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सत्यमेव जयते

Access to Clean Energy

A GLIMPSE OF OFF GRID PROJECTS IN INDIA

Produced By:

सत्यमेव जयते
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Access to Clean Energy

A GLIMPSE OF OFF GRID PROJECTS IN INDIA

content

दीपक गुप्ता
Deepak Gupta

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FOREWORD

India is on the path of high economic growth. The demand for energy - a prime mover of economic development is also rising. Availability of power to all becomes a crucial factor as it has a direct impact and influence on the sectors of education, health and even food security. Inadequacy of energy supply adversely affects these vital and essential requirements of any society. In India, while urban centers can be connected to central power grid, it is the rural areas that are facing the energy challenge. A large number of people in our villages do not have access to energy. Apart from supply shortage in remote locations, difficult terrain and forested area of several villages makes it difficult to connect them to the main power grid. It appears, therefore that these barriers can only be overcome by decentralized renewable energy for electrifying such villages that will also help in their economic and social development.

To meet the rising demand of energy for overall development of the country, the government has an ambitious plan for conventional power development. Simultaneously, it is also laying great emphasis on developing renewable energy as a sustainable solution. Harnessing renewable sources to generate off – grid power to supplement the traditional sources is receiving increasing focus. A number of projects that have been successfully implemented in villages by enterprising individuals and several NGO's have shown great possibilities. The case studies compiled here relate the stories of zeal to bring about a change, a determination to overcome barriers and an innovativeness to adapt technologies to suit local requirements.

Almost all the projects covered as case studies in the following pages had to face several challenges while implementing such as locations not properly connected to the main towns or hilly locations of indifferent and unenthusiastic attitude of the people and projects seemingly commercial unviable. These projects have succeeded as stand alone plants generating electricity using locally available raw materials, making social and economic development an integral component of the project, and have demonstrated their financially viability.

The following case studies have been carefully selected from across the country illustrating utilization of all available renewable sources with a range of applications across various sectors. The aim of presenting them is to illustrate that renewable energy projects are possible and obstacles can be overcome. To make the renewable energy sector a success in the country, the projects have to be up-scaled and have to be integrated in the mainstream development strategy of the country to achieve the desired objective.

I am sure that this compilation, which is only a glimpse of a few successful attempts, will encourage many other organizations, not only in India but also in other developing countries, to attempt similar path-breaking projects which will provide access to clean energy for rural people in remote areas with consequent benefits on their livelihoods.

Deepak Gupta

introduction

India is growing at an impressive rate of 8.2% and this is likely to continue. This would further drive the demand for electricity. The supply challenge is of such magnitude that there are reasonable expectations that severe shortages may occur. Electricity shortage is not the only problem. Its spread is an equally serious issue. More than 40% of the population has little or no commercial energy access for their living and livelihoods. Others with access often have to cope with poor and erratic availability. Not only is this a basic human need for quality of life but it constraints generation of productive activities and incomes and employment in rural areas which has itself become a critical factor in India's future development process. Further, the little supply that comes in such areas is from the use of kerosene for lighting and diesel for powering irrigation pumps and small enterprises. Both these are imposing further financial burdens on the economy because of high levels of subsidy and add to the problems of energy security. India has undertaken a very ambitious programme of conventional power generation in an attempt to meet these gaps and to leap frog to a higher growth access. It is clear from the above that India's needs for secure, affordable, and environmentally sustainable energy has become one of the principal economic development challenges for the country. And it is in this context that the role of renewable energy in India has to be seen. It is now no longer 'alternate energy' but has become a key part of these solutions.

The development and utilization of renewable energy sources has been accorded high priority by the Government of India. The policies and programmes implemented by the Ministry of New and Renewable Energy have been successful in creating an large and diversified infrastructure to promote renewable energy, technologies in the country including in rural areas. In spite of these efforts, renewable energy is still away from the rural energy mainstream. Lack of innovative delivery models, adequate repair and maintenance servicing locally, limited financing to defray the high upfront capital cost of renewable energy devices, inability to link renewable energy applications for productive end uses, unfamiliarity of entrepreneurs to structured commercial viable proposals are somehow the major barriers in mainstreaming renewable energy in the rural energy sector.

But, there is a wind of change as several projects have been successfully implemented across the country based on renewable resources. Several NGO's also have been successful in providing electricity through renewable sources in a number of villages across the country. A number of technocrats, committed to sustainable development have utilized their skills for improving technology for use in small businesses and several urban local issues have also been solved using renewable technology.

Implemented in a project mode, the programmes have been largely commercially sustainable with an add-on package of improving the livelihoods and consequently the living conditions of the users. They offered employment opportunities, improved medical and educational facilities and an opportunity for the villagers to broaden their horizon of working. It aims to put those living in the rural areas at par with others in the country to avail of the technological development and for example, stay connected using mobile phones. A number of these projects benefitted from the several incentives provided by the government both at the Centre and the State. Most importantly, a number of these projects have busted the myth that the rural people cannot afford and maintain technology and that it is not possible to run a commercial venture that fulfils a social objective. These renewable energy projects have touched the lives across the section of the society in rural as well as the urban areas. Even the most visited temple in the country– Tirupati in South India

introduction

- has embraced renewable technology for better efficiency. The case studies show how technology based on renewable energy has benefited small businesses where it is being applied to enhance production value and provide cleaner and a greener technology.

The following pages unfold a glimpse of success stories of seemingly impossible situations where there was no development for providing clean energy. The case studies are a compilation of some of the best examples of renewable energy projects. A number of them have been awarded the prestigious Ashden award. Many of them are path- breaking efforts, trying to match the needs of villagers, small businesses, local residents with available local resources at an affordable price and green technology and culminating towards safeguarding the environment.

These success stories also show the way for India and the developing world that development, particularly rural development can perhaps go hand – in – hand with preserving the environment. These projects are based on various renewable energy technologies and devices, such as improved cook stoves, biogas plants for various applications, biomass gasifiers using different feedstock's, solar photovoltaic lighting, solar thermal water heating systems and water mill from different parts of the country, appropriate to rural areas and capable of providing access to clean energy in rural areas. The innovativeness is not only in the technology application for various end uses but also in developing and implementing a sustainable delivery and revenue model, in many cases without using the government incentives.

bioenergy- gasifier

CASE STUDY 1

GOSABA ISLAND GASIFIER - A Ray of Hope

Transmission Lines to the Gasifier Plant

Biomass is a high potential energy source in India that enjoys a strong support of government-both at the centre and state. To obtain the maximum utilization of such latent energy source, Ministry of New and Renewable Energy, Government of India has given an impetus to various researches such as technologies, resource assessment and system modelling of biomass energy sector. Consequently, India has now become a leading country of biomass energy utilization. Gosaba island gasifier is an epitome of how this energy source can change the lives of people in the remote areas of country.

CHANGING COURSE

Life would come to a standstill for people residing in Gosaba, a remote island in West Bengal's Sunderban region. Cut off from the main grid, the village, much like many other areas in this delta region of Sunderban had no electricity as it is not economically feasible to extend power from the grid to many of these wide-spread islands. With sunset, darkness would envelope the entire area until West Bengal Renewable Energy Development Agency (WBREDA) and Vadodara based Ankur Scientific Energy Technology came along and changed it all. The company, in collaboration with WBREDA, set up a biomass power plant in the village. Soon kerosene lamps gave way to electric bulbs and in no time, shops, hotels, and even computer centres sprang up. Today, Gosaba is a small town.

Why was Gosaba island off the grid?

Located about 80 km south west of Kolkata, it takes around 1.5 hours to reach the island by boat from the nearest port. The geographical location and wide separation from mainland by rivers or creeks is the major hindrance in getting power from grid.

Prior to the establishment of this power plant, electricity was available only to a few houses situated near market place or shops that used small diesel generators to supply electricity for 3-4 hours every day. This system not only polluted the environment but also forced the villagers to pay the price of the electricity as demanded by the owners of the generators. Invariably, the illumination from this electricity was low and they also had to pay ₹14 per day, per point, for either a 40 W bulb or a tubelight, a rate which was far higher than what people on mainland paid for grid power. Hence by and large people relied on kerosene. But this too hindered development. Children could not study at night, fishermen couldn't store fish, shopkeepers lacked display facilities and the only medical store in the area couldn't stock life saving drugs.

It was in 1996 when on the basis of a survey of the area, WBREDA decided to intervene in Gosaba and set up a biomass run power plant, based on gasification technology from a company called Ankur Scientific Energy Technologies located at Baroda, Gujarat; which provided the technology, machinery, installation and commissioning support. The company has two & half decade of experience in using wood, wood waste (branches, saw dust, roots), agricultural residue and even poultry litter to generate a combustible gas called Producer gas through gasification. The gas thus produced is used to generate heat and electricity. The technology can generate 10 kWe to 2,200 kWe power and even more through its modular installation.

THE RIGHT CHOICE

Biomass gasification has some better advantages over other alternative energy sources. The technology's conversion efficiency is high. It can be applied over a wide range of output metrics with only a small variation in overall efficiency and investment. Most important of all, it guarantees uninterrupted power supply as it is based on locally available feedstock and the process is dynamic enough to be used for captive purposes, as well as for grids. A combination of all these factors ensured that the per-unit cost of biomass gasification is the lowest among renewable.

Illuminated in its Own Light: Gasifier Power Plant

Once the decision was taken to install this plant in Gosaba, it was necessary to make the beneficiaries aware of its potential. But for villagers it was difficult to fathom that branch and twigs of trees could give them power and that too better than what generators and kerosene did. So door-to-door visits were carried and the technology and process was explained to Sarpanch, who in turn explained it to people. Initially there was stiff resistance from kerosene suppliers as they saw the move as a competition for their business.

So when the 500 kW (5 x 100kW) biomass gasifier dual fuel power generation system (70% biomass + 30% diesel) was installed at Gosaba Island, Sunderbans in June, 1997, there were only 25 customers, as people did not believe the system would really work. But number of customers increased very quickly and there came a time when almost 1,150 houses were connected.

WHAT MAKES IT WORK?

The project is 100% funded by the Government of India and the State Government of West Bengal since this is a pilot project but owned and operated by Gosaba Rural Energy Cooperative set up by WBREDA. This cooperative has 13 board members the first lot of which was nominated by the government and after three years election were held. It is this cooperative that takes all the major decisions like which area need to be given priority for distribution line and what should be the tariff.

Summary of Gosaba Island Biomass Electrification

Plant capacity	: 5 x 100 kW
No. of consumers	: 1185
Operation hours	: 14 hours (10:00 am to 12:00 midnight)
Tariff structure	: ₹5 / kWh for domestic ₹5.50 / kWh for commercial ₹6/kWh for industrial (telephone exchange, hospital, bank and soil analysis equipment of NGO)
Length of distribution line:	High tension: 20.25 km approx. Low tension: 18.67 km approx.

In order to ensure regular supply of high quality of woody biomass for the plant, the cooperative, with support from Panchayat samiti and Block Development officer has also organised 71 ha of energy plantation in low-line river bank silt beds. This plantation on one hand, along with the biomass provided by farmers on another, helped in the smooth functioning of plant. These plantations play an effective role in checking soil erosion and maintaining the ecological balance of the region.

Now even the critics have been silenced by the success of the plant. The experienced kerosene suppliers, who were extremely critical of the project in the beginning, have been employed as plant operators.

ROAD TO OPPORTUNITY

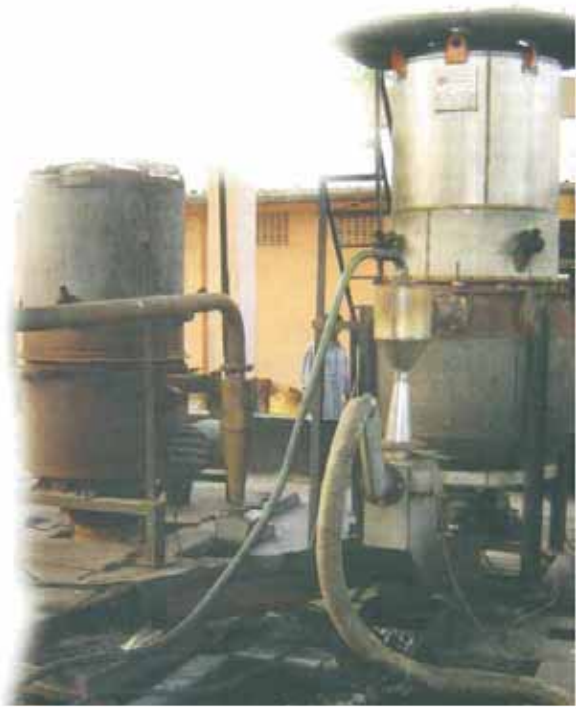
The plant operates 14 hours a day (10:00 am to12:00 midnight) and this has changed the scenario in the island dramatically. There are now many commercial stores and more than 10 hotels in the island. People from nearby islands come to Gosaba for shopping. There is a bank too that supports economical activities. Telecommunication system is also available along with internet and a computer training centre.

The hospital can now even conduct basic operations and the electricity is also used for public purposes such as street lights, school lighting, drinking water supply and irrigation along with powering the small-scale industry like boat repairing works, lathe machine units, grill welding and domestic iron implements sharpening machines to name a few.

Accordingly, income levels have enhanced and this has led to a flourishing township in a place where once people almost lived from hand to mouth. This has all been possible only because of the proper use of biomass generated electricity.

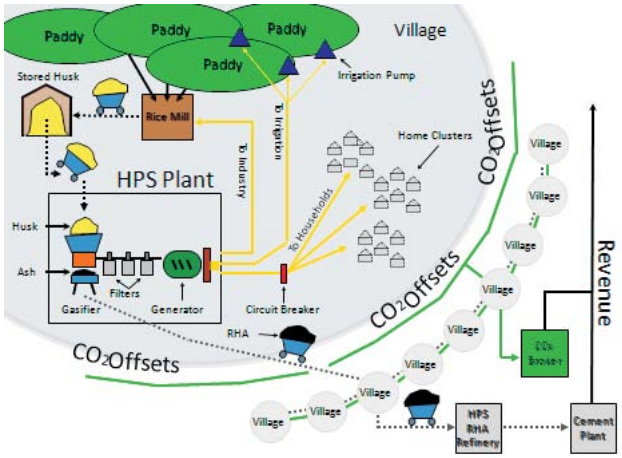
Names of electrified hamlets

Village	Area (hectare)	No of house-holds	Population		
			Male	Female	Total
Gosaba	379	1113	2887	2601	5488
Arampur	477	1264	3320	3046	6366
Rangabelia	527	650	1852	1735	3587



Biomass Gasifier Power Plant

ELECTRIFYING RURAL INDIA with Husk Power



Bamboos being used for a Low Cost Infrastructure

In remote villages sans electricity, a silent revolution is literally electrifying lives. Today almost 22 villages with over 50,000 villagers residing in the rice belt of India are the proud beneficiary of Husk Power System (HPS) - a financially sustainable and environment-friendly village generator.

THE BRIGHT IDEA

It all began when Manoj Sinha, a bright young electrical engineer from the University of Massachusetts, Amherst, USA, made an all out effort to remove darkness from the lives of hundreds of people residing in the off-grid villages of India. Growing up among them in the rural state of Bihar, he knew what it meant to be living without power. It was the good fortunes of fellow villagers that Manoj Sinha kept exploring ways to convert farm waste into electricity, even while working for Intel Corporation.

In 2007, while studying business in the University of Virginia, he teamed up with Charles Ransler, a fellow student, along with Gyanesh Pandey, another engineer from Bihar and HPS was born. The concept also won them the first place in 2008 in the University of Virginia business plan competition and the Social Innovation competition of the University of Texas, Austin.

Under the guidance of Ministry of New and Renewable Energy, they took their first step towards the green revolution. They got their gasifier fabricated at a local workshop and procured a cheap CNG engine modified to suit their purpose from a small supplier.

What had been a rather lofty and continuously unyielding idea for over five years took less than five months to realize and on the 60th anniversary day of India's Independence a remote and run-down village of 'Tamkuha' (Literally meaning Fog of Darkness) in the infamous Dhanaha region (often called the University for Kidnappers) of West Champaran district in the state of Bihar experienced electricity for the first time.

'After sixty independent years, we have found freedom from Darkness', said Mr. Rambalak Yadav, a local teacher on the occasion.

Initially these engineers thought of building small generators for few villages. But now they already own and operate 35-100 kW mini power plants that use discarded rice husk to generate producer gas to generate power. The system produces enough electricity to cater to the needs of 300 to 500 households for almost 8 to 10 hours a day.

Interestingly, while rice husk is a waste product of rice mills and is found in plenty in India, it is not often used for generating electricity. The added advantage of these generators is its by-product-silica, which is a valuable ingredient in making cement. HPS - produces electricity following the golden mantra of three R's with a little difference. For HPS the three R's stand for 'always Reliable, Renewable, and Rural'.

DEMAND-DRIVEN BUSINESS MODEL

HPS has adopted a demand driven approach and only villages where people are eager to get the power connection can benefit from this technology. To begin with, HPS team surveys each household and quantifies the potential demand in watt-hours. As a thumb rule, this exercise can be undertaken only when at least 250 households agree to take the connection. Uniqueness in this approach is that this willingness is not just verbal from

The First Plant in Tamkuha Village

all the involved households; they also have to give a token installation charge of ₹100 per household. This money not just ensures compliance by the users, but also covers a substantial portion of grid distribution expenditure, which in totality brings down the fixed investment in infrastructure like power plant shed and storage space, which is almost 5% of the total investment.

The innovation in HPS is not just limited to the use of rice husk to generate electricity. It is also in the manner in which locally available, low cost material is used instead of the usual brick and concrete, which actually brings down the infrastructure cost of the power plant. HPS on one hand ensures that the power plant machinery meets the requirement of the power plant and on the other hand it is kept simple and cost effective. Therefore instead of procuring machines from renowned manufacturers, local manufacturers of gasifier and gas engines are approached.

THE NITTY-GRITTY OF MAKING IT WORK

To keep things simple and uncomplicated, HPS owns and manages the decentralized power generating units. However for the day-to-day management, every power plant has one operator and one husk loader, where in the operator carries out the routine maintenance. The operators are trained by HPS in Patna, Bihar, for two months and then sent for on the job training in one of the operational plants. In addition, two more people are associated with these plants- one of them handles husk buying and ensures a regular supply of raw material, where as another one is an electrician for the cluster of villages.

Besides trained manpower, HPS has also taken due care to ensure smooth supply of low cost raw material. On one hand these generators are demand driven so there is never any problem in getting back the electricity charges from the villagers. On the other hand, at the market end, the promoters have evolved strong relationship with the rice husk suppliers, which is not limited to just buyer-seller relationship. Due care has been taken to build lasting relationships as a result HPS intervenes to get insurance done for the family members of rice husk suppliers, provides a technician free of cost for the maintenance of de-husking machines and gets them contract agreement for regular purchase of husk at a fixed cost, which is subject to annual revision. This husk is transported by tractors simultaneously to about 7-8 plants in one cluster. The transportation work is handled by a cluster manager.

This system of local buying ensures purchasing at the micro level. However, to receive a continuous supply of raw material, promoters are also working towards signing contract for bulk supply of rice husk from bigger organizations like Food Corporation of India.

THE ECONOMICS OF POWER

HPS is based on a proven biomass gasification technology of standard fixed bed, down draft type, which is suitable for rice husk based power generation of a capacity range below 200 kW. A differential pricing method is adopted by the promoters to calculate the electricity charges. Accordingly, every household has to pay a fixed monthly charge of ₹45 per CFL of 15 W, whereas shops pay a per month charge of ₹ 80/CFL. For households seeking connection to operate fan and television etc. charges are calculated on similar wattage

basis. Cost of electricity is not a barrier to the villagers/shop keepers because of the added advantage, which electricity brings, to there life.

Though there is seasonal fluctuation in revenue collection, last three years of operations have on an average, led to the collection of ₹ 40,000 per month as user fee, whereas the expenses are to the tune of about ₹20-25,000 per month, making the project financially sustainable.

In order to have maximum utilization of raw material, even the only by-product of the process, the charred husk, too is put to good use. The semi-burnt husk is converted into ash-balls and is a wonderful fuel source for household cooking, or manure, or even as Rice Husk Ash (RHA) for use in the cement industry. With the commercial use of by-products, this power plant on stand-alone basis also ensures high returns for the promoters.

BUILDING STRONG SYSTEM

Enthused by the response received from people, HPS is growing from strength to strength. They have institutionalized the standard procedures and practices like power plant commissioning, operation and maintenance schedules. A trained pool of skilled manpower has also been created along with developing a strong network of vendors. Currently there are 22 existing plants in 3 clusters and installation of about 30 plants is in the pipeline. The organization is expecting to meet the target of operating 2,016 plants by the year 2016.

HPS Partners – A Rice Mill Owner

Beneficiaries of HPS Electricity– Dinesh, A Vendor

Though it is an acceptable fact that till date, renewable energy projects in general, and biomass based projects, in particular, are not cost competitive as compared to fossil fuel based projects. However, considering the remoteness of the project location chosen by the HPS, future is extremely bright for both the system as well as the people living in the off-grid villages, especially owing to their long term plan of linking the HPS to carbon credits.

TURNING DESTRUCTIVE PINE TO PRODUCTIVE GAS
Pine based Gassifier

Kumaon Valley

Solar PV in Village at Kumaon

Even as the chilly winter gives way to a balmy summer of the Himalayas, the villagers of the Central Himalayan region are filled with trepidation. They are apprehensive of the forest fire that smoulders in the lower ranges of the Kumaon and Garwhal regions in Uttarakhand almost annually in the summer months, mostly from April to June, its orange blaze destroying the forest, the ecosystem and affecting livelihoods of the villagers.

In 1999, devastating fire burnt forest wealth worth more than ₹ 600 crore in the Garwhal and Kumaon regions. As per the report of the National Remote Sensing Agency (NSRA), Hyderabad, around 22.64% (5,086.6 sq. km) forest area was burnt while about 1,225 sq. km was affected severely. In 2008, the forest inferno also claimed the life of a woman who was trying to douse the fire to save her home, and that of a child.

In addition to the destruction of the flora and fauna of the region, the effect of the forest fire is felt most harshly by the over 70 lakh people in the Central Himalayan region living close to large tracts of pine forest. The devastating fire diminishes their access to fuel wood, water and other life support systems.

The pine chir tree that grows in abundance in this area offers little shade. But it has its advantage for the nearby villagers who use it as fuel wood. It is the combustible pine needles that carpet the forest and is one of the several causes of forest fire in the area.

AVANI - a voluntary organization working in the villages of Central Himalayas in the field of appropriate technology has found a productive use for the pine needles. In its latest initiative, AVANI aims to set up an enterprise employing unemployed youth based in collection and utilization of fallen pine needles to generate producer gas which will be used to generate electricity that can be sold to the power companies through the existing grid.

A study has estimated a total production of about 14.65 MW of electricity from biomass in the State. With its rich forest resources, Uttarakhand has huge opportunities for electrification through gasification, a comparatively cheaper, easily accessible and durable technology for the State.

PINE BASED GASIFIER

The 9 kW gasifier developed by AVANI is already operational at its centre at Pithoragarh, Uttarakhand for the last three years. Out of the 9 kW, 1.5 kW is consumed for running the system and a continuous output of 7.5 kW is available for productive use. The cost of this gasifier manufactured at Baroda, Gujarat is approximately ₹4,85,000 while a 100 kW gasifier would cost approximately ₹48 lakhs.

The gasifier system pyrolizes sized pine needles to volatize them into producer gas, which is mixture of combustible gas. The producer gas is then passed

Solar Water Heater

through a series of filters consisting of saw dust and fine cloth to be cleaned of tar and other impurities. The resultant clean gas is used to run a modified diesel engine that runs on 100 per cent producer gas.

The AVANI project doesn't stop at just generating electricity but extends its scope beyond. It aims to usher in a 'Green Economy' for the villagers being environmentally and economically sustainable. It proposes to address the interdependent issues of employment, health and improving the overall quality of life of the villagers in this region.

BENEFITS FROM THE GASIFIER

AVANI's pine needle gasifier project proposes to address the most energy intensive and vital household process – cooking effectively utilizing charcoal, a by - product of the gasifier. This village – level cooking energy solution will reduce fuel gathering time by 70% and provide smoke – free homes. The gasification process produces about 10per cent residue, which incidentally is high quality charcoal and is used for cooking in village households. Residue from a 120 kW gasifier system will be sufficient to meet the cooking fuel needs of 100 households. Families can pay for the charcoal, which is cheaper than gas or kerosene, either by cash or by collecting pine needles in lieu for it. Replacing fuel wood as a medium for cooking would also mean saving time on wood collection. The quality and the health of women, the prime collector of wood, will also improve cooking in a smoke - free environment and will see a reduction in the respiratory related health problems.

As a renewable energy project, the pine needle gasifier contributes towards reducing greenhouse gas emissions. The project provides an alternative to LPG for cooking

Renewable Energy–Making an Eco-living

Pine Needles for Biomass Gasifier

At the macro level, the benefits of the project will percolate to enhance ground water recharge, regenerate biodiversity, and reduction of the fire - fighting efforts.

Already plans are afoot at AVANI to install gasifiers at two villages at Malla Balta and Talla Balta of the same Gram sabha in Almora district, Uttarakhand by the end of this year. These villages like many others in the area are surrounded by pine forest. Families of these hamlets are dependent on wood for cooking and have to walk almost 5 hours daily for gathering fuel wood. Most of the men here work as casual labourers, when they can find work and the women have no scope for gainful employment.

and protects the environment from green house gas emissions, which would have gone into burning wood from unsustainable supplies that can be calculated on 2 kgs per capita per day. By producing energy from biomass, the project aims at reducing 0.89 kg of carbon dioxide for each unit of electricity generated. As the biomass burns on the forest floor without providing any useable energy, the project will further contribute to the reduction in carbon emissions by eliminating all those wasted emissions.

Taking a leaf from their previous projects of investing in capacity building of the local residents for technology and management, AVANI proposes to set up an enterprise employing unemployed youth who will be trained to operate and maintain the gasifier.

Installation of Solar Panels

Pine needle collection will generate employment opportunities for the villagers. It is estimated that one family can collect upto 100 – 200 kg of pine needles in a day depending upon the time they spend in collection. By

monetizing the collection of pine needles and use of charcoal, AVANI aims at addressing the economic disparity at the village level. While the unemployed can earn wages by collecting pine needles and every family in the village can buy charcoal for cooking including the well-off in the village, who may not participate in the pine collection. It is proposed that the sale of electricity will create surplus to employ more people in collection of pine needles than are needed to meet the cooking needs, thus creating a sustainable livelihood at the village level, involving local youth.

IMPROVING THE ENVIRONMENT

While benefiting the villagers and upgrading their living conditions, the removal of pine needles will benefit the entire biodiversity of this region. The monoculture of the pine over a period of time as an exotic tree has degraded the biodiversity of the Himalayas. For one, the carpet of pine needles does not retain water. During monsoon, rain water drains off its slippery surface taking a lot of loose soil with it causing soil erosion and depriving essential ground water recharge. Further the acidic nature of the pine needles makes the soil infertile and prevents the growth of any other plant species, especially native trees like oak and rhododendron, preventing a mix of different variety of plants that is invigorating for a healthy biodiversity.

Protection and restoration of local species so precious for the very existence of these forests in turn will increase the percolation of rainwater making it a healthier cycle every year. This would help in restoring the moisture regimen and all the benefits associated with it. In the absence of pine needles, other sapling that are sowed by human intervention annually will have a chance to survive and a mix of different trees and plants will enrich the biodiversity further; a moisture improved regimen will, in the long run help the farmers to grow and reap better crops. Regeneration would also improve other local applications like timber, medicine fodder, fibre yielding plants, water and fuel availability thus enhancing supplementary livelihoods proposed to be augmented in the project.

The forest fire, caused by the littering of pine needles, chokes the atmosphere and adversely affects the air quality forming a cloud of smoke in the summer months till the monsoon washes it away. Clearing of the pine needles and gasification would eliminate the smoke build-up by converting the biomass into combustible gases and help in providing a clear environment.

FUTURE SUSTAINABILITY

To ensure the future sustainability of the project, AVANI plans to form a producer's company with all the players in the production chain as share holders. The company would undertake the setting up of more such power plants, generating profits, which in turn will be shared by the producers and pine needle collectors, sustaining the institution.

There is a good scope for the pine needle gasifier in the Central Himalayan region to succeed and be replicated as pine needle is found in plenty. 1 m² of pine forest will yield 1.19 kg pine needles. A 100 kW gasifier running for 24 hours would require 4,500 kg of pine needles and 115 hectares of cleared forest every year will give 1,350 tons of pine needles per year.

According to estimates, gasifier has a scale up potential to generate electricity in the central and the western Himalyan region. Electricity thus generated from clean energy source can meet the energy needs of 1.4 crore families and the cooking energy needs of 7 lakh families.

The following figures reflect its economic viability:

Cost: ₹70,000 per kW of installed capacity.

Finance: Through grants/subsidies/loan and equity.

Terms of credit/loan: calculated at 10% capital cost

Returns/ profit: IRR of 12%

Payback period: 8 years.

TRANSFORMATION OF ARARIA
The Gasifier Way

Feedstock-Dhencha

Baharbari village in Dabhrha panchayat, Jokihat block, Araria district in the state of Bihar is situated at the foothills of the Himalayas. The village has 250 households and like several villages in Bihar has not benefited from any economic development. In spite of being blessed with extremely fertile land with enough water to reap three harvests, the farmers were constrained by the total absence of infrastructure like roads or power- crucial for development. The villagers had to irrigate with diesel run pumps, the nearest diesel – pump dealer being 40 km away and the closest battery – charging shop about 16 km walking on a dirt track.

The villagers could watch Doordarshan (the national television channel) on battery – run television sets. Incidentally, today Baharbari is an “electrified” village proudly proclaiming its new status, but this has changed nothing about the fact that there is no electricity from the grid delivered to the village.

In 2001, Decentralised Energy Systems India Private Ltd. (DESI Power) identified the powerless Baharbari as a potential site for a 50 kW power station, based on gasification of rice husk briquettes. The raw material was available in abundance in neighbouring villages. By 2004, the lifestyle of the villagers was transformed as household power connections on fixed monthly rental were being provided. According to DESI Power's concept of 'EmpPower Partnerships for rural development', power and energy availability and simultaneous investment in micro-enterprises led to local value addition, agro-processing industries, and increased agricultural productivity. These micro-industries and the power plant generate regular jobs and additional farm income which in turn increases purchasing power for electricity, energy services, drinking water, health services and education. In a poorly developed state like Bihar, which is underdeveloped according to all the social, economic development yardsticks, there is a huge electricity deficit. As of 29 February 2008, Bihar had the maximum number of non-electrified villages with a number as high as 18,395. According to the recommendation of a Special Task Force set up by the Government of India in 2007 to study the power situation in Bihar, the State has a potential of about 200 MW to set up biomass based power projects including co-generation projects. Rice husk based biomass gasification and combustion technology for industrial application and decentralized power generation can be one of the important sources for power generation in the State, particularly in northern region of Bihar.

DESI POWER PROJECT

DESI Power in 2001 set up a project to harness electricity from bio mass. In addition to Baharbari, it installed decentralized gasifiers in two more villages of Araria - Vebra in 2007 and Gaiyari Village/ Zero Mile in 2008. Desi Power is a not-for-profit-to-the-promoters renewable energy power company. Its business model is to supply electricity and energy services to two distinct decentralised electricity markets:

- Through Independent Rural Power Producers (IRPPs) to villages and semi-urban areas.
- As captive power plants to small scale industries which depend upon diesel generators (due to unreliable grid supply) including mobile phone towers.

Adopting a sustainable and self reliant approach towards its projects, DESI Power's IRPP business model is always

Biomass Gasifier at Gaiyari

a joint venture. DESI Power takes on the role of providing reliable and affordable supply of electricity in a mode that ensures the development of the village. The role of the local partners is to establish local industry, micro businesses and agro-forestry for value addition and employment generation for the villagers. Here the productive applications would include rice mill, wheat flour mill, water pumps, and lighting requirements. The local partner here could be a village organization, which may be the village Panchayat, a company, cooperative or an NGO. In the 'joint venture' DESI Power promises to provide affordable electricity using locally available renewable energy sources. The local partner ensures the supply of raw material for the gasifier and according to a pre-decided price, promises to buy the electricity generated. For the economic viability of the power plant, it is vital that maximum electricity is sold and the villagers produce and sell their product profitably to support the virtuous circle of development.

The second business model of DESI Power is to cater to the requirements of the small and medium industries including mobile phone towers. In the past decade, in the abysmal scenario where development seemed to have frozen in Bihar and it being the only state in the country unable to meet the peak demand, diesel sets ruled the roost. In the absence of regular power supply, most of the industries opted for their own on-site generation and the small and medium ones were dependent on diesel generation. Adding to the existing woes, the grid electricity price also increased with the removal of subsidy. DESI Power stepped in here to offer an affordable and sustainable solution to the small and medium industry. The Zero Mile decentralized gasifiers set up in Araria district in 2008 with an installed capacity of 150 kW and connected load of 125 kW is supplying electricity that is competitive with the grid supply in many states.

MAKING THE PROJECT VIABLE

Starting a project is just the first step in the entire process. The success lies in its successful implementation, management and delivery overcoming challenges. When DESI Power initiated its project in Baharbari, it had no partner with whom to implement it. No NGO had worked in the village earlier and this kind of concept that DESI Power was espousing of forming a partnership with a local organization was unheard of. DESI Power facilitated the forming of Baharbari Udyogic Vikas Swavalambi Shakari Samiti – a cooperative to partner the project. Today the cooperative has 19 members and it owns water pumps, chura and paddy mills. The other challenge was the lack of trained staff to operate the gasifier. This was overcome by training staff at Indian Institute of Science at Bangalore. Now a team of 3-4 trained staff oversee the operation of the plant. Well insulated underground cables supply electricity and a meter at the receiving end provides details about usage. During the assessment for installing a project itself, DESI Power ensures that the criterion of availability of raw material is met. Without fulfilling this basic and vital aspect, a project is not promoted. One of

the key strengths of DESI Power is in the management of the feedstock. This can be seen in their constant effort to broad-base the variety of feedstock and their continuous effort to explore all possibilities.

When DESI Power began its project in Baharbari, Ipomoea (locally called besharam) was combined with hardwood as a feedstock. This was the second plant in the country using Ipomoea as feedstock. But as the demand for electricity increased, the search for an additional feedstock led to maize residue. To add additional substitutes, 'Dhencha' - a leguminous plant with low investment was identified as a possible raw material. Dhencha was commonly used by the villagers as a material for backyard wall of the houses. The potential as biomass fuel was tested in house tests and the size, optimal moisture content and mixing proportions standardised. It was found that Dhencha had a good calorific value and was also a nitrogen fixing plant with a short production cycle of four months. People in the district were encouraged to grow this crop. DESI Power has prepared a feedstock calendar for the entire year for Araria districts to ensure year round supply. This reflects the importance that they attach to this vital link in the entire chain. With an eye on the future expansion and the accompanying demand, the company is also thinking on the lines of captive forestry dedicated for the biomass plant feed. As the area is rich for bamboo cultivation, a fast growing bamboo is being considered as another substitute for raw material.

As part of its strategy towards a feasible and financial viable project, DESI Power has always been keen on productive rather than lighting load. Such an approach gives the organization control over managing the feedstock, operation of engines and power supply. An evaluation of the three projects in Araria proves that this approach has resulted in financially viable business model. The payment of tariff has been regular. As the plants are standardized and the financing and operation and maintenance cost vary only marginally within each site, the financial performance of each plant therefore depends essentially on the biomass cost and the plant load factor. The projects are also providing a commercially acceptable Return on Investment and Internal Rate of Return over a 10 – 15 year evaluation period. In the IRPPs in contrast it expected to take longer for the industry linked power plants to become financially viable, as they depend directly on the build up of the local electric loads and energy service. Connecting power plants to mobile phone towers will henceforth provide many DESI Power village power plants with an anchor load which will ensure quicker financial sustainability.

The following table details the project at Araria:

Place	Year of Installation	Installed Capacity & Equipment make	Connected Load	Power Supply Duration	Feedstock	Number of Staff	End User profile
Baharbari Village	2001	61 kW (50 kW at the installation time)	60 kW	05:00 pm to 10:00 pm	Hardwood, husk, maize residue, dhencha	3	Water pumps, Chura mill, Battery charging, Paddy mill, Welding, Evening lighting in the HH
Vebra Village	2007	61 kW (11 kW at the installation time) (DF- 50 kW installed later)	60 kW	01:00 pm to 09:00 am	Hardwood, husk, maize residue, Dhencha	3	Rice mill, aata chakki, chuda mill and water pumps
Gaiyari Village/ Zero Mile	Nov, 2008	250 kW (2PG-75 kW, 2DF-50 kW) Engine from Cummins, Gasifier	125 kW	10:00 am to 05:00 pm	Average feedstock Consumption 800 kgs/day. Hardwood (70%), dhencha (15), maize/ Ipomoea (15%)	5	15 Micro Enterprises

CHANGED LIFESTYLE AT ARARIA

The project in the Araria district has brought about a tangible transformation in the lifestyle of the villagers. The economy of the villages is thriving with nearly 70 per cent of the total revenue of operations being pumped back into the villages in the form of payment for feedstock and salary to the local staff. The productivity of the farming sector has gone up due to low cost of irrigation and regular profits in the local enterprise because of assured power supply. Both these result in empowering the people by increasing their purchasing power. In the beginning of the project, the focus of DESI Power was on providing power for productive load. Then in 2004, light in the evening was provided to the houses for a limited period. A shop was also opened at a central location to sell manure and fertilizers to meet the needs of the farmers. Gradually nearly 25 shops came up in the area catering to the needs of common grocery to computer parts. The overall development due to electricity has encouraged youngsters to find employment in the village itself instead of migrating to nearby city or towns.

FUTURE PLANS

Buoyed by the success of the project, DESI Power's future vision is to spread the benefit of the project to 100 villages in Bihar and other states as well, perhaps with a better technology which definitely is a possibility in this sector. The crucial factor remains the availability of feedstock without harming the land of the villagers. DESI power is already envisaging a plan of dedicating 10 hectare land for growing feedstock- a definite must for a large scale replication.

Further plans are afoot to link not only the gasifier but any suitable local renewable energy technology with telecom towers for a regular anchor load for village power plants of any technical specification whether hybird PV, biogas, or biomass gasification. This model will give IRPPs based on any renewable energy technology the basis for financial sustainability. Towers are planned to make up around 20% to 40% of any village power plant load. This approach to IRPP load and technology optimisation is being tested in Gayari and Bhebhra, and will be further tested in 30, 100 and 1,000 villages in the next five years.

Hardwood Cutting Storehouse

CASE STUDY 5

A DREAM COMES TRUE

Local Dhaincha Plantation

In a poorly developed state like Bihar, there exists a huge electricity deficit. The average per capita consumption of electricity is of 75 units, compared to the national average of 613 units. As of 29 February 2008, Bihar had the maximum number of non electrified villages with a number as high as 18,395.

Under the Government of India's Rajiv Gandhi Grameen Vidyutikaran Yojana (RGGVY) a scheme that promises electricity to all by 2012, Bihar is one of the priority states. Yet, there are several unelectrified villages still – with the deadline two years away – that have to receive electricity.

For example in Saran district, nearly 84 crores rupees has been spent under the central government's scheme yet, most of the connected villages failed to receive regular electricity supply after the initial few weeks.

Needless to say, that the poor power scenario is one of the reasons for the underdeveloped status of Bihar. The abysmal power scenario has thrown up many social entrepreneurs across the state, which in their zeal to improve and develop their home state has set up renewable energy projects to electrify pockets of the state aspiring to extend their projects.

FOUNDATION OF SARAN RENEWABLE ENERGY

V.K. Gupta is one such entrepreneur. During his growing up years, he had a firsthand experience of the hardship faced by the people of his home town in Bihar's Saran district, 'The problems brought about by no power situation', Gupta always wanted to find a solution to this problem….to bring electricity to his home town.

So when, ICICI bank where he was employed, was considering setting up renewable projects as part of their Corporate Social Responsibility, Gupta thought about his dream. He asked his cousin, Ramesh Kumar to carry out a feasibility study on the availability of land, fuel and electricity demand in Garkha, Bihar.

In 2006, V.K. Gupta set up Saran Renewable Energy (SRE), a small family owned firm with his brother and grain merchant father. SRE has built a biomass gasification plant at Garkha, 70 km from capital Patna to gasify biomass purchased from local farmers to generate electricity which is sold to local businessmen. A densely populated village, Garkha was plagued by unreliable supply of electricity forcing people to opt for high cost, polluting diesel generators. Now, the electricity from the gasifier replaces these environment disaster generators and supplies power to nearly 1,000 businesses and households, a school and two medical clinics.

Electricity from Eco Gen-sets

SRE's efforts were rewarded as the company was awarded the prestigious Ashden Award in 2009 for providing reliable electricity to small businesses from a biomass gasifier and for enabling farmers to earn reliable income for producing the biomass.

The gasifier installed at Garkha by SRE is designed to supply 128 kW electricity at 240 V, a high voltage for a gasifier with two 3 kV transmission lines, each 1.25 km provide link to the customers. The plant is run for 10 hours every day using 35% of the total capacity. The gasifier used by SRE is down – draught – open – top gasifier made by Netpro under the license from Indian Institute of Science, Bangalore. Gas engines are used to generate electricity.

A SUITABLE RAW MATERIAL

When Gupta was searching a location for the plant, one vital pre requisite was the regular availability of raw material near the plant site. The search ended in Saran district. Here vast tracts of the low-lying land between the rivers Ganga and Gandak are water-logged. This makes it unsuitable for cultivating most crops.

But dhaincha thrives in such a soil. It is low on maintenance and has a short cropping cycle of 6-8 months. The gasifier at SRE uses about 70% dhaincha as raw material and the rest is from a variety of other sources like corn cobs, wood and other local plants similar to dhaincha.

To maintain an uninterrupted supply of this marshy crop, SRE gave a beneficial offer to the farmers to grow dhaincha – free seeds and some incentive. For the farmers it was a win – win situation as they could utilize their otherwise uncultivated land and also earn a secure earning from it. Nearly five tonnes of dhaincha can be grown on one hectare yearly. This translates to ₹7,500 - 10,000 per hectare from a plot of land that had otherwise been idling. Moreover, growing this crop was easy as it does not require any fertilizer or special care. SRE introduced dhaincha carefully not to pit it against other food crops. Dhaincha not only earns from an otherwise water logged land that was uncultivated, but also contains nitrogen – fixing property that is useful for the soil and may reduce the need for fertilizers and improving the environment.

SRE Electricity - The Cleaner Option

GASIFIER AT GARKHA

The power generated by the SRE plant mainly caters to about 200 businesses and shops, two grain mills, a cold storage unit, a cinema hall, a saw mill and several genset operators. Most of the genset operators are those who were earlier running diesel generators to sell electricity in the villagers. The gasifier has not affected their business as they now sell electricity bought from SRE and retail it to households and business establishments.

The sale price of electricity to the consumer is ₹7.5 per unit. The cost is calculated taking into account the pay back of the loan taken by SRE to set up the gasification plant. Although the cost by the state electricity board is pegged at ₹6 per unit, customers are willing to pay a little extra for reliable supply, stable voltage and higher frequency. The charges for power from diesel generator are ₹12–16 per unit. But as demand goes up and more customers join, the cost may scale down.

SRE is very particular about the payments and expects customers to pay up according to the usage. A meter attached to the supply of each customer records the consumption every day. If the payment is late by more than week, the supply is disconnected.

The gasification plant operates daily for about 10 hours from 10:00 am to 09:00 pm (one hour break) with a current peak demand of 90% of the capacity with an average demand of 65%. Twelve staff and 5 casual workers run the

Battery Replaced with Electricity from SRE.

plant. But with such a continuous load on the plant, maintenance and proper running assumes significance. The plant is maintained by technicians who have been trained in Bangalore. If maintained properly, the life of the machine can be up to 15 years.

That will give enough time for the promoters to pay back the capital loan. The cost of the entire system is ₹83,00,000. The proportionate cost of the gasifier and generation plant would be 90% of the total cost and the remaining 10% for the two 3 kV distribution lines.

For setting up the plant, a major portion of the finance was provided by the Directors of the company, while ICICI bank loaned ₹20 lakh. Thirty per cent of the state government promised ₹18 lakh has been received so far. The difference was paid by the directors. Although the company recorded a loss in the first year of production, it was able to make a profit of ₹6 lakh in 2008.

In the break - up of the expenses incurred, the largest portion goes towards paying off the investment (55%), fuel cost (35%) and operation and maintenance (15%). No doubt all this effort has been well rewarding for V.K. Gupta when he sees his dream being realized….that of development and a better life for the people of his state.

GASIFIER TRANSFORMS GARKHA

The Garkha project has of course been quite encouraging on several fronts. Most important is giving belief to the people, who had perhaps given up hope that reliable, uninterrupted power supply is possible and linked to that realizing the aspiration for employment, better living. For example, a farmer with a hectare of marshy land can hope to earn some income from it. A dhaincha crop of about 5 tonnes a year can earn him an extra ₹7, 500 to ₹10,000 per year. This is a substantial amount in a region of low incomes. SRE buys agricultural waste and dhaincha from nearly 100 farmers. The price varies between ₹1.5 – 2 per kg depending on the moisture content.

It has improved the business of many of the customers of SRE. They include grain and oil mills, a saw mill, a welder, a battery charging station supplying lighting. All benefit from an increase in their business from a reliable supply of electricity.

Farmers living close to the transmission line use electricity to operate about ten irrigation pump. A farmer

From Diesel to SRE Powered Grinding System.

now pays ₹150 for the same water supply from the gasifiered powered pump in comparison to ₹300 paid earlier to use a diesel pump.

A medical clinic can now run something as simple, but important, as a nebulizer, which is used for respiratory problems, especially among children. Earlier due to erratic supply this was rendered useless resulting sometimes in death. The doctor at the clinic is so relieved that now he will not be helpless.

A blood collection lab now can work unhindered by paying ₹200 per day as compared to ₹300 per day for supply from a diesel supply. This reduction in running cost will mean improved revenue.

Further development in the area fuelled by SRE includes a study centre where electricity is provided free by SRE. It has also subsidized cost for electricity to a computer training centre to support education.

As compared to the polluting diesel run generators, the gasifier, which uses 10-15% diesel for ignition, saves 0.35 litres of diesel per kWh of electricity generated. The 110 MWh generated during 2008, replaced nearly 38,500 litres of diesel. This avoided the production of about 103 tons of CO_2. At the current level of demand, the savings would be 77,000 liters per year of diesel and 206 tons per year of CO_2. The plant is also protects the environment reducing the emission of other pollutants like nitrous oxide, sulphur dioxide and particulates.

The success of the project in Garkha has encouraged SRE to develop the project further in Bihar and outside. The current plant at Garkha itself has a huge potential for expansion and is already built with scope to double its capacity.

The potential of course is better where cluster of small business are close to farms from where biomass can be supplied easily. Already several such locations have been identified and dhaincha cultivation already started in two of them.

Adjoining country of Nepal has also shown a keen interest in such a project and SRE is actively in discussion with them about the setting up a plant in Bharatpur, Nepal.

Replacing Diesel with Electricity.

Biomass Power Plant

CONVERTING THE CULPRIT OF FOREST FIRES INTO A RENEWABLE ENERGY SOURCE

Biomass Briquettes from Forest Waste

Biomass Briquettes

Raw Material Processing

Raw Material for Further Processing

Millions of tons of biomass gets generated from forest residues especially pine needles. These pine needles if not removed from the ground can cause lot of damage to the environment. Firstly due to their highly inflammable nature, they often become the cause for forest fires in the Himalayan forests. Pine tree trunk is heat resistant, hence in case of a forest fire, pine trees survive the fire but in the process destroy the growth of other plant species whose produce provide sustenance to villagers and thus also disturb the ecological balance of the region. Secondly, dry pine foliage stops water from being absorbed by the soil and thus causes the depletion of ground water table. Thirdly, fallen dry pine foliage acts like a carpet on the forest floor and blocks the sunshine reaching ground and thereby stops the growth of grass which the cattle feed upon. Although dry pine needles and other forest residues have high caloric value, this biomass cannot be used directly due to its low bulk density and high moisture content.

Rural Renewable Urja Solutions Pvt. Ltd (RRUSPL) located in Garhwal region of Uttarakhand state is manufacturing and supplying the biomass briquettes using pine needles and other forest residues and agricultural wastes. The composition of briquettes produced using forest residues and other industrial and agricultural wastes is 60% of dry pine needles, 30% of saw dust and 10% of other agricultural waste like lantana, cow dung and sugar mud.

RRUSPL, a private limited company founded by Dr. Rajesh Rawat and Mr. Brijesh Rawat initially involved fifty villages located near Kotdwara in the Pauri-Garhwal district of Uttarakhand in the project. Village self help groups formed by 8-10 members (mostly women) collect biomass primarily comprising of agriculture waste and forest waste including highly inflammable pine needles. A cluster operator coordinates with these village self help groups for procuring the biomass raw material. Pine needle collectors are paid ₹1,000/- per ton of pine needles collected. This raw material is briquetted to a density of more than 650/m³. These briquettes have a gross caloric value of 3,927 Kcal/kg. 1.3 kg of briquettes replace1 kg of coal and 3 kg of briquettes replace 1 kg of LPG usage.

The Final Product

RRUSPL produces and directly supplies these briquettes to institutions and industries like brick kilns, industrial boilers, restaurants, schools that run mid-day meal programs, ashrams, cafeteria, and school hostels, who primarily use coal or LPG for their energy requirements.

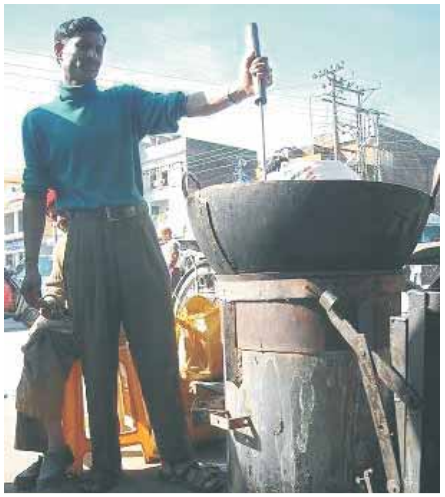
The cost price of one ton briquettes used for replacing LPG works out to ₹ 4,500. Cost price of one ton briquettes used to replace coal works out to be ₹ 3,920. RRUSPL sells one ton of briquettes for LPG replacement for rupees six thousand and in case of coal replacement the selling price is rupees three thousand nine hundred and fifty only. The cost price worked out by the company includes all the costs like payment to the pine needle collector, operation costs, packing costs and transportation costs. Transportation costs include transportation of raw material to the production site and transportation of briquettes to customers.

A briquette processing unit of 15,000 tons requires an investment of ₹2 crore. Initial investment can be raised through bank loan at 14% interest rate with a 5 year loan term, with subsidies and own finances. Investors start getting approximately 20% of rate of return after two to three years. Profits are generated by selling briquettes, gasifier chulhas and selling carbon credits generated by reducing the carbon emissions of fossil fuels. The project generates ₹542 against replacement of coal and ₹382 against replacement of LPG per ton of briquettes. MY CLIMATE, a Switzerland based agency has entered into agreement with RRUSPL to buy these carbon credits generated by the project. MY CLIMATE in turn will sell these carbon credits to the air travelers who want to reduce their carbon footprint. With this arrangement while the project at one end contributes to generate renewable energy and empower rural population, at the other end, at global level it aims at enabling high society air travelers living in far off European countries reduce their carbon foot prints.

There is a scope for setting up of five such units in the pine and lantana regions of various hill states of India. The current unit also can be expanded to produce a total of 10,000 tons of biomass briquettes per annum from its current capacity of 4,000 tons per annum and thereby prevent 15,000 tons of GHG emissions.

Environmentally, briquette manufacturing using waste pine needle hugely helped in preventing and reducing forest fires and by replacing the coal and LPG usage, briquettes reduce the carbon emissions and also the dependency on coal and LPG supplies.

Kiln Running on Briquettes



Briquette Operated Stoves

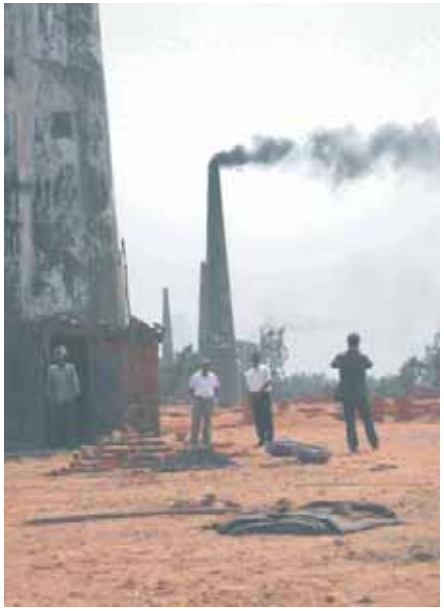
The project of pine needle removal and using them in briquette making is one of the pioneer ventures in Garhwal region and may ultimately lead to self employment and improve the economic situation of local people. In future it will be one of the important measures adopted for controlling forest fires and income generation.

Usage of dry pine needles for briquette making controlled almost 50% of forest fires in Lansdowne area range alone. The impact was more than 50% in civil forests. If continued in the same earnest in van panchayats, the project may well revolutionize the pattern in mitigating the forest fires. More and more entrepreneurs should set up briquette manufacturing units not only using dry pine needles but also using Lantana camara twigs and leaves.

At societal level briquette manufacturing units provide employment to rural people. Up to 500 people can be employed to collect pine needles during the peak season of biomass availability. Setting up briquette manufacturing units leads to the development of associated trade networks like distribution and transportation networks for raw material collection and supply of briquettes and pellets. Most importantly briquette manufacturing from forest and agro wastes generates huge economic value for agricultural, industrial wastes and forest residues.

However awareness has to be created through innovative leadership, vision and initiatives among people to accept the use of briquette in place of fossil fuels not only for industrial and commercial operations but also for domestic uses like cooking, room heating etc. People have to be encouraged to use gasifier chulhas. Initiatives have to be taken for capacity building among local communities.

Briquette manufacturing from forest residues and agricultural waste is relatively new technology. In order to promote briquette manufacturing, training has to be given on technical know how to people on production, operation and maintenance of briquetting units in the hill regions of India.



Chimney of Briquette Based Kiln

HYBRID VERMICOMPOST BIODIGESTERS
Empowering the Rural Households

Adding Cow Dung in Biogas Plant

Application of Vermicompost

Karnataka is one of the developed states of India. Bengaluru, the capital city of Karnataka is known as the Silicon Valley of India. However the affluence is mostly concentrated in urban cities of Karnataka. Economy of the rural Karnataka is still based on agriculture where food is still cooked using firewood on open fires and traditional inefficient stoves. Rural women and children have to spend at least two to three hours in a day on collecting firewood from nearby forests and other common lands. As more and more forest are depleting and common lands are taken up for setting up industries or urban residential complexes, rural women are finding it difficult to gather firewood required for domestic use.

SKG Sangha (SKGS) a non-profit organization based in Kolar district of Karnataka is setting up hybrid Vermicompost biodigesters in rural Karnataka and in other states of India with the twin objectives of providing clean cooking gas generated through biogas to these rural areas and to enable the rural households to earn additional income by making saleable fertilizer from biogas residue and other unmanaged agricultural and domestic organic wastes.

The biogas is produced using cow dung. The biogas built by SKGS consists of an underground brick built digester, an inlet at the ground level to feed the digester with new feedstock and two separate outlets to collect biogas and to remove the residue.

Galvanized steel pipe is used to collect the gas from the plant and HDPE pipes are used to transport gas from the outlet to the biogas stoves in the kitchen. Cow dung mixed with equal amount of water is collected in the inlet tank. This then flows into the digester due to gravitational force and displaces an equal volume of the residue, which gets collected in the residue tank constructed at the residue outlet of the plant. The biogas plant is constructed with locally available materials except for the gas burners and HDPE pipes. SKGS builds biogas plants with a production capacity of 2, 3 and 4 m^3gas/day from an input of 50 to 100 kg cow dung from 2 to 6 cows.

Roughly 36 to 72 tons of output liquid residue is produced per year from 18 to 36 tons of wet feedstock. The residue can be directly used as a fertilizer but being in liquid form it cannot be transported to distant locations. In order to transform the liquid residue to easily portable organic manure, SKGS uses the vermiculture technique. The vermicomposting unit comprises of two brick chambers of one cubic meter each with a concrete floor and a permanent roof. In this process, the liquid residue from the outlet reservoir tank is transferred to vermicomposting unit built at the ground level adjacent to the biogas plant.

The residue is then mixed with fibrous material such as straw, green and/or dried leaves and the mixture is turned once in few days and allowed to decompose for 20 days. Then the earthworms are introduced on the mixture. The mixture is covered with straw or jute mat to avoid direct sunlight and to protect earthworms being eaten by birds, rats etc. A little water is added to the mixture to maintain

Vermicompost

the moisture. Every few days the top layer of the worm casts are scraped off and stored for using as vermicompost.

SKG Sangha has built and supplied over 80,000 biogas plants in rural areas of India. When a customer approaches SKGS for constructing a biogas plant, an assigned technician co-ordinates the work which includes arranging for the equipment and components required for installing the biogas plant, supervising the construction of biogas plants, checking the quality of construction, arranging for inspection by designated officials, training the villagers in plant operation, maintenance and management of the plant and maintain the plant for its life time of more than 20 years.

Cost of a typical 2m³ biogas plant comes about ₹18,000, overhead costs are about ₹2,000. Constructing the vermiculture system adds about another ₹12,000 to the total cost.

SKG Sangha currently has two business models. One to work through Government subsidies and the other one is work through carbon money.

a) The business model with government subsidies for installation of biogas plants:

The Government of India gives subsidies for constructing approved models of biogas plants, which will cover up to 50% of the total biogas plant. Customers pay the remaining 50% cost. Usually customers bear these expenses in kind by providing construction material like sand, gravel, and bricks; by taking part in the construction process and providing food to the construction workers etc. The cost of constructing the vermiculture unit has to be borne entirely by the customer either from his own pocket or through a loan from a bank or a micro finance institution.

b) SKGS also works on an alternative business model by utilizing the Carbon Money:

In this model SKGS conducts a base line survey of a selected project area and approaches a Certified Emission Reduction (CER)/Verified Emission Reduction (VER) buyer who is willing to pay upfront for the project. Once buyer agrees to the condition,

Employment Generation at Bidadi

Feeding a Biogas Plant

then SKGS selects the eligible women beneficiaries and conducts a series of meetings for the stakeholders and prepares them for the project. In this model, the CER/VER buyer pays up to 75% of the implementation cost of the hybrid system and the beneficiary pays 25% of the cost, which is usually given in the form of providing locally available building material like sand, metal chips, and in the form labour etc.

Vermicompost production is a profitable income generating activity. Vermicompost is sold at ₹90 per 30 kg. Usually villagers keep 50% of the total vermicompost produced from their biogas and vermicompost units for self use and sell the remaining 50%. They earn around ₹12,000 per year by selling 50% of the vermicompost. With this income they are able to repay their loans and

Cooking on Biogas

also have additional income to the income generated through their regular farm activities which will be around ₹18,000 per year. SKGS helps the women beneficiaries in marketing the vermicompost, till they gain confidence of marketing their compost by themselves.

BENEFITS OF THE PROJECT:

a) As there is no smoke or soot produced while cooking with biogas, many respiratory and eye ailments caused due to smoke and soot generated during firewood cooking have considerably reduced thus improving the health of the people especially women and children.

b) Cooking with biogas saves a lot of time for women as they need not spend time in collecting firewood, can cook food much faster, cleaning of utensils also takes less time as no soot gets collected on the utensils.

Hybrid Vermicompost Biodigester

c) Women are able to cook food before their children leave for school, children are able to have breakfast at home and carry lunch to the schools. Since children are no more assisting in collection and processing of fire wood and on hungry stomachs, they could concentrate on their studies at school

d) Biogas programs generate employment to local people.

e) The Vermicompost replaces chemical fertilizers. This results in reducing import bill for the country.

f) Vermicompost enriches the soil and results in better crop yields that give higher income to the farmers.

g) Vermicompost reduces the use of chemical pesticides and this result in good health and lower investment on agriculture.

h) Usage of Vermicompost increases the water retention capacity of the soils - saving on power bills, conservation of the water resources.

i) One of the major benefits is reducing the investment on agriculture- this helps the farmer to lower the borrowings for agriculture investments.

j) The shortage of chemical fertilizers can be addressed through these units as vermicompost replaces the usage of chemical fertilizers.

k) Creates rural employment. Urban migration can be reduced by creating rural employment.

l) Gender Equality can be achieved as these units are provided exclusively to women beneficiaries.

Economic empowerment is social empowerment.

m) Rural waste management can be achieved as the waste is input for these vermicompost units.

n) Each hybrid Vermicompost biodigester saves about 6 tons of carbon dioxide, helping to reduce the green house gases in the atmosphere.

Although hybrid vermicompost biodigesters have been accepted by people, promotion and propagation of these units sometimes gets hindered because still majority of the population is not aware of these programs. There is a dearth of trained personnel who can install these units successfully and also difficulty in availing finances to install the biogas plants. If these issues are addressed by private and government institutions, then this programme can contribute in a major way in protecting the environment and making the society self reliant in renewable energy resources and agriculture.

BEFORE

AFTER

Changes Introduced by Biogas Unit

DON'T KILL OUR SILENT FRIENDS
The Trees!

Biogas Mixing Tank

Ranthambore National Park is one of the biggest and the most renowned national parks in Northern India. This former favourite hunting ground of the Maharajas of Jaipur was turned into a tiger sanctuary in the later part of the last century. The deciduous forest bounded by rivers on north and south is the home of the wild Indian tigers which attract tourists from all parts of the globe.

There are number of villages around the park with significant population of poor people. The villagers depend on fuel-wood for cooking. The visible deforestation all around the park suggests that the demand far exceeds the sustainable supply and as a result wood is illegally taken from inside the park. The villagers derive little benefit from the income brought in by tourism and therefore do not really hesitate to put pressure on park's fragile forest. With the increase in population at an alarming rate of 3.2% per year, the need for fuel-wood also increases. The conflict between the human need for survival and preservation of the ecosystem leads to many difficulties such as litigation between the villagers and the park authorities over allegations of trespass for wood collection and animal grazing.

An NGO, Prakratik Society, came up with a solution to this problem. The organization installed 250 biogas digesters in villages around the park. These digesters produce clean and safe biogas for cooking from cattle manure and thus save fuel-wood in the process. The digester output is used as fertilizer. The technology greatly reduces the emission of carbon dioxide and carbon monoxide from burning of fuel-wood and thereby minimizes the impact on climate change and environment.

Action for Food Production (AFPRO) in Delhi developed Deenbandu model of digester in 1984 as an improvement over the Janta model; this same model was used at Ranthambhore. This digester is a round tank with a volume of about three cubic metres. The tank is made up

of brick and mortar and sunk in a pit in the ground. A hand-operated rotator, installed at the inlet of the tank is used to mix cow dung and water. The slurry of dung and water gets decomposed in the tank and finally comes out of the outlet due to the pressure exerted by the biogas which is produced in the process. The biogas is taken from the top of the tank to a biogas cooking stove through a pipe. The slurry is collected and used as fertilizer.

Digester Under Construction

The reliability of the technology alone cannot ensure long term usage of biogas as there are several instances where such plants were successfully installed and later abandoned. In order to eliminate such possibility, Prakratik Society selected those families who will find the use of the technology beneficial for them, over a long period of time. Since the digester needs the manure of at least four cattle to operate well, the selection of families was also based on the number of cattle they own. These families fall under the middle-income group, and they represent about half of the total population of about 2 lakh people in the 96 villages around Ranthambhore. The aim of the project was to build at least one digester in each village, so that all villagers have the opportunity to see the technology in action. The idea was quite effective as large number of villagers later requested for new biogas plants after observing the benefits of the installed ones.

Construction Underway In Village Soorwal

Besides financial support, the families also extended support in the form of unskilled labour to construct the digesters. The Prakratik Society employed two full-time field workers to visit the digesters regularly and ensured that they are working properly. The biogas digester installation programme started in 1999, and by March 2004 the organization installed 250 digesters.

The Prakratik Society was founded in 1994 by Dr. Goverdhan Singh Rathore, a medical doctor and the son of the first Director of the Ranthambhore Park. Dr. Singh was aware of the poverty of the villagers and was also eager to save the park from deforestation. The technology and the resulting project addressed both the issues. Till date the organization has installed 587 digesters; it currently employs about 100 people and is also involved in other social activities.

The total cost of a plant is around ₹14,000 which excludes the cost of labour arranged by the family. The family contributes 30% of this and the rest is funded by Prakratik Society. Prakratik's funding comes from a number of charitable donors and aid organizations such as David Shepherd Wildlife Foundation, the USA National Fish and Wildlife Foundation, the Jake Eberts Foundation, Irish Aid and ICAP of UK.

There is tremendous growth potential of this technology within the state and in the entire rural India at large. Awareness is the key for which Prakratik Society works closely with local NGOs involved in afforestation. It also works with NGOs around other National Parks in India, to encourage the development of similar programmes. School children from other park areas are encouraged to visit Ranthambhore and its

Biogas Digester

surrounding villages so that they can learn from local children about the benefits of biogas digesters.

One of the major contributions of biogas is to reduce the consumption of fuel-wood. Considering the average daily fuel-wood consumption as 1.1 kg per person, a digester used by a typical family of six people saves about 2.4 tons of fuel-wood per year. The installed 250 digesters therefore save about 600 tons of wood per year.

Smoke is formed when wood is used as fuel for cooking. The inhalation of this smoke works as a major cause for eye disease, respiratory illness and premature death. The use of biogas clearly reduces smoke and keeps the kitchen atmosphere a lot cleaner. Poor villagers in the park's fringes also get relief from extensive walking inside the park in search of wood, which sometimes involve a round trip of 20 km. On the other hand biogas reduces the emission of carbon monoxide and other products of incomplete combustion. It is for this reason the Ashden Award to the Prakratik Society was generously sponsored by J. P. Morgan, the organization which funds new projects to reduce the emission of greenhouse gases. The estimated saving of emission from each digester is equivalent to about 4.7 tons of carbon dioxide per year.

Prakratik Society also supports better husbandry of cattle, through a programme of artificial insemination and the encouragement of tethered feeding for cattle for certain periods. This has increased milk production besides maintaining an accessible supply of manure to run the digesters. The output slurry from the digesters is an excellent organic fertilizer, which produces good crops and saves money on purchase of fertilizer. If sold, the fertilizer from each digester can yield about ₹10,000 per year.

To provide seedlings for the development of agro-forestry in the villages around the park, the organization has also started a tree nursery. This further provides a fodder for cattle, timber for furniture and also supply fuel-wood for those who do not have access to biogas digesters.

Lack of awareness amongst the people is the main hurdle for the propagation of this technology. Until this project, most people around Ranthambore were dependent on fuel-wood from the park which was illegal but free. A lot of effort had to be made to convince them that although the cost initially is high but it will result in benefits in the long

Covered Outlet Slurry Tank

run. The other constraint was to find space near their homes to build the unit as the proximity of cattle and water source is important from the standpoint of supply of raw materials to the plant. The technology has a lot of potential and can really flourish if proper awareness campaign can be launched across entire rural India.

Collection Tank-slurry

CASE STUDY 9

EMPOWERING COMMUNITIES

100 cm^3 Biogas Plant with FRP Gas Holder

Bio-methanation Plants

When Vivekananda Kendra (VK) and Natural Resources Development Project (NRDEP), combined efforts, spread across quarter century with learning's from field experience, they came up with an improved biogas plant; little did they know that few years later this innovation will usher them into a revolutionary patented technology, which will change the manner in which people look at biogas plants. This organization is a unique combination of a spiritually oriented service with a focus on innovative designing and field testing of sustainable technologies. Based in Kanyakumari, South India, the organization is engaged in popularizing these technologies in rural communities.

The success of their efforts can be gauged from the fact that they have already sold and installed 2,000 biogas plants in southern Tamil Nadu, a feat which was possible only because the organization has obtained a thorough understanding of the problems that exist amongst current biogas installations in India.

THE BEGINNING

It all began when the organization, situated in an area where people were primarily engaged in agriculture, was quick to realise the significant contribution that a biogas plant could make in the rural agriculture environment. So what started as an intervention to provide cleaner cooking gas option, as against normally used fuel wood, translated into a massive movement to reduce air pollution and fly-borne disease and make effective use of easily available cow dung.

VK-NARDEP, working closely with rural communities, value-added their work by continuously engaging in research to improve the biogas plant technology and was also awarded the prestigious Ashden awards for sustainable energy for engaging in popularising rural technologies in energy efficient construction. Gradually the sustained field efforts of the organization paid rich dividends and VK-NARDEP got a thorough understanding of the problems which exist amongst many current installations in India. Making the best use of this knowledge, the organization developed a well-researched, low cost biogas plant (Shakti Surabhi) design to suit the requirements of the customers. Accordingly, Shakti Surabhi is now a patented technology, renowned as a well-researched kitchen-waste based bio-methanation plant model that suits the needs of the people.

SHAKTI SURABHI- A BLESSING FOR ALL – BE IT RURAL OR URBAN POOR

The major deterrents for general biogas plants are their big size, installation cost, need for large quantities of cattle dung, and space restriction. However, Shakti Surabhi has effectively eradicated all these and is an improvement over the general floating drum type biogas plants. What makes it unusual is the fact that in conventional plants, cattle dung is not only a major input, but is also required everyday to be mixed as slurry and poured into the gas tank. But Shakti Surabhi only requires cattle dung for the initial charging. There after kitchen and other waste are sufficient to produce the required gas.

Bio-methanation Plants being Transported

The standard model comes in 1000 litres capacity. It is easy to fix or relocate and can be installed either at the backyard of a house, or on the terrace. Though it works like any other biogas plant, VK-NARDEP has modified it sufficiently to suit present day environs and requirements. Technically in Shakti Surabhi digester volume is less and it has simple, yet effective improvisations: like providing a stirrer for homogenous mixing and smooth movement of gas-holder. It is so light in weight that it can be lifted by two people and can also be easily repaired in case of damage.

In the past, the organization had developed a package of value added agro-products in relation to cattle-dung based biogas plant, including enriched backyard cultivation of Azolla as bio-feed. Like any other model, the output residue of this biogas plant too can be used as a natural nutrient supplement providing significant benefits to the agricultural productivity. Realizing the multiple benefits and ease in usage of this model, Shakthi Surabhi has been accepted by the Ministry of New and Renewable Energy, Government of India, as a standard model for bio-gas dissemination.

WHAT MAKES IT WORK?

Making Shakti Surabhi work requires constant supply of domestic waste. So anything from leftover cooked food to vegetable wastes, or flour mill waste to non-edible oil seed cakes can be used as feed materials for Shakthi Surabhi. About 1.5 kg of this waste is required for a one cubic metre plant, which is equal to 0.43 kg of LPG.

The plant consists of an inlet pipe for waste feed, a digester, a gas holder, a water jacket, a gas delivery system and an outlet pipe. The gas thus generated contains 60 to 70% of methane a small amount of water vapor, whereas the rest is mainly carbon-dioxide. The gas coming out of the plant is used to run a biogas stove in the kitchen or for lighting. The process is quick and hygienic and it makes the kitchen environment devoid of any odour and flies.

The users are carefully selected by making them attend awareness camps on the technology and are also provided guidelines for the installation and management of the plant.

ECONOMICS OF USING WASTE

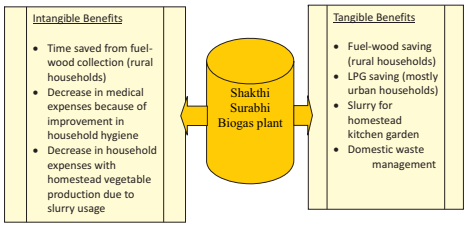
The cost of one m^3 standard model is ₹18,000 which includes single-burner stove. The biogas produced normally replaces fuel wood, and also household LPG consumption. In addition, people get cleaner environment. Apart from being the domestic energy provider, the plant more importantly plays a vital role in decentralized solid waste management converting waste to wealth. The economic return on investment is estimated at three to four years and there are tangible and intangible benefits that need to be taken into consideration in undertaking cost-benefit analysis, which is yet to be accomplished for the plant.

However, the tangible benefits include the saving of the fuel-wood in rural households and economization of LPG in urban households and the use of the nutrient rich slurry in agricultural and homestead applications.

In terms of intangible benefits, the domestic solid waste management becomes a wealth producing activity. There is also considerable saving of time in the collection of fuel wood as far as village women are concerned. The overall

Proud Owners of Biogas Engine (10 kWh)with H_2S Scrubber

hygienic environment created after the removal of kitchen waste reduces the medical expenses of the household and the slurry works as a catalyst for the backyard kitchen garden as people want to make use of this evidently useful nutrient rich slurry. This usage decreases the household purchase of vegetables from the market to some extent. However there isn't any detailed study to understand the long standing economic gains from these hidden benefits. Though preliminary investigations do showcase almost 80% renewed interest of the customers of this plant in kitchen gardening.



COMMUNITY CASCADING EFFECT:

With domestic waste management becoming a real problem for most of the village households as well as urban households, the technology has helped both the communities in solving this problem and has taught them in a user-friendly manner the art of producing wealth from waste.

Many housewives feel a sense of accomplishment with this technology. They have also acted as the epicenters of technology dissemination by word of mouth. Almost every household that uses this technology has made sure that neighbors and friends attend the technology awareness camps. This cascading effect of a sustainable technology speaks volumes about the usefulness of the technology, which is not just designed in a user-friendly manner, but also offers related solutions for multiple problems, almost initiating a change in the thinking and lifestyles of the people, orienting them towards sustainable development.

BIGGER SIZE BIOGAS PLANT FOR ELECTRICITY GENERATION

Scaling - up potential of this technology is also tremendous. In fact the organization is extremely upbeat about their innovative model and is of the opinion that time is not far when every household, much like the necessary presence of appliances like refrigerator and washing machine, will also have a bio-methanation plant in near future. To suit every requirement, Shakti Surabhi 1 m^3 plant can also be scaled up to the tune of 500 m^3 and even more based on the available organic waste. The organization has already installed three 100 m^3 plants in Tamil Nadu that are being used to generate electricity.

Be it the generation of electricity or cooking gas or kitchen waste management what's important for us is to understand the opportunities that wealth from waste offers and present it in a technologically feasible manner to the population in a way that becomes useful in their day to day life. Towards such attempts at developing green technologies, all these little steps made by organizations like VK-NARDEP become a big leap in creating a sustainable future.

NABARD Commissioning the Plant

LET'S NOT WASTE OUR WASTE !

Biogas Unit in Patahanapuram

Kerala, the state in South India is known for its timeless beauty of the palm fringed beaches, the majesty of the undulating hills and the serenity of the pristine backwaters. No wonder, it has a thriving tourist industry with sheer abundance of exotic beach resorts. Besides normal tourists, it also attracts medical tourists through its famous Ayurveda centres.

The state is on a prosperous track and observes a steady growth of middle class population. The suburban areas demand a clean and hygienic disposal of waste from homes, institutions and municipalities as opposed to the rural practice of leaving out waste for animals. Many local councils operate services to collect wastes from doors, but the stray animals in search of food often tear open rubbish sacks kept outside, and thereby create more litter. On the other hand the market places are characterized by huge heaps of organic waste with barking dogs fighting for the garbage. The hovering flies and mosquitoes make it look even worse and alarming as they are carriers of numerous diseases.

Needless to say, that these unhealthy situations arise due to the absence of proper waste management system at the source of waste generation. Consequently they create perennial problem for the local administration authorities like panchayat, municipality and corporation and they desperately look for an effective way out to create and maintain clean and hygienic public places as part of their great responsibility of "Clean Kerala".

BIOTECH, an NGO based in Kerala, has come up with some solutions to the problem. It has developed biogas digesters which capture food waste, other organic waste and waste water at source and produce biogas through a technology called Biomethanenation. The organic materials are taken into airtight vessels where bacteria break it to release biogas. This gas is a mixture of methane and carbon dioxide with the percentage of latter being less. The biogas can either be burned directly as a cooking fuel or can be used to generate electricity after purification. The solid residue can be used as organic compost.

BIOTECH has developed plants of six different sizes to cater to three different sectors namely, 1) Domestic (individual households), 2) Institutions (schools, hostels, hospitals, hotels) and 3) Local councils (market places).

The standard domestic plants with volume of 1 m^3 produce about 1 m^3 of biogas per day with a maximum daily input of 5 kg solids and 20 litres of organic waste.

The digester vessel is made up of two components namely, 1) a precast (from ferro-cement) digester tank sunk into the ground and 2) a gas holder drum constructed from Fibreglass Reinforced Plastic (FRP) which floats over the tank. BIOTECH also manufactures portable digesters that stand on the surface, to install in areas where excavation is impossible or undesirable due to reasons such as high water-table. Food waste, the main feed stock for the plant is mixed with organic waste water from the kitchen in a bucket and fed into the plant inlet with no additional water. Cowdung is used initially to provide a culture of suitable bacteria which triggers the digestion process. The biogas evolves with decomposition of waste, gets collected in the gas-holder and is finally taken to special biogas-stove in the kitchen through a pipe connected with the gas-holder. A valve is used to open and shut the flow and a regulator varies the flame. Nearly 22,000 domestic plants have been installed serving 88,000 people. This includes quite a few plants which have latrines connected.

The biogas plants in schools and hostels are bigger than the domestic ones. With a capacity range of 10 m^3 to 25 m^3 each plant on an average can serve about 200 people. The digester tank is built by excavating a pit and constructing a brick or ferro-cement wall with an impervious lining on top. A steel drum coated with FRP (or FRP only for smaller plants) floats on top and collects the biogas. About 200 institutional plants have been constructed to manage kitchen waste, and a further 22 include latrine connections as well.

The large scale energy-from-waste plants are built from one or two 25 m^3 biogas digesters and are installed for local councils or fish markets. Dry bio-degradable waste, glass, plastic etc. are sorted out by hand from the overall municipal waste and sold for recycling. The wet waste is then fed into the biogas plant. To speed-up the digestion process, the organic waste is broken down to a uniform size by a mechanical chopper. Water separated from the output slurry can be recycled by mixing it with the feed material. The biogas produced in the process is used to generate electricity with the help of generators. BIOTECH has completed 52 such projects so far; 8 more are nearing completion.

Mr. A. Saji Das founded BIOTECH in 1994, and is still actively involved in the development of the organization. BIOTECH promotes biogas technology through its participation in symposia, seminars, exhibitions and demonstrations at state and national level. It has its own workshops where it manufactures all the plants maintaining high quality. It also records the details of all plants in order to avail the subsidy from Ministry of New and Renewable Energy (MNRE). To ensure smooth functioning of the plants, BIOTECH sends its staff to each new customer every three months for two years and also provides necessary support for old plants.

The cost of a typical domestic biogas plant is about ₹9,500. MNRE provides subsidies for plant installations. For each domestic plant of capacity upto 10 m^3, MNRE offers a subsidy of ₹2,700, which is paid to the beneficiary through BIOTECH after a government official's inspection of the plant. The local and district panchayats (councils) also offer subsidies of ₹2,700 and ₹3,500 in urban and rural areas respectively. The purchaser pays the rest directly. MNRE subsidies are likely to be phased out in future; however, the support from panchayat is expected to continue.

The cost of an integrated waste management plant is about ₹30 lakh. MNRE provides a subsidy of ₹1.2 lakh and a portion is shared by the local and district panchayats. BIOTECH offers some capital, and charges on annual operating fee to run the plant.

BIOTECH is experiencing an increasing demand for domestic scale systems. With nearly 30% of urban population in the country, there is a huge growth potential of this technology. In rural areas also the potential is considerable provided panchayats work on creating awareness among people and arrange for budgets. However, the greater potential is possibly at the municipal level, where there are serious public health risks from large volumes of organic waste, including pollution of water supplies.

The main benefit of BIOTECH plants is that they provide clean disposal route of food waste from households and institutions and huge amount of organic wastes from markets and councils and thus prevent the release of methane from uncontrolled decomposition of waste. Latrine connected plants help to avoid contamination of ground water with human sewage. Additionally, all these plants produce clean biogas which partially replaces LPG or firewood as cooking fuel and in turn cut down CO_2 emission. Biogas from domestic plants replaces about 50% of LPG use and thus saves a family about ₹2,280 per year. This means that the family can recover its share of the cost of the plant in about three years. Institutional plants with latrines attached replace 50 to 75% of their LPG use, through additional biogas production from the sewage waste. Energy-from-waste plants generate 3 kW to 5 kW of electricity from biogas which is used for lighting the market and adjoining areas. The biogas works as an advanced and convenient means for cooking in rural areas where most cooking is done using firewood or kerosene. Biogas is also safer than LPG for cooking, because it cannot be lit accidentally by a spark. The odourless effluent from the plant is used as garden fertilizer as it contains high percentage of nitrogen, phosphorus and potassium.

A significant amount of employment has been generated from the manufacture, installation and maintenance of the biogas plants. This is estimated as 13 days for each domestic plant, 55 days for each institutional plant and 80 days for each waste to electricity plant. An estimated total of 500 days/year is required for maintenance and servicing and 140 days/year for operation of the institutional plants.

The success story of Pathanapuram Grama Panchayat in Kollam district should be an eye opener for all the civic bodies who would like to create clean and hygienic environment in their localities. The Panchayat controlled public market area was facing severe health hazard and environmental problems as approximately 1,000 kg of organic waste is daily generated in the market with major contributions from slaughter-house waste, fish waste, vegetable waste and waste water. In order to overcome these problems The Grama Panchayath committee approached BIOTECH and got a positive response.

BIOTECH first conducted an awareness programme for the Panchayat members about the hygienic disposal of waste and the possibility of generating electricity from the same. This was followed by data collection about the quantity and type of waste and a site visit by the technical experts of BIOTECH. The project was found feasible and BIOTECH submitted a concept proposal to the Panchayat including brief description of the waste treatment plant, approximate cost, return on investment and the terms for the installation. The proposal was approved and subsequently BIOTECH submitted a Detailed Project Report (DPR) to the Panchayat. The Panchayat committee approved the DPR and awarded the project to BIOTECH. An agreement was signed between the Panchayat and BIOTECH and the proposed site was handed over to BIOTECH for the implementation of the project.

BIOTECH completed the project within the stipulated time frame and activated the plant using BIOTECH culture and cow dung as initial feed. Trial runs were conducted for 7 days during which the Panchayat president and other members visited the site to observe the functioning of the plant. The plant was formally commissioned in October 2003. An operational agreement was signed between BIOTECH and the Panchayat at the time of commissioning of the plant after which BIOTECH selected three local unemployed youths and trained them to work as operators. BIOTECH conducted another awareness programme to educate the merchants of the market about systematic collection and hygienic disposal of the waste generated in the market and also demonstrated the functioning of the plant.

A part time supervisor from BIOTECH monitors the performance of the plant and guides the operators who work on a regular basis. Through this arrangement BIOTECH provides performance guarantee to the project.

Bio-electricity Lighting up Streets

The total cost of the plant was ₹26 lakh which proved to be an excellent investment from various aspects. The successful performance of the plant encouraged the Panchayat committee to increase the capacity of the plant from 250 kg/day to 1,000 kg/day (in three phases) over the last seven years of operation. As a result the lighting capacity also has increased from 20 CFL to 100 CFL. About 60 cum of biogas is produced everyday through which the plant generates 90 kWh of electricity to cater to the requirement of all newly constructed fish stalls. The plant also yields 400 to 500 litres of liquid fertilizer per day. With all the items put together, the net annual income from the plant is estimated to be ₹10.73 lakh. This way the total cost of the plant could be recovered in 3 to 4 years.

Through this initiative, the Pathanapuram Grama Panchayat reduced approximately 22,000 cum of methane emission per day, created a clean and hygienic environment in the market area and substantially reduced the heavy amount of electricity charges. This success has encouraged other civic bodies to come up with similar projects. The Pathanapuram Grama Panchayat therefore deserves every credit for pioneering and revolutionizing the eco-friendly waste management project. The contribution of BIOTECH, Trivandrum also should be acknowledged for proper implementation of the technology and smooth functioning of the plant.

JATROPHA
An Emerging Option for Rural Electrification

Test Firing

Street Light Illuminating the Village

India's 70% population still lives in villages, but the irony is that many of these villages are still not connected to the electricity grid. As there is a very close link between access to electricity and development, the inhabitants of these villages still lead a life similar to the life style of primitive eras. Ranidhera village in Chattisgarh state was one such typical village suffering from darkness for centuries-a village with around 100 households and 600 population belonging to Gonda and Baiga tribes. Villagers daily routine and activities depended on the availability of day light. The children failed to do well in their studies because they could not accommodate both studies and attending to daily chores within the limited day light available to them. They lived in abject poverty because lack of electricity limited many income generating options. India has many such villages. Government of India cannot realize its goal of providing 100% electricity to every individual household by the year 2012 until and unless it devises ways and means of promoting decentralized power based on sustainable renewable energy sources.

Winrock International India, a non-profit organization working in the field of renewable energy sources, started this unique initiative of exploring the viability of oil extracted from the seeds of jatropha plant as a means for rural electrification. Jatropha is a shrub that grows on arid and non-cultivable land. It bears black wrinkled seeds which contain oil. This oil can be used as fuel. Besides being a crop grown on non cultivable land, jatropha is also pest resistant and consumes very little water.

Winrock Ranidhera for its pilot project of rural electrification using jatropha seed oil. The project was jointly supported by the British High Commission, the Swiss Agency for Development and Cooperation and the Ministry of New and Renewable Energy. The project started in early 2005, with the primary objectives of studying the potential of providing electricity to remote rural areas using bio-fuel generated from jatropha seeds; ensure energy security, generate livelihood opportunities and stimulate development through improving energy access. The project was also intended to serve as a model for replicating it in close to around 6,000 such remote villages all over the country. A detailed project report was prepared by Winrock keeping in view of all the above said objectives.

After preparing the project report, Winrock field staff campaigned to create awareness about the potential of jatropha plant as viable alternative for providing electricity.

Household with Access to Electricity

As part of community mobilization, several meetings were held with villagers to discuss the issues involved and convince them to participate in the process. Villagers were initially hesitant to accept the proposal because they feared that agreeing to set up an alternative energy based power supply system might deprive their chances of accessing conventional electricity through mainstream grid facility. However, extensive confidence building initiatives like house visits, meetings with local leaders and community heads convinced the villagers to give jatropha project a chance. Winrock conducted extensive field studies to assess the individual household requirements of energy, future requirements etc. Based on the data collected through these studies, system size, mode of distribution and a detailed layout of the power plant was developed.

Winrock has set up Arun Vikas Samiti - a Village Energy Committee (VEC) comprising of 12 members including 5 women and 7 men. The VEC was entrusted with the responsibility of deciding the tariff structure, collection of bills, maintenance of the power plant and other related administrative tasks. Bank accounts were opened in the name of VEC to ensure accountability and transparency.

Once the ground work was completed, the villagers were given the jatropha saplings to be planted in bunds and boundaries of the agricultutal fields. Initially the project financed the purchase of jatropha saplings. The villagers through “shrama dan” or voluntary labour planted the jatropha saplings in and around the village. Later the Forest department of Chhattisgarh, subsequently provided additional saplings to the villagers.

Meanwhile, Ranidhera panchayat initiated the process of acquiring land for constructing the building from where power could be generated and distributed to the village households. District authorities granted the required land on lease to construct the power house. The power house was designed to accommodate oil expelling facility, power generation units, rice dehusking facility and a warehouse with sufficient space to store jatropha oil seeds. Local masons and labour were involved in constructing the power plant.

Parallely, along with diesel engine manufacturer P M Diesel, trials were conducted to establish the feasibility of using straight jatropha oil to run a diesel engine. Necessary engine modifications were carried out for smooth and trouble free engine operation. Lubricant manufacturing company Castrol India Limited helped the project by formulating a special crankcase oil for these DG sets.

The power plant with a capacity of 11 kW started functioning from April 2007. It supplies electricity for 3 hours every day for households and 3.5 hours for street lighting. There are three distribution networks covering the entire village. Villagers were given training on each aspect of generating electricity from jatropha seed oil

Extra Work, More Benefit

Computer Classes Running on Renewable Energy

starting from oil expelling using the oil extracting and filter press, running of DG sets and electricity distribution, and for running the rice dehusking facility. They were also given training for regular maintenance and upkeep of the diesel engines and other associated systems. Village Energy Committee collects the bills as per the tariff decided by the committee. The power plant is running with zero down time since its commissioning and the villagers are paying for electricity services-a rare feat in any rural electrification project in India.

Electricity generation through bio fuels has tremendous impact on the life style and living conditions of the people in Ranidhera village. Most importantly, it improved the health of the people as otherwise they used to work under ill illuminated conditions spoiling their eye sight and suffering from respiratory problems due to prolonged inhalation of harmful kerosene fumes. Children now are able to spend daily one to two hours extra on completing their homework and other studies. Shopkeepers and other commercial enterprises could extend their daily productive work hours by at least two hours. Street lighting enhanced the safety and security of the village.

Besides these social benefits, rural electrification has also helped the village households to save on expenditure incurred on purchasing kerosene and spending money on transporting their rice to and from distant dehusking mills as today they have the rice dehusking facility in their village itself.

During the pilot project, Winrock established vital linkages with various national, state and local government agencies like Chhattisgarh Renewable Energy Development Agency, Forest department, State planning commission, Irrigation and water resources department and local administration and have been able to mobilize resources for the village through convergence of various government schemes aimed at promoting rural development.

A COOK STOVE WITH A DIFFERENCE

Earth Stoves
Clean Combustion

In 1999, when Ramesh Nibhoria decided to use his briquetting consultancy experience in launching a small-scale business, he had never imagined that his efforts will revolutionise community cooking methods and will give a fillip to India's renewable energy scenario. Today his firm-Nishant Bioenergy Pvt. Ltd. is renowned for its patented and largest range of community cooking stoves that have also won him the most coveted accolades like the Ashden Climate Care Award and the winner of Petroleum Conservation Research Association Award. Nibhoria's unique Sanjha Chulha (community cook stove) has not only transformed the waste agricultural product of little economic value into a cash income for the farmers, but has also given a boost to more than 200 biomass briquetting plants that were on the verge of closure.

ONE SOLUTION FOR MULTIPLE CONCERNS

The community cook stoves of Nibhoria are truly an innovation for many: farmers, environmentalists, biomass briquetting plant owners and workers, along with institutional cooking vendors. For farmers in India and across the globe, the problem of quickly disposing the agricultural waste left after harvesting, to make the fields ready for sowing the pre-monsoon crops, is always a challenge. Most commonly used method is to burn the waste in open fields. But this process adds to air pollution.

Alternatively, many commercial briquetting plants are also in place in the country that convert this bulky, low density biomass into high density, energy concentrated fuel briquettes, which are easy to transport, store and burn and are typically used by brick kilns. However, demand for this product is variable and the price which brick makers are willing to pay is low because coal, the alternative easily available for kiln operators, is much cheaper. To add to the woes of briquetting plant owners, coal's burning capacity per unit volume is also higher and it doesn't require much storage space as compared to briquettes. So, briquetting is gradually becoming a non-viable commercial option.

On the other hand, the briquettes are a good source of fuel for cooking because these are cheaper than liquid petroleum gas (LPG) and its maximum attainable temperature (1,000° C) is more than adequate for cooking purposes. The community cook stoves not only provide the briquetting industry with a more sustainable and high-priced market but also gives institutional scale cooking a much cheaper option. Amidst this novel juxtaposing of economics, need and technology, environmentalists are the happiest lot, as with each stove almost 10 tons of carbon dioxide is saved per year.

Mr. Ramesh Nibhoria receiving Ashden Award from HRH Prince Charles at Clearance House, London-2005

COMMUNITY STOVES OPTIONS

Realising that one size doesn't fit all; Nishant Bioenergy Pvt. Ltd. designs stoves and furnaces on the basis of the requirement of the targeted market segment. Accordingly, there are four segments:

a) Mid day meal manufacturer stove that can cook more than 40,000 meals per day in a centralised kitchen. This stove is provided with a briquette fuelled steam boiler and stem-kettles that save up to 70% of fuel bills when replaced with LPG.

b) Micro entrepreneurs stove for making fried snacks (namkeen) is an automated powdered biomass stove (Surya stove) having temperature controlling facility. As a result fuel feed can be controlled on the basis of the heat requirement of the food being cooked (or fried). This stove saves up to 50% of fuel when replaced with diesel fired stove.

c) Company and college hostel canteen stove for cooking meals for 1,000 people. For such institutions Nishant Bioenergy Pvt. Ltd. suggests steam boiler as well as biomass briquette fired Earth stoves (model ES10) and leaves it to the client to decide on the option depending on their financial ability. These options, when replaced with LPG help save up to 70% in fuel bills.

d) Restaurants and road side dhabas stoves come in two models-ES2 and ES3 and save up to 70% of fuel when replaced with LPG. These models come with briquette fired, Earth stove operated with DC powered blower.

In fact, whatever cook stove model is used, each has the potential to save almost 50% of fuel cost, which when translated into numbers of LPG cylinders is almost to the tune of 750 LPG cylinders a year. The models also have a strong body to withstand heavy work load of community kitchens. These use comparatively non-hazardous fuel as compared to LPG, diesel and kerosene and are environment friendly as these replace greenhouse gas-emitting hydrocarbon fuel with biomass fuel, which is carbon neutral. Interestingly, this fuel also has the potential to give an impetus to rural employment by turning waste into wealth.

BUSINESS MODEL

Much like its products, the firm also has an innovative business model to create Green Entrepreneurs in which the Earth stove models like ES2, ES3 and ES4 are sold at a discounted rate. 16% of the stove cost is adjusted against the advance of carbon credits.

It is expected that these Green Entrepreneurs in the long run will be able to establish the stoves free of charge in

Cost analysis of running one community cook stove for 500 people

Average consumption of briquettes	150	kg/day
Total Expenditure on Briquette per month (considering briquette cost ₹6 per kg)	27,000	₹/month
LPG consumption (for same heat value)	112	Numbers/ month
Total Expenditure on LPG Cylinder per month (considering LPG cost ₹350 per cylinder)	39,200	₹/month
Net Saving	1,31,760	₹/year
Cost of one stove	1,51,750	₹

Earth Stove User - Dhaba Owner

the client's premises and establish briquette supply chain for these customers, similar to the existing LPG delivery system prevalent in the country, where in the customers can get free home delivery of LPG cylinders as per requirement.

To make the business more viable for the Green Entrepreneurs, 60% of the carbon offset money is used. In the long run, the firm hopes to create thousands of such entrepreneurs operating self sustaining, commercially viable and environment friendly businesses. It is estimated that with a mere investment of ₹5 lakh, such an enterprise can be created that can generate an income of ₹15,000-20,000 per year and also has the potential to employ almost five workers in the long run.

The firm has a small workshop near Chandigarh, Punjab, where manufacturing of stoves is done and orders are delivered. They have already installed more than 350 stoves in many parts of the country including Punjab, Haryana, Rajasthan, Bihar, Tamil Nadu, Andhra Pradesh and Maharashtra for diverse clients, including clients making 40,000 meals per day, to small road-side

Loading Stove With Briquettes

restaurants. Till date, the installed capacity of the systems is more than 11 MW that has led to a saving of more than 2,000 tons of LPG per annum, besides saving 8,000 tons of carbon dioxide.

There is enormous potential to scale up this technology and use it for a variety of small-scale industries. Literally starting from scratch, the firm lacks the much needed catalyst of capital investment to strengthen its manufacturing infrastructure. But having ironed out the teething troubles, the patented technology of community cook stoves has indeed set a precedent for others to follow.

Business Summary
Business: Biomass briquette fired community cook stoves and steamers
Enterprise: Nishant Bioenergy Pvt. Ltd.
Market: Institutional / community cooking enterprises
Location: Chandigarh, Punjab
Revenue: ₹2 crore/annum
Profit: 19%

ENVIRONMENT FRIENDLY STOVE

Firewood Unloading

PYRO Frying Stove

In southern India, an estimated eight million people work in small and tiny businesses. This includes food processing and preparation, textiles, ayurvedic medicines and brick-making to name a few. These businesses run with small turnovers and for achieving a healthy bottom-line overheads are kept at a minimum. So when it comes to choosing a heat source for various manufacturing process, it is the low cost wood and other forms of biomass. Fuel efficiency is not given much consideration. However, there is an adverse impact on the environment for it contributes to pollution, and forest degradation. But because of ignorance and no other option for these low profit businesses, these issues are of least concern. Even the hazard to their health is overlooked which is high for those working long hours over open fire or inefficient stoves.

To mitigate these environmental concerns, Technology Informatics Design Endeavour (TIDE) developed a range of energy efficient stoves for the grass – root businesses to improve their operations using less wood. An improved stove works more efficiently by better heat transfer and combustion of the fuel and improved insulation to minimize the heat loss. The programme was initiated in Karnataka and Kerala but now may be expanded to Tamil Nadu and Andhra Pradesh.

TIDE was awarded the prestigious Ashden Award for this environment friendly technology in 2008.

TIDE established in 1993 is a non-profit organization that aims at applying appropriate technology to rural situations. TIDE's core competence is in dissemination of technologies. It does not innovate, but adapts products developed by research institutions to fit the user requirements and local conditions. The organization based in IT hub of India, Bangalore, Karnataka works through a network of grass root entrepreneurs. These entrepreneurs, sometimes university graduates, are trained by TIDE about the new technology that has to be disseminated. After adequate training, the entrepreneurs are encouraged to set up their own enterprise, and they usually prefer to do it.

TIDE STOVE DESIGN

The TIDE stoves are innovative as they are equipped with well designed combustion chamber volume resulting in high combustion and heat transfer efficiencies. The stoves are designed to burn the fuel totally with high temperature with optimized air-to-fuel ratio. The area of contact between the hot gases and the heated vessel is maximized in order to increase the heat transfer process. An efficient insulation minimizes the heat loss and reduces the risk of burning from direct contact. An optimally designed chimney to vent the flue gases is designed to reduce heat losses to the atmosphere. The chimneys take smoke away from the users, thus producing a cleaner and safer working environment.

The TIDE stove is manufactured keeping the customers usage in mind. While retaining its core concept, TIDE designs according to the particular sectors usage but most importantly, involving the user. This minimizes any modification later. For example while manufacturing a multi – purpose cook stove for a restaurant, stoves are based on a survey of need and usage.

The manufacturing site for the stoves is always close to the location where it would be used and as far as possible they use locally available material. TIDE works with small town fabricators for different components of the stove: with masons for mud and ceramic part and smiths for

Biomass Stove for Tea Boiling

metal parts. The large – sized stoves, used in bleaching vats or jaggery units are built on site, whereas the smaller ones for silk reeling or areca – boiling, the components are made in a production facility and are assembled on site.

TAKING CARE OF THE CUSTOMER

As a majority of customers are small or medium businessmen and cannot afford even a day's loss in business, TIDE takes care to install the stove without much disruption to the customers working schedule. The

Biomass Dryer for Drying Coconuts

customers are initially a little apprehensive about using a new technology. They are worried that the changing work pattern may affect their business. To tackle such anxiety, TIDE arranges courses for the stove users spanning a large area. This also helps the users to interact clearing any doubts and giving a sense of reassurance about the product.

TIDE creates awareness and undertakes marketing of the stoves and subsidises the demonstration units. But there is no subsidy or discount when it comes to the cost of the stove that covers the cost of manufacturing it and also provides for a reasonable profit for the entrepreneur.

AFFORDABLE STOVES

The cost of the stoves range from ₹2,000 for a simple silk reeling stove to over ₹65,000 for a larger one. The payment is linked to the stages in manufacturing. Normally a deposit is required when a stove is ordered with a further payment when the construction starts and the balance on completion. Some industries using several units often replace one at a time and thus the capital cost is spread over a period. The payback time for the capital invested is usually one year and for some it is less than two months.

The stove comes with a year's guarantee. Like any other product, after sale service is in place. Entrepreneurs offer service and repair on a chargeable basis and informally check on the working of stoves periodically.

Cooking Stoves at Sai Dhaba

As the cost of the stoves is quite affordable, there is not a demand for loans. TIDE had facilitated loans through financial and industry associations for the areca stove customers, but there were hardly any takers.

Sometimes an industry specific subsidy may be available. For example the Department of Sericulture of Karnataka government provides a 40% subsidy for silk – reeling stoves which is paid to the entrepreneurs when the user has paid their 60% contribution.

Quality control is an area where TIDE lays a lot of emphasis. To sustain the popularity of any product is an area that cannot be neglected. Towards this, they collaborate with leading institutes. The Central Power Research Institute tests the efficiency of the product, while The Centre for Sustainable Technologies at the Indian Institute of Sciences occasionally collaborates in the development process, carrying out field tests and in data collection. It is mandatory for each entrepreneur to keep a complaint book and TIDE makes random checks on its own system and that installed by the entrepreneurs.

TIDE is also careful about the financial viability of the stoves. They, as a rule, discourage the development and commercialization of a biomass heating system if it is not affordable without subsidy support from the industry for which it is intended. In fact some designs were not developed as the cost was turning out to be high.

IMPROVED STOVE – IMPROVED PROFITABILITY

For the small business men, advantages from the improved stoves are two folds: saving on money and increased productivity. According to an assessment carried by TIDE in 2006 the stoves then in use were saving 3.9 crore per year in fuel costs (With the fuel cost at ₹1/kg).

Now four years later, the price of fuelwood is ₹2/ kg. For a silk – reeling stove (costing ₹2,000) the saving is ₹5,000 per year and the payback period is less than six months.

Taking this forward, a textile stove costing ₹25,000, the wood saving is ₹50,000 per year with a payback period of six months. For an ayurvedic medicine stove costing ₹4,000, the payback time is two months as the saving on wood is about ₹25,000 per year. Agriculture residues like coconut shell cost a similar amount to wood per kg. However as they are more compact and have lower moisture content, they burn more efficiently and hence less is needed.

Along with cost saving, the stove improves productivity. This is due to design of the stoves that generate more heat and also retains it. This speeds up the production in some businesses. For example, the improved areca nut stoves can process four batches per day as against two earlier.

An increase in the profitability translates to better wages and largely benefits those sectors where wages are directly linked to the output of the worker.

For the workers, the several features of the stove improve his work environment. It is now safer and also has a positive impact on his health. The chimney in the stove removes smoke reducing the risk of respiratory and eye diseases. The insulation around the stove cools it thus reducing the incidents of burns and the working environment does not get heated. In the humid, hot climes of tropical south India, this offers a comfortable atmosphere for the workers to work in relative ease. The benefits are more or less same for the domestic users as well, but it is more for the workers in a small industry.

BENEFITTING THE ENVIRONMENT

The TIDE fuel efficient stove also benefits the environment enormously by saving on biomass. For assessing the biomass savings, TIDE has developed an accounting methodology. This is based on test done by the Central Power Research Institute. The findings reveal that on an average the stoves save at least 30% of biomass. While some sectors like textile and community cooking stoves record a higher savings of 40-50%.

Result from the methodology put an estimate of 43,000 tons/year of biomass saving for stoves installed till the end of 2007. For the stoves that were installed in 2000, a cumulative 1,50,000 tons has been saved. TIDE estimates that saving in the greenhouse gases based on the number of stoves used till 2007 is about 77,000 tons per year CO_2.

BETTER EMPLOYMENT OPPORTUNITY

TIDE provides employment to 24 full time staff and some of the staff is engaged in developing the stove enterprises. Further, it has created employment opportunity by training 14 entrepreneurs, who in their business employ about 40 skilled and 90 semi-skilled workers for making the stoves. These entrepreneurs also have the opportunity to develop new types of stoves, or improve the existing ones. The indirect employment from the stove project is estimated to be about 9,000 people – per days per year.

Benefiting the women workforce, the project helped women self – help groups in increasing income generation in the areas of fish – drying, cashew nut processing and drying of coconuts, spices and other food products.

Many more workers and the environment can benefit if TIDE expands its project. A survey of small and tiny industries using biomass fuel in Karnataka and Kerala done by TIDE in 1998 identified about 1,25,000 industries using an estimated 30 lakh tons per year of biomass. This offers a potential for TIDE to extend its reach.

THE FUTURE

Like any entrepreneurial venture, this also has it challenges. Currently, TIDE and its entrepreneurs are

PYRO Tava Stove

installing 1,300 stoves per year. For taking this project forward, TIDE needs to train more entrepreneurs. But finding the right candidate for training is a limiting factor. To overcome this, TIDE has now streamlined training.

FUEL EFFICIENT COOK STOVES
A Boon for Road Side Dhaba Owners

Traditional Cook Stove

Running a way side hotel, popularly called as 'dhaba', is one of the common income generating occupations in rural and semi urban areas of India. These way side dhabas provide simple and staple vegetarian food and some limited non-vegetarian food and snack items to many working population at very affordable prices. As they have to provide food to a large number of customers, the cooking starts very early in the morning and on an average a kitchen in a small hotel runs for 8 to 10 hours in a day without any break in between.

TRADITIONAL COOK STOVES

The food is cooked using highly fuel inefficient open cook stoves constructed using bricks and mortar. Three sides of the stove are covered by bricks and the front is kept open to insert fire wood. On top of the stove sometimes, a mesh made of a metallic wire is kept on which the cooking utensil is placed. Placing the cooking utensil directly on top of the stove is also a common practice. As the cook stove is open, the heat generated from burning the wood gets easily dissipated into air and heats up the indoor environment of the kitchen. Firewood burns very fast requiring large quantity of fire wood to cook food for 8 to 10 hours in a day. Fuel efficiency of these open stoves is only about 8 to 9% due to which the stoves generate more smoke and soot. Indoor air contains high concentrations of carbon dioxide and carbon monoxide. Around 100 to 150 kg of firewood is used everyday by a typical hotel.

Winrock International India (WII), a non-profit organization working in areas like natural resources management and energy efficiency undertook a project in Andhra Pradesh to improve the energy efficiency of these cook stoves. The aim was to reduce and optimize the consumption of firewood and to help these small entrepreneurs in saving their fuel costs and improve the

health of the people working in the kitchens of these hotels. As a first step to provide improve cook stoves in these dhabas, Winrock's office in Andhra Pradesh conducted a base line survey of dhabas and hotels in almost 10 districts of Andhra Pradesh. The survey found that there are around 4,000 small way side dhabas operating in rural and semi urban areas of Andhra Pradesh, which consume almost 1 lakh tons of firewood annually at the rate of 100 to 150 kg of firewood per day. Hotel owners spend on an average around ₹300 to 400 per day on firewood.

DESIGN OF THE IMPROVED STOVE

To introduce the concept of the improved cook stove, WII distributed one page flyers in the selected 10 districts of Andhra Pradesh explaining the advantages of improved cook stoves; organizing visits for interested hotel owners to project sites where improve stoves were already in operation; and displaying banners and hoardings at major junctions and crossings of the villages and towns in order to create awareness and generate interest on improved cook stoves among the stakeholders. From among the hotel and dhaba owners who showed interest in improved cook stoves, WII selected 100 small hotels and dhabas for installing the improved cook stoves.

WII modified the improved cook stoves designs to suit the requirements of users maintaining the same basic design of the earlier stove. The improved cook stove is a 2 pan stove based on the combustion technology. In this design the volume of the combustion chamber has a uniform 1:6 fuel, air mix capacity, i.e. one kilogram of fuel requires six kilograms of air for better combustion. The stove's inner wall was insulated by using cold face insulation bricks. Grate, primary and secondary openings were provided for efficient burning of the fuel and chimney to let out the smoke. A top metal plate which is mounted on the stove

Environment Friendly Cook Stove Designed by WII

body is filled with fire crate (castable) refractory to retain heat (it retains heat upto 1,200º C). Priming hole is provided near chimney for serving two purposes firstly, for heating the chimney when the stove was started for the first time and secondly, for removal of the soot that gets deposited on the inner side of the chimney walls at regular intervals approximately once in 15 days. A heat recovery vessel is provided after 2 pan position to utilize the waste heat which escapes through the chimney. These improved stoves were constructed by specially trained local masons and fabricators. About 80 local masons and 12 fabricators were trained to construct the improved stoves based on this design. Once the stoves were installed and commissioned at the selected sites, performance evaluation was carried for these stoves after a week or ten days. It was noted that the improved stoves showed 20 to 22% improvement in efficiency in comparison to the traditional stoves which had only 8 to 10% efficiency. Fuel consumption was reduced by almost 50%. Carbon monoxide emissions were noted to be around 480 µg/m³ in comparison to 4,260 µg/m³ recorded by older model stoves.

Shifting from conventional stoves to improved cook stoves involved both one time and recurring costs. Hotel owners had to invest ₹12,000/- to ₹15,000/- as one time cost depending on the model of the stove installed. For a stove consisting of one tawa and one pan the cost was around ₹12,000 and for a 2+1 type stove costs were about ₹14,000 to ₹15,000. Dhaba owners bore the entire cost of installing improved cook stoves in their hotels. Recurring costs were around ₹1,500 which had to be spent once in every 12 to 18 months to replace the grate and fire crate cement.

ADVANTAGES OF THE IMPROVED STOVE

Improved stoves saved about 50 to 60% of the fuel previously consumed by conventional stoves. On an average 75 to 100 kg of firewood was saved daily by each improved stove installed amounting to a total saving of about 3,600 tons of firewood per year for 100 stoves, which is equivalent to reduction in 3,402 tons of carbon dioxide emissions per year. In financial terms the hotel owners could save about ₹72,000 per year on fuel expenses. Overall ₹7.2 crore were saved by all hundred hotel owners. Reduction in firewood consumption automatically reduced the carbon emissions.

Improved stoves also brought hygiene in the kitchen area by reducing smoke and soot in the air. Concentration of carbon monoxide was brought down to 480µg/m³ from 4,260 µg/m³ in the indoor air. Room temperature of the kitchen was also brought down by at least 8º C. This had a direct impact on the health of the people working in the kitchen and indirectly contributed to their increased productivity.

Improved cook stoves also led to employment generation. They provided employment to 80 masons and 12 fabricators, and many people may get employment as the popularity of improved cook stoves increases. The technology is very easy to replicate and costs involved are very low. Due to these factors improved cook stoves have huge potential for replication not only in Andhra Pradesh, where there are about 4,000 way side hotels but also all over India, wherever conventional stoves are used for cooking food in way side hotels, dhabas and individual households.

HARNESSING SOLAR ENERGY

Solar Irrigation Pump

Aurore is a community-owned enterprise based at Auroville, near Puducherry in Tamil Nadu, India. The organization has already facilitated the installation of nearly 2 MWp of photovoltaic (PV) systems, which is inclusive of 845 PV-powered water pumps, 8,700 domestic PV systems and over 6,000 PV-powered lanterns.

Aurore endeavours to test the technologies and delivery systems for different small-scale renewable energy (RE) applications and offer scaling up opportunities. What makes the efforts of this enterprise different from other organizations is the ideology to make these RE options financially sustainable and a sound business proposition.

Accordingly Aurore, since inception, has not relied on any investments in form of grants, equity, or long term loans for its existence and has shown an unmatched and optimistic profitability record while working in areas like solar PV pumping, solar lighting, solar water heating, solar cooking, biomass gasifiers, biogas and electric vehicles. These efforts of Aurore has also been applauded and awarded with Ashden awards for sustainable energy.

THE CATALYST

Solar PV has enormous potential in India; if not to totally replace the existing fossil-fuel based energy services, but to provide reliable alternatives. Primary barriers in achieving this potential are high up-front cost, non-availability of suitable systems and long-term reliability. Aurore's role in such a scenario is to act as a service provider rather than any other seller or installer of technology. To ensure smooth functioning, the enterprise has already made institutional tie-ups with the topmost Indian suppliers of PV systems like Tata-BP and BHEL. For social engineering there are arrangements with six social sector NGOs, along with financing and leasing companies for easy availability of funds.

The business model of the enterprise revolves around successfully pilot testing a project, followed by a small scaling up of the project in other parts of the country. Once the technology and delivery system works effectively, the learning and knowledge is shared with others either through training programmes or policy advocacy. So, in a nut shell, Aurore acts as a catalytic organization, networking and facilitating the key components for establishing an innovative concept. They have already achieved successful scaling up in number of technologies. The enterprise is also getting a boost in its endeavours from government subsidies because by and large RE technologies are very expensive.

Understanding Aurore

Aurore is a unit formed as a trust under the Auroville Foundation, a body incorporated under the Auroville Foundation Act 1988 of the Parliament of India. The enterprise was initially established as a research budget in 1993 under the Centre for Scientific Research Trust of Auroville and in 1998 a separate trust was created called the Auroville Renewable Energy (Aurore) Trust.

Solar Pump for Drinking Water

MAKING IT WORK

Aurore primarily focuses on three types of PV systems: water pumps, solar home systems and solar lanterns. Given below are three small examples to highlight how Aurore intervenes and makes things possible:

- Solar power to solve community drinking water issues: In 2000, Aurore joined hands with Shajeevan - a local partner based in Bhuj district of Gujarat to provide solar pumps. Objective of this hand-holding was to wean away the villagers residing in remote, off-grid villages of Bhuj from diesel pumps (used in pumping drinking water) and make them rely on solar pumps.

Initially, two villages were identified for the intervention. After lot of deliberations and actual installation of pump, the villagers were convinced of the effectiveness of the technology. Once the technology was accepted, villagers agreed to contribute 10% of the cost. Consequently, each household contributed ₹50 towards the maintenance of the pump, whereas, matching funds were procured through MNRE subsidy and financial benefits like (tax and soft loans) were provided by IREDA to the leasing company.

Economics of using Solar PV pumps	
Cost of equipment	: ₹4,50,000
MNRE subsidy	: ₹2,70,000
Financial Incentives	: ₹60,000
Shajeevan contribution	: ₹1,20,000

Solar PV

Solar Lanterns

Today, Government of Gujarat is scaling-up the programme in 3,000 villages of Gujarat. For which Aurore has done the capacity building of the local government officials. This intervention has not just given the villagers a more reliable technology, but has also saved them of huge investment on the running and maintenance of the system. The biggest impact of this technology has been on energy and water security. Aurore is now supplying similar systems to NGOs in Maharashtra, Orissa, Assam, Jammu and Kashmir (Ladakh), Haryana, Tamil Nadu and Karnataka. It is opined that a concentrated government programme can open vistas for nearly 5,00,000 solar PV pumps in the country and if used on such mass scale, the cost of each pump would also be in the tune of ₹2.5 lakhs to ₹5.5 Lakhs (for 400 Wp to 2,000 Wp capacity).

- Solar PV lights for traders and hawkers: The idea of providing solar street lights was conceived in 2002, when Ananth Padmanabhan, Executive Director of Green Peace, discussed with Aurore the concern of employing students from slum and Poornima, a teacher, shared her concern about their future. This discussion happened in Ananth's house overlooking Besant Nagar beach in Chennai so the thought process also took a note of the number of petromax that came up in the make-shift shops of hawkers the moment dusk enveloped sea and beach in its vastness.

Survey of kerosene based petromax usage gave birth to the idea of providing solar lanterns to the vendors on rental basis by charging the lanterns at a central place.

With an initial investment of ₹40,000 from Ananth and Aurore; Sunmin- a company for renting solar lights was initiated. It grew to such an extent that investors like Harish Hande and S^{3}IDF pitched in and almost 100 lanterns with a total investment of ₹4 lakhs was provided to customers for rent, who were happy paying ₹15/day. In the very first year, the company not only made a profit of ₹1 lakh but could also employ six local boys who could complete their education with the money earned.

There is lot of potential in such initiatives as rough estimate shows that there are more than 1 crore hawkers in India. So the total potential of PV in this application alone would be 100 MWp. Enthused by such demand and the successes of the Rent-a-Light-model, many organizations were inspired to emulate it in other parts of the country. Aurore was involved in knowledge sharing in several of these efforts.

- Solar PV pumps for irrigation: Unreliable grid supply does make solar pumps a more reliable option but the high cost of pump is a deterrent. Aurore was launched with this project in 1993 to provide reliable options to farmers residing in Auroville, near Puducherry. It was this initiative that made it possible for MNRE's new scheme of subsidy to solar PV pumps and soft loans from IREDA to kick start in the state.

Recharging unit of Solar Lanterns

Solar PV Run Irrigation Pumps

The first pilot of 13 pumps was initiated with Tata-BP equipments and Wipro lease support, where in later IFCL, a Chennai based company and SREI, Kolkata, based company was roped in. With help of direct subsidy, soft loan and sharing of income tax benefits the cost of the system could be brought down to 10% of its original value. A pump costing ₹2,50,000 was now available for ₹25,000, making it a viable option for the farmers to opt for. Consequently, 158 pumps were installed between 1993 and 1996 and Aurore has not looked back since then and has further extended it to other states. However, in 2004, MNRE reduced the subsidies making the pumps financially unattractive to the farmers. Till date, Aurore has installed 1,500 solar pumps in 16 states of India. Each pump costs ₹3.5 lakh on an average. The total outlay of this installation is to the tune of ₹52.5 crore. What it requires is service providers like Aurore with combination of subsidies and making available soft loans through rural banks easily to the target market segment.

THE SUNNY FUTURE!

What future holds for these technologies much depends on multiple factors. Much of the PV market in India is based on high subsidies, which discourages a culture of enterprise and ownership. So to make renewable energy (RE) technology application a viable business option, it is required to maintain healthy balance between subsidy and soft loans. The model of subsidy needs to move from an upfront capital based subsidy to performance linked subsidies.

Another challenge is that main users of this technology like farmers are not connected to banking services. To make them conversant with RE technologies it is required to innovate advanced technologies of payment like smart cards. In fact, sky is the limit and future indeed is sunny only if we take the right steps making effective use of learning from such projects and initiatives.

Solar Pumping for Drinking Water

POWER TO THE PEOPLE

Solar Energy User - Laxmi, Bangalore

Only a fraction of solar energy has been productively utilized to fullfill energy needs so far and only a fraction of our energy need is being catered by solar energy based technologies. But when we link this energy for productive use, the economic condition of the poor can be improved substantially. This was the philosophy with which Dr. Harish Hande founded SELCO Solar Light Pvt. Ltd. (SELCO) in 1995, along with Mr. Neville Williams. Since then, the cofounders of SELCO, along with SELCO-the company, have come a long way.

Today the company is renowned for making energy services accessible to the poor of India. It focuses primarily on solar photovoltaic technology to provide electricity for lighting, water pumping, communications, computing, entertainment, and small business appliances- an effort that has won SELCO innumerable recognitions and awards including the Ashden Award (2005, 2007), the Social Entrepreneur of the Year Award (2007) and Financial Times Arcelor Mittal Boldness in Business Award in 2009.

AN IDEA THAT BROUGHT REVOLUTION

Dr. Hande got the idea of bringing solar lighting systems to rural India when he was doing his PhD on sustainable energy at the University of Massachusetts. During a field visit to Dominican Republic, he was surprised to find poor villagers using solar lighting and reasoned that if it was possible for the poor in Dominican Republic to use solar lights, he should be able to bring solar lighting to rural poor in India too.

By early 1993, Dr. Hande made up his mind and focused his PhD on solar lights as means for rural electrification. To understand the linkages between energy and poverty he travelled all the way to the remote village of Galgamu, near Anuradhapura, in the hills of north Sri Lanka. Making best use of scholarship money, Dr. Hande took with him few solar panels and a solar powered laptop to gain firsthand experience of issues and challenges faced by people in a village that had no access to electricity. These six months of his life were an excellent experience that helped him develop an in-depth insight of issues and challenges and firmed up his belief in the potential of solar energy for improving the productivity of the rural households.

Dr. Hande was now confident that the economically backward would be able to leverage solar technology and it was possible to build a profitable business model even while such business met a larger social objective. However, he believed that the success, as well as sustainability of such initiatives, largely depended on providing doorstep financing and doorstep services, along with the customization of products and associated services for the specific needs of poor. And true to his ideology, Dr. Hande is indeed empowering his customers by providing a complete package of product, service and consumer financing at the customer's doorstep.

IMPACT OF EFFORTS

In its 15 years of operation, SELCO has improved the lives of over 1,20,000 direct beneficiaries and over 6,00,000 indirect beneficiaries through its customized solar energy systems. Its innovations in financing and customer service have positively impacted the environment in which companies and institutions serve the underprivileged.

What's more? SELCO has basically set out to bust three myths – that the poor people cannot afford and maintain technology and that it is not possible to run a commercial venture that fulfils a social objective. But SELCO proved it all wrong and till date has been able to reach out to over 1,20,000 families and build a committed skill force of over 170 employees in 25 energy service centres in Karnataka and Gujarat. This was only possible because company's business model revolves around building the necessary parts for a sustainable and scalable model for energy services delivery through its bottom-top approach.

Solar Energy Beneficiaries - Pushpa, Mangalore

A DIFFERENCE APPROACH: CUSTOMIZED PRODUCTS AND TECHNOLOGY

What makes SELCO different from other companies in this business is its approach towards lightning solutions. Dr. Hande believes that while solar lights as such appear to be a standardized product, lighting solutions need to be carefully configured keeping in mind the needs of the customers and their capacity to pay the loan instalments. The company doesn't believe that one size fits all and spends considerable amount of efforts in pre-sale activities, all of which are done by the technicians as they are in the best position to understand customer's requirements.

Contrary to SELCO's approach, other companies in this business, when it comes to the poor prefer standardizing solutions as that helps save cost, but not SELCO. The poor, in SELCO's view, are not a homogenized mass. The fruit vendor has different requirements than the farmer, who differs from the midwife and so on. The poor are also

AN EYE-OPENER

One of the best financial lessons that Dr Hande learnt was from a street vendor who told him that she can afford to pay ₹10 a day, but would find it difficult to pay ₹300 every month! This was when he realized that to sell solar lights; the poor need to be provided with doorstep financing which ensured that payback patterns were synchronized with their income patterns.

the segment of the population with the fewest resources to adapt the technology. Therefore it falls on SELCO and its small cadre of technicians to assess needs and adapt existing materials along with designing full value chains to make energy resources work for its customers. So there aren't any marketing budgets and it is these efforts that act as their marketing tool and translates all their customer service agents to the mantle of marketeers when they are dealing with the customers.

Another strong point of SELCO is its ability to innovate and continue devising novel energy solutions. This is primarily because SELCO's design process is extensive. Every customer's needs are looked up to and this is what makes SELCO's products and solutions different from the rest in the market.

CUSTOMIZED FINANCE

For the majority of SELCO's individual clients, the solar system they purchase is the most expensive system in their household, and will probably be the most costly item

Using Solar Energy - Radhabai, Sirsi

Solar Energy Beneficiaries - Ratnamma, Devanhalli

they have ever owned in their lives. So it was easy for the company to understand that the rural poor require loans to afford the upfront payments of the systems, and they need financing schemes that are at par with their meagre income and cash flows. Therefore working with the financial institutions to create innovative financing solutions becomes as important to SELCO's mission, as technical solutions for particular energy requirements.

THE SUNNY WAYS

An impact assessment study by the World Resources Institute in 2007 reported that the majority of SELCO's customers cited significant savings in energy costs as their primary benefit of using SELCO products, while the rest pointed to their children's education as the primary benefit.

The other benefit of using solar lights is that it is a non-polluting source of energy which contributes to environmental benefits. Even SELCO's inclusive business model has led to the creation of employment, not only for its own employees, but also for several rural entrepreneurs who rent out solar lights to vendors and institutions.

The company, and more broadly, the industry's biggest challenge and constraint on growth are finding skilled employees or entrepreneurs. India's top graduates want lucrative, prestigious jobs in technology or business, not in villages. Dr. Hande laments that our education system is not geared towards social consciousness.

SELCO is looking at up scaling through replication. The company believes that while it is possible to scale by standardization for a want, needs require customization based on the context. SELCO therefore is looking to scale the concept of SELCO and not necessarily the company SELCO.

In the coming years, SELCO aims to have a growing clientele of customers lower in the economic pyramid. SELCO will go beyond its present offerings to include a range of energy services and will expand its operations into bordering regions of neighbouring states of Maharashtra and Andhra Pradesh. SELCO aims to serve 2,00,000 additional rural homes over the next three years resulting in greater positive social and environmental impact. So for the company, there are still miles to go!

SUNLIGHT AT NIGHT
Solar Lanterns of D.Light

Little Sun Helping in Kitchen in India (NOVA series)

My Nova Little Sun for Birght Future

Even in the 21st century, there are billions of people around the world who can not have access to electricity and India is no exception to the situation. The lighting requirement at night of these people is met by either kerosene lit lamps or candles. Both of them produce fumes which are harmful to human health as they cause eye and respiratory track ailments. Kerosene fumes are responsible for killing about 16 lakh people each year due to indoor pollution. People living in rural areas are forced to time their activities either according to the day light available to them or continue the activity in the poor light from these low quality sources and risk their health. Either option curtails their productivity in the long run and is one of the main reasons for their prolonged poverty. With prices of crude oils escalating day by day, even the price of kerosene is going up every day and adding to the burden of a householder. Moreover, using highly inflammable kerosene always makes the household vulnerable to fire accidents and the fear of loss of life and property.

D.Light Design, Inc is a multinational energy enterprise, registered in the US, aiming to bring light to homes in rural and far flung areas which are not connected to the electricity grid. Funded by Silicon Valley and Indian venture capitalists, the company sells its solar products in about 32 developing countries through local distributor networks. Head quartered in Hong Kong, D.Light has its offices in India, China, Tanzania and the U.S. Indian sub continent operations are headed by Mr. Mandeep Singh. D.Light using solar and LED (Light Emitting Diodes) technologies produces solar lanterns in three basic models.

The key to provide customers with the kind of products they want to use by D.Light is the extensive research efforts put in for each of their product line. Before finalizing a product model, D.Light carries an extensive research to find out the most efficient and sustainable design, then it develops a pilot product and field tests them with their end users in India, East Africa and worldwide. If these pilot models satisfy the requirements of the users, only then D.Light launches those models in the market.

Nova, the largest of the three models was launched in June, 2008. It has a 1.0 or 1.3 Wp detachable photovoltaic (PV) module with an outdoor cable. With one day of charging, the Nova model can give four hours of brightest light which can be used for activities like running a shop or a service center or for studies at night etc. and also as a night lamp. If used as night lamp, Nova model can run up to 150 hours from a single day charging. Nova model has a handle, so people can hang this up on a ceiling or on a pole at a height to light up a wider area. Provision has also made to charge the mobile phones. Nova is priced at ₹1,699. The second model Solata is of a medium range. Launched in June 2008, Solata has a 0.625 Wp detachable PV module with an outdoor cable and can be used as a desk lamp. This model provides four to fifteen hours of lighting from one day of charging. Kiran the smallest of the three models is very cheap costs to the customer only ₹549. Kiran was launched in October, 2009 and has an integrated 0.3 Wp PV module and provides light for four to eight hours for a market stall or for a room. This model has to be put up in the sun in order to get charged.

All three modules come with a rechargeable battery with the possibility of controlling the charging. Charge controller protects the battery both from overcharging and quick discharging. The PV module is expected to last for at least 10 years with a battery life between one to two years. The LED light has an estimated lifetime of 50,000 hours and efficiency of other parts mostly depends on use and care of the solar lanterns. These solar lights are manufactured in China and stocked at warehouses located in various countries from where D.Light supplies the lanterns to dealers and distributors mostly located in rural areas of the country. D.Light gives a six month warranty on all its lantern models. Each has a serial number and warranty card which carries the stamp of the dealer and the mobile number of the rural entrepreneurs (REs) who sells it. In case any lantern becomes defective within the six months of its purchase, then the lantern will be replaced free of cost. After the warranty period is over, the rural entrepreneur or dealer will order the spare parts to repair the lantern and provide services for the same.

Kiran-S10 in Leh, India

D.Light conducts road shows, demonstrations in market places, village gatherings etc, to create awareness among people about its products and sells these lanterns both directly to individual customers and through local dealers and rural entrepreneurs. Local dealers and rural entrepreneurs purchase D.Light lanterns in bulk and sell them in their villages on retail for a profit.

Studying using Dibbi

Kiran-S10 - A Brighter Tomorrow

Most of the customers buy these lanterns for down payment. However some rural entrepreneurs give lanterns to customers on credit, if they know their customers' credentials and those customers payback the loan on terms and conditions agreed upon mutually by the customer and his dealer or REs. There are some efforts to give lanterns to customers through micro credit and financing schemes, however such initiatives have yet to happen at a large scale. Local dealers and REs are free to adopt their own strategies to market and sell the lanterns. Some dealers even allow their prospective customers to use the lanterns on trial basis. If customers like the product they purchase it, otherwise they are can return the product back to the dealer.

In India, kerosene is subsidised at ₹15 per litre, on average ₹100 are spent on kerosene for lighting one lamp per month. In comparison to the expenses incurred on

kerosene lamps, solar lanterns from D.Light make more economic sense. The low end Kiran, which costs about ₹549, can pay for itself with in five months of its purchase and the most expensive Nova in less than two years. Each household is entitled to only three litres of subsidised kerosene per month, very often people purchase kerosene from the open market at a price of ₹25 or more per litre. If this expense is also considered then the pay back period for solar lanterns becomes much shorter.

Since its inception in 2007 up to May 2010, D.Light sold over 2,20,000 solar lanterns in 32 countries and

Village Head with bough S10 on Demo

Village Teacher - The First One to Used S10

benefitted around 11 lakh people on a basis of five people per household. D.Light solar lanterns are able to replace the use of kerosene thereby reducing that much carbon emissions. A typical kerosene lamp, consumes about 80 litres of kerosene each year, thus emitting 0.2 tons/year of CO_2. Even on a conservative estimate the 2 20,000 solar lanterns sold to date are able to save at least 17 million litres/year of kerosene, and reducing CO_2 emissions by at least 44,000 tons/year. Usually one solar lantern is able to replace more than one kerosene lamp burning, thus the savings may be even higher than estimated.

Apart from reducing carbon emissions, solar lanterns provide bright, clean light for a minimum of four to five hours every night. So by using solar lights people put in more hours for productive work, which in turn may improve their chances earning more income. Students get at least two to three hours of extra time for their studies thus indirectly helping them to do well in their studies. Security and safety also increase as well lit homes deter miscreants and anti social elements causing any harm to people or property, which they can do without being identified or caught in the darkness of the night. For women working in the kitchen at night, it will be a relaxed activity as they can cook food under the light provided by solar lanterns.

As solar lanterns produce no hazardous fumes people can be free from eye and respiratory track ailments and can enjoy better health. Another major advantage of using solar lanterns is reduced or totally eliminated risk of houses or property catching fires due to kerosene lamps. Even children are able to operate solar lanterns with minimum care and training.

Solar lanterns reduce the monthly expenditure on kerosene purchase and also enhance income generating activities that is a result of extended shop hours, mobile phone charging and craftwork in the evening.

With the growing demand for electricity by urban areas and industry sectors, in countries like India it is very difficult to meet the electricity requirements of rural and far flung areas. Hence there is an enormous potential for solar lanterns.

Lighting up Lives with Kiran

SOLAR LANTERN: Lighting People's Lives

Solar Lanterns is making Nights Bright

Ashima Begum is a member of Self Help Group in village Sureri, block Rampur in Jaunpur district. She purchased a solar lantern in August 2004 for her household use replacing the traditionally used kerosene lamp. But she soon realized that the lantern's use could be extended to increase the productivity of the family business - carpet weaving.

Ashima's family earning is primarily from carpet weaving. On several occasions, to meet pressing deadlines, work was carried well in the night under the dimly lit room from the kerosene lamp. It slowed down pace of work due to low illumination, straining the eyes. Kerosene lamp was financially unviable with expensive and hard-to-get kerosene. But with the solar lantern, additional working hours in the night became a possibility without straining the eyes. Improved working conditions resulted in increased productivity. The children in the family also found it convenient to study in the light of the solar lantern. The indoor atmosphere was much cleaner without the polluting smoke of the kerosene lamp making Ashima a much relieved mother.

Ashima and many like her in the villages of Rampur today are living an improved life where solar lanterns have replaced kerosene lamps. This has improved their productivity, reduced their expenses on kerosene thus increasing income and the less polluting environment has resulted in better health.

Jaunpur district in Uttar Pradesh is a predominantly agrarian society with small land holdings, landless workforce, low per capita income and low literacy rate. Traditional family business of carpet weaving and scent production is the other economic activities in the district.

Like several other districts in eastern Uttar Pradesh, Jaunpur also lacks reliable access to conventional forms of energy systems that have the potential to bring about improvements in quality of life and support development by enabling public services for instance, education and health and by increasing the productive hours in a day.

A large portion of the rural population - most of it poor - has to depend upon un-economical and environmentally

harmful options such as kerosene to meet their lighting requirements.

Winrock International India (WII) is a non-profit organization working in the areas of natural resources management, clean energy and climate change. WII's mission is to "develop and implement solutions that balance the need for food, income and environmental

Exhibitional and Promotional Event Organized in Jaunpur, Uttar Pradesh

quality."

WII's project in Jaunpur was to make available solar lighting systems. The primary aim of the programme was to provide access to clean and reliable sources of energy primarily for women and children in 200 villages of Rampur and Ramnagar blocks in Jaunpur. It was expected that the improved quality of life would support education and health and other crucial development in the area.

ESTABLISHING A SUPPLY CHAIN

Keeping with the mandate of WII of addressing rural development and sustainable resource management through education and empowerment programme, it established a supply chain to make solar lanterns and lighting system available to the villagers and also created a support system for the programme to sustain. The programme created awareness among villagers about the benefit of the product; provided training and also facilitated availability of loan.

Of all Solar Photovoltaics (SPV) available, solar lanterns was found to be compact, easy to use, easily available and affordable and was initially introduced in the programme area. It was later followed by solar home lighting.

As solar lantern was a new technology for the villagers, it was expected that there would be resistance in accepting and using it. Trust had to be built and the various features of the product demonstrated to convince the villagers. The motivators selected were local residents and already well – known to the villagers. A number of awareness generation camps were organized mainly in the night to demonstrate the usefulness of the solar lanterns. A special drive to encourage women to attend the camps was initiated as they would benefit from the lamps the most and thus influence decision on purchasing.

IMPLEMENTING THE PROJECT

In addition to the awareness camps, several interactions between the self help groups, villagers, individuals were organized to explain the benefits of this clean energy and the impact it will have on improving their income and in providing relief from kerosene emission. A marketing network comprising of the stakeholders - field level motivators, electricians, bankers was formed.

Training for repairing the lantern was provided to the village electricians and Focused Branch Manager Training Programs for the bankers was organized to train them in giving loan for the product.

The solar lanterns are sourced from a manufacturer in Delhi and transported to Bhadoni in Uttar Pradesh from where to three identified dealers in the project area. Like any other product in the market, this also comes with a warranty, regular maintenance and repair with a service cards maintained with the buyer and the dealer.

The cost of the lantern is at a very affordable ₹3,000 for a solar lantern and ₹18,000 for a solar home lighting

Improved Visibility in Rampyari`s Kitchen

system. The buyer can either make the payment directly to the dealer, or avail of the micro-credit facility provided by WII or finance it from the local bank. Loan from the bank would generally attract an interest of 11-12%.

The amount in case of direct payment or repaying the loan was not a very tough proposition as the use of solar lantern resulted in an increase in income. According to an assessment report by WII, the average increase in the annual income earned during the extra productive hours was ₹5,504. The maximum income recorded was ₹27,000. This was possible because of an improvement in the number of working hours with an additional 2.1 hours.

The augmentation in the income was also due to the saving on decreased consumption of kerosene. For an average household the consumption had decreased from 8.32 to 3.63 litres/ month reducing the expenditure from a high of ₹ 114 to ₹54 per month.

With the help of such saving in expenditure the payback period was limited to one to two years.

SOCIAL BENEFITS

On a more social aspect, the children's interest and result in studies showed a marked improvement. They were now able to study in the evenings and the less polluting environment inside the house also helped. Their eyes were less strained and did not irritate.

With a vast improvement in the indoor pollution levels, the incidents of chronic cough found some relief and breathing problems were also limited. For women, working in the kitchen was a lot easier.

It is indeed amazing as to how just a spark, in this case, a solar lantern to provide electricity brought about a cascading effect in all spheres. Light from the lantern also meant a more active social life for the villagers. They were now able to hold religious activities like bhajans in the evening. Communication improved as provision was now available to charge a cell phone.

WII's successes in the first phase of covering 50 villages encouraged expanding the scope of work to more villages. With the efficient establishment of the components of the supply chain - a vital for the sustainability - the programme has been extended to 200 villages.

The programme's accomplishment can also be attributed to the receptive attitude of the people of the village. Once they experienced the positive impact of the solar lantern in their lives, they readily accepted the new technology. WII's team has been instrumental in bringing about this change by being constantly working in the area since the programme was implemented, overseeing its smooth implementation.

Now people of the 200 villages live an improved life with their confidence restored. Households selected for testing the emissions after the programme implementation have shown a marked improvement in the indoor air quality pre and post use of solar lantern.

Dr. Kamta Prasad Soni - Improved Treatment Facility with Solar Light

FUTURE MARKETS

WII's efforts in implementing the programme successfully have resulted in a ready market for any similar product manufacturer. A number of products are in the market and may be offered soon. Newer products with wide ranging options are being researched and tested. For example research is on for a LED based solar products.

A learning from WII's experience is that any product can succeed as long the supply chain components is in place and the trust of the people is in the model. Social mobilization is a vital aspect in any similar initiative and is a time consuming process. So if there is enough resources – both personal and finance, this model can be replicated anywhere.

WOMEN POWER

Power Station at Kurawa Village

VEC Members

PRADAN (Professional Assistance for Development Action) is a non-government, non-profit organisation that works with India's rural poor. Working in seven of the poorest states in the country, PRADAN promotes Self Help Groups (SHG) develops locally suitable economic activities, mobilises finances and introduces systems to improve livelihoods of the rural poor and sustain their progress.

Commenced in October 2009, the project was implemented in ten of the poorest villages in Dumka and Poraiyahat districts of Jharkhand where PRADAN was working with women in SHGs linked to economic activity of tussar yarn. Under the project, solar photovoltaic powered machines replaced the diesel generated ones. This helped in improving the economic status by increasing the earnings and also upgrading the lifestyle of the villagers.

In these ten villages, the women attached to the SHGs weave yarn using a motorized-cum-paddle operated by diesel gen-set. But with the rise in diesel prices, it unaffordable and the women were forced to operate the machine using the cumbersome paddle alone.

Women yarn producers in these villages are organized into 'primary activity group' at village level and are federated into a Producers Company (named as MASUTA Producers Company Limited or MASUTA). The project is implemented by Scatec Solar with field support from PRADAN and MASUTA.

Working with these women in an earlier project, PRADAN had constructed work sheds, one each for the primary group, where 30 – 35 women could work comfortably. The families had also been provided with yarn making machines along with relevant skill enhancement training. The work shed and the machines were now owned by the women primary group.

The solar photovoltaic or the power stations were installed in these work sheds. The solar panels were installed on rooftop and batteries and other devices were kept in a room. New solar powered yarn machines replaced the old ones. Besides, each of the villagers purchased a solar lantern could be recharged in the power station. Each of the power stations has charging hubs that can recharge a number of mobiles at a time. The power station is equipped with power supply to run a community television in future.

For implementing and sustainability of the project, Scatec Solar imparted technical training to a selected person from PRADAN. Each village selected an operator and PRADAN, with the help of Scatec Solar trained them on operation, maintenance and book keeping of the power station. The training was also provided to the individual women-user.

The training will be phased and repeated to make the operators and users well equipped with the regular functioning and maintenance of power station. Besides, an exposure visit will be organized to a well functioning solar power station.

To make the project financially sustainable, the project included payment for the power used. The revenue was deposited in a separate bank account for future replacement of batteries, recurring expenses and maintenances.

Availability of power has improved the economy of the village and also proved advantageous for the education and social needs of the villagers. Now with the solar lighting, the work of women can chose to work at night as well.

It was of particularly useful this summer when the temperature rose to an all time high of 40 degrees Celsius with very low humidity. The condition was not conducive for extracting yarn as it is inclined to snap. Due to the lighting in the sheds, the women could take a break at noon and resume in the afternoon to continue working till night. This extra work helped increase production and earning by 15%.

In eight power stations, 4 to 7 existing (old) reeling machines are run by motor, powered by the solar power. These machines are now producing 250-300 gm of yarns a day compared to 100-150 gm production a day from the same machine when run by paddle.

The solar power is also helping the students with their education. In Danidh, the operator runs a tuition class for 20 children of his tola (hamlet) in the power station. In all the villages, the students come to the reeling shed at night for a night-study which was impossible or difficult with kerosene lamp earlier.

Improved Yarn Making Machines

VEC Leader Inside Battery Room

Connectivity and use of mobile has also increased in the village. Charging mobiles is the most common use seen in all the villages. People now need not to travel 3-5 km to deposit their mobile for recharging and again travel the next day to collect the mobile from the nearest market. The light in the reeling shed has become a good place to meet by the villagers at night listening music from the mobile!

MASUTA operates a MIS cum accounting software for keeping records of transactions within the group and with others. Earlier one computer was installed in the block headquarter for each cluster of yarn producing groups. But it was difficult to operate due to irregular and supply of power. Now two computers are working for two clusters making it possible to supply required MIS and ensure payment of yarns on time to the producers.

The villagers have discovered the multiple spheres where their lives are touched and improved by power.

Community Computer at Chukapani

CAPTURING RAYS

Solar Lantern Charging Station in Bhopal

Local Market Lit by Solar Lantern During Night

In a city once devastated by the clouds of poisonous gas that escaped from Union Carbide Chemical, a small intervention made an all out effort to keep its air free of pollution. This project by Madhya Pradesh Gramin Vikas Mandal (MPGVM) provided market vendors and street hawkers with solar lighting solutions that are cleaner, cheaper, and safer than the normally used kerosene lamps or lamps powered by diesel generators. Experts say that solar power, if used nationwide, can effectively make use of 5,000 trillion kilowatts of solar energy that India is endowed within a year.

Incidentally, Jawaharlal Nehru National Solar Mission (JNNSM) has already put an ambitious target for the country, giving vast opportunity for the exploitation of renewable energy sources. Keeping up with the trend, what makes this project innovative is the manner in which the vendors were weaned away from traditionally hired kerosene lamps or electrical lamps, normally used to light their wares at night. These lamps are not just comparatively expensive, but also polluting. However MPGVM ensured through this project that the vendors were given a cheaper option of hiring solar lanterns.

SPOTTING POTENTIAL

In Bhopal, the capital of Madhya Pradesh, much like other cities of India, there is a huge population of pavement, pushcart vendors and stallholders that are a part of makeshift markets. These small-scale entrepreneurs move from one part of the city to the next as hours' progress, with the intention of making ends meet. And with the advent of dusk, these vendors become a part of the night markets that start taking shape at around 04:00 pm and continue until 10:00 pm, or later. As it gets dark, there arises a need to light their stalls and this is when each of these stalls and pushcarts get adorned by kerosene lamps and lamps powered by diesel generators that are traditionally available, but pollute the market too.

It is a common knowledge that this smoke is detrimental to the health of all-vendors, their families, as well as the people shopping on these stalls and living near these markets. To make matter worse, the gases emitted by these lamps also add to carbon emissions and global warming. It was this realisation that made MPGVM search for alternatives.

The organization, a development NGO, based in Balaghat, Madhya Pradesh, is a member of Rural Energy

Network. The organization first conducted a feasibility study to gauge the willingness of the vendors to use solar lamps. The study also gave due emphasis to the cost of maintenance of solar lamps, its delivery and collection and reiterated that it will be easy to cover all costs if the project keeps the amount of hired solar lights less than the vendors are used to generally paying for lighting.

Armed with this information, a proposal was submitted by MPGVM to the Canada-India Rural Energy Project (CIREP) that offers small grants to members of the Indian Rural Energy Network. Accordingly the idea got the much needed momentum when the organization was awarded a small grant by CIREP in 2002.

ON ROAD TO IMPLEMENTATION

With funding in place, 100 solar lanterns were purchased that had a 7 W CFL lamp and were powered by a 12 V battery. Three full time staff was trained to charge, deliver and collect lanterns and the rent. Capacity building of these people enabled them to handle routine repair and maintenance of the lamps.

To create a demand for the lanterns, a three-wheeler was specially adapted and fixed with shelves to hold the lanterns. Every evening, this vehicle took the charged lanterns to the markets, where the vendors hired these for ₹8 per night. As this price of the lanterns was almost half the charge of a kerosene lamp or electric light, vendors were too happy to opt for this option, more so because of the ease with which they could get this lantern right in the market itself.

When the market would start winding up at around 11:00 pm, project staff of MPGVM would go around the markets to collect the rented lanterns. Once collected, these lanterns were taken back to the project premise, where these were recharged using an installed solar PV panel. On extremely persistent cloudy days the charging was alternatively done using electricity.

THE CHALLENGES

Solar Lantern Charging Unit

Even after receiving fairly encouraging response (as suggested by the initial feasibility study), the project was not financially cost effective for MPGVM with just 100 lanterns. Though demand of product existed, along with the acceptance of new concept, but the low rental acted as a deterrent for financial sustainability. It was calculated that there should be at least 250 lanterns to achieve break even. But due to shortage of funds, additional lanterns couldn't be brought, nor could the rental of the lanterns be enhanced as the project was catering to poor vendors who couldn't afford a cost higher than this.

MPGVM ENDEAVOURS TO:

- replicate this project in other parts of country by encouraging and training entrepreneurs for similar initiatives.
- encourage the formation of self-help groups of the hawkers to be able to get credit from micro-finance organisations and initiate small-scale enterprises.

Experience also highlights that the lanterns need to be stronger to withstand the rough handling by vendors; improved to give better, brighter and long-lasting light than what it gives now. Hence the search is on for better solar lantern models.

This project also makes it very evident that such low-cost initiatives require seed money to cover infrastructure. However, even after such a support is given, the primary requirement to make the project sustainable can only be attained by economies of scale.

Solar Lantern Distribution Vehicle

Shop Keeper using Solar Lantern

LIGHT AT NIGHT - Community Solar Power Plant

Sun Shine at Night

Community Power Plant at Rampura

Rampura, a small hamlet of Paheguan panchayat in Jhansi district, Uttar Pradesh, comprises of 69 households with a population of about 326. Agriculture and animal husbandry are the main economic activities of the villagers. Of the 69 households, 19 are below poverty line. Till two years back, people living in Rampura never had the experience of electricity as it was not connected to the national power grid. Kerosene lamps (lantern & "dibri") were their sole source of lighting at night time. On an average, each family consumed 3 liters of kerosene per month. The annual consumption of kerosene was 2,489 litres costing ₹27,324 at the subsidized rate of ₹11/litre. Villagers had to finish most of their activities before the night fall and there was a felt need for a regular source of energy among the villagers.

Development Alternatives (DA), which is working on commercially viable technology based on renewable energy sources for the past two and half decades, adopted Rampura village five years back and since then has undertaken a number of development initiatives in the village. DA was aware of the energy requirements of the village. Scatec Solar – a Norway based organization with its office in India was keen to provide electricity to villages based on solar power. So both DA and Scatec Solar collaborated and short listed Rampura for their pilot project of setting up a Community Solar Power Plant (CSPP). DA was responsible for village mobilization and capacity building while Scatec Solar was responsible for funding and commissioning the solar power plant technology. Scatec Solar is also involved with a Gurgaon-based electronics company, DD Solar 23 India Pvt. Ltd, under the banner of Bergen Group, to provide the engineering know-how and execution of project on a turn-key basis.

The solar power plant technology commissioned in the pilot project comprised of:

- A poly-crystalline solar panel having 3 strings of 20 modules each and each module consisting of 50 cells. Each module has a capacity to generate145 Wp and the total panel has a capacity to generate 8kWp.
- A mini distribution grid 0.75 km to supply 220 V alternate current for domestic, community use
- Battery-back up to secure 3 days of electricity supply in the absence of sun shine
- 13 street lights
- Provision to supply 220 V AC electricity for enterprise load up to 3 HP

The project was commissioned on a "Build-Own-Operate-Transfer" (BOOT) approach where the village community would be the ultimate owner of the project. For the smooth functioning and efficient management of the project, a

village electricity committee (VEC) was constituted. Care was taken to have representation from all sections of the village community while constituting the VEC.

The cost of commissioning the off grid community solar power plant was about ₹29.5 lakh. This included cost of civil works, cable laying, battery, power controlling unit, mini grid etc.

Individual household had to bear the initial cost for necessary infrastructure and appliances required in the individual household such as electrical wiring, electrical points for connecting and getting the electricity supply from the mini distribution grid, electric bulbs, fans and television sets etc. VEC has collected ₹500 from each individual interested in getting a connection from the solar power plant as security deposit.

Individual households have to pay monthly service charges to VEC. The tariff structure was decided by VEC with the guidance from DA and Scatec Solar. Initially the tariff included fixed and variable charges. Fixed charge was to recover the replacement cost of batteries and variable charge to meet the daily operational and maintenance costs. But it was realized that some of the households were drawing more power using additional light and fan points. The tariff model has been changed by VEC to consumption based model to avoid physical policing and social conflict. The revised tariff based on consumption has been calculated on the basis that, on an average.

Leader of Success

- A single household approximately consumes 0.24 kWh/day and total average monthly domestic consumption is about 308 kWh.
- Average daily commercial load is 2.2 kWh.
- Commercial load constitutes about 20% of total consumption.

So tariff for domestic and commercial load was decided as per following tariff structure.

TARIFF STRUCTURE

	Slab-I	Slab-II	Slab-III
Type	0 – 5 kWh	5 – 10 kWh	More than 10 kWh
Domestic			
Fixed	₹20	Rs. 90	₹160
Variable	₹4.5/kWh	₹5.5/kWh	₹6.5/kWh
Enterprise			
Fixed	₹200		
Variable	₹6.5/kWh		

The project started functioning since January 26th 2009. Out of 69 households, 40 households are connected to CSPP mini-grid supply. Remaining households could not be connected to the grid as those households were lacking sufficient funds to avail the facilities. From the time the solar plant was functioning till 31st January 2010 the villagers had consumed approximately 8,000 kWh of power. The break up of estimated annual revenue from and expenditure on the solar power plants is as follows.

REVENUE

Annual revenue from domestic load: ₹40,843 (includes ₹4,800 from street light)

Annual revenue from commercial load: ₹4,819

Total annual revenue: ₹45,662

EXPENDITURE

Annual operator's salary: ₹14,400

Annual salary of security guard: ₹14,400

Estimated annual expense on maintenance: ₹4,000

Annual insurance premium: ₹3,500

Total annual expense: ₹36,300

Annual Saving is ₹9,362

Brighter Evening

The plant was designed in such a way that it can meet the energy requirements of up to 2 HP. This can be used for

- Running small enterprises like flour mill etc.
- Water pumping and distribution
- Drying cash crops
- Running sewing machines etc.

Rampura now has flour mills that run on motor using solar energy. Power supply through CSPP enabled villagers to explore their hidden entrepreneurial qualities. One enterprising villager has set up a home refrigerator and started offering services like storing medicines, selling refrigerated soft drinks and butter milk etc to other villagers. He charges them for the services provided.

Regular supply of electricity has a positive impact not only at family level but also at the societal level. CSPP has contributed more than one way both directly and indirectly to the development of the village.

- Comfortable living conditions – as villagers could use electric lights, fans and coolers.
- Improved Productivity – certain activities like sewing, flour making etc, which were done earlier either manually or with diesel etc are now carried out through electricity thus saving time and human energy.
- Improved Safety and security – Well lit streets are deterrent for anti-social elements from causing threat to the villagers' life and property.
- Improvement of Health and hygiene – Clean and safe energy improved the health of the population and also the environment. People are adopting hygienic habits like building toilets with in the premises of individual households, as well lit streets discourage people from open defecation.
- School going children get at least valuable 1.5 to 2 hours of extra study time.
- Increased the purchasing power of the villagers as people are now ready to buy electrical gadgets and appliances like coolers, fans, TV sets, DVDS etc.

Apart from bringing a positive change in the life style of individual households, CSPP has brought in a new energy at the community level also. The constitution of VEC has developed project management skills among villagers and gave them the confidence that they are capable of taking care of projects like CSPP on their own. Continuous involvement of villagers and village community in deciding the tariff structure, disciplining the village community from misusing the benefits provided by CSPP, brought a feeling of ownership among the villagers of Rampura.

Installing and maintaining such community solar power plants do have their share of challenges like:

- Mobilizing villagers and convincing them for upfront payment
- Making villagers pay their electricity bills on time, monitoring and controlling villagers from unfair practices like power stealing and overloading etc.
- Developing a viable model to meet the irrigation load requirement
- At present the net annual saving from the plant is only ₹9,362. This amount is not sufficient to replace battery in 10 years (expected life) even if the money is put in a term deposit @ 8% interest.

The project has huge potential considering the unmet energy requirements of rural India, however to make the project financially viable external aid in the form of government subsidies and institutional funding is essential.

Modern Technology Touching Lives

LIGHTNING LIVES

Solar Home Lighting Systems

Credit Camp for Solar Photovoltaic System

Regular power still remains a distant dream for a large number of villages in Uttar Pradesh, where 70% of the population lives. Even in villages where grid is available, there are frequent power cuts. Realising the need of the hour, Aryavart Gramin Bank took the onus of literally illuminating the lives of thousands of villagers across six districts of Uttar Pradesh with a novel, easy financing scheme for the purchase of solar home lights. The 2008 Ashden Award to this bank highlights the significant contribution banking sector can make in bringing solar photovoltaic (PV) electricity to rural families.

The bank has received many other laurels in the form of India Power award 2009 along with appreciation from government of India, Reserve Bank of India (RBI), Bank of India and National Bank for Agriculture and Rural Development (NABARD). NABARD has even issued a circular for all the Regional Rural Banks (RRB) to replicate this venture.

RAYS OF HOPE

It is a well-known fact that progress and development opportunities are inhibited due to inadequate power supply in rural areas and life comes to a standstill after dusk. Villagers are forced to use alternatives like kerosene lamps, dung cakes, firewood and crop residue to light their homes. These fuels, unfortunately, have an adverse impact on health, environment and safety of the people. Villagers do make an effort to overcome these issues in indigenous ways. For example, some shopkeepers earn extra money by providing battery-charging services that enable people to operate lights and small appliances from car batteries. But these are not options that many can afford.

What are RRBs?

RRBs are an initiative of the former Prime Minister, the late Mrs Indira Gandhi, who had the vision to launch the social banking system in rural areas, under the aegis of RBI and NABARD. These banks follow the objective of providing banking facilities in rural areas, along with making small loans accessible to farmers and other rural people.

Aryavart Gramin Bank, a RRB operating in six districts of the Uttar Pradesh state -Lucknow, Barabanki, Farrukhabad, Hardoi, Kannauj and Unnao, too had to grapple with similar issues. It was constituted in 2006 after amalgamating three RRBs (namely Avadh Gramin Bank, Barabanki Gramin Bank and Farrukhabad Gramin Bank) as per the Government of India directives. It was quite evident to the bank authorities that to operate a modern, computerised bank with no power is not reliable, alternative backup system was imperative. To begin with, the bank decided for installing photovoltaic (PV) systems in five of its branches and the outcome was impressive. These PV systems were highly effective in providing a reliable supply of electricity.

How does a Solar home light operate?

The PV modules generate DC electricity in sunlight, which is stored in the rechargeable lead-acid batteries. These batteries are used to run an inverter, which converts DC to AC which is used to light homes.

Mr N K Joshi, Chairman of Aryavart Gramin Bank, realised that what has worked wonders for them can be the solution to the problem faced by many of his customers residing in 8,500 villages covered by the bank, out of which almost 2,500 villages were totally without grid power. The bank was also aware that the villagers, even if appreciative of the concept can ill afford such a system. It was this realization that led to the conception of a unique loan finance scheme for the purchase of solar home lightning system (SHLS).

IMPLEMENTATION OF SCHEME

The bank first identified TATA BP Solar model Venus SHLS, available in two models as a cost effective option for the villagers. These models are:

- 35 Wp of PV with two fluorescent lights and a socket, and
- 70 Wp with four lights and a socket.

These systems cost ₹15,000 and ₹30,000 respectively, including installation and one year of service. This scheme was launched with much fanfare and a catchy slogan: “Ghar ghar me ujalaaa” (light in every house).

Another out of the box thinking of the bank management was bulk-order of the PV system through Solar Power Systems - the main dealer of Tata BP Solar to reduce cost of the system along with initiating the scheme of providing loans to the customers.

The help of Kissan clubs (Farmers' clubs) was also taken to popularize and sensitize the masses about the scheme. For villagers to get the first hand experience of the product, few systems were first installed at prominent places like bank branches, schools, community centres, village panchayats and residences of some of the valued customers of the bank. This had tremendous impact on the psychology of the villagers as seeing is believing.

BUSINESS MODEL

The bank negotiated with the company to reduce the cost of the above-mentioned SHLS to compensate for the non availability of subsidy. Since the bank had projected a demand of the SHLS in large quantity, the company agreed to reduce the price from ₹15,000 to ₹13,000.

The bank took some very effective steps towards ensuring the sustainability of the scheme. As a result, solar loans were provided to those customers, who had an established track record of reliable credit repayment. Secondly the customers also needed to have an assured source of income.

Bank Financed Lanterns

Such customers were invited to mega credit camps, where SHLS demonstrated the scheme. Usually more than one thousand customers sign up for these SHLS loans in each of these camps. The bank has fully utilized the Ashden Award money in promoting the use of solar energy by providing financial support in setting up service centres, making provisions for business facilitator's kits, community development and awarding the best performing branches of the bank for promoting SHLS. So far almost 29,077 households have availed of this facility.

The finance package offered by the bank for the purchase of 35 Wp system requires a down-payment of ₹ 2,520 by the customer and the bank provides a loan of ₹11,000 at 12% p.a. interest, which is repaid with a monthly instalments of ₹245 over five years. This amount is cheaper than ₹280 needed earlier for the purchase of eight litres of kerosene by an average household. In totality, each SHLS saves about 100 litres/year of kerosene, thus systems installed to date reduce emissions of about 1,900 tons/year of carbon dioxide.

The bank has also developed an innovative way of providing maintenance for the SHLS, which also brings employment to rural areas, where part-time 'business facilitators' are trained by TATA BP Solar and its dealers. Each facilitator is paid a monthly fee to keep a check on at least 100 SHLS, with the incentive of a larger bonus at the end of the year if all the systems are working well.

Solar Home Lightning System economics		
Project cost	:	**₹13,520**
Amount of finance	:	**₹11,000**
Down payment	:	**₹2,520**
Equal monthly instalments	:	**₹245 (in 60 EMIs)**

A villager presently uses SHLS for 2 hours for cooking dinner, which requires consumption of minimum 8 litres of kerosene per month costing ₹280 approx. (as per market price of ₹35 per litre). Thus the borrower does not face any extra burden of the cost, instead he saves ₹35 per month.

A cost-benefit analysis done by the bank reiterates that SHLS is far more cost effective in the long run than the use of kerosene based lightning options. Though the initial

David Fullford One of the Judge of Ashden Trust, London Visited the Villages of Unnao

investment cost is very less in case of kerosene based appliances, but over a period of 25 years the operational cost of kerosene based system is almost to the tune of ₹87,360 as compared to ₹38,220 required by SHLS. Thus the entire capital and revenue expenditure gets totally repaid in 10 years 11 months, even without taking into consideration other benefits such as improvement in living environment, uninterrupted and sufficient light for a longer period, benefit of carbon credit, air pollution and other health hazards. Needless to say it is a win-win situation all the way for all the parties involved: bank, business facilitators, TATA BP Solar and above all the villagers.

WAY FORWARD

The vision shown by the bank management has now taken this SHLS financing scheme to a different level of sustenance by collaborating with a US based company to trade carbon credits generated from this unique financing model. It is estimated that almost ₹30 lakh per annum will be generated for a period of five years at the present scale of operations.

Bank Financed Lanterns

The bank endeavors to utilize this money in strengthening after-sales services, training, development and promotional activities. In a way, the bank now has a double bonanza of innovative mechanisms to make the lives of villagers truly enlightened.

FRESH VEGETABLES IN THE COLD DESERT OF LADAKH

Solar Passive Greenhouse

At an altitude of more than 3500 m above sea level, Ladakh district of Jammu and Kashmir state is one of the famous cold deserts of the world characterized by cold breeze and blazing sun. Ladakh receives a very low rain fall. In winters, the temperature can be as low as -25º C. The climate makes it very difficult to grow fresh vegetables and other crops in the open for almost 9 months in a year as plants die because of freezing. Airlifting the vegetables from plains in winter and bringing by road in summer is a normal practice for the people living in Ladakh, making these fresh vegetables expensive and their availability limited. Most of the locals rarely get to eat fresh vegetables; as a result many suffer from malnutrition.

Being a rain shadow area means the sky is mainly devoid of clouds. Ladakh experiences clear sunny days for almost 300 days in a year. Exploiting this sunny climate of Ladakh, GERES (Groupe Energies Renouvelables, Environment et Solidarités) started developing improved Passive Solar Greenhouses to grow fresh vegetables and other crops indoors even during the winter season. For the last ten years GERES is working in this area in collaboration with the Ladakh Environmental Health Organisation (LEHO), Ladakh Ecological Development Group (LEDEG), Leh Nutrition Project and Skarchen and Spiti Transhimalayan Group/Ecosphere (STAG).

GERES developed an improved greenhouse (IGH), to maximise the capture of solar energy during the day, minimize the heat loss at night and thus prevent plants from dying due to freezing. The greenhouses are designed in such a way that they are sufficiently heated using only solar energy and do not require any supplementary heating. Some of the salient features of the improved green houses are:

- The greenhouse is oriented along an East-west axis with a long south facing side.
- This long south side has transparent cover made of heavy duty polythene with an extra stabilizer to

withstand the intense UV rays present in the sunlight. The polythene is built to last for a period of more than five years. A double layer of polythene is used in severely cold places.

- The north, east and west side walls of the greenhouse constructed using mud bricks in low and medium snow fall areas and with stone or rock in heavy snow fall areas to enable the green house to absorb maximum heat from the sun during the day and release the stored heat at night to maintain a temperature suitable for healthy growth of plants inside the greenhouse.
- The walls on north, east and west sides are constructed as cavity walls to help in minimising heat

Commercial greenhouse of Gulan Razul

loss from the greenhouse. The 100 mm cavity in these walls is filled with insulating material such as sawdust or straw. The roof is slanted at an angle of 35º to allow maximum direct sunlight during the winter season. At night the roof is covered with thatch and the polythene on the south side is covered with a cloth or tarpaulin to prevent heat loss.

- Vents are provided on the walls and on the roof to avoid excess humidity and heat and also to allow controlled natural ventilation.
- Inner side of the north and west facing walls are painted black to improve heat absorption and the east facing wall is painted white to reflect the morning sunlight on to the crops. There is a door in the wall at one end.

Except the polythene used for covering the south side of the greenhouse, entire greenhouse is constructed using the locally available material. The main frame of the roof is made using local poplar wood, willow for struts and straw or water resistant local grass for the thatch. Rock, stone, mud bricks or rammed earth are used in walls construction. The polythene sheet has to be procured from places like Mumbai. Local masons were employed to construct the greenhouse by providing special training wherever required.

The greenhouse comes in two sizes. A smaller greenhouse with 4.5 m breadth and 9.7 m length for domestic use and a bigger greenhouse with 4.8 m breadth and 27.3 m length for commercial use.

The construction cost of a domestic use IGH is approx. ₹30,000. The owner of the domestic IGH has to either pay or collect all the locally available material like wood for the roof frame, straw for thatch, mud bricks and the material used for insulation etc. Owner also has to provide the labour or pay the labour required for construction. The NGO pays and provides the doors, vents and the special UV stabilized polythene, which comes to about 25% of the total cost. Some subsidy is given for domestic IGH. Construction of the greenhouses is timed in such a way that they match the agricultural cycle of Ladakh.

GERES monitors the IGH construction by providing methodology and design. LEHO and other local NGOs coordinate in selecting the prospective owners, training them on greenhouse maintenance and operation and providing other support needed for constructing the greenhouse to local owners.

Local NGOs have set up certain criteria to select the prospective owners of a domestic IGH like

- Families belonging to below the poverty line category.
- Should have a site suitable for greenhouse construction.
- Family must be keen to use the greenhouse successfully and also willing to share the products with wider community.

A wide variety of vegetables including spinach, coriander, garlic, radish, onions, lettuce, and strawberries are grown in winter. Tomatoes, cucumbers and grapes are grown in autumn and in spring seedlings are grown in the greenhouses. Some families have even started growing flower plants and potted plants.

Construction of a Passive Solar Greenhouse at 14,000 feet

Improved greenhouses have benefited the people of Ladakh, especially in terms of health. Prior to introduction of IGH, during winter people used to consume fresh vegetables only once or twice in month, but since the time IGHs were introduced, the consumption has increased to two to three times in a week. On an average one IGH owner provides fresh vegetable to nine other families and barters with six other families, resulting in health improvement of the people. Villagers are able to save on an average ₹500 to 1,000 on vegetable purchases as local grown fresh vegetables cost less as compared to imported vegetables.

Production of fresh vegetables locally, reduces the dependency on imports from plains, thus saving on expenditure on transportation. According to some estimates of GERES, the 560 greenhouses presently in operation are able to save about 460 tons of carbon emissions per year.

IGH has also brought employment opportunities to locals - around 220 masons and 15 carpenters have received training and got livelihood through constructing greenhouses.

IGHs have increased the income for their owners, as they can earn additional income by selling vegetables and seedlings for cash. Surveys conducted have revealed that on an average an IGH owner earns ₹8,250 per year by selling their excess produce and about 30% increase in their income levels.

The scale up potential for IGHs in high altitude regions of Himalayan states is very high.

In Ladakh alone the potential demand for IGH to produce fresh vegetables for civilian consumption is about 3,000 units, it may double up to 6,000 units if military requirements for fresh vegetables is included. At present technologically replacement of UV resistance polythene sheet every 5 years and also lack of awareness among agricultural/horticulture department at state level is proving to be a barrier in the promotion of IGHs. The solar passive concepts of south facing glazings, high thermal mass and insulation can also be used in other constructions like individual houses, public buildings, schools, hospitals and government offices etc.

Passive Solar Greenhouse in a Land Covered by Snow in Basgo

TIRUPATHI
The Green Temple

Solar Cooker by Gadhia Solar at Tirumala Devasthanam

Tirumala Tirupati Devasthanam (TTD) is the richest temple in the world with the largest number of devotees visiting on any single day, is a fact that is well known. But perhaps few may be aware that it is also one of the temples in India that is slowly but surely becoming environment friendly.

The temple in south Indian town of Andhra Pradesh has gradually been introducing renewable energy along with the traditional ones. Solar power is used for cooking, windmills meet some part of the temple town's power requirement; about 40-45% of the energy required by TTD is coming from its non-conventional sources. A water re-cycling plant purifies all waste water to reuse in the temple city's gardens. What is more, the canteen provides free mineral water through pipe lines to discourage use of plastic bottles.

The temple is also making records of sorts as far as renewable technologies goes. The largest solar cooker in the world was installed in the temples canteen in 2002. The system put up at the Nitya Annadanam complex at Tirumala has the capacity to prepare food for 15,000 persons at a time. Nearly 50,000 kg of rice along with sambar and rasam (a kind of curry) are cooked in the kitchens of Tirumala every day of the year without using conventional gas.

SOLAR TECHNOLOGY

The solar technology fixed at the temple's canteen is a scheffler parabolic dish technology installed by Gadhia Solar. The Gujarat based company is an innovative Solar Thermal Energy Company, focused on providing energy solutions by using Parabolic Concentrated Technology, backed by technical support from HTT GmbH of Germany.

Today, the country generates almost 1,748 MW power through solar energy. That's a low when compared to India's total demand of almost 1.3 lakh MW every year.

However, companies with investments in the technology believe that the potential for solar energy is much larger than the above share.

In India, the renewable energy growth story has been limited to either villages with no distribution networks or the government's initiative of using clean energy for public lighting systems. Over the last few years, almost 3,000 villages have tapped into solar technology to fulfill their basic needs of lighting, heating, cooking and entertainment.

The technology deployed at Tirumala has the potential to generate temperature of 500ºC and more. The mechanism of conversion of solar to thermal energy is fundamentally similar to the traditional thermal system except that use of solar energy as the source of heat.

Using the power of sun as source of energy, Gadhia Solar has implemented some of the world's largest Solar Thermal Systems in last two decades. Be it industrial, agricultural, institutional or domestic, Gadhia Solar has been a pioneer with major breakthrough in this area. With extensive experience in installing solar thermal energy systems throughout India and armed with ever improving production facility, Gadhia Solar is the market leader in solar thermal energy systems.

SOLAR COOKER AT THE CANTEEN

The Solar Steam Cooking system at the temple canteen uses the Gadhia Solar Concentrating System for cooking using thermosyphon principle based on the natural convection principle. The solar dish concentrators convert water into high pressure steam, which cooks the food. The solar concentrators capture the solar radiation from all the directions possible at one point so that the total energy available is the maximum. Parabolic dish type collectors are generally used for generating steam at 8-10 bars from solar power. A mirror is used to concentrate sunlight on an insulated receiver placed at the focal point, which transfers heat from the receiver to water and generates steam. This steam generated from solar system is used for steam cooking application.

The systems automatic tracking systems follows the sun throughout the day. The system is hooked onto the existing boiler that works on diesel so that it can work under all climatic conditions.

The solar cooking system is designed to generate over 4,000 kg of steam a day at 180º C and 10 kg/cm^2, which is sufficient to cook two meals for around 15,000 devotees.

Modular in nature, the system consists of 106 automatic tracked parabolic concentrators arranged in series and parallel combination, each of 9.2 m^2 reflector area. Each unit of concentrators is connected to a central steam pipeline going to the kitchen. The system is made of indigenous components and the reflectors are of acrylic mirrors having reflectivity over 75%.

Solar Cooker

The total cost of the system is about ₹110 lakh, which includes back up boiler, utensils and annual maintenance contract for 5 years. Out of the total cost, the temple's share of expenditure was ₹63.5 lakh and the Union Ministry of Non-conventional Energy Sources provided the rest as subsidy. This was under the demonstration scheme by the Central ministry. The maximum saving is around 450 litre/day (furnace oil) adds upto ₹37,12,500 and the payback period is 2 years.

The solar cooker requires no plant modification and involves one time installation and relatively free running over a life span of 25 years. For developing the project, Gadhia hired the services of several qualified engineers. After the installation of the solar cooker was completed, a team from Gadhia conducted a workshop to provide training mainly to the users as this was a totally new system at the temple. At the workshop, details on operation and maintenance were explained.

Prior to the solar cooker, firewood and LPG cylinders were the traditional energy sources for cooking at Tirumala. The solar cooker was designed to generate over 4,000 kg steam per day which replaced the usage of furnace oil requirement which requires high amount of conventional source of energy.

The cooks at the temple's kitchen are the first in line to feel the benefit of the system. According to them, their work now is easier and quicker. A huge improvement on the gas that took longer to cook. Now it takes just an incredible 20 minutes to complete cooking.

As far as the impact on environment is concerned, the TTD has been saving an average of 450 litres of diesel per day resulting in a reduction of more than 1,350 kg of green house gas (carbon dioxide) in the atmosphere. The use of solar cooker has also resulted in the decline of pollution in the area. It has created awareness about renewable sources of energy among the devotees who visit the temple and also the nearby villages.

FUTURE PLANS

The Tirumala Tirupati Devasthanam management plan to utilise the surplus steams generated by the solar plant to meet the requirements of Kalyanakatta - where on an average 10,000 pilgrims get their heads tonsured daily.

Recently, in its efforts to reduce green house gas (GHG) emission, the German Government was in the process of buying carbon credits from the solar kitchen of TTD. It identified the TTD kitchen as one of the projects from which it would buy certified carbon reductions (CERs).

After installing world's largest solar steam cooking systems at Tirupati and then at Shri Saibaba Sansthan at Shirdi and creating solar crematorium, Gadhia has now developed world's first and largest solar air conditioning system. The 100 tons AC has already been installed and running successfully from the last 10 months. Gadhia is also in the process of installing 500 kW solar thermal system for captive purposes which will be the first of its kind in the country.

Traditional Smoke filled Kitchen

Eco-friendly Solar Powered Kitchen

HASSLE FREE WATER HEATING SYSTEM
Evacuated Tube Collector Water Heating System

Solar Water Heater at MCM DAV College Hostel, Chandigarh

Growing power tariffs and frequent power outages are driving urban dwellers to look for alternative energy sources, primarily solar energy options to compliment and supplement their energy requirements. Recognizing the growing demand for solar energy products, Synergy Solar Pvt. Ltd., an ISO 9001 – 2008 certified company for the last two and half decades is producing and promoting renewable energy devices like solar water heaters, solar street lights, home lights, solar power plants etc. Synergy solar has successfully installed solar water heating systems in various multi storied residential complexes and educational institutions etc.

Solar water heaters are designed using either Flat Plate Collectors (FPC) or Evacuated Tube Collectors (ETC). In flat plate collectors, there are blackened metallic absorber (selectively coated) sheets with built in channels or riser tubes to carry water. These metallic tubes are placed in an insulated metallic box covered on top by a glass sheet. Solar radiation is absorbed by the metallic absorber, which then transfers the heat to the water flowing inside the metallic tube. An Evacuated Tube Collector consists of double layer borosilicate glass tubes evacuated for providing insulation. The outer layer is transparent and allows solar rays to pass through with minimum reflection. The outer wall of the inner tube is coated with selective absorbing material (Al-Cu-Ss). This helps absorption of solar radiation and transfers the heat to the water which flows through the inner tube.

One of the major problems of FPC based water heating systems is its inability to absorb light from invisible infrared radiation. As a result, FPC water heaters can not heat up the water when it is most required like during peak winters, non sunny days, and days when the sky is over cast and raining thus defeating the sole objective for which water heaters are installed in the first place. However, ETC is designed to absorb heat from infrared radiation also. More over because of double borosilicate glass tube, scaling slides off the outer layer of the tube and gets collected at

the bottom. Vacuum created between the two layers prevents heat loss in to the environment via conduction or convection. ETCs can be serviced without shutting down the system. The ETC once installed can give optimum performance for about 15 to 20 years.

ETC based solar water heating systems have other advantages like:

- Do not occupy large area
- Installations costs are less
- Deposition of salts present in water on and around the water tubes is minimum
- Require minimum maintenance efforts
- Drop in water temperature is very low
- Water does not loose heat into the atmosphere due to convection and conduction

Because of these features of ETC based water heating systems, customers interested in installing solar water heating systems prefer ETC based solar water heating systems.

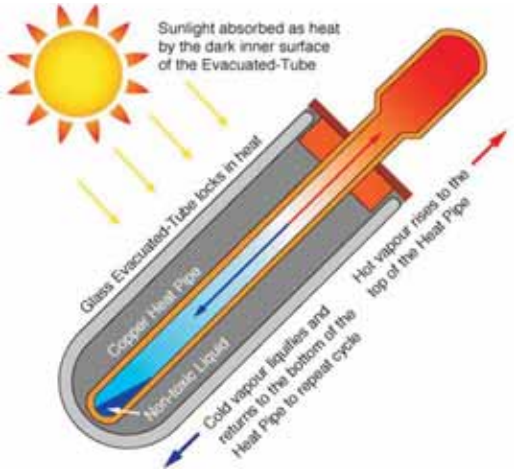
MCM DAV College for Women, Chandigarh one of the clients of Synergy Solar Pvt. Ltd., had installed ETC based solar water heating systems in two blocks of their hostel building.

Using ESCO mode, Synergy Solar Pvt. Ltd., has collected ₹90,000 from MCM DAV College which includes 25% of the total project cost (refundable security for a period of 10 years) and non-refundable installation charges at the rate of ₹20 per litre. Billing is charged at the rate of ₹1.25 per litre of water consumed. The system will be transferred in the name of the beneficiary after 10 years after adjusting the refundable security deposit.

The installed capacity of the solar water heating system at MCM DAV college for women is 4,500 LPD which caters the hot water requirements of approximately 250–300 people. The college is able to save approximately ₹15,000 to 20,000 on electricity bills. The college authorities and students are very much satisfied by the performance of solar water heating systems and the management is planning to install it under the same scheme in other college hostels.

The scope and potential market for ETC solar water heating systems is very high especially for individual households, hotels, hostels and other residential complexes. In peak winters due to high demand often supply is shut down by the government run electricity distribution agencies like, electricity boards, causing great inconvenience to the school going children and office goers etc. Maintaining conventional alternative heating arrangements like heating on gas or kerosene stoves are very time consuming and cumbersome to operate.

At present, state governments offer subsidies to individuals, institutions and industries to install solar water heating systems. However due to lack of awareness and also because of the formalities involved in claiming the subsidies, majority avoid to adopt these technologies. Government institutions and manufacturers of solar water heating systems and other solar energy devices have to actively educate the people about the advantages of using alternative energy devices and promote the use of the same for clean energy and comfortable living.



Evacuated Tube Solar Water Heating Technology by Synergy

UPGRADED WATERMILLS
Generating Synergy between Traditional and Modern Technologies

Nozzle-Spear-Runner

Runner

Himalayan hill region has several perennial streams, rivulets and rivers where water flows down with great speed and force, thus becoming the source for generating hydro power. For centuries people living in these regions use this hydropower to run their flour mills called as “Gharats”. However as these traditional watermills produce less than one kilowatt mechanical power and are able to grind only 5 to 10 kg flour/hour, diesel run flour mills are gaining popularity and are giving tough competition to traditional watermills thereby pushing traditional water mills out of business. Many traditional watermills in the hill state of Uttarakhand are either abandoned or on the verge of closure.

A traditional watermill consists of a grain hopper, mill stones, water chute and a wooden runner. The grinding capacity of the traditional watermill is 5 to 10 kg of flour/hour with an efficiency of less than 20%. Performance of a watermill depends upon:

- The force with which the water hits the runner
- Revolutions per minute (rpm) of the runner and the stone
- Stone dressing
- Gap between bed stone and drive stone
- Weight of the top stone
- Feed rate from the hopper

Based on these parameters, the improved watermill was developed to maximise the grinding capacity of the existing mills stones at an affordable cost, so that the watermills could compete effectively with the diesel mills. In the upgraded watermill design the wooden runner is replaced by a smaller size metallic runner, to improve the rpm, the point at which the wooden chute releases the water jet to hit the runner blade is adjusted in such a way that it can hit the water with greater force. Alternatively a nozzle made of PVC pipe has been introduced. The advantage of the nozzle is it can generate more force even when water flow is less, where as the traditional

Construction of Flow Cannel for Water Mill Unit

open wooden chute needs greater water flow to generate the same force with which it can hit the blades. Shisham bush and the rynd will maintain an optimum gap between the mill stones. Appropriately chiseled groves on grind stones would help the stones get cooled down at high speed milling and prevent them from breaking due to the heat generated at high speed grinding. Grooving also helps in effective grinding of the grain and speed up grinding process.

IT Power India, a renewable energy engineering consultancy firm with an objective to bring out improvements in the way poor communities harness water resources upgraded the traditional watermills by making some simple modifications to the design. The upgraded watermills have a grinding capacity of 20-25 kg per hour in comparison to the 5 to 10 kg/hour output given by the traditional watermills.

IT Power India implemented a pilot project in the Chamoli district, Uttrakhand for The Chamoli Watermill Association (WMA) with a seed money of ₹60,000 assigned to WMA. As part of the pilot project, IT Power India has:

- Provided training on installation, commission of upgraded water mills and demonstrated the upgraded water mills in two districts of Uttrakhand through two training programs
- Conducted training programs for the financial institutions on business prospects of upgraded watermills
- Regularly interacted with watermiller groups and strengthened WMA's awareness on upgraded watermills and helped in their capacity building activities
- Published best practice manuals, leaflets and brochures for promoting upgraded watermills.

Traditional watermill can be upgraded with an initial cost of ₹15,340, inclusive of hardware costs, material costs and labour costs for civil works, channel-GI sheet costs, technical assistance, and installation and commissioning costs. About ₹2,000 per year has to be invested towards

Rice-huller Set-up

meet the initial expenditure, traditional water mill owners interested in upgrading their watermills can avail loans from rural and agricultural banks like NABARD. Some nationalized banks and regional rural banks expressed willingness to provide loans for the same, at 12.5% interest and with repayment period of three years.

Initially WMA helped the interested traditional watermill owners in acquiring loans, site appraisal, procuring the hardware and equipment required for upgrading their watermill, and supervising the installation etc. Originally the mill owners used to earn approximately an annual income of ₹3,500. With upgraded watermill they would be able to earn an annual income of about ₹17,000 with an average case upgrade to ₹22,000 with a best case upgrade. With almost a six fold increase in their income, watermill owners were able to repay their loans on time and also able to meet their own needs.

'Dressing' the Millstones

It is estimated that at one time there were about 2,00,000 water mills operating across various Himalayan states of India. According to a survey conducted in 2003 there were about 2,160 watermills in Chamoli district alone. Out of which 1,150 i.e. about 53% are still functional. Thus the scale up potential for the upgraded watermills is very high.

Moreover upgraded watermills have a positive impact on health as the loss of nutrients in the process of grinding is very minimal. Diesel run mills generate more heat while grinding the grain because of their high rotational speed (700 rpm). High heat damages the nutritional quality of the flour. Upgraded watermills in comparison generate low heat because of low rotational speed (200 rpm) hence retain the nutritional quality. Food prepared using this flour is healthy and tastes better. Women especially prefer upgraded watermills because they need not walk long distances to reach the diesel mills. They can save time in going to the watermill. Earlier with the traditional mills women had to make two trips to the watermill, once to drop the grain for grinding and then to collect the flour from the watermill, as upgrade watermill grinds the flour faster they wait and collect the flour in one trip itself.

Upgraded watermills with three fold increase in efficiency meant more business for the mill owners. According to a market survey, a single household produces around 270 to 350 kg/year of grain including wheat and millets. As an upgraded watermill is expected to process at least 20,000 kg per year, one water mill can provide services to 75 to 100 families.

Upgraded watermills reduce dependency on diesel run mills thereby reducing the consumption of diesel which in turn reduces carbon emissions and save the environment.

Even technologically, upgraded water mills are easy to maintain. In the case of traditional mills the wooden runner has to be replaced once in two years and the wooden blades has to be tightened once in 2 or 3 years, while for upgraded watermills the metallic runner can be used for more than 10 years and only the pin bearing has to be repaired once in 2 to 3 months. The efficiency of the watermill would increase further if a nozzle made of PVC pipe is used as water coming through the nozzle would be able hit the runner more forcefully than the water coming through the wooden chute.

*The Milling House **BEFORE***

*The Milling House **AFTER***

notes