Installed Capacity	KW	1
	Units Generated (per year)	kWh	5519
	No. of units consumed per month	kWh	150
	Useable Units (per year)	kWh	1800
Unused un its		kWh	3719
Savings			
	Savings from replacement of kerosene first year	Euros/year	17.02
	Savings from replacement of kerosene in second year	Euros/year	17.19
	Savings from subsidy after repayment of loan & interest amount	Euros	0
	Earning from electricity in first year	Euros	75.6
	Earning from electricity in second year	Euros	76.4
Expenditure in first 10 years		Euros	0
Total expenditure in 11th year		Euros	76.6
Total Expenditure in 12th year		Euros	77.4
Levelised Cost of Generation		Euros/kWh	0.01
Payback period		Years	5.83

4.5.5 Environment Benefits

As in most of the cases a natural stream of water channel is harnessed to drive the system, there is no negative impact that is caused to the surrounding, considering the topography of the region. It is one of the most environmental friendly solutions for providing energy access to an unprivileged community

4.5.6 Health benefits

Users have seen benefits out of the system mainly through minimal or no usage of kerosene for lighting purpose. There are reportedly lesser cases of respiratory, breathing and eye problems.

4.6 SWOT analysis of the business model

4.6.1 Strengths of the business model

- Considering the fact that the region where the project has been implemented is thickly protected forest area of Western Ghats, the project has been able to provide not only sufficient basic lighting solution but also helped the users in carrying out other domestic activities such as grinding, refrigeration etc.

- The model has helped in strengthening the energy services by building strong supply chain.
- Pico hydro is perhaps one of the few clean energy technologies that works in this area where technologies such as solar may not be as effective.
- The most important driving factor of the business model is the trust relationship that the dealer shares with the cooperative banks. It is this relationship which sometimes guarantees loans to even the non-members[29] of the bank for the hardware and installation of systems. Most of the times the dealer is himself a member of the cooperative bank and has credit worthiness that allows him to be the guarantor or the receptor of the loan.
- Timely loan payments by members and non-members have encouraged these cooperative banks to lend more and increase the number systems. Several non-members are being taken up as permanent members and these members can now access loans for various other purposes.
- This business model has helped in providing employment opportunities across the value chain, especially in case of local business associates in different areas.
- Having government support to these systems has helped in reducing financial burdens of the customer. Customers are now aware of various government schemes over and above the IWMS scheme. Assessing the success and evaluating the benefits of this scheme, the central government is presently considering increasing the subsidy amount that would help to cover some amount of civil cost of the beneficiaries as well.

4.6.2 Weakness in the model

Though government subsidy sustains the whole business model it could also act as an impediment in the long run. The cash flow depends on the government subsidy scheme and timing of release of subsidy. This fails to instil faith in commercial banks who could also lend loans at lower interest rates compared to the cooperative banks, making the market more competitive. Presently the households with pico-hydro potential have a low energy footprint and hence a large amount of energy that is generated is going un-utilised and being lost as heat.

4.6.3 Opportunities through the model

- Picking from the above point this un-utilised heat could be well captured to carry out several mechanical as well as electrical based economic activities. S3IDF is working closely with technology providers and the dealer to find a plausible solution to tap this heat as well for the benefit of beneficiaries. Some of these solutions that they see are electric fencing, *Arecanut* or cardamom leaf plating.

[29] People that have no accounts with the bank and this case it is critical, since cooperative banks in rural India rarely lend to customers with no bank account or documentation proofs.

- This model through its local connections and through the approach of credit guarantee (provided by S3IDF) has been able to successfully encourage local cooperative banks local to participate in projects from the start. This approach has shown positive result in this case where two banks without hesitation have come forward to support this technology. Replication of such model is crucial to gain trust of bankers who otherwise wary from investing in such projects. Although, currently it is linked to IWMS, in order to make it scheme free, it is important to link it to livelihood applications.

4.6.4 Threats from the model

Dependence on government subsidy may pose a risk to the model in the longer run and the non-standardized process of subsidy release might affect the market.

5.0 Discussions

While both the technology solutions and their respective business models have been developed to provide decentralized solutions differently, there are certain similarities and dissimilarities to learn from. The following discussion attempts to understand various factors that have helped these two models develop differently in the states through various dimensions.

5.1 Techno-economic dimension

It is seen in both the cases technology solutions were developed after understanding the people's need, and resource available at the locations to improve the uptake of the models. This is important to ensure long term viability of a project. Solar and pico hydro options which have been selected as solutions for energy access in their respective areas seem to fit well with the region. The non-fixated systems provided by SELCO have been developed to match the nomadic life style of the people there. In view of customer's current purchasing capacity, the system has been designed to provide at least basic lighting solutions. The modular nature of the technology allows for it be expanded later when and if the requirement increases. In the case of pico hydro, although enough power is being generated to meet the current household domestic power demands there still remains some un-utilized power. Therefore it seems that subsidy amount being provided by the government or the loan taken by the customers doesn't match the capacity requirement. Up-scaling of these systems to micro grid is not possible due to substantial distances between houses as well as high cost of setting up T&D network in those heavily forested areas.

SELCO has worked towards adopting the already existing business set up to reach out to people with the benefits and thereby creating linkages of energy access to income generation. They played a very small role in advising the entrepreneur on an appropriate business model, but provided the required support to help them create a delivery mechanism around the selected business model. On the contrary, Pico model, has worked towards entrepreneurship development in a more planned way, in order to have a proper division of work from bottom to top and thus strengthen the supply chain.

The approach of linking livelihood support to SHLS model has worked positively towards adopting the technology and has improved the functioning of the model. Basic understanding of the business model provided by SEWA Bank in this case has substantially helped the entrepreneur to spread her business and help customers to make the best out of this technology.

Most importantly in both cases, in order to ensure the model works, it is important that the customers repay the amount on time to the bank or the entrepreneur on time.

Aftersales services, assistance from local BAs and presence of local service centers have been good technology adoption drivers. This seems an important criterion in both the cases, which has helped beneficiaries developing trust in the technology in serving their needs for a longer term

REEEP grant plays a vital role in driving the business model. In both the cases amongst other funding, REEEP grant funding gave these entrepreneurs to take risk, allow the development of standards of operations, to venture into changeable markets and provided the flexibility to try out different mediums of business. One of the important REEEP funding criteria by which REEEP's projects are selected is based on their market driven replication[30] and scale up potential. REEEP is currently working with project implementer to develop grant to market investment pathways. For most projects to succeed, the process of transition from grant based funding to private investor funding needs handholding and advisory support and possibility filler funding to iron out the loop holes. The shift from grant funds to market based funds needs to be well-programmed, fluid and well-timed possibly riding on the then existing market sentiments. Further, the grant has acted as a catalyst in both the cases where the financial support has been used to create different clean energy models. While SELCO mostly used for creating market and meeting the transaction costs, S3IDF on the other hand has deployed the funds in creating a revolving fund to expand its market and service.

In terms of ownership of model, ownership of the system was with the solar entrepreneur until full EMI had been paid back. On the contrary, in case of Pico hydro, the involvement of beneficiary is there right from the beginning which also includes money invested during construction work (civil work). In a way, belongingness of beneficiary to the system is more in case of pico model, ensuring it is being taken care of in a better way.

[30] Replication means transfer to a different location of a tested concept, a pilot project, a small enterprise, and so forth, in order to repeat success elsewhere. Market driven replication means increasing its geographical area through entrepreneur based efforts to create demand of the technology.

5.2 Governance dimension

If we look at the models from the point of view of compatibility with existing regulatory arrangements, these systems have been well accepted, considering the rich resource potential. However, in case of Gujarat, since most of the state is grid connected; off-grid or decentralized solutions are not much on the state government's agenda. Despite that, there have been no hassles in the uptake of this technology through the market. The Gujarat model can teach us how a clean energy delivery chain could be developed without any intervention of the Government, particularly without any dependence on subsidy. This could be done through selecting the appropriate players who could actively take up role of maintaining and earning from the value chain. This activity however would require extensive understanding of the place, knowledge about the demography, people's need and most importantly capacity building at all levels. Looking from a different perspective, considering the existence of schemes provided by the state and central governments, high cost abatement models such as pico hydro is good, especially when the system costs are as high as that of pico hydro systems, which is otherwise very expensive for the beneficiary to pay. In pico hydro model, though the dependence on the subsidy continues yet this work has been done effectively. Rural Energy businesses are long term, low return prospects; private businesses are unlikely to be significant players unless required by regulation. In the absence of any such strong regulation, utilities and governments need to play a stronger role in low-carbon rural energy (Parthan; Osterkorn; Kennedy; Hoskyns; Bazilian; and Monga, 2010).

5.3 Socio-political dimension

The project implementers have tried to make the technological solutions sufficiently affordable to their respective beneficiaries. It is up to the users to choose how to optimize the use of these energy solutions. However, gender benefits from these solutions vary from region to region. For Solar model, though the women of the society were confined to their houses yet they generated income through creating artifacts and working from home. In remote regions where the Pico hydro systems were set up the society seemed relatively more open, women were seen moving out of the houses and the impact of the system was in the form of improved lighting solutions. Based on our field visit it was seen that the systems have been able to significantly contribute in betterment of lifestyle in the remotest part where grid connectivity has not yet reached or could not reach successfully. Both systems have improved productivity, women and children health and increased the role of women in decision-making.

These systems have been accepted by the political systems at village level as well as in the community. In case of SELCO the key player is the solar entrepreneur while, in case of Pico hydro model, most of the effort has been made by the local business associate. These systems do not require any behavioral changes as these systems are being used for domestic purposes. The costs of these systems would have to be lower for the first system to be sold in these households.

5.4 Environmental dimension

In these two cases, the technology provider has developed environmentally safe energy access solutions. Being sure of the abundant supply of the resources, the technology choice for the beneficiaries has proven to be right technologically and economically. These clean energy systems have not shown any detrimental effects on the users, inhabitants or the environment. The pico-hydro systems are set up in protected forest areas where there are stringent environmental regulations for any technology implementation. The economic activities that the beneficiaries are engaged in are in harmony with their habitats and have no detrimental effect on the environment.

6.0 Common implementation drivers and barriers

Both the solar home lighting systems and the pico hydro systems were technologies best suited for the consumer and the location. The REEEP seed funding played an important role in the developing, testing and innovating the models. The most challenging hurdles were to bring in the financial institutions and rural banks to finance the users for the technology directly and here is where the models differ. The technology providers in both cases focused on providing sales services, building the capacity of the local business associates and created local services points. A Comparative model considering the key research questions have been mentioned table 6.

Table 6: Comparison between two models

Model	**SELCO Solar**	**S3IDF**
Cost-effectiveness	Yes	Yes till being partly supported by IWMS
Secure and reliable local off-grid electricity supply solutions for long term	Yes	Yes
Socially acceptable	Yes	Yes
Environmentally desirable	Yes	Yes
Potential of attaining commercial viability	Yes	Yes
Potential of attaining commercial scalability	Yes	Yes
Support from national clean energy related policies as one of the deployment and uptake driver	No	Yes, availing benefits of IWMS
Scaling-up and replication potentials of local solutions	Yes but it requires a strong willed Entrepreneur	Yes, mainly due to the geography of the state
Potential to provide electricity access to wider population	Yes	Yes

7.0 Lessons learnt and recommendations

The paper analysed two case studies supported under REEEP programme using a common framework of identifying need based energy technology and suitably tailoring it to fit the pockets of the poor.

We present seven main conclusions for energy development practitioners and policymakers based on the two case studies analysed in the paper which are as follows:

1. Developing innovative and participatory energy delivery models for rural households is a time and resource intensive task and very few organizations would look at it as a profitable business. Hence the initial grant support (such as from REEEP) plays a critical role by allowing the project implementers the flexibility to innovate and experiment with different models and in absorbing the risk associated with piloting/demonstrating the project.
2. However, the disadvantage with grant support is that if the organization continues to exploit grant funding year after year on the long run it could restrict the entrepreneurial approach and tend to make a project more dependent on external support. Therefore, grant support should be designed such that it is used to develop models and plans to guarantee long term private sector investments and attain commercial viability.
3. To measure the success of any business or financial model, extensive field survey is crucial, that includes all the parameters from resource availability, beneficiaries' portfolio mapping, and studying relevant demographic characteristics.
4. For the people who have lived without electricity for decades, these technologies have provided them with luxuries that they never experienced. This impact cannot really be qualified but we can certainly see the difference good quality clean energy technology can make especially to the women, youth and children by opening new possibilities, making them a part of decision making and possibly empowering them. These factors create a sense of belongingness and dependence towards the technology improving its sustenance.
5. The Solar home lighting case study has proved that aspects such as user capacity building, affordable and timely servicing and maintenance play an important role in the long term sustainability and project replication. These help improve the reputation of the technology provider.

6. The Pico hydro case study demonstrated importance of providing consistent good quality electricity supply in rural areas that have the capacity to match the grid supply, electricity that could be used not just for lighting but to run televisions and home appliances. But it failed to set-up a mechanism to improve the productive use of this supply.
7. Implementation models that catalyze strong linkages at the rural level between energy services, income generation and appropriate financing may show better community acceptance. But these systems should be flexible enough so it could be expanded in-case of higher demand and generation requirements.

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Disclaimer

The views expressed in this report are those of the authors and do not necessarily represent the views of the institutions they are affiliated to or that of the funding agencies.

OASYS South Asia project

The Off-grid Access Systems for South Asia (or OASYS South Asia) is a research project funded by the Engineering and Physical Sciences Research Council of UK and the Department for International Development, UK. This research is investigating off-grid electrification in South Asia from a multi-dimensional perspective, considering techno-economic, governance, socio-political and environmental dimensions. A consortium of universities and research institutes led by De Montfort University (originally by University of Dundee until end of August 2012) is carrying out this research. The partner teams include Edinburgh Napier University, University of Manchester, the Energy and Resources Institute (TERI) and TERI University (India).

The project has carried out a detailed review of status of off-grid electrification in the region and around the world. It has also considered the financial challenges, participatory models and governance issues. Based on these, an edited book titled "Rural Electrification through Decentralised Off-grid Systems in Developing Countries" was published in 2013 (Springer-Verlag, UK). As opposed to individual systems for off-grid electrification, such as solar home systems, the research under this project is focusing on enabling income generating activities through electrification and accordingly, investing decentralised mini-grids as a solution. Various local level solutions for the region have been looked into, including husk-based power, micro-hydro, solar PV-based mini-grids and hybrid systems. The project is also carrying out demonstration projects using alternative business models (community-based, private led and local government led) and technologies to develop a better understanding of the challenges. It is also looking at replication and scale-up challenges and options and will provide policy recommendations based on the research.

More details about the project and its outputs can be obtained from www.oasyssouthasia.dmu.ac.uk or by contacting the principal investigator Prof. Subhes Bhattacharyya (subhesb@dmu.ac.uk).

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