Release of Compendium titled ***Empowering rural India the RE way: inspiring success stories*** by H.E. Mr. Samuel A. Hinds, Prime Minister of Guyana and Dr. Farooq Abdullah, Union Minister for New and Renewable Energy during the International Seminar on Energy Access on 9th October 2012 at Vigyan Bhawan, New Delhi. H.E. Mr. Majid Namjoo, Minister of Energy, Iran, Mr. K. C. Venugopal, MoS (Power) and Mr. Gireesh B. Pradhan, Secretary MNRE were also present.

About the book

India is home to several innovations and successful examples of providing energy access to the remotest areas of the country. However, the challenge is to ensure that access to modern energy is rapidly scaled up, even while ensuring that access is environmentally, institutionally and financially sustainable. This compendium titled *Empowering rural India the RE way: inspiring success stories* contains live examples from different parts of the country of the zeal to bring about change, a determination to surpass barriers in access to energy, and a drive to adopt and promote renewable energy technologies to suit local requirements. The 28 success stories presented in this publication illustrate best practices in expanding access to modern energy. It thereby collates knowledge on low-emission technologies, innovative business and delivery models, entrepreneurship, institutional strengthening, and financing.

We hope this publication will inform and inspire other organizations, in India as well as other developing countries, to attempt to provide sustainable energy solutions to millions of rural households for meeting their energy requirements, for domestic and productive uses. At the same time, this would also be useful for the entrepreneurs exploring business opportunities in the area of energy services for rural communities.

V K Jain
S N Srinivas

Ministry of New & Renewable Energy
Government of India

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emPOWERing rural India the RE way

inspiring success stories

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सत्यमेव जयते
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Ministry of New & Renewable Energy
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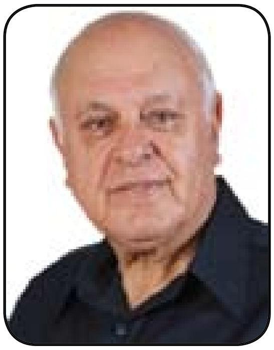

Energy plays a central role in addressing the two great challenges of poverty and climate change. As one of the key requirements for fulfilling human needs, it helps in achieving greater productivity, prosperity, and comfort. Lack of access to modern energy sources means use of polluting kerosene lamps for lighting, cooking with inferior fuels and therefore, extended exposure to harmful smoke and fumes, and in most cases, ending the productive day at sundown. Expanding access to energy for citizens would lead to multi-dimensional solutions for various urgent and interconnected challenges. It would help in bringing improvement to the quality of lives of communities in terms of energy cost savings, health, education, communication, access to information, and would also empower women. It would also contribute towards the generation of more and more economic opportunities for people leading to an increase in their incomes and an increased use of their capabilities. Energy access is, therefore, an essential part of any vision of inclusive growth.

I am happy that the Ministry is bringing out a compendium of energy access projects installed across the country. These projects demonstrate how even the remotest areas of the countrycan be given access to energy through various renewable sources of energy.

Nearly all these projects have shown immense potential in scalability, technology demonstration and sustainability. Many of them also have innovative business models backing them. I hope that lessons from these projects will be useful for government, entrepreneurs and multilateral institutions alike. I also hope that these lessons will educate, instruct and advise all other stakeholders who are involved in tackling the challenge of expanding energy services to the un-served people and are keen to ensure that this access happens rapidly, sustainably, and affordably.

Dr Farooq Abdullah
Minister, Ministry of New and Renewable Energy,
Government of India

Message

Empowered lives.
Resilient nations

Access to modern energy services is a major driver of inclusive growth and human development. One third of the world's population, 1.6 billion people, most living in Africa and Asia-Pacific, have no or little access to electricity or clean energy options.

The United Nations Development Programme (UNDP) is committed to supporting achievement of the global targets of the UN Secretary General's Sustainable Energy For All initiative. By 2030, the goal is to provide universal access to sustainable energy for everyone. This will not be easy.

Expanding energy access to poor families and communities is a complex development challenge, particularly in rural areas. In India, 400 million people do not have access to electricity and 625 million people depend on biomass as traditional cooking fuel. There are limitations to the expansion of the electricity grid as well as supply of electricity through the grid. Diesel and kerosene, neither of which are sustainable solutions, are being used to fill the gap.

UNDP is proud to support the Government of India in expanding access to sustainable energy options by building national capacity for sustainable energy development through renewable energy, promoting best practices, and supporting strategically selected interventions.

We are pleased that the Ministry of New and Renewable Energy (MNRE) is bringing out a compendium *emPOWERing rural India the RE way – Inspiring success stories* to be released at the International Seminar on Energy Access on 9th October 2012.

The compendium details the demonstration projects and business models piloted in various parts of India, many of which have successfully used technically viable and replicable clean technologies for enhancing energy access.

These case studies demonstrate the importance of an integrated strategy that: a) ensures that the energy solution is appropriate, b) involves the communities which will use energy in the design of the solutions, c) builds commercially viable markets for energy products and services, d) secures adequate financing and e) is supported by the right energy policies.

Together, these case studies tell a convincing story of transformation of lives and livelihoods of the 'energy poor' by providing access to clean/modern energy. They are good stories that show that the deployment of renewables leads to substantial reduction of local pollution and avoids Green House Gas emissions.

The hope is that they will inspire India and other countries to address the steep technological, institutional and market challenges faced in expanding access to modern energy.

LISE GRANDE
UN Resident Coordinator
UNDP Resident Representative

FOREWORD

Ensuring energy access to all is a key catalyst for economic and human growth. However, extreme poverty inhibits people from gaining access to essential energy services, resulting in a vicious cycle. Lack of access to energy (energy poverty) and its impact on human welfare, including health of women and children, education and income, continues to be a significant cause of poverty in developing countries.

Though the countries in South Asia and Sub–Saharan Africa, together with the international community at large, are engaged in supporting change-related initiatives to increase access to clean, reliable, and affordable energy services (modern energy), a huge gap still remains. According to the IEA (International Energy Agency) estimates, there are almost 2.7 billion people (about 40% of the global population) who rely on the traditional use of biomass for cooking and at least 1.3 billion people (20% of the global population) do not have access to electricity. It is also reported that more than 95% of the people lacking access to modern energy services are either in Sub-Saharan Africa or developing Asia and 84% live in rural areas.

In India too, the situation is not different. In spite of several policy initiatives undertaken by the Government of India in the recent past, with significant progress in extending the national grid and the scaling up of decentralized distributed generation models using renewables, challenges continue. Recent estimates reveal that almost 400 million people in the country lack access to electricity and a significant proportion relies on firewood, animal dung, and agricultural residues for cooking and heating. Although the grid has been extended to a large part of the country, even in electrified villages, electricity supply is erratic and unreliable. The annual per capita consumption of electricity in rural areas is about 100 kWh (kilowatt hour) against the national average of 780 kWh, the latter itself being far lower than the world average.

At the same time, India has considerable experience and is home to several innovations and successful examples of providing energy access through renewable sources of energy to the remotest areas of the country. These also have a scale-up potential in other parts of the world. It has also been well established that the cost of decentralized renewable energy decreases in comparison to conventional grid-powered electricity; the farther away from the grid the electricity is used. However, the challenges before us are to ensure that this access happens rapidly, while ensuring that the sustainability-related constraints are taken into account. I am of the firm view that renewable energy technologies, which permit local control of the energy resources and power generating systems, are suitable for smaller applications and can offer a viable means of providing electricity and clean fuel to the presently un-served people, besides, creating employment and entrepreneurship opportunities, mostly in remote and rural areas. However, this requires tremendous innovation in technology choices, supportive policy frameworks, and mobilization of additional public and private financial resources.

The case studies, included in this compendium, handpicked from different parts of the country, are living examples of the zeal to bring about a change, the determination to surpass the barriers, and the urge to adopt and promote renewable technologies to suit local requirements. These projects are based on a variety of renewable energy technologies, specific to regional and state conditions and carry tremendous promise in providing crucial lifeline services to the bottom of the pyramid through energy access. Many cutting-edge practices and pathways act as an instrument in mobilizing communities to take charge of their own development and most importantly aid in livelihood enhancement and poverty reduction. These successful examples also illustrate good practices and lessons learned in expanding energy access and collating knowledge for dissemination of low-emission technologies, innovative business and delivery models, entrepreneurship, institutional strengthening, and financing.

I believe that the publication, which provides illustrations of a few successful attempts, will show the way to many other organizations, not only in India but also in other developing countries to attempt similar projects for providing sustainable energy solutions to millions of rural folk for meeting their cooking, lighting, and other energy requirements, besides enhancing their livelihoods. At the same time, this would also be useful for the corporate sector in developing business opportunities in this area.

Gireesh B. Pradhan
Secretary, Ministry of New and Renewalble Energy,
Government of India

Preface

Energy availability, particularly in a convenient form, is a major issue confronting the poor of the world. Despite dedicated efforts by respective governments and international aid agencies to improve the situation, current estimates indicate that about 2.4 billion people have nothing other than traditional biomass to rely on for satisfying their energy needs. Further, about 1.6 billion have no access to electricity globally. In India, an estimated 364 million people live without access to electricity and 726 million people rely on biomass for cooking. This indicates the need for enormous efforts to ensure energy access for all, which is also the objective of Sustainable Energy For All (SEFA), an initiative launched by the United Nations Secretary General.

Expanding energy access to poor households in rural and remote areas is a complex development challenge. The task of expanding access to modern energy, both for domestic and productive uses, to the 'energy poor' poses a formidable challenge to planners and development practitioners. There are limitations to the expansion of the electricity grid as well as supply of electricity through the grid. There are constraints to providing acceptable and affordable solutions to meet energy requirements especially in the rural and remote areas. A part of the gap is known to be met by the use of diesel and kerosene, which are exhaustible and highly volatile in availability and costs. Use of inef cient energy conversion devices such as traditional cookstoves not only results in indoor air pollution but causes stress on natural resources as well.

There is considerable scope for the use of renewables in bridging this gap. The compendium Empowering rural India the RE way: inspiring success stories brings out the experiences of entrepreneurs, non-governmental agencies, and development practioners in their bid to provide access to clean energy to the poor in rural and remote areas of the country. The studies presented primarily cover three sources of renewable energy—bio-energy, micro-hydro, and solar. But what binds them together is the commonality in their objectives: providing affordable and clean energy to the poor to meet their lighting, cooking, and thermal needs.

Covering pilot projects and innovations in business models and technologies, these 28 successful cases demonstrate the need to (a) get the energy solution just right, (b) involve communities, which will use energy in the design of the solutions; (c) build commercially viable markets for energy products and services; (d) secure adequate financing; and (e) have supportive energy policies.

Together, these case studies tell convincing tales of transformation of lives and livelihoods of the 'energy poor' brought about by access to modern energy. An added dimension attained through deployment of renewables is the substantial reduction of local pollution and GHG (greenhouse gas) emissions. We feel this is the most appropriate time to bring out this compendium to highlight and emphasize upon the importance of the year 2012, which has been declared the International Year of Sustainable Energy for All. This global initiative aimed at facilitating access to energy for the entire world by 2030 has the following focus:

- Providing universal access to modern energy services.
- Doubling the global rate of improvement in energy ef ciency.
- Doubling the share of renewable energy in the global energy mix.

We hope the examples carried in this publication will encourage developing and under-developed countries to address the steep technological, institutional, and market challenges being faced in expanding access to modern energy. If some of them replicate the best practices presented here in the times to come, we would consider that the very objective of publishing this compendium has been met. We would like to thank the contributors to these 28 case studies presented in this compendium. A number of people/organizations were involved in making the interventions: (1) implementing agencies who implemented the pilots (NGOs, ministries/departments, individuals, etc.); (2) funding agencies (such as Government of India, state governments, multilateral agencies such as the like UNDP (United Nations Development Programme) and the Global Environment Facility; (3) bilateral agencies such as Swiss Agency for Development and Cooperation) who provided technical assistance and financial support; and (4) beneficiaries who patiently endured the trials and accepted the interventions. Financial assistance of MNRE (Ministry of New and Renewable Energy), Government of India, and UNDP for the publication is greatly acknolwedged. Thanks are also due to the senior of cials at MNRE for having guided the publication of this compendium. We acknowledge the support of Mr Rohit Kansal, Joint Secretary, MNRE, and Mr Srinivasan Iyer, Assistant Country Director, UNDP, for providing inputs in conceptualizing the compendium. We offers our sincere thanks to of for help in the ;and Ms Chitra Narayanaswamy of UNDP for reviewing some of the case studiesThe publication of this compendium would not have been possible without the publishing services support provided by ADCS (Academic and Development Communication Services) at a short notice.

S N Srinivas
V K Jain

Bio-energy

CASE STUDY 1

BIO-ENERGY

Providing biomass energy for rural India*
the story from Karnataka villages

The BERI (Biomass Energy for Rural India) project is conceptualized at developing and implementing a bioenergy technology package to reduce GHG (greenhouse gas) emissions and to promote sustainable and participatory approach in meeting rural energy needs. The total budget for the initiative is $8,623,000 and the project proponents include the GoK (Government of Karnataka); Gram Panchayat people's representatives, private investors, and people residing in the targeted project villages; UNDP (United Nations Development Programme) funded by the GEF (Global Environment Facility); and co-financed by the ICEF (India-Canada Environment Facility); GoK; MNRE (Ministry of New and Renewable Energy), GoI (Government of India); and beneficiaries.

The project is being implemented since 2001 in five village clusters consisting of 28 villages in Tumkur district of Karnataka. The project has been designed to showcase bioenergy technologies that include bioelectricity produced from biomass gasification, community biogas plants, and ef cient cookstoves. It was designed in such a way that the bioelectricity produced makes use of the biomass coming from energy plantations raised for the purpose.

Energy plantation, biomass gasifier plants, and evacuation of power

It was estimated that to run a 1000-kW biomass gasifier plant, approximately 3000 ha of land and a biomass yield estimated at 12,000 tonnes per year (4.2 tonnes per hectare per year) were required. Tree plantations were raised in 2930 ha (1983 ha of forest land and 947 ha of tree-based farming) to support the biomass requirements of the power plants. It has supported the livelihoods of over 240 women in 81 SHGs

Jasmine crop grown through irrigation facility provided under BERI project in Kabbigere village

* *For further information, contact:* Dr E V Ramana Reddy, IAS, E-mail: principalsecretaryrdpr@gmail.com

(self-help groups) who raised about one million seedlings. Thirty households have been employed for tree-based farming.

Gasifier-based plants were established in three clusters. A 500-kW capacity system was installed in Kabbigere (including two gasifier systems of 100 kW each and one of 200 kW using 100% producer gas and another with 100 kW dual fuel). These plants together have generated 1,520,000 kWh of electricity as of June 2012. In addition, two more gasifier-based power plants of 250-kW capacity each have been installed in Seebanayanapalya and Borigunte.

Biomass gasification system

The power generated is evacuated to the BESCOM (Bangalore Electricity Supply Company) grid. Generation and distribution are synchronized to the grid through a dedicated 11-kV transmission line. The BERI Society and Tovinakere Grama Panchayat have signed a first-of-its-kind PPA (power purchase agreement) with BESCOM to sell the power produced to the state power utility. The tariff set was Rs 2.85/kWh.

Operations of the gasifier power plant

Biomass is raised on the plantation. The VFCs (village forest committees) are involved in managing the plantation. The VBEMC (Village Biomass Energy Management Committee) and panchayat together are involved in taking decisions in biomass procurement and gasifier plant management. The power generated is metered and evacuated to the grid. A diagrammatic representation of these linkages is shown in figure 1.

Engagement with the local community

Four NGOs (non-governmental organizations) were identified to work with the communities to create awareness on energy issues and promote the project. They are BIRD-K, Mother, IYD, and Srijan (Table 1). The activities included provision of borewells, laying of drip irrigation systems, and construction of community biogas plants and improved cookstoves for village households.

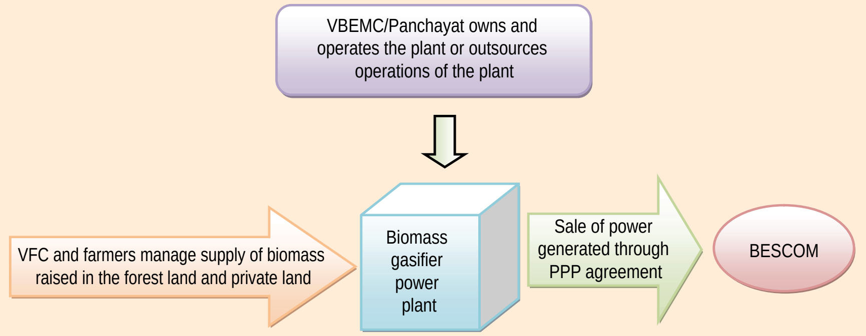

Figure 1 Flowchart of operations

Table 1 NGOs involved in the project

S. No.	NGO	*Cluster*
1.	BIRD-K	Koratagere (5 villages)
2.	BIRD-K	Madhugiri (5 villages)
3.	MOTHER	Gubbi (7 villages)
4.	IYD	Tumkur (5 villages)
5.	SRIJAN	Sira (6 villages)

Community borewells, biogas plants, and improved cookstoves

Fifty-six borewells were dug benefiting 127 households. The borewell water is shared among three to four neighbouring families. These borewells are connected with drip irrigation systems that ensure saving water and have reduced the energy required for pumping it from a depth of over 300 feet. The project has leveraged other schemes of the government, such as RLMS (Rural Load Management Scheme) that has ensured better quality of power for longer durations, to benefit the villagers.

Other initiatives have been construction of 51 small community biogas plants estimated to have generated more than 95,000 m^3 of biogas. Provision of improved cookstoves in households has helped reduce the fuel consumption and indoor air pollution.

Community irrigation programme

The creation of WUAs (water users associations) is one of the most critical initiatives of this project. The project area is primarily rainfed and farmers in the project area mostly grew rain-fed crops like ragi and jowar. As an entry point activity, and a long-term strategy, the establishment of community irrigation systems was facilitated. The borewells were dug in the project village and the plan was that they would be ultimately run through biomass-based electricity produced under the project. The main purpose of this programme was to augment existing livelihoods, generate income, improve the socio-economic condition of poor farmers, and cultivate the habit of paying fee for service.

Most importantly, these activities brought in and put in place platforms for discussions, discipline, awareness, and rules and norms, which bound the larger community. These served a larger purpose of community ownership and the spirit of working together.

Project impacts on the community, its scalability

Under the project, a 1-MW biomass gasifier power plant has been installed in three villages in Koratagere taluka. These systems together have generated approximately 1.5 million units of electricity by 30 June 2012 contributing to a reduction of 1200 tCO_2.

An analysis during the last year showed that the cost of power generated is in the range of Rs 4.50 to Rs 8.28 per kWh depending on the PLF (plant load factor), quality and cost of biomass, optimization in operation, and so on. The revenue generated by selling it to the grid was only Rs 2.85 per kWh (tariff support by the government). Hence, the tariff support needs to be addressed to encourage small-scale power production.

The small-scale power production has significant intangible benefits such as green cover, increase in rural economy, and employment. The energy plantation in 3000 ha was expected to yield 12,000 tonnes annually. However, it is yielding only about 5000 tonnes per year.

One of the estimates indicates that these plantations have resulted in sequestering approximately 26,580 tCO_2 annually. Fifty-one group biogas plants were installed and according to a survey carried out in 2010, 40 of them were functional. These reduce 148 tCO_2 annually. The project details and technical performance data are uploaded on the website, which is perhaps the only project uploading basic data (www.bioenergyindia.in).

The distribution of cost of production of this biomass power is as follows: 57% on fuel (biomass), 18% fixed cost, 15% maintenance, and 10% on labour. Thus, the project provided enormous social benefits as 45% of total generation cost remain within the community. The project spread in 28 villages also provided 32 borewells for 127 farmers, and 20 community borewells. These have resulted in increased crop intensity – more than two crops per year now – which, in turn, has increased farm income by 20%–30% (now it is about Rs 40,000–50,000 per acre). The project established 26 village bio-energy management committees, 26 village forest committees, and 72 new SHGs, and strengthened 68 old SHGs covering 2244 households (74%), 31 WUAs (216 hhs) and 33 biogas user groups (BUGs).

The project has invested about Rs 7 crore on the 1-MW power plant. When fully operational, it can generate Rs 1.5–2.5 crore per year by selling power. Assuming a per capita income of Rs 12,000 per year (Tumkur district), in a typical grama panchayat with about 8000 persons, the turnover can be about Rs 9 crore. The project is spread over 4 grama panchayats, and thus the total turnover is about Rs 35 crore. Therefore, such a green intervention can enhance the overall income by about 7%–8%. It can also add to employment. About 100 people can be employed in the management of bioenergy packages that largely include biomass power generating units. In addition, employment in the plantations management and nursery arrangement can also add to green outcomes.

Scale-up potential

BERI appears to be a replicable model of provision of tail-end support to base loads and has showcased how distribution of decentralized power can benefit local communities. If tariff support is restructured, especially at sub-megawatt scale, it has the potential to replicate, proliferate, encourage entrepreneurs and benefit rural populace. The decentralized unit would ensure no or low transit loss and cost associated with energy losses during transmission. Fast-growing species like *Prosopis juliflora*, *Lantana camara*, Epil-epil (Subabool), Glyciridia, and bamboo in dedicated energy plantations can provide the fuel supply linkages and can enhance the green cover and carbon sequestration.

CASE STUDY 2

BIO-ENERGY

From destructive pine to productive fuel*

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

In 1999, a devastating fire burnt more than Rs 600 crore of forest wealth in the Garwhal and Kumaon regions. As per the report of the NSRA (National Remote Sensing Agency), Hyderabad, about 22.64% (5086.6 km^2) of forest area was burnt while about 1225 km^2 was affected severely. In 2008, the forest inferno also claimed the life of a woman and her child while she was trying to douse the fire to save her home.

Equipment for gasification of pine needles

* *For further information, contact:* Mr Rajnish Jain, E-mail: rajnish@avani-kumaon.org

The forest fire not only affects the f ora and fauna of the region, but also hampers the lives of about 70 lakh people residing in the central Himalayan region close to the large tracts of pine forests. Additionally, it also reduces 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. However, it is a source of fuel wood for the nearby villagers. The combustible pine needles that carpet the forest are one of the several causes of forest fires.

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, the organization aims to set up an enterprise involving unemployed youth. This initiative will involve the collection and utilization of 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 a huge potential for generation of electricity through gasification, which is a comparatively cheaper, easily accessible, and durable technology for the state.

Pine-based gasifier

A 9-kW gasifier developed by AVANI is already being utilized at its centre in Pithoragarh, Uttarakhand, for the last three years. Out of this, 1.5 kW of power is used 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 Rs 4.85 lakh. However, a 100-kW gasifier would cost approximately Rs 48 lakh.

Avani Bio Energy Pvt. Ltd is now in the process of setting up a 120-kW power plant in Chachret village of Pithoragarh district of Uttarakhand. The following have already been achieved in terms of project implementation.

- PPA with UPCL has been signed
- Permission received from the forest department for collecting pine needles
- Funding has been received for setting up the power plant
- Land has been made available by community members for setting up the power plant
- Cooking trials with charcoal briquettes are being done in the village
- Technicians/operators are also being trained

The capital expenditure for the project is Rs 70 lakh with an expected 17% return on investment. The power plant will be operational by December 2012 and start commercial production by March 2013.

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

Making fuel briquettes with residual charcoal

Training of operators

a series of filters consisting of saw dust and fine cloth to remove tar and other impurities. A modified diesel engine thus runs on the resultant 100% producer gas.

The AVANI project does not limit its scope to generating electricity. It also aims to usher in a 'green economy' for the villagers by making their livelihood environmentally and economically sustainable. It proposes to address the interdependent issues of employment and health and also improve the overall life quality 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, which is, 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 a smoke-free environment to the villagers. The gasification process produces about 10% residue, which incidentally is high-quality charcoal. This, in turn, is used for cooking in village households. Residue from a 120-kW gasifier system will be suf cient 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. Using charcoal as a cooking medium in place of fuel wood will result in many benefits for the villagers. It will save time, improve health of the women, and provide a smoke-free environment thereby reducing all health-related issues.

As a renewable energy project, the pine-needle gasifier contributes towards reducing GHG (greenhouse gas) emissions. It is also an alternative to LPG as a cooking source.

The project has many advantages at the macro level as well. It will indirectly contribute to enhancing ground water recharge, regeneration of biodiversity, and reduction in fire-fighting efforts.

Efforts are already on at AVANI to install gasifiers in two villages, namely, Malla Balta and Talla Balta, belonging to the same Gram Sabha in Almora district, Uttarakhand, by the end of 2012. These villages, like many others in the area, are surrounded by pine forests. 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.

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 f oor without providing any useable energy, the project will further contribute to the reduction in carbon emissions by eliminating all those wasted emissions.
In many earlier projects, AVANI had focused on capacity building of the local residents for technology and management. Taking a leaf from these projects, the organization proposes to set up an enterprise employing unemployed youth who will be trained to operate and maintain the gasifier.

Pine-needle collection will generate employment opportunities for the villagers. It is estimated that one family can collect up to 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

Cooking on pine needle charcoal fire

disparity at the village level. While the unemployed can earn wages by collecting pine needles, every family in the village can buy charcoal for cooking including the economically better-off families in the village, who may not participate in pine collection. The surplus generated through sale of electricity will help in employing more local youth for collection of pine needles, as the demand increases, and thereby create a sustainable livelihood for the villagers.

Environmental advantages

Removal of pine needles from this area will benefit the biodiversity of the region in general. The monoculture of pine, over a period of time, as an exotic tree has degraded the biodiversity of the Himalayas. 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 thereby causing soil erosion and inhibiting the recharge of ground water. 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. This hampers the growth of different variety of plants, which is essential 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 will also help in restoring the moisture regimen and all the benefits associated with it. In the absence of pine needles, other plant species can thrive and a mix of different trees and plants will enrich the biodiversity further. Improved moisture content will, in the long run, help the farmers to grow and reap better crops. Regeneration would also improve other local applications like the use of timber medicine fodder, and fibre-yielding plants, as well as water and fuel availability. This will help in 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 cleaner 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 will 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 of replicating this gasifier model in the central Himalayan region since pine needle is found in plenty. A pine forest area of 1 m^2will yield 1.19 kg of pine needles. A 100-kW gasifier running for 24 hours will require 4500 kg of pine needles, and 115 ha of cleared forest every year will give 1350 tonnes of pine needles per year.

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

Bio-energy

Biomass gasifier for electrification of cluster of villages*

an Ankur Scientific experience

Ankur Scientific, a company founded by Dr B C Jain is situated in an eco-friendly environment in Savli, Vadodara, the industrial city of Gujarat, and is a global technology leader dealing in RETs (renewable energy technologies) for over 25 years. The company has created an enviable position for itself in the area of biomass gasification systems. Ankur Scientific, apart from having credits of ISO 9000, ISO 14000, OHSAS 18000 and CE certifications, also exports its systems to about 30 countries. It also has numerous installations within the wide cross-section of Indian industries.

The MNRE (Ministry of New and Renewable Energy), Government of India, is exploring the possibility of generating 10,000 MW of power in the next 10 years from surplus biomass, both agro and forest residues and also by way of dedicated energy plantations. In addition to this, lower capacity biomass power plants could be set up for feeding power at the tail end of the grid (11 kV line). These plants would ensure that power reaches many villages in rural India. It would also have several other benefits such as the ones listed below.

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- Small plants of up to 2 MW help in improving the voltage of the 11-kV grid as also the power factor. The grid frequency stabilizes and limits transmission and distribution losses to a large extent (about 7% losses are prevented)
- Greater probability of success and long-term sustenance
- Creation of large-scale employment for unemployed/partially employed rural people
- Likely creation of a large number of small entrepreneurs in rural areas
- Rural 11-kVA grids become net producers of electricity thus ensuring uninterrupted power supply to rural areas
- Round-the-clock/on-demand generation of electricity and hence ability to meet peak demand
- Very short gestation periods of a few months
- Almost 80% of the cost of generation is returned to the local economy through purchase of biomass and creation of local jobs
- Perennial and sustainable green power and, therefore, mitigation of global warming
- Increased, long-term self suf ciency on the energy front
- Potential for cogeneration through inclusion of cold chains in the power projects
- Greening of barren and waste lands through production of sturdy energy species as small plants are conducive to energy plantations, leading to afforestation

The power plant at Sankheda, Vadodara

Recognizing the above benefits, Ankur Scientific has set up a 1.2-MW grid-connected, biomass power plant based on its own gasification technology in Sankheda Taluka of Vadodara district. This project is the first of its kind in Gujarat and also the first project to be set up under the status of 'Model Investment Project' implemented by MNRE and UNDP (United Nations Development Programme) with partial financial assistance from both.

Dr B C Jain (Chairman, Ankur Scientific), Mr D P Joshi (Director, GEDA), and Mr V K Jain (Director, MNRE) with Mr Deepak Gupta (former Secretary, MNRE) at Ankur's Sankheda Plant

The project was commissioned in a record time of about six months, including identification of land, biomass surveys, acquiring permissions, manufacturing, and import of state-of-the-art equipment. This would not have been possible without the unstinted support of the local villagers and farmers, panchayats, the taluka of ces, the collectorate and departments of land conversion and town planning, the District Industries Centre, the pollution control board, the Gujarat Energy Development Agency (the state nodal agency of MNRE), the Madhya Gujarat Vij Company Ltd, the Gujarat Energy Transmission Corporation Ltd, and MNRE. The project includes many innovations as listed below.

Fuel supply linkage

The major reliance of biomass is on crop residues of the common crops available near the project site, mainly cotton, *tur*, and astor stalks, mango seeds, and corn cobs. The surrounding area of the project site is rich in cotton, *tur*, and maize cultivation. The farmers and villagers very willingly give their agri-residues, which, in turn, provides them with some added revenue for these otherwise wasted products that were generally burnt.



Development of entrepreneurs for secured and sustained fuel supply

Ankur Scientific is also developing entrepreneurs out of these farmers and villagers for secured and sustained fuel supply. This is because the villagers and farmers are taking interest in the project and getting some additional revenue out of the waste feedstock. A few young enthusiasts amongst the villagers and the farmers have been identified and trained into becoming entrepreneurs. They then manage the supply chain on a sustainable basis.

Technology

Ankur Scientific has installed two woody biomass-based gasifiers designed and manufactured by them and coupled to three units of 400-kWe each running on 100% producer gas engine gensets.

The following innovations have been included in the power plant.

Biomass-based gasifiers

Waste heat recovery for biomass drying

The waste heat/f ue gas from the exhaust of the two engines is being used for biomass drying. The f ue gas is being used in the two bin dryers with a total capacity of 16 m^3, which is suf cient to meet the dried biomass requirement of the two gasifiers. The bin dryers reduce the moisture content in the biomass to less than 20% as that is preferable in 'Ankur' systems.

Waste heat recovery for VAM chiller

The Ankur biomass gasification system requires chilled water for the heat exchanger to cool the producer gas and condense the moisture in the producer gas. A normal scroll-type chiller is used for this purpose wherein the power consumption of the chiller is about 45 kWh.

To reduce the power requirement for the overall auxiliaries, Ankur is recovering the waste heat/f ue gas from one of the engine exhausts transferring it to hot water through a heat exchanger. This hot water is then fed into a VAM chiller to generate 36 TR chilling with a temperature profile of 13–8 ^{0}C. In this case, the total power requirement for the VAM chiller including its auxiliaries would be about 17 kWh.

Utilization of charcoal/biochar

The quantity of char produced is approximately 5% of the weight of the biomass used. Further, the char is discharged through the dry ash char removal system and collected in bags. Hence, no f y ash is generated.

Char from Ankur gasifier has a reasonably high calorific value and is useful as a fuel for small-scale industries requiring thermal energy. It can also be used as filler-cum-fuel by brick kilns filler in concrete hollow bricks, or as a raw material in the manufacture of precipitate silica. Therefore, part of this is sold off to such units at a nominal price.

Char from Ankur gasifier

Briquetting of char

The char discharged from the systems is segregated as follows.

- Sizes above 10 mm are partly sold and partly given to the villagers for cooking. Ankur Scientific, as a part of its corporate social responsibility, has developed a special charcoal stove and distributed the same to the local villagers for smokeless cooking.

- Sizes between 1 mm and 10 mm are used for briquetting. A separate briquetting machine has been installed at the project site and the briquettes thus made are partly sold to industries for their thermal application and partly given to the local villagers for smokeless cooking.

Biochar from 'Ankur' gasifiers: a boon

Char of size less than 1 mm is used as biochar. Biochar is the carbon-rich product when biomass is heated with little or no available oxygen.

The properties of biochar and its potential impact on soil are listed below.

- Has 7%–10% ash and 70%–75% fixed carbon
- Calorific value ranges from 5500 kcal/kg to 6500 kcal/kg
- Enhances the health of the soil

- Increases the pH of acidic soils (as biochar is typically alkaline)
- Increases water and nutrient retention
- Biochar carbon is chemically altered during gasification and is thus resistant to attack by micro-organisms
- Biochar carbon can remain stable for long periods of time (100 to 1000 years)
- It is an important way of storing carbon that has been scavenged from the atmosphere during photosynthesis

Snapshots from the field

BIO-ENERGY

Electrifying rural India with husk power*

In remote villages sans electricity, a silent revolution is literally electrifying lives. Today more than 300 villages and hamlets with over 200,000 villagers residing in the rice belt of India are the proud beneficiary of HPS (husk power system), a financially sustainable and environment-friendly village generator.

The genesis of HPS has been more an evolution than serendipity. What started as a casual conversation between two childhood friends in 2002 – one in his of ce at Los Angeles and the other in his of ce at Patna – took over five years to come to fruition. The duo sincerely felt the need for rural development especially in Bihar. They also saw immense opportunities throughout India. Rural electrification was more of a necessity than an option. The conventional technologies and grids have failed to deliver and the pervasive energy starvation in the country is a rather known reality. A solution that used non-conventional technology for distributed generation of electricity was a no-brainer.

What needed years was finding the right technology that fit the economic model for the rural space. A hunt that dedicated efforts from nanotechnology-driven polymer solar cells to jatropha-based bio-diesel, and pretty much everything in between, only led to the realization that how the different non-conventional technologies employing renewable resources lacked substance when it came to applying them to solve a broader problem.

Having run out of the more talked about and presumed promising options, a chance encounter with a gasifier salesman, Mr Krishna Murari, proved to be a fresh ray of hope in the so far rather frustrating pursuit of the two friends. They learnt how several rice millers in the state of Bihar were using the decades old technology of biomass gasification to power their mills using rice husk – largely a no-good by-product of their operations. Rice husk – perhaps the only bio-waste in the lives of rural folks – was the perfect source to power the dream of rural electrification. There was a catch though. All of the prevalent rice husk-based gasifier systems ran in what is called the 'dual-fuel' mode of operation where the producer gas produced by the gasifiers was used in conjunction with 35%–50% diesel to power the diesel engines. This suited a rice miller just fine by saving him 50%–60% diesel but was not good enough to fit the economic model of rural electrification.

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The obvious question was, why not use gasifier-based systems in 'single fuel mode' without any diesel. The answer, from multiple research sources in many reputed institutions, was very negative. Rice husk, an amorphous and low-density fuel produced a gas that had very high tar content and was rather dirty in general. The experts deemed it unfit for the single-fuel mode of operation.

Having demonstrated remarkable yield levels in one of oldest IC Fabrication units of North America, Gyanesh did not see it as much of a problem. The simple thought was, dirty gas can clog the engine but if the engine is cleaned before the clog hampers the operation, why can't it work. The concept was much appreciated by MNRE (Ministry of New and Renewable Energy), and without any previous experience with biomass gasification, the persevering duo undertook the revolutionary task of shifting the paradigm in the rural as well as renewable energy space.

Under the guidance of MNRE, 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.

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, the 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. The uniqueness of this approach is that this willingness is not just verbal from all the involved households. They also have to give a token installation charge of Rs 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 first plant in Jamkuha Village

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 the 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, whereas the other one is an electrician for the cluster of villages.

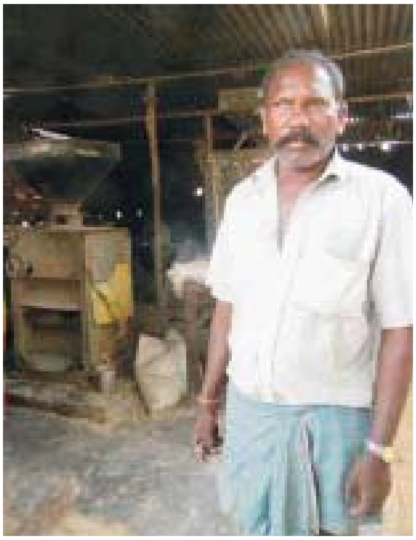
Besides trained manpower, HPS has also taken due care to ensure smooth supply of low-cost raw material. These generators are demand driven so there is never any problem in getting back the electricity charges from the villagers. At the market end, the promoters have evolved a strong relationship with 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 seven to eight 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 standard fixed-bed, down-draft gasifier technology, 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 Rs 45 per CFL of 15 W, whereas shops pay per month charge of Rs 80 per CFL. For households seeking connection to operate fan, television, and so on charges are calculated on similar wattage basis. The cost of electricity is not a barrier to the villagers/shop keepers because of the added advantage, which electricity brings to their life.

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



HPS partners: a rice mill owner

For 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 source of manure and fuel for cooking or even for use as rice husk ash 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 a strong system

Beneficiaries of HPS electricity: Dinesh, a vendor

Enthused by the response received from people, HPS is growing from strength to strength. It has institutionalized the standard procedures and practices like commissioning of the power plant, and its 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 more than 75 existing plants in 5 districts and installation of about 20 plants is in the pipeline. The organization is expecting to meet the target of electrifying more than 5000 villages and hamlets by 2017.

It is a 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, the future is extremely bright for both the system as well as the people living in off-grid villages, especially owing to their long-term plan of linking the HPS to carbon credits.

CASE STUDY 5

BIO-ENERGY

A dream comes true in Saran village, Bihar*

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

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

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

Local dhaincha *plantation*

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One can say that Bihar still remains an underdeveloped state, thanks to the power scenario. The abysmal power scenario has given birth to many social entrepreneurs across the state, who in their efforts to improve and develop their home state, have set up renewable energy projects to electrify pockets of the state aspiring to extend their projects.

Foundation of Saran Renewable Energy

One such entrepreneur who dreamt of providing electricity access to this small village is Mr V K Gupta. 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. Mr Gupta always wanted to find a solution to this problem—to bring electricity to his home town. Therefore, when ICICI Bank, where he was employed, was considering setting up renewable energy projects as part of its CSR (corporate social responsibility), Mr Gupta thought about his dream. He asked his cousin Ramesh Kumar to carry out a feasibility study on the availability of land and the fuel, and electricity demand in Garkha, Bihar.

In 2006, he set up SRE (Saran Renewable Energy), a small family-owned firm with his brother and grain merchant father. SRE has built three biomass gasification plants in the Saran district of Bihar and is in the process of setting up three more such plants as a part of its plan to set up 100 off-grid village electrification power plants over the next three years.

These power plants gasify biomass purchased from local farmers to generate electricity, which is then sold to local households, farmers, and businessmen.

Garkha, a densely populated village, was plagued by unreliable supply of electricity forcing people to opt for high-cost and polluting diesel generators. The gasifiers have now replaced these generators and supply power to nearly 1000 businesses and households, a school, and two medical clinics.

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. Two 3-kV transmission lines, each 1.25 km, connect them 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 license from the IISc (Indian Institute of Sciences), Bengaluru. Gas engines are used to generate electricity.

A suitable raw material

When Mr Gupta was searching for a location, one vital prerequisite 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 six to eight 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 use 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 was otherwise lying waste. Moreover, growing this crop was easy as it does not require any fertilizer or special care. SRE introduced *dhaincha* carefully and did not mix it with other food crops. *Dhaincha* not only earns from an otherwise water-logged land that was uncultivated, but also has nitrogen-fixing property. This is useful for the soil and may reduce the need for fertilizers and improve the environment.

Use of wastelands for biomass production is one of SRE's key innovations that will help in sustainable development and also sustain the power plants in the long run. SRE is using low-lying lands, which are waterlogged due to excess rain/river water for most part of the year, and hence no crops or trees can be grown in these lands. There are other lands that are waterlogged in monsoon months and hence only one crop can be grown in the winter season.

Water-resistant plants being sown in wastelands

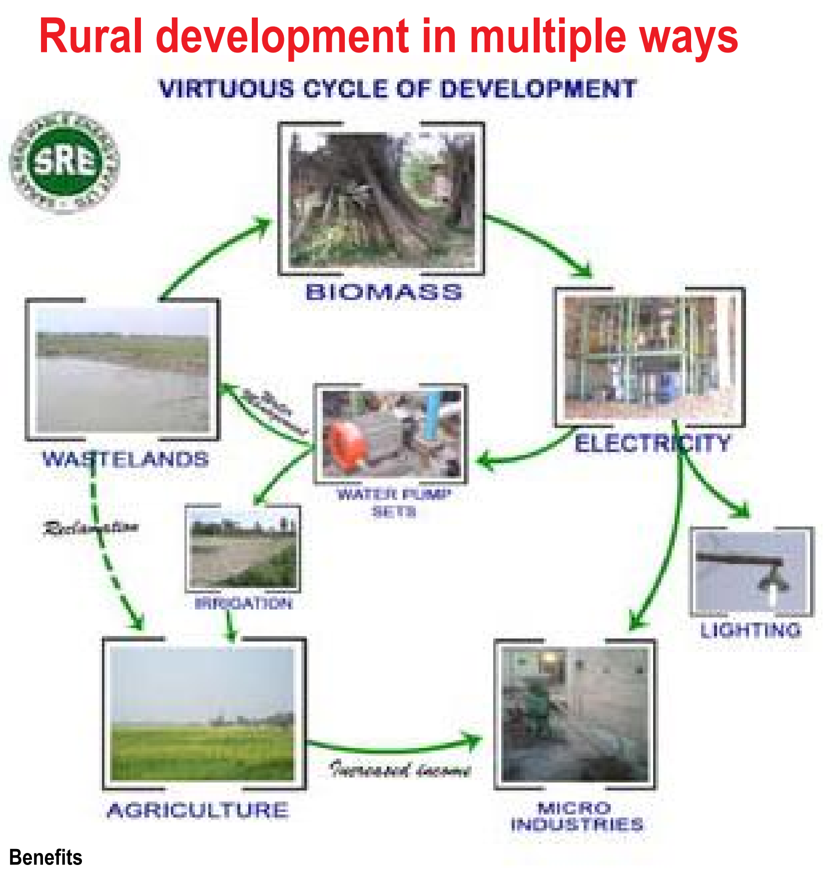
These wastelands have to be tilled and made ready for growing biomass. Once the land is prepared for the plantations, there are no inputs required apart from seeds so it is an investment- and risk-free crop. SRE guarantees purchase of biomass.

SRE's model delivers sustainable social and economic benefits to the rural poor, enabling them to increase their incomes, gain access to energy, and improve their quality of life. It has devised innovative methods to solve the two major problems of energy crisis and excess water.

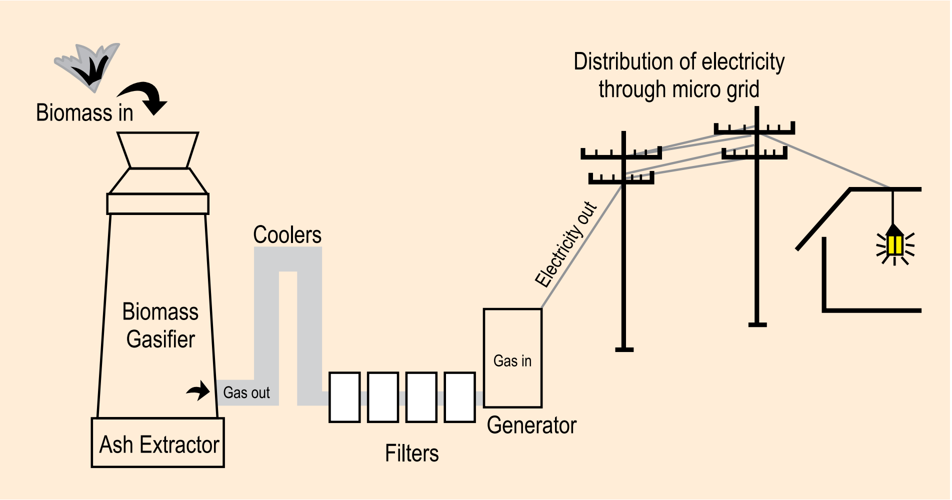
The approach is an integrated one wherein SRE uses techniques to manage excess water and use waterlogged wastelands. Energy plantations are done during periods of excess water and using the biomass grown to run biomass power plant for producing electricity to be used for irrigation and development of agriculture and micro industries.

Gasifier at Garkha

The power generated by the SRE plant mainly caters to about 200 businesses and



Benefits
- Wasteland reclaimed for agriculture
- Energy crops for generation of electricity
- Electricity for irrigation, lighting and small industries



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 Rs 7.50 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 Rs 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 Rs 12–16 per unit. However, as the demand goes up and more customers join, the cost may come down.

SRE is 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 am to 9 pm (one hour break) with a current peak demand of 90% of the capacity and an average demand of 65%. Twelve staff and five casual workers run the plant. However, 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 Bengaluru. If maintained properly, the life of the machine increases to 15 years.

This would give enough time to the promoters to pay back the capital loan. The cost of the entire system is Rs 83 lakh. 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 Rs 20 lakh. Out of the Rs 18 lakh promised by the state government, 30% 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 Rs 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 Mr 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 been quite encouraging on several fronts. Most importantly, it has given belief to the people, who had perhaps lost hope that reliable uninterrupted power supply is possible and aspire for employment and 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 Rs 7,500 to Rs 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 Rs 1.5 and Rs 2 per kilogram depending on the moisture content.

It has improved the business of many SRE customers. Some such customers include grain and oil mills, a saw mill, a welder, and a battery-charging station supplying lighting. All accrue benefits in their business thanks to a reliable supply of electricity.

Farmers living close to the transmission line use electricity to operate about 10 irrigation pumps. A farmer now pays Rs 150 for the same water supply from the gasifier-powered pump in comparison to the Rs 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, sometimes resulting in death. The doctor at the clinic is no longer helpless.

A blood collection lab now can work unhindered by paying Rs 200 a day as compared to Rs 300 a day paid earlier for the 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 of cost. 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 kilowatt-hour of electricity generated. In 2008, 110 MWh of electricity generated replaced nearly 38,500 litres of diesel. This avoided the production of about 103 tonnes of carbon dioxide. At the current level of demand, the savings would be 77,000 litres per year of diesel and 206 tonnes per year of carbon dioxide. The plant also protects the environment by 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 a scope to double its capacity.

The potential of course is better where cluster of small businesses are close to farms from where biomass can be obtained easily. Already several such locations have been identified and *dhaincha* cultivation has commenced in two of them.

The 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.

Biomass-based power plant

Making the steel re-rolling mill sector more energy efficient*

India is currently the world's third largest consumer of energy.[1] Ranked third, India's contribution to global GHG (greenhouse gas) emissions is estimated at 1.7 billion tCO_2 (tonnes of carbon dioxide) a year (5% of global emissions)[2].The steel sector in the country contributes approximately 70 million tCO_2e/ year[2]; out of which, the contribution of the SRRM (steel re-rolling mill) sector is pegged at 16 million tCO_2e/year (11% of the steel sector)[3].

The SRRM sector, which largely consists of SMEs (small and medium enterprises), contributes to two-thirds of the total steel products manufacturing in India. India is now the fourth largest producer of steel in the world with a production of 72.2 million tonnes[4] of finished products in 2011/12. In India, the private sector contributes to 80% of total finished steel production and the SRRM sector accounts for 46% of the private sector[5]. Energy being a critical input to the production process in the SRRM sector, bringing ef ciency in the use of energy in this sector attains prominence.

Hot billet after being ejected from the energy-efficient re-heating furnace

[1] *Global Energy Yearbook 2011 (http://yearbook.enerdata.net)*
[2] *INCCA (Indian Network for Climate Change Assessment), India: Greenhouse Gas Emission 2011. Ministry of Environment and Forests, Government of India, and World Steel Association*
[3] *Ministry of Steel, Government of India (steel.nic.in)*
[4] *Ministry of Steel, Government of India (steel.nic.in)*
[5] *World Steel Association*

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Need for an energy-efficiency improvement project

The SRRMs have grown unsystematically, utilizing technologies that are outdated and energy intensive, and have low investment and high production costs. The direct energy use in this sector involves heating fuels (furnace oil, natural gas, and coal) and electrical energy while indirect energy usage involves use of energy-intensive raw materials. To produce one tonne of steel, the specific energy use ranges from 44 litres to 72 litres of furnace oil or 65 kg to 143 kg of coal when coal is used as fuel, and electricity consumption ranges from 52 kWh (kilowatt hour) to 188 kWh. The direct energy cost in the SRRMs is estimated at 25%–30% of the overall conversion cost.

With high investments and lack of knowledge, SRRMs find it dif cult to remain cost-competitive and adopt new energy-ef cient technologies without the guidance of experts and assurance of performance. Also, with the growing threat of climate change, it is essential to adopt greener technologies and processes.

The project and its objectives

The UNDP/GEF (United Nations Development Programme/Global Environment Facility) Project (Steel) has been facilitating the penetration of cost-effective, energy-ef cient, low-carbon technologies in order to lower end-use energy levels, improve productivity and cost competitiveness, and reduce GHG emissions. The Ministry of Steel, Government of India, in collaboration with the UNDP and GEF, has been executing a project on 'Removal of Barriers to Energy Ef ciency Improvement in the Steel Re-rolling Mill Sector in India' in India through their PMC (Project Management Cell). The broad objective of this project is to reduce GHG emissions by augmenting energy ef ciency levels in the SRRM sector and accelerating the penetration of environmentally sustainable, energy-ef cient technologies. The project has classified India into six clusters and resident missions have been set up in each cluster to extend services of the project.

Front view of the energy-efficient re-heating furnace at Pulkit Steel Rolling Mills, Puducherry

Biomass including coconut shell, groundnut shell and other agricultural waste assembled in the unit to be converted to biomass briquettes

There are about 1800 SRRM units in India and 198 SRRMs in the South Cluster, which includes the states of Tamil Nadu, Puducherry, Karnataka, Kerala, and Andhra Pradesh. About 43% of these units used furnace oil as fuel and 57% were coal-based furnace. Presenting below is a case study of Pulkit Steel Rolling Mills in Puducherry, which adopted energy-ef cient technologies and other process improvement practices to good effect.

Pulkit Steel Rolling Mills Pvt. Ltd, Puducherry

Established in 2005, Pulkit Steel Rolling Mills manufactures TMT (thermo mechanically treated) reinforcement bars from billets and ingots. This unit partnered with the UNDP/GEF Project (Steel) to introduce energy-ef cient technologies in the manufacturing process.

During the project implementation (2008/09), there were several changes made in the selected unit according to the recommendations of the PMC. The major changes included switching to biomass (briquettes) fuel, systematic changes in furnace components, and arrangement of mills according to the recommended measures.

The company enjoys benefits from the project in terms of enhanced productivity by 53.77%, reduction in production cost, higher ef ciency in operations, and enhanced quality of products. The project resulted in marginal reduction of SPC (specific power consumption) (0.61%) and increased mill yield (1.63%). It also resulted in 100% savings in CO_2 emissions from the unit, due to the use of biomass as fuel. The unit received the Energy Conservation Award (2009) from the Government of Puducherry for its contribution towards energy conservation.

Economic feasibility

The total investment in the unit for the project was approximately Rs 1.173 crore. Considering an average annual production of 35,000 MT (million tonnes), the annual saving on fuel comes to about Rs 4.795 crore. Thus, the payback period on investment is less than three months. Moreover, the unit is eligible for capital subsidy and reimbursement of consultancy fees, which makes this project profitable for the unit.

Project implementation details

Pulkit Steel Rolling Mills used furnace oil as fuel at an unaffordable price for its production process. The unit operated with an old energy-intensive 16 TPH capacity reheating furnace. The unit had outdated mills and depended heavily on manual handling of the materials, which in turn resulted in high energy and fuel consumption. As the unit agreed to partner with the project, the PMC visited the plant and suggested various measures to bring in energy ef ciency in their operations. Recommendations given to the unit included a switchover from furnace oil to biomass-based producer gas as fuel and installation of a gasifier.

Many changes, such as the ones listed below, were implemented.

- The unit switched over from furnace oil to biomass-based producer gas as fuel. Towards this end, a biomass gasifier was installed.
- The existing furnace was modified to an energy-ef cient reheating furnace of capacity 20 TPH was done. Other changes include installation of a modified furnace with a better design, high-ef ciency metallic recuperators, a modified combustion system with installation of gas burners, and an automation and temperature control system for optimum burning loss.
- In the rolling mill, replaced fibre bearings with roller bearings, installed universal couplings and spindles in mill stands, use of antifriction roller guides in the finishing mill side, installed an automatic cooling bed with high-speed delivery system.
- Implemented several capacity-building initiatives through workshops and training for both shop-f oor and managerial personnel. The initiatives include programmes on performance improvement (skills development), 5S and lean

Biomass-based producer gas plant at Pulkit Steel Rolling Mills, Puducherry management, roll-pass design, standard operating practices and standard maintenance practices.

- Technical manuals (17) were prepared and distributed to managers and shop-f oor workers as ready reference material.

Results

The various interventions on process and technology produced encouraging results in terms of energy ef ciency, productivity, pollution control, improved product quality, enhanced worker safety, and organizational ef ciency. A few specific results are listed below.

- The average production of the unit increased significantly from 9.54 TPH (tonnes per hour) to 14.67 TPH, resulting in a 53.77% increase in productivity.
- The use of biomass brought about savings in fossil fuel consumption; the specific fuel consumption of furnace oil is 55.25 L/MT (51.94 kg/MT, considering density of furnace oil = 0.94), while that of biomass briquettes is 113.85 kg/MT.
- The average specific power consumption improved from 113.00 kWh/MT to 112.30 kWh/MT, that is, a reduction of 0.61%.
- The specific energy consumption, calculated as sum of thermal and electrical energy consumption, reduced by 12.91%, saving about 77, 580 kcal/MT.[6]
- The average burning loss increased from 1.242% to 1.73%.
- As the net emissions from biomass are taken as zero, there is 100% reduction in CO_2 emissions from the unit; the average annual reduction of emissions from the unit is 8600 tCO_2e and life-time cumulative (20 years) emission reduction is 1,72,000 tCO_2e.

The way forward

Pulkit Steel Rolling Mills has performed its social responsibility by adopting green fuel for production. The company has installed a biomass briquette plant for its fuel supplies. Agricultural waste, saw dust, and coconut shell are collected from nearby villages to make briquettes. Thus, it has also provided productive employment to local people.

It is now working towards adopting all the recommended measures for energy ef ciency and is planning to increase its production capacity. For this, the capacity of the gasifier will be enhanced.

As India is poised for rapid development in the infrastructure and industrial sectors, the demand of steel is bound to increase exponentially in the coming decade. The intervention and implementation of the energy-ef cient technologies in the sector will benefit the country environmentally in the future.

[6] *Eligibility calculations for capital subsidy*

BIO-ENERGY

Generating biogas from waste*

Biotech's initiative

Christened as 'God's Own Country', the state of Kerala is known for its palm-fringed beaches, majestic and undulating hills, and its pristine backwaters. No wonder, it has a thriving tourism industry with an abundance of exotic beach resorts. Another draw for tourists coming to Kerala are the famous Ayurveda centres.

The state is on a prosperous track and is observing a steady growth in the middle class population. The suburban areas demand clean and hygienic disposal of waste from homes, institutions, and municipalities as opposed to the rural practice of leaving out waste for animals. Though there are many local bodies providing door-to-door services for collecting waste, the stray animals often tear open waste bags kept outside, and thus 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 f ies and mosquitoes make the situation even worse as they are carriers of numerous diseases.

All this is due to the absence of a proper waste management system at the source of waste generation. Consequently, it creates a perennial problem for the local administration like panchayats and the municipal corporation.

Biotech, an NGO based in Kerala, has come up with some solutions to these problems. It has developed biogas digesters that capture food and other organic

Biogas unit in Pathanapuram

** For further information, contact:* Mr A Saji Das, E-mail: asajidas@gmail.com waste and waste water at the source and produce biogas through a technology called biomethanation. The organic materials are taken into air-tight vessels where bacteria break them to release biogas. This resultant gas, which is a mixture of methane and carbon dioxide (with the percentage of the latter being less), 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.

- Domestic sector (individual households)
- Institutions (schools, hostels, hospitals, and hotels)
- Local councils (market places)

The standard domestic plants with a volume of 1 m^3 produce about 1 m^3 of biogas per day with a maximum daily input of 25 kg of solids and 20 L of water.

The digester vessel is made up of two components: a precast (from ferro-cement) digester tank sunk into the ground, and a gas holder drum made from FRP (fibreglass reinforced plastic), which f oats over the tank. Biotech also manufactures portable digesters that stand on the surface, to be installed 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. Cow dung is used initially to provide a culture of suitable bacteria, which trigger the digestion process. Biogas is generated by the decomposition of waste, gets collected in the gas holder, and is finally taken to a special biogas stove in the kitchen through a pipe connected to the gas holder. A valve is used to open and shut the f ow and a regulator controls the f ame. Nearly 22,000 domestic plants have been installed serving 88,000 people. This includes many connected to lavatories.

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) f oats on top and collects the biogas. About 200 institutional plants have been constructed to manage kitchen waste, and a further 22 include lavatory connections as well.

The large-scale energy-from-waste plants are built from one or two 25-m^3 biogas digesters and are installed in local councils or fish markets. Dry biodegradable waste, glass, plastic, and so on 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 hasten 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 and another 8 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 the state and national levels. It has its own workshops where it manufactures all the plants and also maintains a high quality of production. It also records the details of all plants in order to avail subsidy from the MNRE (Ministry of New and Renewable Energy). 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 Rs 9500. MNRE provides subsidies for plant installations.

For each domestic plant with a capacity of about 10 m^3, MNRE offers a subsidy of Rs 2700, which is paid to the beneficiary through Biotech after a government of cial's inspection of the plant. The local and district panchayats (councils) also offer subsidies of Rs 2700 and Rs 3500 in urban and rural areas, respectively. The buyer pays the remaining amount directly. MNRE subsidies are likely to be phased out in future. However, support from the panchayat is expected to continue.

The cost of an integrated waste management plant is about Rs 30 lakh. MNRE provides a subsidy of Rs 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.

There is an increasing demand for domestic-scale systems and this technology has a huge growth potential. In rural areas also, the potential is considerable, provided the panchayats work on creating awareness among people and arrange for budgets. However, there is a greater potential at the municipal level, where there are serious health risks due to the generation of large volumes of organic waste and pollution of water supplies.

The main benefit of Biotech plants is that they provide a clean disposal route for food waste from households and institutions, and huge amount of organic wastes from markets and councils. Therefore, they prevent the release of methane from uncontrolled decomposition of waste. Plants connected to lavatories help in avoiding contamination of ground water through human sewage. Additionally, all these plants produce clean biogas which partially replaces LPG (liquefied petroleum gas) or firewood as cooking fuel and in turn cut down carbon dioxide emission.

Biogas from domestic plants replaces about 50% of LPG and thus results in a saving of about Rs 2280 for a family per year. This means that the family can recover its share of the cost of the plant in about three years. Institutional plants attached to lavatories 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. Biogas works as an advanced and convenient means in rural areas where cooking is mostly done using firewood or kerosene. It is also safer than LPG, since it cannot be lit accidentally by a spark. The odourless ef uent from the plant is used as garden fertilizer, as it contains high percentage of nitrogen, phosphorus, and potassium.

The installation of these biogas plants has also helped significantly in employment generation. The manufacture, installation, and maintenance of these biogas plants 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 Gram 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 many health and environmental problems as approximately 1000 kg of organic waste is daily generated in the market with the major contributors being slaughter-house waste, fish waste, vegetable waste, and waste water. In order to overcome these problems the Gram Panchayat 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 that included a 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 DPR (detailed project report) 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 seven 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 youth 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.

The total cost of the plant was Rs 26 lakh, which proved to be an excellent investment. The successful performance of the plant encouraged the panchayat committee to increase the capacity of the plant from 250 kg/day to 1000 kg/day (in three phases) over the last seven years of operation. As a result, the lighting capacity has also increased from 20 CFL to 100 CFL. About 60 m^3 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 Rs 10.73 lakh. This way the total cost of the plant could be recovered in three to four years.

Bio-electricity lighting up streets

Through this initiative, the Pathanapuram Gram Panchayat reduced approximately 22,000 m^3 of methane emissions per day, provided a clean and hygienic environment in the market area, and substantially reduced the electricity charges. This success story has encouraged other civic bodies to come up with similar projects. The Pathanapuram Gram 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.

BIO-ENERGY

Bringing light to Thalingi

The Thalingi tribal settlement in the Amaravathy Forest Division of Coimbatore district, Tamil Nadu, is a cluster of villages, which for years had no electricity because they were six kilometres off the main road. The lack of roads made the construction required for electricity generation dif cult. Now, thanks to the NERD (Non-conventional Energy and Rural Development) project initiated here, the community has been empowered by electricity generated through biogas. They now live in a more environmentally sustainable manner. The project is titled 'Renewable Energy of Community Promoted Electrification through Biogas for the Thalingi Tribal Area'.

The NERD society was established in 1984. It works towards implementing many programmes including the empowerment of women through the promotion of SHGs (self-help groups) and renewable energy programmes, such as those related to biogas, solar energy, improved smokeless *chulha* (cookstove) use, and waste management and treatment. NERD also works in the area of water conservation, vermi-composting, and organic farming. Creating greater awareness on the conservation of natural resources is also an important aspect of their work in communities.

The NGO works in the Amaravathy Forest Division, in the Coimbatore district of Tamil Nadu. The need for light in this remote area was initially being met through the use of kerosene. Electricity access was dif cult in these areas due to the lack of roads. A detailed needs assessment exercise was conducted to prioritize the needs of the locals and it was unanimously decided to have power through biogas as the first priority. The NGO approached GEF SGP (Small Grants Programme) CEE to help address this problem. Several meetings led to the development of a community-based approach to the issue.

The project through community-managed biogas programmes was a direct result of the discussions. It also promotes the use of cooking with biogas besides encouraging organic farming with the bio-digested slurry of biogas plants.

Project objectives and working

The project from the very start had some clearly stated (expected) outcomes. Electrification of the Thalangi hamlet would help prevent the cutting of trees and create a healthy atmosphere. It will work to reduce the barrier in adopting renewable energy technology besides reducing the greenhouse gas emissions happening through conventional thermal power generation and the burning of firewood in inef cient conventional chulhas[1].

NERD made facilitating the communities to develop SHGs on informal and kinship basis an important aspect of the project. The SHG members are trained in health, educational factors, and motivated to conserve natural resources by adapting renewable energy resources. The NERD of cials understood early on that strengthening SHGs could help them connect to the families in the villages, and help link them to banks to ensure regular savings and credit systems for all the members, no matter what their level is in the group.

Families were encouraged to use the biogas generated from the plant and utilize it for electricity and cooking. The project also worked towards connecting the toilets in the village to the biogas plants for additional benefit and maximum usage of resources. To help create a sustainable business model in the management of the biogas units and encourage the use of this environment-friendly option, many demonstrations of the use of bio-digested slurry obtained from the biogas plants in the cultivation of horticultural and medicinal plants was done.

The biogas project promotes renewable source of energy. This project keeps climate change in consideration and is designed to mitigate the adverse impacts of the same. This will also spur investments in the promotion of renewable energy[2]. Communities pay for the use of gas through the SHGs by fixing monthly charges to suit the maintenance and upkeep costs of the biogas plants installed.

There are seven women and youth SHGs in the project site of the Thalingi tribal settlement. They have also formed a federation of SHGs in the area. This was started without formal registration in 2006. A total of Rs 4 lakh have been saved through these SHGs, which have about 120 women members. NERD has facilitated a grant of Rs 500,000 from private banks for the SHGs to take up income generation activities. The members have been trained in managing their loans and repayments. They are trained in effective account keeping as well.

The communities have also formed a federation, and an institutional body to manage resources like the power tiller, oil engine, tractor, and trailer that were given to the federation of SHGs. All the SHGs are members of the federation. Each member pays about Rs 20 per month to the federation for the maintenance of the system. As the tractor hire charges and other miscellaneous transactions are booked in the first federation account, another federation account has been formed in the State Bank of India, Jallipatti branch, located at Kurichikottai, exclusively for the maintenance of biogas-based electricity generating system. The total amount available in the new federation account is about Rs 10,000.

[1] *http://sgp.undp.org/index.php?option=com_sgpprojects&view=projectdetail&id=8806&Itemid=205*
[2] *http://sgp.undp.org/index.php?option=com_sgpprojects&view=projectdetail&id=8806&Itemid=205*

The NGO has also introduced mulberry rearing and the sericulture department has sanctioned four mulberry sheds for the tribal communities to encourage sustainable livelihoods. The MNRE (Ministry of New and Renewable Energy, Government of India) has sanctioned special funds for training and capacity building for those who train communities in the use of biogas. Two local youth have been trained for the maintenance and upkeep of the biogas units.

The NGO has also facilitated links with the livestock and the cattle size per family has increased. With the installation of the biogas plants and the use of biogas, families in the region have also increased the numbers of their livestock. Most have reported an increase of approximately 300 cows, 95 buffaloes, 51 goat, and a few horses. NERD is focused on maintaining the livestock of the families as well.

Working of the biogas facilities

The power generating capacity of the generator is 12 kW. The average daily running of the generator is five hours and the daily power generation is 5 x 12 = 60 kWh. In a year of 300 days, the annual average generation of power is 60 x 300 = 18,000 kWh. It is estimated that each unit (kWh) of power generated through conventional sources of energy releases about 1 kg of CO_2 (carbon dioxide) to the atmosphere. Therefore, generation of 18,000 kWh of electricity through the biogas technology is able to reduce 18,000 kg of CO_2 emissiom, that is, approximately 18 tonnes of CO_2 annually. As 1 tonne of CO_2 emission reduction is equal to 1 CER (certified emission reduction), the reduction of 18 tonnes amounts to 18 CERs per year.

The daily biogas production expected from the two biogas plants commissioned through this project is 100 m^3 per day. It is possible to generate 160 units of electricity per day. However, as of now, the actual electricity generation is 60 units only (instead of 160 units) per day from the daily gas production of about 40 m^3. This low generation of electricity is due to under-loading of the plants at the rate of 800 kg to 1200 kg of dung per day instead of the normal recommended loading of 2500 kg of dung per day.

Project results

The project has resulted in enabling the people of this remote hamlet gain access to many facilities. About a thousand families received free television sets from the Government of Tamil Nadu. They could not use these earlier due to lack of electricity. Even though solar panels have been installed for six street lights and 40 individual houses, the power obtained from these was not suf cient to operate the television sets. The biogas-based power is useful for the operation of television sets.

Besides promoting an ecologically sustainable life for the community, NERD has always had a strong focus on the social and cultural life of the area. To encourage a healthy atmosphere of cooperation, NERD has given time to develop interpersonal relationships and build mutual trust within the communities. The locals have been trained in the management of resources and today they are able to manage both technical and financial aspects. They have been continuously supporting the programme. The approach of community volunteers is a great payoff in the project.

The participatory process has fostered self-confidence and self-reliance in the locals.

It is important to understand that sustainable approaches always need to focus on understanding the realities of village life, assisting the communities in forming local associations, and informal institutions managed by communities themselves. Only programmes that have the faith of the targeted beneficiaries achieve maximum impact and are truly successful. NERD is replicating this approach in other areas. The Department of Renewable Energy, Tamil Nadu, has given great support to the NERD.

The dynamic communication process between the locals, which NERD encourages through trust building facilities like the SHGs, acts as important catalysts for identifying the real problems of the locals. It helps in recognizing and successful formulation of possible routes to empowerment and reliance. They are then successful at building a sense of independence and healthy interdependence.

CASE STUDY 9

BIO-ENERGY

Project Surya*

improved cookstoves intervention

Over three billion people, living in developing countries, rely on burning of firewood, crop residue, and cattle dung in traditional mud stove/three-stone/open fire to prepare daily meals. Smoke from such traditional cooking is toxic for the women and children resulting in loss of nearly two million lives annually. Literature reviews indicate that indoor air pollution significantly increases the risk of pneumonia in children and chronic bronchitis and other ailments in women. Smoke plumes during cooking also consist of climate change agents such as black carbon (light-absorbing carbon particles) and potent greenhouse gases, such as carbon dioxide and methane.

There are commercially available improved cooking technologies that are clean (less smoke per kilogram of fuel burnt), fuel-ef cient (less fuel required per meal cooked), and with better firepower (heat). Adoption of such technologies can help

Stove Demonstration of a stove

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improve health (less exposure to smoke: quantity and time), reduce drudgery (less fuel consumption: less effort to collect and process firewood, and quick cooking: less time spent in kitchen), save forest (less felling for firewood), and slow down global warming.

Inspired by the belief that stoves must adapt to people and traditional cooking habits, not the other way around, TERI (The Energy and Resources Institute) has developed variants of forced-draft cookstoves that meet the socio-cultural and economic objectivity of the rural population of India. A series of prototype clean cookstoves have been developed – including a top-loading single-pot stove, a front-loading single-pot stove, and a front-loading double-pot stove – each of which employs a fan-based forced draft to aid combustion and a standardized stove combustion chamber that can be fitted with additional components that meet localized needs. In addition, where possible, all components of the stove system will be based on nut-and-bolt systems and use parts that are commonly available even in village markets (like AAA dry cell batteries for powering the fan). The stoves provide options such as a solar charging unit and adding additional stove heads for large families.

Project Surya

Project Surya is a cookstove intervention that aims to provide sustainable, effective, incentive-based action plans, infrastructure, and novel technologies to enable rural communities to switch over to improved cooking technologies. Its uniqueness also lies in its science focus: undertaking the most comprehensive and rigorous scientific evaluation to date on the ef cacy of reducing biomass-fuelled cooking on climate warming, air pollution, health, and human well-being.

Strategy

Project Surya has been undertaking an unprecedented effort to measure and document the impact of cleaner cooking practices on people and the planet. The aim is to deploy improved cooking technologies in rural communities. This technology change will rapidly cut emissions of major pollutants, including black carbon. The project will measure the resulting 'black carbon hole' across space and time to quantify the multi-sectoral impacts of better cooking technologies.

Villages in rural India using improved cookstoves to prepare their daily meal

It aims to use two low-cost sensor technologies (patent pending) to estimate black carbon emission savings due to improved stove usage. The first technology provides real-time data of stove usage—how often and how long. The sensor attached to the stove records the temperature (high temperature signifies usage) and transmits real-time temperature readings through an adapter circuit and thermistor to an attached mobile phone through its headset jack. This technology can be operated on any Java-enabled low-cost mobile phone that is widely available with these households. The second technology utilizes a miniaturized aerosol sampler where a filter is exposed to the indoor air particles. Any cell phone with camera and GPRS can be used to photograph the filter and wirelessly transmit the picture to a centralized server. A complex computer algorithm will then estimate black carbon emissions from the blackness of the filter in the picture. These low-cost wireless technologies can aid in mainstreaming black carbon emission savings in carbon finance by addressing two primary barriers to claim carbon credits: it dramatically reduces the transaction costs; and provides technology-centric, verifiable, and cost-effective monitoring of stove usage.

Results

The pilot phase of Project Surya was successfully completed in 2011, the highlights of which are listed below.

- Various cookstove technologies were tested in field to identify the best technologies from the perspective of mitigating black carbon emission.
- Baseline measurements of black carbon were collected before and after the dissemination of improved cookstoves in 485 households in one village situated in Uttar Pradesh.
- Demonstrated link between indoor and outdoor concentrations of black carbon in and around the Surya pilot village with cooking activities.
- Identified forced-draft stoves as superior amongst improved stove technologies.
- Developed low-cost cell phone-based technologies that make it possible to measure black carbon on the ground with unprecedented spatial resolution for the first time.
- Established and validated methodologies to measure black carbon from space, in order to scale the results beyond the deployment site.
- Identifying socio-economic barriers and drivers related to cookstove adoption

Outlook

Project Surya is now positioned to embark on the demonstration phase, which requires an area that is large enough to be captured by satellite sensors (approximately 100 square kilometres) and a population of about 50,000 people to constitute a valid and viable test spanning approximately 40 neighbouring villages. TERI is working with NEXLEAF Analytics and the University of California, San Diego, to develop a robust, low-cost, and reliable methodology to claim carbon credits. Furthermore, TERI is continuing to conduct research, development, customization (to suit local cooking practices and fuel availability) and demonstration of affordable cooking technologies to improve access to modern energy. While the work has been primarily focused India, similar initiatives have been launched in Africa. Partners will continue to develop and foster linkages with the private sector including financial institutions, government agencies, civil society, and other stakeholders.

Indeed, the efforts placed in conducting extensive research into improved cooking activities will provide direction for existing stakeholders to produce more effective and scalable alternative cooking technologies.

Stove experiment

CASE STUDY 10

Bio-energy

Mitigating climate change through alternative gadgets and fuels

For the women of Yelandur taluka, Karnataka, the mornings begin in front of the ovens! For them, the oven smoke from the dimly-lit kitchens and the resultant tears in the eyes are the ingredients that go into the making of food. It has been an endless woe for them.

However, the Vivekananda Trust has been trying to address these problems. In the whole taluka, women use the traditional mud oven in which forest firewood or sticks are used as fuel for preparing food. The Vivekananda Trust has set an objective of constructing 1000 smokeless ovens that will improve the villagers' health and hygiene and will also be an environment-friendly cooking option. The Trust is working in five villages under a programme called Climate Change Mitigation and Improvement of Livelihood with Alternative Cooking Gadgets. Some of these like the smokeless oven cost about Rs 1200. Seventy percent of the cost is borne by UNDP/GEF/SGP/CEE, as subsidy for the project. The low-cost three-vessel smokeless oven, about three feet in length, and one foot in height and width, is constructed mostly using locally available materials. A cement pipe of 10 feet length, caste iron grate, MS rods, cement, and a specially designed semi-conical aluminium vessel are the only things brought from outside by the organization. The beneficiary saves over 55%–60% of firewood because of this oven. In some of the ovens, broken wall-tiles are experimentally used to improve the ef ciency of the ovens, which brings down the firewood consumption by another 15%.

The focus area of the project is the fringe areas of B R Hills wildlife sanctuary. Located on the conf uence of Eastern and Western Ghats, B R Hills is considered as a hotspot of biodiversity and is home to unique f ora and fauna belonging to both the Eastern and Western Ghats. The forests have been a source of firewood for the once sparsely populated villages in the surrounding areas. Ever since the surrounding villages started receiving the canal water from 1972, there has been relentless pressure on the forests from the ever-increasing population, resulting in a 30% reduction in the forest cover as revealed by the satellite images. In the fringe area villages of B R Hills, like Komaranapura, Yeragamballi, Krishnapura, Vadagare, and Gangvadi where the use of forest firewood for cooking food is huge, the rainfall has been steadily coming down from 125 mm in 1975 to 109 mm in 2010!

Objectives of the project

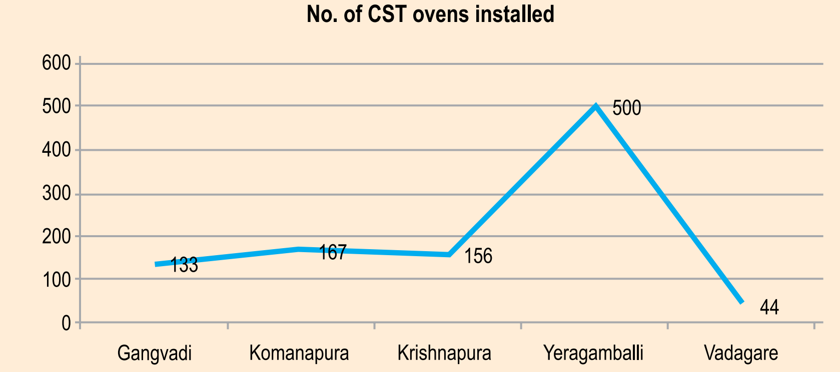
- Mitigate climate change and create awareness about the effects of deforestation
- Reduce the consumption of forest firewood by installing locally assembled but scientifically designed low-cost ovens in 1000 households
- Improve health and livelihood

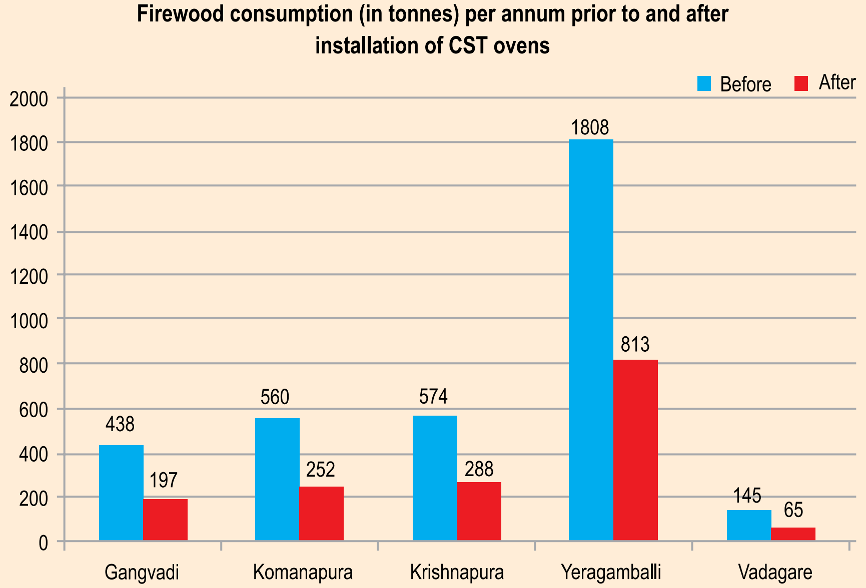
Number of villages	:	Five with nearly 1700 households
SGP Grant	:	Rs 13.91 lakh
Co-financing	:	Rs 14.60 lakh (rural banks, communities, NABARD, and government subsidy)
Project time period	:	August 2009 to August 2011
Geographical area	:	South India, Karnataka State (Chamaraja Nagar District, Yelandur Taluka, nearest city Chamaraja Nagar/Mysore)

Initially an awareness generation campaign on the adverse impacts of deforestation, global warming, and climate change was carried out in schools in the form of interactions, and competitions such as drawing and painting, and essay writing. For the elder lot, awareness was generated through training of SHGs (self help groups) of women and youths.

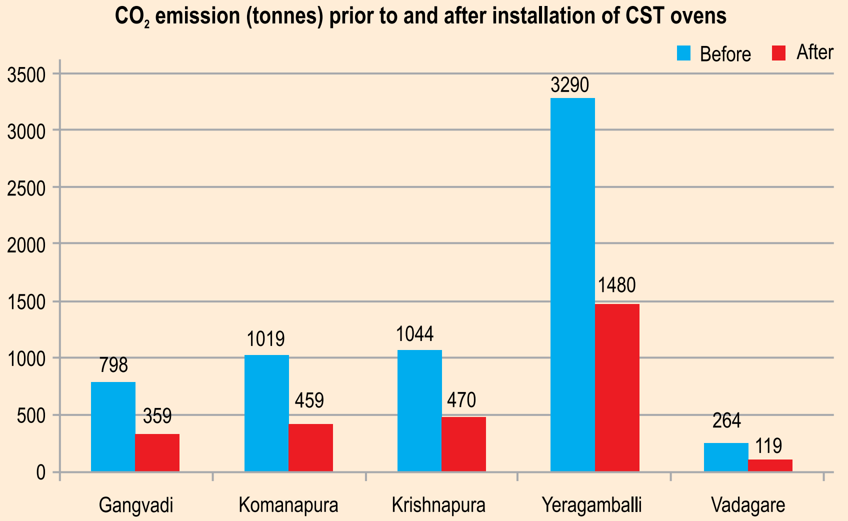
Benefits

- Capacity-building of the marginalized com-munities especially ladies (1000 ladies)
- Creation of assets for the marginalized communities (1000 ovens)
- Improved soft and hard skills for the targeted community
- 50%–60% reduction in the demand on forest for firewood from the targeted communities (see graphs)
- Increased forest cover and greenery
- Replication of the programme in the neighbouring communities and the resultant incremental benefits
- Bank linkage for income-generation activities like dairy is being followed up. Many of the families were linked with banks through SHG for loans. Details are being collected and tabulated.
- Money saved on purchase of firewood per annum is about Rs 15,000 per household on an average
- Money saved on treating problems related to lungs and eyes is about Rs 2500 per annum per household



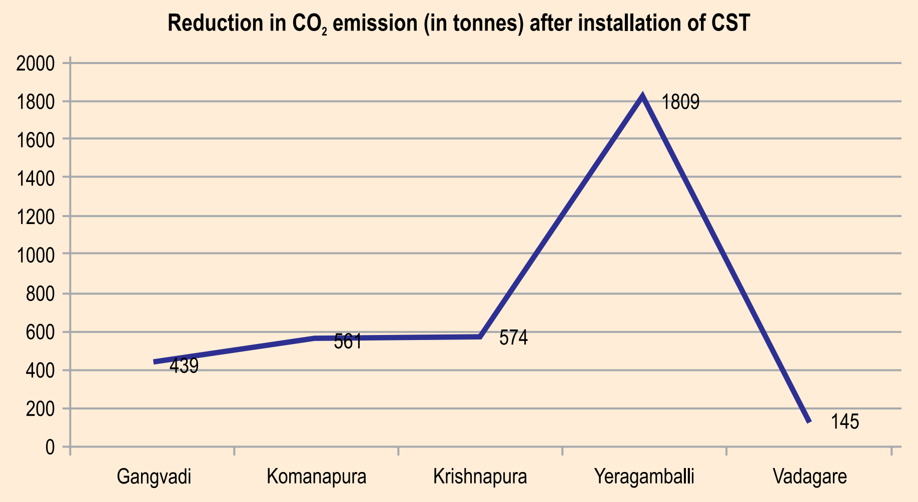


Source: Household sample survey (2009)

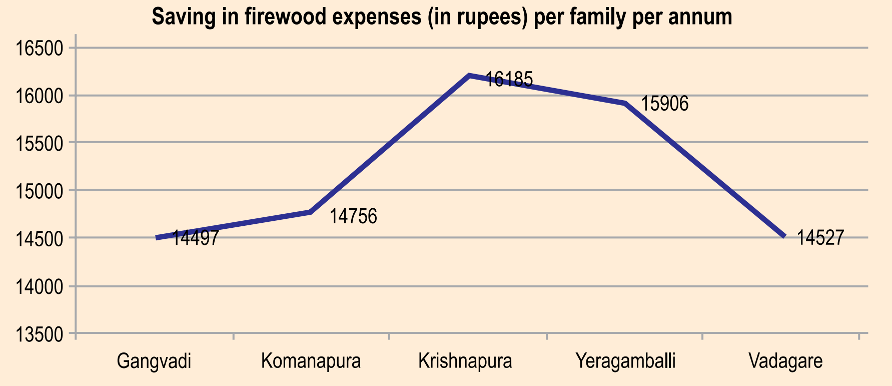


Note: There has been about 55% reduction in the firewood consumed with CST ovens. Where the wall tiles were lined inside the ovens, the firewood consumption has come down to 65%

1 tonne of firewood burnt = 1.820 tonnes CO_2 emission



Note: Basis for calculation, 1 tonne of firewood burnt =1.820 tonnes CO_2



Note: Basis for calculation, Rs 8/kg for firewood

BIO-ENERGY

Environment-friendly stove*

In southern India, an estimated eight million people are employed in small and tiny businesses. This includes food processing and preparation, textiles, ayurvedic medicines, and brick-making, to name a few. Extrapolating from a recent market survey, there would be about 8,00,000 small commercial kitchens in south India alone. There are several reasons why people opt for working in such conditions. Some of them are poverty, lack of critical skills for employment, and no education. Many such people move from remote villages to small towns in search of work. These small businesses run with small turnovers and their overheads are kept at a minimum in order to achieve a healthy bottom line.

TIDE (Technology Informatics Design Endeavour) has helped create and operationalize a rural enterprise model for disseminating fuel-ef cient wood-burning stoves among rural/small town industry clusters. For this, it was awarded the prestigious Ashden Award in 2008. TIDE used the award grant to spin off Sustaintech India Pvt. Ltd as a social venture to demonstrate an enterprise model for the rapid adoption of fuel-ef cient stoves by street food vendors. Under this arrangement, TIDE develops fuel-ef cient stoves and Sustaintech develops the marketing network. The for-profit enterprise model of Sustaintech has also been conceived as a sustainability plan for TIDE.

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The approach has been to focus on user-friendly stoves that require minimal maintenance. Spares as required are available locally. Fuel is saved through good combustion ef ciency by optimizing the air–fuel ratio, the right combustion chamber volume, and use of a well-designed chimney. Good heat transfer ef ciency is achieved by maximizing the surface area exposed to heat and minimizing wall losses through good insulation. The programme was initiated in Karnataka and Kerala but has now been expanded to Tamil Nadu, Andhra Pradesh, and Rajasthan.

Most cooks and operators of conventional stoves experience and react to the rising cost of firewood without being aware of the adverse impact of their use on the environment, air quality, pollution, and forests. The rising price of LPG (liquefied petroleum gas) and the fact that firewood is an unregulated fuel is pushing more small businesses to move towards use of firewood as the preferred heat source. Their lifestyle does not permit them to pay attention to the health hazards resulting from prolonged exposure to smoke. Among stove users who purchase fuel, there is interest in adopting fuel-ef cient stoves. However, mindset issues and the discomfort with the unknown were preventing them from adopting energy conservation measures.

To mitigate environmental concerns, improve productivity, and profitability of small businesses, and address cultural barriers and health impacts, TIDE developed a range of fuel-ef cient stoves for the grassroots businesses. Additionally, it is also offering energy conservation services to the tea industry that uses a lot of firewood for withering and drying of tea.

TIDE stove designs

TIDE has developed a range of stoves for different industry clusters. Initially, its strategy was to train local masons to construct fuel-ef cient stoves. While it still

adopts this strategy for large stoves, for example, those used in jaggery making, textile bleaching, and dyeing, it is gradually moving to factory-produced stoves for uniformity in design, consistent fuel-saving features, lower rejection rates, and quality assurance features. Financing for end users is also easier with factory-produced stoves when compared with on-site constructed stoves that lack standardization. Some of the areas where TIDE has developed and disseminated fuel-ef cient wood burning stoves are as follows.

- Large specialized cookstoves for a range of cooking operations (including dosa, frying, and tea-coffee making stoves)
- Customized large cookstoves for big kitchens like those in marriage halls and temples
- Stoves for preparation of herbal medicine, making rubber bands, processing arecanuts, making jaggery, boiling turmeric, and those for textile bleaching and dyeing, and silk reeling

While retaining the core heat-transfer principles, TIDE designs stoves as per usage by the particular sectors, but most importantly, involving the user. This minimizes any modification later.

For factory-produced stoves, the manufacturing site for the stoves is always closer to the location of the end user to the extent possible. TIDE works with small-town fabricators for different components of the stove: with masons for mud and ceramic part and smiths for metal parts. The large-sized stoves, used in bleaching vats or jaggery units, are built on site, whereas the components for smaller stoves used in silk reeling or boiling areca are made in a production facility and assembled on site.

Customer care

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 their working schedule. Factory-produced stoves make this possible. The customers are initially a little apprehensive about using a new technology. TIDE also arranges sensitization meetings for the stove users. This helps them to clear any doubts and gives a sense of reassurance about the product.

The organization creates awareness and undertakes marketing of the stoves by providing free or subsidized demonstration units to obtain user feedback. However, there is no subsidy or discount in the sales process to ensure a reasonable profit

for the entrepreneur. Some effective ways of reaching the consumer are through vehicle campaigns and participation in exhibitions during village fairs.

Affordable stoves

The stoves come with a year's guarantee. Like any other product, after-sales service is provided. Entrepreneurs offer service and repair on a chargeable basis post the warranty period and informally check on the working of stoves periodically. When TIDE and Sustaintech were selling stoves to cluster-based industries, the need for consumer financing was not felt very strongly and entrepreneurs offered staggered payment options. However, as the user profile has expanded to reach out to more needy customers, the need for end user financing has been felt and a consumer finance scheme with Madura Microfinance has been operationalized in Tamil Nadu for factory-produced stoves.

Sometimes an industry-specific subsidy may be available. For example, the Department of Sericulture, Karnataka, provided a 40% subsidy for silk-reeling stoves, which was paid to the entrepreneurs when the user had paid 60% contribution. The Hasiru Karnataka scheme of the Forest Department in Karnataka entails working with women stove entrepreneurs and encouraging them to install fuel-ef cient smokeless stoves in forest fringe homes.

TIDE lays a lot of emphasis on quality control. It has developed a quality assurance protocol for the factory made stoves. Only stoves that pass the quality assurance parameters are moved from factories to warehouses or user locations. It is mandatory for each entrepreneur to keep a complaint book and TIDE makes random checks on its own system and those installed by the entrepreneurs.

TIDE is also careful about the financial viability of the stoves. The organization, as a rule, discourages 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.

Improved stove, improved profitability

For the small businessmen, advantages from the improved stoves are two folds; saving on money and increased productivity. According to an assessment by TIDE in 2011, the stoves installed by TIDE and Sustaintech have so far saved Rs 8 crore in fuel costs and 60,000 tonnes of carbon dioxide emissions annually. About 2,00,000 people have benefitted through their interventions.

Daily cash flow of a typical customer

Revenues: Rs 2500

Expenses: Rs 2200

Profits: Rs 300

Expenses on fuel: Rs 160

Fuel saving through use of PYRO stoves: Rs 70

Cost of a multipurpose stove: Rs 12,000

Payback period through fuel saving: 170–180 days of usage

Viability of the stove businesses

Stove businesses must create their own distribution channels in rural areas and in small towns because existing channels servicing this segment (selling mobile phones, insurance, and two-wheelers) are neither interested nor competent in selling eco- friendly products. The key challenges are in reaching the customer, catering to the very price-sensitive markets, and developing strong marketing and sales strategies (this is not the norm as stove dissemination has largely been the domain of non profits with different focus and skills).

A commercial cookstove business is innovative and inclusive making an impact on the lives of the underserved. Such businesses are not the norm and a lot of time and effort is required in building an enabling environment. A lot of expenses have to be incurred in awareness creation and market development. In the short term, a stove business without grant funds would not be viable, but with initial investments from social investors and when a scale of about 4000 stoves /year is reached, it would be a real alternative to a mainstream business.

Women's enterprises

Women stove builders trained by TIDE have constructed about 20,000 Sarala stoves where the users pay the entire cost of the stove. The women stove builders ask the household to arrange materials locally (bricks, soil, cement pipes, and so on) and charge Rs 100 as their labour charges. Several people are coming forward to donate a smokeless stove. TIDE has converted about nine villages to smokeless villages through these women's enterprises.

This project has helped the 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.

Social benefits

Fuel-ef cient stoves, with complete combustion of biomass released, significantly lower the percentage of products of incomplete combustion. Health hazards associated with conventional stoves are quite high. About 28% of all deaths in the developing world due to indoor air pollution occur in India. Besides this, several cooks and workers suffer from respiratory and eye-related ailments. Use of fuel-ef cient stoves developed at TIDE (with chimney) ensures a safe working atmosphere and increases the productive life span of the workers.

Economic benefits

The stoves developed and disseminated by TIDE and its partner organizations offer a path out of poverty for small businesses. Use of the stoves ensures a saving of Rs 70–100/day. A stove business also creates employment for different supply chain elements like manufacturers, welders, fitters, masons, transporters, for warehousing and intermediate production centres, marketers, salesmen, and entrepreneurs. It has the potential to generate livelihoods in rural areas and arrest migration.

Environmental benefits

Large, fuel-ef cient biomass stoves for cooking and for industrial applications can reduce fuel consumption by about 40%. This translates to an average of 8–10 tonnes of firewood conserved/stove/year. In the business-as-usual scenario, the global warming commitment per meal or kilogram of output is therefore very high.

Biomass briquettes: a viable alternative to the use of firewood in industries

TIDE also understood that an option for reducing deforestation was to convert industries currently using firewood to briquettes. If bulk users of firewood migrated to briquettes then the cost of firewood could perhaps be contained and more firewood would be available to the smaller users.

TIDE therefore worked with the tea industry in south India and motivated them to use briquettes. Most factories have indicated that they would prefer to use a combination of firewood and briquettes for tea drying. TIDE understood the briquette-making process, especially the machinery for briquette-making. It figured that drying of biomass was important for increasing the productivity of the briquette plant. TIDE also explored in great detail, the supply chains for loose fuels that go into biomass briquettes. It has offered technical and part financial assistance to three briquetting units to produce and supply briquettes to the tea industries. The calorific value of the briquettes produced in these units is more than 4000 kcal/kg.

To date, TIDE has been able to add a production capacity about 6000 tonnes of briquettes annually. This is low compared to the demand of 2,50,000 tonnes of briquettes annually.

Conclusion

Cookstove businesses that include the poor are environment-friendly, and profitable. Though there are good market opportunities, innovation and adaptation are necessary. Given improved framework conditions and involvement of donor communities in the initial stages, the success rates and ability to deliver social, economic, and environmental benefits would be even higher.

Micro Hydro

CASE STUDY 12

Micro Hydro

Micro-hydro power plants powering rural India*

Pico-hydro in Karnataka*

There has been a significant development in setting up of pico-hydro projects in Karnataka in the last four years. Since 2007, about 500 pico-hydro projects have been set up till date and the numbers is increasing steadily. By March 2013, the number of installations expected is 700–800. This trend is likely to continue.

Impact on farmers and villagers

Pico-hydro systems have a significant impact on farmers and villagers who have no access to electricity. A number of such installations are in very remote locations with no electricity. Many installations have been done in isolated places near reserve forests, coastal regions, and national parks where it is not possible to lay transmission lines by DISCOMs. In such places, the pico-hydro systems have been a boon. In hilly areas, grid and solar power are unreliable due to monsoons and therefore, pico-hydro is a convenient solution. A 1-kW pico-hydro plant provides

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24 kWh of 220 V, 50 Hz AC power per day and all available equipment can be used. The users have access to the kind of power available in urban areas. The equipment that can be run using electricity generated from pico-hydro include lights, TV, grinder-mixer, and household items. Some users have also utilized it for income generation activities.

Chembu village in the Coorg District of Karnataka has seen a major change due to installation of pico-hydro systems. The village is surrounded by forests and is typically inhabited by poor farmers who had no access to electricity but had almost perennial streams running through their habitation. Today, about 80 houses in the village have installed these systems 40 more are expected to receive electricity supply by this year. The village is on the way to becoming a 100% pico-hydro-powered village.

A sustainable environment has been built for the execution of this project Karnataka. The ecosystem has been nurtured by the technology providers Prakruti Hydro Labs, Bengaluru, and includes implementers like Nisarga Environmental Technology, Shimoga; Karawali Renewable Energy, Belthangady; and Credit Cooperatives, which provide financing to beneficiaries like Sharda Souharda Society, Siri Souharda Society, and support from the NGO Small Scale Sustainable Infrastructure Development Fund.

The prospective beneficiary applies through the website to KREDL (Karnataka Renewable Energy Development Agency) with a registration fee expressing his/her intent to install a pico-hydro system in his/her property. The application gets registered in KREDL. The applicant then goes to any of the implementers who helps him/her in getting bridge finance for the project and helps in installation of the system. After a set of installation at site, a completion report is sent to KREDL. KREDL technical personnel visit the site to check the installation and its performance. After they are assured of the system's working, KREDL processes the request for subsidy release and releases to the end beneficiary.

The state has identified about 1500 potential sites in Chikkamagalore, Uttara Kannada, Dakshina Kannada, Hassan, Udupi, Kodagu, and Shimoga districts. With continued financial support from the Ministry of New and Renewable Energy, Government of India, in future, the task will be completed and the dif culties in laying transmission lines and providing regular power supply by DISCOMs could be minimized.

Micro-hydro plant at Putsil

The micro-hydro plant installed at village Putsil has catalysed visible changes:

increase in income, work sharing, leisure time, and community initiatives; sanitation and cleanliness; awareness and empowerment; management of local natural resources, protection of forests, and sustainable practices of land utilization; and so on.

The main beneficiaries of electrification are women. This means no more backbreaking work such as pounding and grinding of cereals. They now have a 3-HP rice mill. They no longer come back home hurriedly from the field to cook before dark. Earlier, people used to go to bed by seven in the evening in order to save on kerosene. Now, they have time to attend to household chores at leisure, discuss with friends, watch TV in the community centre, and so on. Houses are cleaner, children take interest in studies, cooking at leisure has improved the quality of food, husbands stay at home in the evenings, and everyone watches TV together. There has been an increase in income-generating activities and most families generate an additional income of about Rs 10, 000–12,000 in a year.

Access to information and the world outside has become easier. There is TV, time, and facility to read books. About 10 families own TV sets and the number of tape recorders and radios has also increased. The village community centre has a TV for community viewing.

The micro-hydro plant has also benefited the neighbouring seven villages. They charge batteries and mobiles and also use the rice mill. Battery charging costs Rs 10, mobile charging Rs 3, and paddy milling costs Rs 12 per bag. The mill helps in collecting income for the community: out of each rupee, 0.50 paisa goes to the community fund. Four young men get direct employment: two in the mill, and two in the plant. As trained electricians, the plant operators now earn about Rs 9000 per annum out of wiring and allied activities in and outside their village. Recently, the community has started pisciculture using husk generated from the mill as fish feed. The women group has plans to augment income by processing local produce through the mill. They intend to start marketing varieties of *dal* and oil through the apex women's federation. At night, people are engaged in processing non-timber forest produce such as hill brooms, *sikakai* powder, and tamarind. Some of the youths are trained to make the woodcrafts mounted with elegant natural colour and lac by the power-operated lathe.

In order to sustain water f ow in the streams, reduce silt load, and restore biodiversity, the villagers have taken forest protection and plantation seriously over 300 hectares of forests are protected. The community is also into a process of capacity building for sustainable use of land. They have earmarked 10 acres of land to learn nursery management and raise saplings for regeneration of endangered or lost species. They are aware of the bulk cash they would need to replace the major components after a decade or two. They have already started planting traditional cash generating trees to raise money. To take care of recurring maintenance, they have bank savings of about Rs 7,00,000 .

Community management: effective adaptation of traditional values

Establishment of the plant was preceded by a series of intensive interaction with the community for about two years. The objective was to build capacity of the community in management of the micro-hydro project; effective use of power and other end use applications; build future vision for sustainable control and management of other resources; and create space for technologists, scientists, and NGOs to interact with the communities on decentralized energy options. Technical consultations and feasibility studies were carried out and the construction work began around January 1999.

The Putsil Micro Hydro Committee comprising 21 members (includes six women) manages the power generation and distribution. Each of the 80 families in the village is a consumer. The consumers are divided into six groups and each group is assigned specific tasks such as repair and management of the catchment area.

One incredible aspect about the Putsil Micro Hydro is the depth of community participation. The community contributed about Rs 2,13,000 in the form of labour towards the establishment of the plant. The approach employed by the community to manage the plant has effective combination of traditional values of concern and f exibility. This is ref ected in the timing of power supply, collection of fees, compensation for services to operate the plant, and other end-use machineries.

Since 1998, each family has been paying an average Rs 20 per month towards electricity fund. However, they are free to give less during the lean season and more when they have a better income. For family use, electricity is supplied from 6 pm in the evening to 10 pm; again from 3 am to 6 am; and later from 6 am to 8 am to run the mill. The early morning power supply was initiated due to a demand by women to complete household chores before leaving for the field. During marriage, childbirth, serious illness, festivities, and other such occasions, power supply is given as per the need.

CASE STUDY 13

Micro Hydro

Remote village electrification through a micro-hydel project*

Arunachal Pradesh, also called the Land of the Rising Sun, lies in the north-eastern most part of the country. The state is mostly hilly and is covered with dense forests. It has got a long rainy season of almost six months. Due to its topography and a long rainy season, there are many streams and tributaries running throughout the year without drying up. Many of the villages lie near such streams and tributaries. This makes the place conducive for hydel projects ranging from pico to micro and mini. These villages are again very remote without road connectivity and located at a large distance from each other.

The MNRE (Ministry of New and Renewable Energy), Government of India, has been pioneering the electrification of such remote villages by providing subsidy for setting up hydel projects of different capacities. The Bikhi MHP (Micro Hydel Project) of 2 × 15-kW capacity, is one such project constructed under the subsidy assistance from the MNRE under the RVE (rural village electrification) programme. This project falls under the Sagalee circle of Papumpare district in Arunachal Pradesh.

Running, maintenance, and revenue collection

The project has been running successfully ever since it was commissioned. There has been no requirement of any kind of special or major maintenance so far. The running and maintenance of the project are being done by the villagers themselves. The concept of Village Energy Management Committee has been introduced in this project and is under assessment and monitoring at present. Technical assistance and general guidance are provided by APEDA (Arunachal Pradesh Energy Development Agency) whenever required.

Benefits from the project

Three villages namely Seema, Gungtung, and Taw have been electrified through this project. A government middle school near Seema Village is also gaining benefits. The plant also provides power to a health sub-centre and the Anganwadi centres of the villages.

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Villages electrified and their profile

Three villages and one government middle school with a boarding facility for boys and girls have been electrified under this project. Details by village are given below.

1. No. of households
   Seema - 19
   Gungtung - 14
   Taw - 09
2. Population
   Seema - 220
   Gungtung - 130
   Taw - 100
3. Occupation
   Agriculture and horticulture are the main occupation of the villagers.
4. Accessibility
   Itanagar to Sagalee by *kutcha* road - 100 km
   Sagalee to Parang by *kutcha* road - 30 km
   Parang to power house through porter track - 5 km

Salient features of the project

Name of scheme	-	Bikhi MHP (2 × 15 kW)
Sanction No. and date	-	31/1/2003-VE-SHP (ARN-PR) dated 31March 2004
Original estimated cost	-	Rs 32.68 lakh
Revised cost	-	Rs 41.63 lakh
Installed capacity	-	30 kW
Types of turbine	-	Turbo Impulse Turbine (Jyoti make)
Type of generator	-	3 phases, 415 volt AC Syn. generator
Gross head	-	32 MTR
Design discharge	-	80 LPS each unit
Length of power channel	-	100 metres
Fund sharing		
MNRE share	-	Rs 18 lakh
State share	-	Rs 23.63 lakh
Implemented by	-	APEDA
Commissioning date	-	28 January 2008
Geographical coordinates of the power house		
Longitude	-	93029'14.09''E
Latitude	-	27020'34.13''N

CASE STUDY 14

Micro Hydro

Jakhana micro-hydel project*

An initiative of UREDA (Uttarakhand Renewable Energy Development Agency), the Jakhana micro-hydel project is a unique model of community-managed power supply system. The basic idea behind the project was to utilize the free f owing water of the perennial Balganga river for generating power and to supply continuous electricity to the nearby revenue villages, namely Jakhana, Bhaldgaon, Toli; their hamlets Bagi, Jamrauli, Budli, and Chauri; and the nearby market on a sustainable basis with a system of community-based operation and management. The project is located at Village Jakhana in Block Bhilangana of District Tehri Garhwal.

Jakhana micro hydel project, capacity 2 x 50 kW in District Tehri Garhwal of Uttarakhand

The uniqueness of this project is that it was planned and constructed with the participation of the community. For planning, construction, operation, and maintenance of the Jakhana project, a VEC (Village Energy Committee) has been formed. It has been registered under the Society Registration Act 1860 with registration No. 622/2005-06. This VEC has been involved from the planning of the project to its commissioning. Operators and electricians have also been provided training on operation, distribution, and safety aspects. Villagers take care of the routine and minor repairs of the civil structure of the project on their own. The VEC consists of eight members, out of which two are women.

* *For further information, contact:* Mr Arun Tyagi, E-mail: aruntyagi@gmail.com

The total power production from the project is 100 kW. It provides power supply to 295 families through a transmission network of 2.58 km and distribution network of 5.87 km. Apart from the main transformer of 80 kVA, 5 step-down 25 kVA 11 kV/415 transformers have been installed on the distribution line.

Control panel and turbines of the Jakhana micro hydel project

The project has been designed on 50 m net head and 149 LPS discharge. The project has two cross f ow turbines of 50 kW, a synchronous generator of 82.5 kVA, a 150-m feeder channel, 1150-m power channel, and a penstock pipe of 150 m. Other structures such as diversion, desilting tank, forebay tank, and power house have been constructed as per the requirement of the project. The project has been insured against natural calamities.

AHEC (Alternate Hydro Energy Center), IIT, Roorkee, provides the technical support like alignment at site, drawing, and maintenance manual along with training to VEC members and operators for construction and operation/maintenance of the project.

Three operators have been deputed by the VEC for the operation and maintenance of the project. A salary of Rs 18,000 per month is being paid to these operators/ electricians. Electricity charges at the rate of Rs 3 per unit from metered connection and Rs 50 per bulb/month from non-metered connection are being taken by the VEC. The VEC prepares and distributes bills on a monthly basis through the appointed electricians. The collection of electricity bill is done at the project site. Monthly bill recovery from the consumers is 93%. The amount collected is being used as honorarium to the operator and for day-to-day maintenance charges. Expenses of Rs 1000 per month are marked as miscellaneous expenses. The VEC also maintains various documents such as day book, bill collection register, log book, complaint register, stock register, and bank documents.

The total cost of the project is Rs 147.42 lakh out of which Rs 59.04 lakh has been provided by the MNRE (Ministry of New and Renewable Energy) as central financial assistance. The VEC has borne 8% of the capital cost of the project in the form of cash/labour and land for the project. The remaining funds have been provided by UREDA (Uttarakhand Renewable Energy Development Agency).

Thanks to the power supply available, the villagers are using refrigerator, washing machine, electric iron, fan, heaters, and so on. A saw mill has also been established in the area. Presently, this project is operating only for six to eight hours every day as per the requirement of electricity. The CUF (capacity utilization factor) is about 30%. To increase the CUF and obtain additional income, the VEC is now planning to provide electricity to the commercial consumers and small/cottage industries in the nearby area during the day.

People working at night after getting electricity supply

The Jakhana micro-hydel project works as a self-sustained small hydro project. Some of its key success factors are identified below.

- Members of the VEC have been selected by the villagers based on population
- The VEC has the authority to penalize defaulters
- Regular salary is paid to operators and technicians
- Load management in peak hours
- Regular account audits by certified chartered accountants
- Insurance of the project equipment

CASE STUDY 15

Micro Hydro

Clean energy for Ladakh*

Traditionally, Ladakh has been an energy-deficient region due to its remoteness, topography, and location. A centralized electricity distribution model is neither feasible nor viable for the region. However, the importance of energy in everyday life cannot be over-emphasized. The extreme weather conditions coupled with scarcity of natural resources render life dif cult, particularly during the prolonged winter season when the temperature plummets below sub-zero. Provision of clean energy sources such as electricity or natural gas by the state agencies has not yet reached the remote and far-f ung villages. Uninterrupted use of fossil fuels is polluting the serene atmosphere of Ladakh and endangering the fragile ecosystem of this high-altitude Himalayan region. The LEDeG (Ladakh Ecological Development Group) therefore encourages a decentralized approach of energy production so as to make the region self-reliant using renewable resources primarily sun and water, both of which are available in abundance in the region.

Micro-hydro power units

The villages in Ladakh are scattered and for three to four months most of the remote villages remain inaccessible during winter due to the snow and cold. In keeping with its aims and objectives, LEDeG decided to install a micro-hydro power unit in Udmaroo village of Nubra Block to improve the living conditions of the inhabitants of this remote village. Udmaroo is situated on the bank of River Shayok in Nubra valley of Leh District and is located at about 150 km from Leh. The village comprises 90 households and the total population of the village is about 540. LEDeG – in collaboration with the EU (European Union), BORDA (Bremen Overseas Research and Development Association), GERES (Groupe Energies Renouveable, Environment et Solidarites), and SD Tata Trusts (for end-use machine) – has successfully commissioned a 30-kW micro-hydro unit during the year 2009. The unit was inaugurated by Dr Farooq Abdullah, Hon'ble Minister for New and Renewable Energy, Government of India, and Shri Omar Abdullah, Hon'ble Chief Minister of Jammu and Kashmir, on 2 September 2009.

Since then, the unit has been functioning successfully and the village electricity committee is looking after and maintaining the unit ef ciently. The villagers have

** For further information, contact:* Ms Sonam Gyalson, E-mail: mail@ledeg.org also installed a carpentry and saw machine, a flour machine, and an oil expeller machine. These have not only reduced the drudgery but also added income to the community and provided livelihood to many families.

Technical details of the system

- Capacity: 32 kVA, presently generating 20–25 kVA
- Head and flow: net head 54 m, design flow 120 litres/second
- Electric component: 415-V three-phase, four-wire system with electronic load governing, live load
- Total transmission length: 3.3 km

Costs and funding

- Total cost of micro hydro system: Rs 22,18,810
- User cash contribution towards capital cost: approximately Rs 1000 per household
- User in-kind contribution: unpaid labour for installation
- Remaining costs covered in grant funds from EU, BORDA, and GERES under the 'Rural Electrification Component' of 'Improving the living conditions of marginalized people in remote villages of Ladakh region,' conceived and implemented by LEDeG. The fruit processing unit was funded by Sir Dorabji Tata Trust.

Solar photovoltaic power plants

LEDeG in collaboration with SCATEC Solar (India) has commissioned four small SPV (solar photovoltaic) power plants during 2011 in four remote villages of Ladakh (Maan and Shayok villages in Leh District and Juldo and Tashistongday in Kargil District). Table 1 provides the details of these villages.

Solar photovoltaic power plant at Juldo

Table 1 Installation details of solar power plants in the four villages

Name of the village	*No. of households*	*Installed capacity of SPVU* (kWp)
Maan	22	8.64
Shayok	25	9.18
Juldo	22	10.17
Tashistongday	24	10.17

All the four SPV units are running successfully ever since their commissioning in August/ September 2011 and the concerned village electricity committees are looking after the plants.

Udmaroo micro-hydro power unit

CASE STUDY 16

MICRO HYDRO

Creating synergy between traditional and modern technologies

The Himalayan region has several perennial streams, rivulets, and rivers where water flows down with great speed and force. This region is therefore a great source for generating hydro power. For centuries, the people living in these regions have been using hydropower to run flour mills, also known as *gharats*. However, since these traditional watermills produce less than 1 kW of mechanical power and are able to grind only 5 to 10 kg of flour/hour, diesel-run flour mills are gaining popularity and are giving tough competition to traditional watermills. These traditional watermills are therefore slowly running out of business. Many such watermills in 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%.

The performance of a watermill depends upon the following points.

- The force with which water hits the runner
- RPM (revolutions per minute) of the runner and the stone


Nozzle-Spear-Runner Runner

- Stone dressing
- Gap between the bed stone and drive stone
- Weight of the top stone
- Feed rate from the hopper

Construction of flow channel for watermill unit

Based on these parameters, an improved watermill was developed to maximize the grinding capacity of the existing mill 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 is also introduced. The advantage of the nozzle is that it can generate more force even when the water f ow is less. The traditional watermill requires a greater f ow of water.

Shisham bush and the rynd will maintain an optimum gap between the mill stones. Appropriately chiselled groves on grind stones will help the stones cool down after 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 thus hastens the the grinding process.

With the objective of bringing about improvements in the way poor communities harness water resources, IT Power India, a renewable energy engineering consultancy firm, upgraded the traditional watermills by making some simple modifications to the design. The upgraded watermills give an output of 20–25 kg f our/ hour in comparison to the 5–10 kg/hour output given by the traditional watermills.

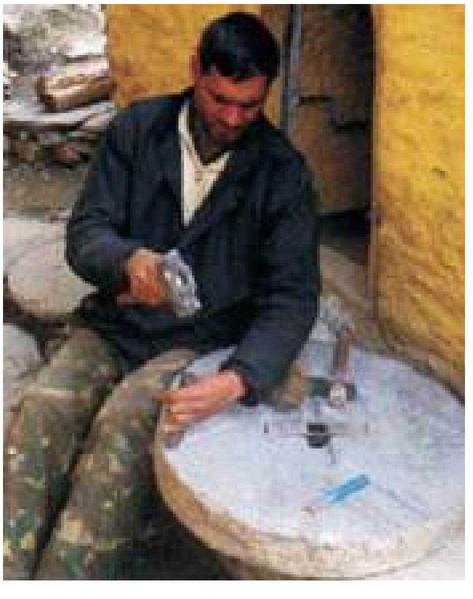
IT Power India implemented a pilot project in the Chamoli district of Uttarakhand for CWMA (Chamoli Watermill Association) with an initial investment of Rs 60,000 assigned to WMA. As part of the pilot project, IT Power India has undertaken the following activites.

- Conducted two training programmes on installation and commission of upgraded watermills and demonstrated the working of the upgraded watermills in two districts of Uttarakhand

- Conducted training programmes for 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, leaf ets, and brochures for promoting upgraded watermills.

Rice huller being set up

Initially, the 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. Originally, the mill owners used to earn an annual income of approximately Rs 3500. With an upgraded watermill, they could earn an annual income of about Rs 17,000 to Rs 22,000. With an almost six-fold increase in their income, watermill owners were able to repay their loans on time and also meet their own needs.



'Dressing' the millstones

A traditional watermill can be upgraded at an initial cost of Rs 15,340. This cost is inclusive of hardware, material, and labour costs for civil works; channel-GI sheet costs; technical assistance; and installation and commissioning costs. About Rs 2000 per year has to be invested towards meeting the initial expenditure. Loans can be availed from rural and agricultural banks like NABARD for upgrading the traditional watermills. 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.

It is estimated that at one time there were about 2,00,000 watermills operating across various Himalayan states of India. According to a survey conducted in 2003, there were about 2160 watermills in Chamoli district alone. Out of these, 1150, that is, about 53%, are still functional. Thus, the scale-up potential for the upgraded watermills is very high.

Upgraded watermills also 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). The large amount of heat generated damages the nutritional quality of the f our. Upgraded watermills generate low heat because of their low rotational speed (200 RPM) and hence retain the nutritional quality. Food prepared using this f our is healthy and tastes better. Women also prefer the upgraded watermills because they need not walk long distances to reach the diesel mills. Their time is also saved as they have to make only one trip to the watermill.

Upgraded watermills also mean more business for the mill owners. According to a market survey, a single household produces about 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 watermill can be utilized by 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 saves the environment.

Technologically, upgraded watermills 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 have to be tightened once in two or three years. On the contrary, 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 two to three months. The ef ciency of the watermill would increase further if a nozzle made of PVC pipe is used as water coming through the nozzle would be able to hit the runner more forcefully than the water coming through the wooden chute.

The milling house BEFORE

The milling house AFTER

Solar Energy

CASE STUDY 17

SOLAR ENERGY

Power to the people*

Of the large amount of solar energy available to us, only a fraction has been productively used to fulfill our energy needs. When this energy is used productively, the economic condition of the poor can be improved substantially. It was with this philosophy that Dr Harish Hande, in 1995, founded SELCO (SELCO Solar Light Pvt. Ltd), along with Mr Neville Williams. Since then, they have come a long way.

Today, SELCO is renowned for making energy services accessible to the poor of India. It focuses primarily on SPV (solar photovoltaic) technology to provide electricity for lighting, water pumping, communications, computing, entertainment, and small business appliances—an effort that has won SELCO many recognitions

Solar energy user: Laxmi, Bengaluru

* *For further information, contact:* Mr Ashis Kumar Sahu, E-mail: ashis@selco-india.com

and awards including the Ashden Award (2005 and 2007), the Social Entrepreneur of the Year Award (2007), and Financial Times Arcelor Mittal Boldness in Business Award in 2009.

An idea that brought a revolution

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

Impact of efforts

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 to the remote village of Galgamu, near Anuradhapura, in the hills of north Sri Lanka. Making best use of the scholarship money, Dr Hande took with him a 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 into the issues and challenges, and firmed up his belief in the potential of solar energy for improving the productivity of the rural households.

Solar energy beneficiaries: Pushpa, Mangalore

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 services, along with the customization of products and associated services for the specific needs of poor. True to his ideology, Dr Hande is indeed empowering his customers by providing a complete package of products, services, and consumer financing at the customer's doorstep.

In the last 15 years, 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 services have positively impacted the environment in which companies and institutions serve the underprivileged.

SELCO has also set out to bust the 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. SELCO, 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 the company's business model revolves around building the necessary parts for a sustainable and scalable model for energy services delivery through its bottom-up approach.

A different approach: customized products and technology

What makes SELCO different from other companies in this business is its approach towards lighting 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 installments. The company does not believe that one size fits all and spends considerable amount of efforts on pre-sale activities, all of which are done by the technicians as they are in the best position to understand a customer's requirements.

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

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 Rs 10 a day, but would find it dif cult to pay Rs 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.

Today the company is renowned for making energy services accessible to the poor of India. It focuses on 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 the needs and adapt the existing materials along with designing full value chains to make energy resources work for its customers. Thus, there are no marketing budgets and it is these efforts that act as their marketing tool and help the customer service agents double up as marketing agents when they deal 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 they have ever owned. Thus, it was easy for the company to understand that the rural poor require loans to afford the upfront payments for the systems, and they need financing schemes that are at par with their meagre income and cash f ows. 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.

Using solar energy: Radhabai, Sirsi

Other advantages

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

The other advantage 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's, 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 scaling up through replication. The company believes that while it is possible to scale up by standardization for a want, needs require customization

Energy beneficiaries: Ratnamma, Devanhalli

based on the context. SELCO, therefore, is looking at scaling up the concept and not necessarily the company.

In the coming years, SELCO aims to have a growing clientele of customers lower in the economic pyramid. The organization will go beyond its present offerings to include a range of energy services and will expand its operations into the 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 impacts. Thus, SELCO still has miles to go!

CASE STUDY 18

SOLAR ENERGY

A case study on Indira Nagar*

Indira Nagar is a small hamlet of Panchayat Soda in District Tonk, Rajasthan, consisting of 13 houses and about 190 inhabitants who are mainly farmers. Most of the families have small landholdings that are cultivated for a single rain-fed crop of pulses and groundnut every year; others work as labourers in nearby towns.

An initiative by Minda NexGenTech Ltd and the local sarpanch Ms Chhavi Rajawat set into motion a series of events, starting with setting up of a solar power-based micro grid that led to a transformation in the village. The initial investment for setting up the power plant was done by Minda NexGenTech Ltd with the intention of providing electricity to the village and also empowering them through income-generation opportunities such as grinding of lentils (pulses), stitching, and educating the womenfolk.

Prior to installation of the solar plant, light meant smelling and inhalation of fumes from kerosene lamps. Activities such as cooking, washing utensils, stitching, and fertilizer mixing were not possible after sunset. However, the 240-W solar power plant installed by Minda NextGenTech Ltd provides basic lighting to all houses in Indira Nagar. The arrival of power has also sparked the entrepreneurial spirit among women. Evening hours are now spent under energy-ef cient LED bulbs grinding pulses and stitching to supplement family incomes. Access to energy has enhanced the studying hours for children, facilitated women's education initiatives, and, in general, brought about a social revolution in the village.

The solar power plant is based on the BOM (built, operate, and maintain) working model with each household contributing Rs 150 as the monthly charge for usage. This has resulted in minimal financial impact on the villagers as more or less the same amount was earlier being paid for kerosene (3 litres), and charging of mobile phones. Some initial hesitation and obstacles were overcome thanks to the active support rendered by village local Mr Harji Lal Bairwato. He addressed the villagers' concerns and issues, and took the responsibility of collecting revenue, distributing pulses, and initiating a stitching and educational centre for womenfolk with guidance and assistance from the local panchayat and Minda NexGenTech Ltd.

** For further information, contact:* Mr P Bhasin, E-mail: pbhasin@mindagroup.com

Technical specifications of the solar power plant	
Component	*Specifications*
PV module	1 × 240 W
LED bulbs	1.5 W × 2 (LED bulbs)
Mobile charging point	5.5–6 V (Single point)
Battery	2 nos, 12 V-150 Ah (ampere hour), tubular lead–acid battery
Other components	Transmission distribution box, household distribution box inter-connecting wires/cables, separate switches, battery box and electrical accessories

Minida NextGen Tech's initiative has played a role in creating income-generating opportunities. With the support from villagers, provision of Rs 5/kg for grinding of pulses was started. The Panchayat has resulted in an additional income of about Rs 547 per month per household. The initiative of providing Rs 5/kg for grinding of pulses started with support from the villagers and the panchayat has resulted in an additional income of about Rs 547 per month per household.

Objective of the activities initiated through the solar power plant

- Basic lighting and mobile phone charging
- Generation of additional income and better standard of living
- Removal of kerosene lamps
- Better health, safety, and education

Activities initiated

Pulse grinding

Pulse grinding involves participation of women beneficiaries from 12 households using extra productive hours during the evening/night time. Each woman collects 5 kg of pulses every alternate day from the distribution centre. The grinding of pulses is done in addition to their daily chores using the LED lighting provided by the solar power plant.

Sewing centre

Sewing centre involves girls from Indira Nagar who are in the age group of 10–18 years. A local representative conducts regular training sessions enabling them to learn a new trade and also generate additional income to support their families. The sewing machines were procured using the collections from the monthly charges from each household.

Education centre

During the evenings, women gather in Harzi Lal's courtyard and learn to read and write under energy-ef cient LED lamps powered by the solar plant. Local students, Shivraj and Savara, have inspired and mobilized the villagers to become educated.

Enabling village-level entrepreneurs

Minda NexGenTech Ltd has adopted an approach to combine energy access in rural areas with sustainable rural development. It is envisaged that VLEs (village-level entrepreneurs) will invest and operate the micro grids to provide basic lighting and mobile charging facilities to rural households for a monthly rental. The monthly rental collected from each household is used for maintaining the power plant, repayment of EMIs, and to generate returns against investments made for installation of the power pslant.

Conclusion

The use of solar power along with the various initiatives and innovations has provided numerous opportunities to the villagers to use the available natural resources for their benefit. The overall impact has been an opportunity to build the future of the villagers, and to provide not only light, but sustainable, all round rural development.

CASE STUDY 19

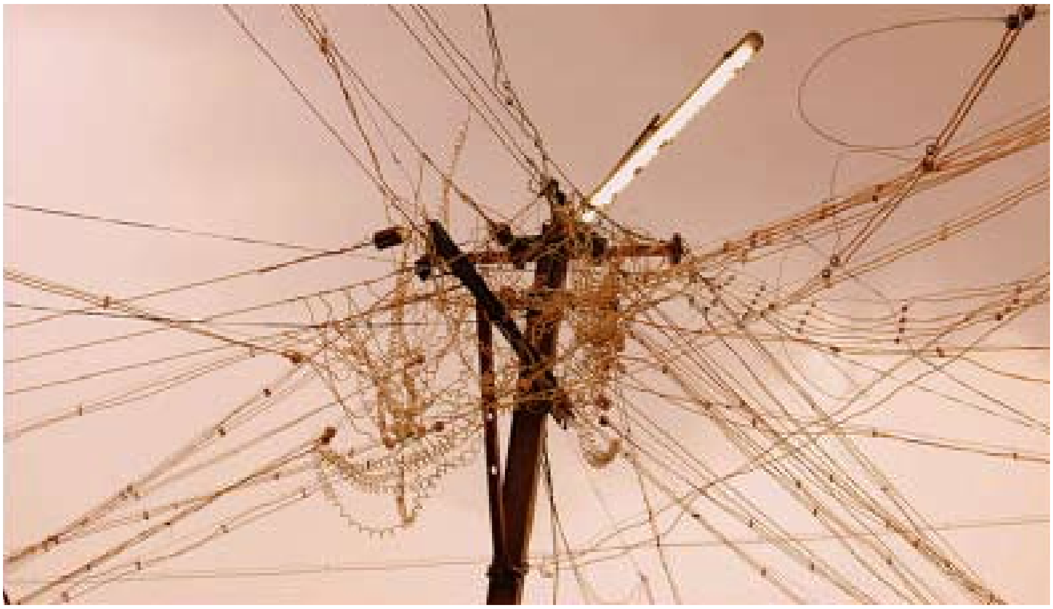
SOLAR ENERGY

Prepaid electricity for rural India*

a Gram Power initiative

There is an acute mismatch of energy demand and supply in many parts of rural India. For more than 30 years, numerous programmes have been put in place to achieve 100% rural electrification. Yet, large portions of Bihar, Arunachal Pradesh, Jharkhand, Meghalaya, and Uttar Pradesh lack grid connectivity.[1] Under the Rajiv Gandhi Grameen Vidyutikaran Yojana, the Government of India has spent over 5.8 billion dollars since 2005 to connect 17 million households to the grid without increasing generation capacity.[2] A village in India is deemed electrified if only 10% of the households buy a connection.

Gram Power, a for-profit company that seeks to provide sustainable electricity to rural India, offers a f exible, modular, and reliable smart micro-grid system that can create access to prepaid 'grid-level' electricity for nearly 40% of the world population at costs lower than their current expenses on kerosene.



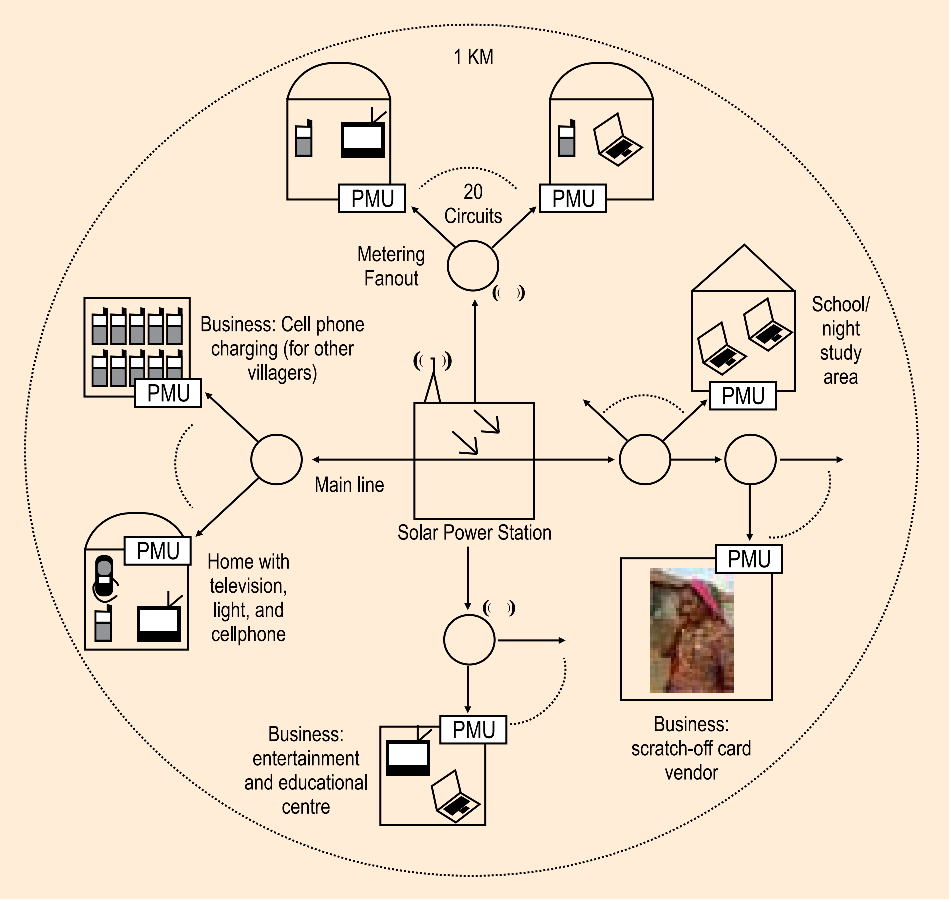
More than 400 million Indians live without access to reliable power
Photo credit: The ZionView (Creative Commons License)

¹ Improving electricity situation in Rural India, Vijay Modi, The Earth Institute at Columbia University
² http://rggvy.gov.in/rggvy/rggvyportal/index.html

** For further information, contact:* Mr Yashraj Khaitan, E-mail: yashraj@grampower.com

Gram Power has identified that distribution of power is the key challenge in scaling up rural electrification models. Their solution is based on two key components: renewable-based captive generation of energy customized for local energy demands and the utilization of multiple energy sources and even utility grid-integrated for energy supply.

The Gram Power micro-grid system at a glance



The Gram Power micro-grid system works along simple lines. Gram Power's Smart Prepaid Meter (patent pending) is installed for every consumer. Thus, power is paid for before consumption. The proprietary grid communication monitors and collects data from all meters. The grid can be managed remotely. There is a configurable load limit on every meter and consumers are charged by hours of consumption. Overload detection and self-recovery on meters are available. Community meters can be provided for communal power usage.

Project implementation and business model

Gram Power's smart micro-grid system typically includes solar-powered generation, energy distribution infrastructure, smart metering, communications hardware, and battery storage. They first work with NGO partners and a survey team to identify villages where micro-grids can be set up. These villages must have populations of

100+ people or 20+ homes. After a careful understanding of the paying capacity, energy demand, necessary distribution network, and willingness of the community to get involved, they select villages to set up the system.

The business model

The micro-grid is funded through government subsidies and private investments from Gram Power or any other corporate organization. Gram Power sets up the micro-grid on a complete turnkey basis. Bulk energy credit is sold wirelessly to a local entrepreneur for power generated locally. The entrepreneur sells power in prepaid mode to local consumers at a retail price. Telecom towers can also purchase this power from Gram Power.

The entire system is set up with community support and labour. Gram Power trains the community on system maintenance and safe electricity usage practices. A local entrepreneur is appointed and trained to sell energy. The prepaid meter charges consumers by the hour, just like pre-paid cell phones. A Rs 50 recharge buys 200 hours of CFL lighting or 50 hours of a fan. The meter constantly displays the number of hours left and as the load increases the number of hours keeps reducing. This makes users aware of their power consumption and incentivizes them to conserve power and use energy-ef cient appliances.

The local entrepreneur makes 10% on every power sale and can earn up to Rs 54,000 annually by catering to 300 connections. The revenue generated from the plant through power sales to the telecom tower and rural consumers pays for its operations, maintenance, and capital recovery, thereby making it a self-suf cient model.

Their distribution technology seeks to address the core challenges of rural electrification.

- **Payment collection:** Gram Power uses a prepaid purchase model to sell electricity in its micro-grids. A local entrepreneur is given an 'Energy Wallet' developed by Gram Power in which the company wirelessly transfers energy credit once the entrepreneur pays for it at a wholesale price. Every home is provided with Gram Power's Smart Prepaid Meter that allows power f ow only when it has a positive balance. Consumers can purchase energy credit from this entrepreneur for amounts as small as Rs 20, making energy access very affordable. Most importantly, this system eliminates payment defaults and is entrepreneur-driven, thereby creating inherent incentives for the entire process to function successfully.
- **Theft detection:** The utility grid suffers often suffers losses as high as 58%, which is mainly due to theft and pilferage. Theft can cause the already expensive renewable power to become prohibitively expensive which is why Gram Power's Smart Micro-grid is designed to detect and eliminate theft on individual meters and distribution lines.
- **Reliable on-demand supply:** Gram Power's micro-grids are designed to provide 24x7 power supply to consumers. They are able to do this with only seven hours of battery back-up due to the high levels of energy conservation

with eliminating theft and increasing consumer consciousness about energy ef ciency through prepaid meters.

Gram Power's system works on the following lines.

- **Energy generation:** Gram Power's smart distribution system can interface with any form of energy generation: solar, biomass, wind or even a hybrid combination of these. This generation infrastructure is installed locally in the village and provides power to homes within 2 km radius. A central controller is set up here to collect generation data and do intelligent grid communication with the smart prepaid meters.
- **Distribution, metering, and communication:** Gram Power installs distribution lines to transmit 240 V (volts) AC from the generation station to every home. Every home is given a single-phase connection and has the proprietary smart prepaid meter that communicates with the central controller using the company's communication protocols to detect and eliminate energy theft, monitor consumer's power consumption, and optimize supply and demand of power.
- **Consumption:** Consumers can operate lights, fans, radios, TVs, cell phones, motors, and other common appliances in their homes. They can also use higher power appliances such as water pumps and motors in wheat mills through the community meters. The meter provided to each home is load-limited using intelligent software. Consumers are given the f exibility to choose from a variety of connection types and payment plans based on their energy needs.

First project in Rajasthan

Gram Power set up India's first smart micro-grid in rural Rajasthan in May 2012 and the response has been extremely promising. The average power consumption of a consumer including line losses on the grid has been only 0.4 kWh/day with 90% of the consumers using the proprietary smart prepaid meter. This stands in contrast to the 2.4 kWh/day that would normally be supplied on the utility grid to provide the same utility. As a result, this system offers up to 84% energy savings.

Gram Power is currently working on another 10 kWp system with another 40 kWp worth of micro-grids in the pipeline.

They are also working closely with the MNRE (Ministry of New and Renewable Energy) to scale up smart micro-grid installations in India through sustainable business models, made possible through cutting-edge technology and community involvement.

Some challenges

Gram Power faces the following challenges.

- **Quality suppliers and technical support:** A solar micro-grid requires many different technical components and it has been a challenge to not only source quality equipment in a timely manner but also to get relevant technical details from manufacturers and dealers.

- **Comparison with subsidized tariffs:** Solar energy cannot be sustained at the subsidized tariff rates that the state governments provide to rural areas. Gram Power focuses on overall monthly expenditure rather than electricity tariff, and its consumers typically spend less on the system than what they would spend otherwise on state electricity for the few odd hours that power is supplied.
- **Community buy-in:** Building trust with the community is a challenging process as several fraud companies claiming to provide reliable power at extremely low prices have approached people in the past.
- **Village panchayat support:** In several instances, due to conf icts of interest and political reasons, it becomes dif cult for Gram Power to get support from the village panchayat.

There are some policy changes that will help Gram Power in scaling up their operations. Some of them are as follows.

- **Subsidy:** MNRE today provides 30% subsidy to all off-grid projects including rural micro-grids. However, rural micro-grids operate in riskier environments with higher costs of operations. It is important that either the percentage of CFA (central financial assistance) is increased or the allowable subsidy is made f at instead of a percentage ceiling. The latter option already exists in the scheme for biomass gasifiers, which incentivizes entrepreneurs to improve cost ef ciency and make projects more viable.
- **Channel partners:** It is a challenge for young companies to qualify all the necessary criteria to partner with the government and get access to subsidies or projects directly. If MNRE can provide policy support to appoint micro-grid operators as channel partners where this appointment is based on performance rather than on the basis of financial muscle or past experience, then this would attract a lot more young entrepreneurs to explore this sector.
- **Renewable energy certificates:** The REC (Renewable Energy Certificate) policy today is only applicable to grid-connected projects and is available when the power sold is greater than 1 MWh. To boost the off-grid rural sector, it is important that decentralized generation projects are also allowed to earn RECs and grid operators are allowed to combine generation from multiple projects to earn RECs.

CASE STUDY 20

SOLAR ENERGY

Mera Gaon micro-grid power*

MGP (Micro Grid Power) builds and operates micro grids to provide lighting to off-grid villages in Uttar Pradesh. MGP develops and operates the lowest cost micro-grid facilities in India. MGP's facilities provide superior lighting through multiple light points for a lower monthly cost compared to kerosene and other household lighting options like battery-operated LED lamps. Low capital and operational costs make for a commercially viable business model with projected returns greater than 30%, allowing a repayment period of less than three years.

Description of business model

MGP's strategy is to design and develop a service-specific micro grid dedicated to providing only household lighting and mobile phone charging. The design requires 90% less solar power generation capacity per customer compared to traditional solar-powered micro grids. In addition to the saving on panels and batteries, MGP has been able to install panels on existing houses within the village and batteries inside the houses. Thus, MGP's solar power stations require very little additional infrastructure. In addition, because MGP distributes power at low-voltage direct current, inverters are not necessary, thereby saving power loss due to conversion and reducing maintenance costs. MGP's facility design has four basic components, all of which are proven technologies and readily available through local, national, and international suppliers. These components are as listed below.

- Renewable generation (100 households would require 300 watts-peak of solar panels, approximately four panels)
- Battery bank (100 households would require 200 amp-hour of storage capacity)

* *For further information, contact:* Mr Nikhil Jaisinghani, E-mail: njaisinghani@vdigroup.org

- Power distribution is for a predefined time at 24 volts direct current. The distribution system is designed to limit distribution distances to under 100 metres from the generation source.
- Through the use of LED lights, power consumption per household is reduced by more than 90% compared to other solar-powered micro grids, cutting the cost of the village-level facility by more than 90% (each household is installed with two or four LED modules).

Village identification and engagement are done by MGP's NGO partner, the Sarathi Development Foundation. A local electrician is trained to fix up household light installation, which takes about two weeks to complete. The electrician visits the village every two weeks to inspect the system, connect new customers, and disconnect non-paying customers. Solar panels are washed once a month to remove any dust accumulated on the panels. Payment collections are done by the local women's group within the village.

MGP is continually improving its technical design, aiming to provide its customers with better service at a lower price. They are currently evaluating and integrating improved components into MGP's design. In particular, MGP expects to increase the luminosity of its lights to 100 lumens by use of improved and more ef cient LED bulbs. It also intends to identify ways to use mobile phone technology to strengthen its operation. GSM-controlled switches will be identified and installed as an improved technology turning power stations off in response to non-payment.

Economics

The actual project expenditure for a village of 100 households is Rs 2,48,380 approximately. Operation and maintenance costs are estimated to be approximately 12% of the capital expenditures. Labour requirements will be limited to tariff collection, solar panel cleaning, and regular inspection of the facility. Tariff collection cost per village is Rs 4516 per year. The average household tariff for lighting is Rs 70 per month for two lights. For a village of 100 households, revenues are estimated to be Rs 83,997. After covering the operation and maintenance expenses, the profit is estimated to be Rs 74,967 for a village of 100 households, resulting in a repayment period of less than three years.

Scale-up potential

MGP aims to reach 100 villages and 7000 clients by the end of 2012. Capital costs to cover equipment will be secured by October 2011. However, additional resources are required to test methods for mobile facility controls, hire and train a small team, and bring in consultants from the micro finance sector to develop a strong payment collection process.

Impacts

- Generated 15% minimum return on investment for investors

- Reduced operational cost and simplified operations to allow MGP to focus on scaling up rather than maintaining projects
- Reduced cost of running rural households immediately while providing improved lighting
- Provided rural households with quality, clean electric lighting (reduced kerosene consumption and the time spent on obtaining kerosene), and reduced indoor air pollution.
- Reduced household lighting expenses.
- Improved student enrollment.
- Facilitated time such that adults can engage in income-generating activities at night and children can study late into the evening
- Lesser environmental pollution leading to lesser clinic visits for respiratory problems

Sustainability

Carbon emissions can be reduced by reducing the dependency on kerosene. As MGP's facilities provide light with a far greater luminosity than kerosene lantern (one light is 10 times as bright as a kerosene wick lantern), MGP has contributed towards the productivity of the population. The strong potential value of MGP's facilities for the women in its customer villages, coupled with the observed strong demand by women to have improved lighting in their kitchens, has led MGP to believe that its outreach activities must integrate female social awareness builders, to demonstrate the improvement MGP's services can have on their lives.

CASE STUDY 21

SOLAR ENERGY

Solar energy for lighting and mobile in the remote villages of Bihar*

In India, rural electrification has been an important policy agenda for the central as well as the state government since independence. Electrification at the village level is an issue in only few states where the rate of village electrification remains low. The rate of village electrification in Bihar declined to 30.2% from 61.3% under the new definition.

The Bhagalpur district is located in the eastern part of Bihar with a population of 24.23 lakh and 4.12 lakh households. There are three villages in the Jagdishpur Block, Bhagalpur District, about 15 km from the 'city' Bhagalpur. One village has access to grid electricity supply, with erratic power supply for two to three hours per day. The other two villages are unelectrified with no access to electricity.

Naturetech Infrastructure Pvt. Ltd has provided lighting and mobile charging service to 51 households in these three villages, supplying electricity to about 80% households in two unelectrified villages and about 40% households in the village with limited access to grid electricity.

The business model

Solar energy is generated at one centrally located place through PV (photovoltaic) panels in the village and stored in batteries, which is distributed through 24-V DC mini-grid covering all the households in the village. Each village is powered with two PV panels of 75 W each on a 20-feet street pole. Power is generated at 24 V and two 40-Ah lead-acid tubular batteries connected in series are charged through

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a charger controller with LCD display and embedded digital timer. The mini-grid is switched on and off through a timer setting available in the charge controller itself. Power is distributed to the households through 24-V DC 2/3 distribution lines, with 1–2 A MCB for overload/ fault protection. To minimize transmission and distribution losses and achieve better tail-end voltage, the distribution circuit length has been kept at a distance of less than 200 m from the battery bank that covers about 30 households.

The services offered are home lighting during evening hours (five hours) and daytime mobile charging (eight hours) for the villagers from semi and unelectrified without compromising on the quality and cost. Naturetech Infra deputes its own trained personnel to erect the PV panels, and lays a distribution network and internal household wiring. The villagers help Naturetech personnel to install PV panels and to lay distribution network within the village. They have identified a person within the village and trained him to operate the PV-based mini-grid system, troubleshoot in distribution network, and collect monthly charges.

Economics of service

The installation cost of the PV-based mini-grid system is about Rs 2500 per household. Naturetech Infra has financed the installing of the PV-based mini-grid system in three villages and intends to take forth the learning from the installation and operation. For future projects, the organization intends to tap finance from commercial and avail grants from various agencies. They look forward to future projects to earn about 20% ROE (return on equity) with a payback period of about three years.

Scale-up potential

As the above model is decentralized, it can be replicated anywhere in the country and has tremendous scale-up potential, which shall reduce the operating and installation cost.

Impact of the project

With the implementation of the project, the villagers have now stopped using kerosene lantern, as also moving around to charge their mobile phone. Besides home lighting, community lighting service is provided free of cost at community places (like temples and other religious places, places of social gathering, and on the streets). The villagers are happy with the services as they get to spend their evening time more productively than ever before.

Sustainability aspect

The project has improved the social life of the villagers as male members are mostly available in the evening hours at community places. The project has no operating cost towards feedstock, does not cause any carbon dioxide emissions, and replaces a highly subsidized fuel like kerosene. The business model comprises simple and straightforward arrangements/features using standard products. This can be taken up in an organized and professional manner to ensure scale-up and channelize funds for such projects. The barriers to the project are non-availability of commercial loan at reasonable interest rate and higher replacement cost of lead–acid tubular batteries.

CASE STUDY 22

Solar Energy

Ramakrishna Mission's economic PV development initiative*

The Sundarbans, situated in the vast swampy delta of the two great rivers, the Brahmaputra and the Ganges, extends over areas comprising mangrove forests, swamps, and islands, all interwoven by a network of small rivers and streams that f ow into the Bay of Bengal. The only mode of transportation into the area and between its countless villages is by boat. The land areas are traversed either on foot or bicycle rickshaw. Home lighting is provided by candles, kerosene lights, dry-cell batteries, and rechargeable car batteries. Recharging of batteries is dif cult because of the large distances over which they must be transported to be recharged, and the unpredictable quality of the available charging services. The Sundarbans is served by the RKM (Ramakrishna Mission), which provides its population with education, agriculture, training, and medical services. The RKM is principally known for its slum-relief activities in Kolkata.

The RKM Ashrama, Narendrapur, is a branch centre of RKM headquartered at Belur Math, Howrah, West Bengal. The Mission's work is carried out at the village level through a number of youth clubs that are coordinated and monitored by local cluster organizations. Today, the RKM *Lokasiksha Parishad* is working with about 40 af liated cluster organizations, with 1500 youth clubs spread over 4000 villages in 12 districts of West Bengal. Renewable energy programmes are an important part of the *Lokasiksha Parishad*. The RKM was recommended as the working NGO (non-governmental organization) to implement the cooperative programme between MNRE (Ministry of New and Renewable Energy) and the UNDP (United Nations Development Programme). The Mission has been responsible for identifying the beneficiaries of the PV (photovoltaic) systems, providing trained personnel to install and maintain the systems, collecting the loan repayments, and working with other funding organizations to expand the programme.

The business model

DOE's (Department of Energy) NREL (National Renewable Energy Laboratory) was assigned the responsibility of managing the United States side of the cooperative agreement. PV hardware was procured under a competitive solicitation. Modules

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and charge controllers were delivered dockside to Kolkata, where MNRE had a contract with Exide Industries to receive the materials and deliver them to the Sundarbans under the auspices of WBREDA (West Bengal Renewable Energy Development Agency). System hardware provided by the Indian side was joined and installed by Exide and WBREDA. The trained Mission installers carried out a major part of the system installation and worked with the end-users to educate them on the correct use of their new power systems.

The GoI (Government of India) provided about 40% subsidy to qualified beneficiaries (the unit costs Rs 14,000 for which the GoI provides Rs 6000). The remaining 60% of the cost (Rs 8000) was provided either in the form of cash or through low-interest loans of Rs 4500 repayable over an extended period of time (a down payment of Rs 3500 was required at the time of system delivery). Typically, the Mission has limited the loan period to less than three years, which was found to be a more effective period to achieve total repayment. The experience to date is that they have achieved repayment rates in excess of 95%, largely due to the good borrowing and banking habits established by the Mission in the communities. Most of the villages that have taken part in the programme had already established village-level banking.

IREDA (Indian Renewable Energy Development Agency) has the responsibility of dispersing World Bank funds for qualified renewable energy projects. To aggregate larger numbers of system sales, a leasing arrangement has been established that removes all subsidies while allowing end-users to access low-interest money for purchasing solar home lighting systems. IREDA has entered into a contract with a private organization for purchasing the solar systems and leasing them to the end-users. The organization treats this arrangement strictly as a business deal. They buy the PV systems directly from a dealer and receive 85% of the purchase price from IREDA as a low-interest loan (2.5% over 10 years). The company is then eligible to receive the full depreciation and tax benefits available from the GoI. They then lease the equipment to the RESCO (Rural Energy Service Company). RESCO then provides the systems to the end-users with a repayment schedule of one or two years. This arrangement has been approved for a trial of 3000 SHS (solar home systems).

Economics

The Sundarbans region was chosen for its remoteness and the fact that the installment of electric grids, if ever successfully installed, would take a long time. The seven villages chosen to receive the PV systems were provided with 300 home lighting systems (one VLX-53 Solarex Polycrystalline Silicon Module and one SunSaver 6 LVD charge controller per home lighting system) that furnished 50 W DC for two 9-W CFL (compact f uorescent lamps) and one electrical outlet of about 30 W for a black and white television set or other appliances. Fifteen street lights were installed for a clinic, a training centre, youth clubs, and two battery-charging stations of 4 kW each, capable of charging 10–100 Ah car batteries from complete discharge to full charge within one day of complete sunshine. The use of solar energy allows for the provision of an additional four hours of light, and allows the young students to study at night. It also allows for additional productivity as seen at the weaving centre, and provides health care at the local clinic, where the vaccine refrigerator makes snake bite serums available. The solar energy street lights are usually deployed in the village gathering places.

Solar lighting systems have been installed at youth clubs in Katakhali, Satjlia, and Shantigachi. The RKM plans to charge Rs 15 per charge initially and finally bring it up to Rs 25 or Rs 30. The RKM has provided the following information for charging a 60 Ah battery three times per month. The battery, with an expected lifetime of two years, costs about Rs 3500, that is, about Rs 150 per month. A battery charge is estimated at Rs 30, that is, Rs 90 per month. The cost of transporting the battery by boat to the charging station is Rs 20 to Rs 60 per month. This brings the total to Rs 300 per month.

Impact and expected changes at different levels

The project impact was clear and brought about a high level of satisfaction among the villagers. None of the systems have hit their low-voltage discharge, indicating that the batteries are operating at a high SOC (state of charge). This was confirmed by taking specific gravity measurements, all of which were at or above 80% SOC. This indicates that the PV systems are under-utilized. Most home owners do not own a television and only power two or three 9-W CFLs for three to four hours per night. Those with television sets (14 W) usually operate it for two to three hours per night. Thus, the 50-W systems are more than adequate to provide additional power beyond this. The RKM is committed to PV for SHS. Since the time NREL systems have been introduced, more than 1100 systems have been sold and installed in the region. Up to now, the RKM has focused its attention on four districts, namely South 24 Parganas, Midnapur, Bankura, and Gosaba. A senior PV technician is responsible for each district. Under him are four or more village-level technicians who work on solar energy systems, taking care of installation, maintenance, and inspections. The RKM plans to expand into three other districts, namely Burdwan, Hoogly, and Birbhum. They have selected 10 new technicians who will undergo training in basic electronics with an emphasis on PV technicalities.

All electronics students at the Mission study solar energy implementation methods in their courses. In other areas of the Sundarbans, the RKM has begun to sell PV systems through shopkeepers. The shopkeeper gets a commission of Rs 600 on the sale of the PV systems for making the contact and setting it up. The Mission does not install or maintain these systems, but sends a technician out to inspect the installation once the set-up is completed. The shopkeeper performs all the follow-on services required. Shopkeepers are responsible for approximately 10% of the follow-on sales. Another indication of the success of their infrastructure is the attention paid to record keeping. The NREL systems are inspected once a month, and a technician fills out an inspection report. Each homeowner is provided a simple homeowner's guide for his/her system. Homeowners were asked what they used for lighting before PV. The majority used hurricane lamps that consume kerosene. The fuel charges were Rs 60 to Rs 80 per month. This provided two lamps for four hours per night.

This collaborative project between MNRE and UNDP has successfully brought the benefits of electricity to a region, which formerly had little or no electrical power. From this information, a definitive statement about the sustainability of these projects can be made. The RKM continues to interact with other funding agencies to expand the electrification effort to other areas in their sphere of inf uence. Their efforts have led to one of the largest and most successful rural electrification efforts in Asia.

The social impact of the initiative, however, will only be known after some time. Clearly, the major inf uence will be on the young man in the village studying under PV-powered lights, moving on from candles or kerosene-fueled lanterns. The quality of health care in the region too will improve with the increase in utilization of PV power for lighting and vaccine refrigeration.

Scale-up potential

This project has already created an impact in rural electrification, improving living conditions, and involving the country's youth force. The business model is sustainable, and the mission has already initiated the process of replicating the project in three other districts of West Bengal. Replication of the project is recommended with the entrepreneurs as resource persons for imparting training on technical aspects of SPV systems. It will not only contribute to the income of the entrepreneurs but also positively affect the overall development of the region.

SOLAR ENERGY

Facilitating last-mile access to solar solutions*

Founded in 2008, Switch ON was dedicated to generate awareness on renewable energy and the environment. With a desire to make substantial contribution to the sector, in 2009, ONergy – a for-profit venture – was formed. ONergy is dedicated to providing renewable energy solutions to India's BoP (bottom-of-the-pyramid) population. Based in Kolkata, ONergy has established operations in West Bengal and Orissa, with plans to expand throughout east and north-east India including Jharkhand, Bihar, and Chhattisgarh in the next five years. The unique aspect of ONergy is that it is a technology agnostic product-service company. In 2012, ONergy has been awarded fellowship to the Unreasonable Institute, Yale's Global Social, Santa Clara's Global Social Benefit Incubator, and DASRA Social Impact.

Building an energy ecosystem

Access to energy is directly related to development and poverty alleviation, but the ultimate challenge is providing energy access. Awareness, accessibility, and affordability of renewable energy technologies are three significant challenges that ONergy is working towards solving. Income-generating activities are required for rural beneficiaries to sustainably afford these energy systems over the long term. Thus, a holistic approach needs to be taken in order for renewable energy to successfully achieve

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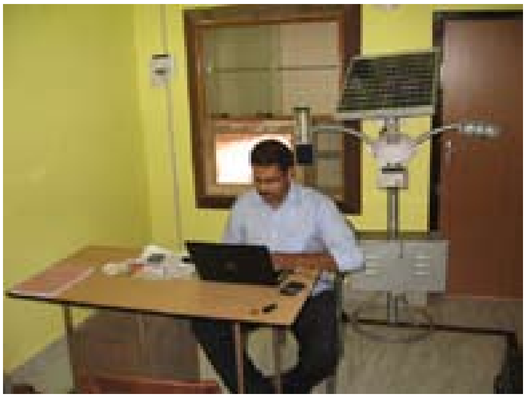
large-scale adoption in rural India. ONergy has set out to build an ecosystem connecting technology, finance, and grassroots organizations to manage the energy needs, aspirations, and resources of rural BoP beneficiaries.

This means starting from the ground level to generate awareness for renewable technologies, running capacity-building workshops for technical training and skill building that can be used for income generation, offering quality products with a strong servicing infrastructure, and ultimately, providing financing options for low-income rural consumers that have traditionally been labeled as 'un-bankable'. Having a strong after-sales servicing and maintenance infrastructure is also vital to ONergy's model, as reliability and confidence in the systems is a critical factor for customers. ONergy employs a unique 'hub and spoke' distribution model.

RECs (Renewable energy centres) or Shakti Kendras are set up in communities to act as a hub—hosting a retail centre, training facility, and servicing team. Rural entrepreneurs are recruited locally for sales and distribution, and are provided with technical training to install, service, and sell the systems, thereby creating direct jobs in the community. The RECs are run in partnership with grassroots' organizations. The distribution and service network is managed by ONergy, leveraging the network, infrastructure, and local knowledge of the partner.



By managing the entire renewable energy distribution and servicing process in rural areas – providing training, after-sales service, and financing options to the end consumer – ONergy fills the missing link in the rural BoP market.

Economics

Cost

ONergy provides customized solutions at a wide range of price points (Rs 1000–30,000+) and also takes up kilowatt-level projects for institutions, in order to ensure no one is excluded from the benefits of solar. Its low-cost LED night lights start at Rs 1000, with small home lighting systems from Rs 2000–5000. Larger home electrification systems, which can power lights, and fans/TVs/radios range from Rs 7500–15,000+, while inverter-based systems, solar water heaters, solar street lights, and so on are priced at Rs 30,000+.

Financing

ONergy partners with various organizations such as MFIs (micro-finance institutions), who typically only lend to their current clients, with SHGs (self-help groups), many of whom have purchased ONergy products after setting solar as a savings goal, and most recently with financial institutions such as rural banks in order to provide low-interest long-term energy loans for the rural market consisting of low-income villagers.

For the low-cost products, (for example, solar LED lamps), customers typically are able to pay the entire cost upfront. Slightly more expensive products (for example, portable lanterns, small home lighting systems) can be afforded by some, or are taken on in installment payments over 6 months–1 year. The larger home lighting systems and other larger scale technologies (solar water heaters, solar street lights), are typically paid back over a 1–5 year period.

Terms of credit / loan

For MFIs, the loans are typically for one to three years at higher interest rates of 12%–25%. SHGs are offered a typically flat rate interest as the required sum is saved up before purchase of product. For banks the programme initiated by the National Solar Mission outlines the suggested terms of credit as

- 15%–20% cost of system as down payment
- remaining 75%–80% paid in installments over life of the loan
- five-year loan
- 5% interest rate

Returns / profit

Unit economics (per REC)

Cost: 6,00,000 and Net margin: 10%

Breakeven: 6 months

Company economics

Gross margin: 25% and Net margin: 6%

Breakeven: 2 years

Payback period

Payback period ranges from 6 months to 5 years based on the size of the system.

Impacts of the project

Since 2009, ONergy has achieved the following.

- *ONergized* 75,000+ lives with solar light or renewable energy
- Established operations across West Bengal and Balangir district of Odisha; Set up six RECs in West Bengal and Odisha
- Partnered with 20+ grassroots organizations (NGOs, MFIs, and CBOs)

- Reached out to over 300 villages
- Trained 300+ rural entrepreneurs and 50+ women's SHGs

Based on its impact assessment surveys, ONergy beneficiaries have reported the following benefits.

- Average saving of Rs 100–200 per month per household on kerosene and mobile charging
- Average reduction in kerosene usage by 3.5 litres per month
- About 82% people are using their solar light for education purposes, 46% for income generation, and 78% for cooking
- About 64% report an increase in their children's study time
- About 94% report that their household savings have increased due to reduction in kerosene use

Scale-up potential

RECs are a scalable, financially viable, sustainable, and decentralized method for reaching the last mile on the large scale.

When an REC is established in a new market, it is beneficial to partner with grassroots organizations as it leverages their reputation, which has already been established in the community. It also uses their human resources, thereby becoming an ef cient method of setting up operations in a new district or state.

Through the experience of setting up the first six RECs, ONergy has built a set of solid operational procedures (for example, translated training and marketing materials, technical staff to 'train the trainers', accurate cost estimates, and so on), which will serve to make expansion and scale-up increasingly more ef cient and effective.

The mission is to *ONergize* 10,00,000 lives (or 2,00,000 homes) by 2016 by providing affordable, clean lighting/electrification solutions to eradicate the use of kerosene.

CASE STUDY 24

SOLAR ENERGY

Clean and reliable lighting solutions for rural communities*

More than 1.3 billion people around the world do not have access to electricity. In developing rural communities, the burning of kerosene lamps and paraf n candles as a lighting solution not only provides insuf cient illumination to carry out basic household chores, schoolwork, and business, but also increases the indoor air pollution. The lack of clean and safe lighting for these people makes life come to a standstill at dusk. It limits the productivity of a quarter of the world's population and is an impediment to development opportunities in sectors such as health, education, and infrastructure. Conscious of the lack of electricity reaching rural communities, TERI (The Energy and Resources Institute) began exploring the scope of adopting suitable technology solutions to overcome this challenge through two interventions.

Solar micro grids in Uttar Pradesh

An SMG (solar micro grid) is a f exible, modular, and reliable solar-powered micro-grid system that can provide electricity access to communities with as less as 10 households and as many as 80 households, at costs lower than their current expenses on kerosene. A typical micro-grid station can disseminate light to 40 households, for four to six hours daily using LED lamps.

Typical solar micro-grid display in rural India

Due to access to light, a villager in India is able to carry on business after dark

** For further information, contact:* Mr I H Rehman, E-mail: ihrehman@teri.res.in

Strategy

Considering participation at the grassroots as one of the key drivers for sustainability of decentralized generation, TERI approached village-level entrepreneurs to invest and operate the SMGs. The entrepreneur is responsible for day-to-day operations, upkeep, and minor maintenance. He collects rent or fee in lieu of the energy service (fixed lighting based) from the users. A part of this revenue thus generated is kept aside for meeting the recurring operation and maintenance costs such as replacement of fuses and batteries while the remaining part is the entrepreneurs' income. In villages where TERI has been involved, the system size ranges from 1000 Wp to 75 Wp, with majority being of 300 Wp capacity.

The SMG, set up by entrepreneurs with support from the technology provider, is managed by selected operators trained by TERI. These trained operators recharge the battery and are responsible for provisioning of energy services through fixed lights to households/shops in lieu of a nominal fee, determined through a consultative process between the operator and user community.

Results

- TERI with support from the Norwegian Ministry of Foreign Affairs innovated and demonstrated SMGs in three village market places of Jagdishpur Block (CSM Nagar District) and Shivgark Block (District Rae Bareli) in Uttar Pradesh. This supplies un-interrupted power to 200 commercial establishments. The system uses LED lights, which require less power thereby reducing the requirements of large quantities of power. The micro-grid is modular and can be set up incrementally starting with 10 connections (up to 200 connections).
- The pre-installation survey indicates regular power cuts during evening hours (from 5 pm to 9 pm) and unreliable supply during other time of the day. In all, 34 micro-grids are being set up to supply clean lighting to 1400 commercial establishments and households in rural Uttar Pradesh.
- The micro-grids not only help the entrepreneurs to enhance their incomes but also replace the diesel gen-sets and use of kerosene at comparable cost, along with providing clean and reliable power to the rural people. As this is an ongoing project, as of today, TERI has installed 17 micro-grids providing connection to 750 shops, households, poultry units and village-level processing units.

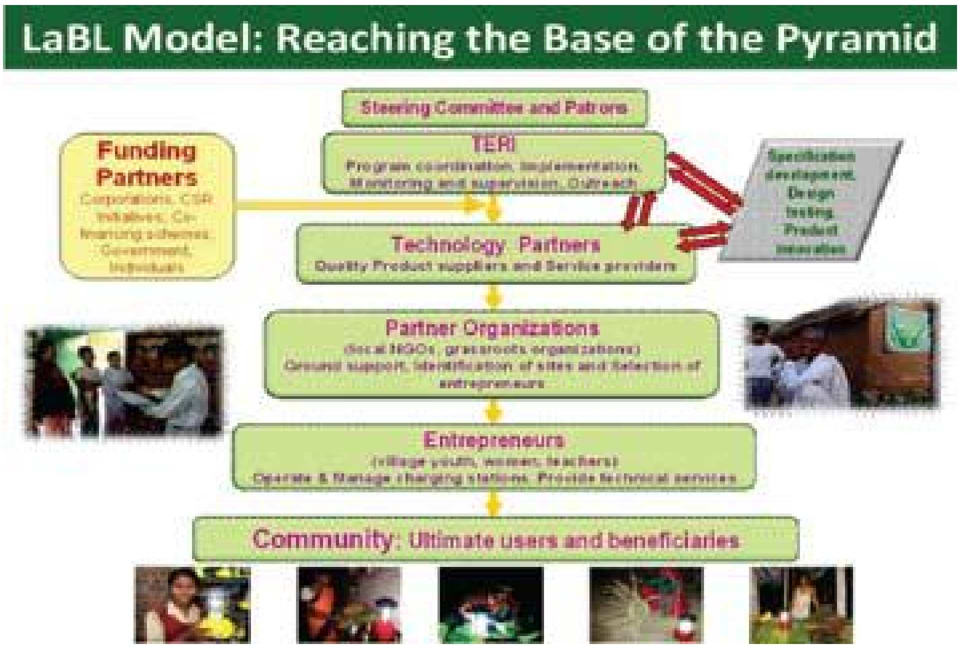
Outlook

The technology and the business model have received a lot of appreciation from the end users and implementers. UPNEDA (Uttar Pradesh Renewable Energy Development Agency) has adopted the model for lighting un-electrified and poorly electrified villages of Uttar Pradesh.

Lighting a billion lives

The project, Lighting a Billion Lives (LaBL), provides a f exible entrepreneurship-based energy service model in which SCS (solar charging stations) are set up in energy-poor communities. Local entrepreneurs are trained to operate and manage the charging station and rent out certified, bright, and quality solar lanterns to the community every evening for a very affordable fee. These entrepreneurs are selected and given support by local LaBL implementation partners called partner organizations. The rent is collected by the entrepreneur, a part of which is used for the operation and maintenance of the charging station and for replacement of batteries as may be required after 18–24 months of operation. TERI provides the required training support to the LaBL partner organizations and the entrepreneurs.

The initiative involves a number of stakeholders with defined roles at the regional and local level, apart from product partners and energy service companies and is depicted in the figure below.



Results

- 1486 villages across 21 states in India benefiting more than 370,000 lives through the use of 74,080 solar lanterns
- 1500 'green jobs' created through rural entrepreneurship
- Trained, handheld, and partnered with more than 80 premier grassroots organizations to leverage rural entrepreneurial capacities and sustain the initiative
- Working towards promoting collaborative research and development of quality off-grid lighting products together with leading industry partners.
- Providing a unique platform to engage socially conscious companies to make a positive difference to communities under their CSR (corporate social responsibility) activities
- Establishment of Solar Lighting Laboratory by TERI supported by the MNRE (Ministry for New and Renewable Energy)
- Accreditation by the MNRE as Programme Administrator for off-grid solar applications under the JNNSM (Jawaharlal Nehru National Solar Mission)

- Africa advance: LaBL programme expanding to African countries through local partnerships, beginning with six charging stations in Sierra Leone and 40 solar charging stations in Mozambique and upcoming charging stations in Kenya, Ethiopia, and Uganda.
- Energy for All initiative: TERI is the convener of the Lighting for All Working Group under this ADB (Asian Development Bank)-supported initiative bringing together leading players in off-grid lighting
- Creation of TRCs (technology resource centres) at the village level to ensure effective after-sales supply and services, handholding, local training, and capacity building.

Outlook

The LaBL initiative has been able to diversify its range of technological intervention and activities. From establishing charging stations at the village level, the intervention has lent itself to creating a support system of entrepreneurs and technicians who can maintain this by linking and synergizing with the initiatives and commitments of the governments, private sector, and donor agencies towards socio-economic development of the communities using lighting as a means for facilitating and advancing their initiatives.

The user – the key stakeholder in the campaign – plays the most important role in sustaining the cause of the campaign. S/he not only uses the illumination from the solar lantern to facilitate her/his daily chores, but is also empowered to facilitate the education of her/his children, initiate livelihood activities, and have better access to health and sanitation facilities.

CASE STUDY 25

SOLAR ENERGY

Solar-based village electrification*
a pilot public–private–people partnership project

Worldwide, 1.6 billion people do not have access to electricity – of those, 1.3 billion live in rural areas – and they spend large sums on dirty fuels such as kerosene and diesel for their energy needs. There are 80,000 unelectrified villages in India out of which 18,000 are remote villages. To lift millions of people out of poverty and avoid migration to cities, the development of rural economies is extremely important. Access to energy is a critical component in this regard. Even though rural electrification has been high on the political agenda for decades, the actual development taking place on the ground has been slow. Renewable energy sources provide an opportunity for electrification of remote villages and for meeting their other energy needs.

This project was an attempt to demonstrate the attractiveness of solar power for those most in need of it. Scatec Solar built two pilot projects in two villages of India. Based on the experience and models used in these pilots, as well as the realization that new partnerships are needed to attract more private investments to the renewable energy sector, the Norwegian and Indian governments decided to form a PPPP (private–public–people partnership) and set up another 28 village

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SPV (solar photovoltaic) plants as a pilot project. The aim was to gain further experience with technical, financial, and organizational issues related to the scaling up of village electrification through renewable energy in rural areas.

The project involved installation and operation of CSPPs (community solar power plants) in 28 villages in four states in India: Uttar Pradesh, Madhya Pradesh, Jharkhand, and Jammu and Kashmir. A total of 290 kWp has been installed serving approximately 1300 families, with the size of each CSPP ranging from 4 kWp to 25 kWp. A variety of installation types, sizes, and models are tried out in the project, for the sake of gaining valuable information, and experience for the project proponents. The CSPPs are installed as either charging stations or mini-grid solutions comprising either a pure PV system or a hybrid configuration (PV/diesel or PV/biogas). In addition to lighting the houses, electricity was made available for commercial activities also, in certain cases. The projects in Jharkhand provided electricity to silk reeling centres.

The partnership comprised MNRE (Ministry of New and Renewable Energy, Government of India) and the Norad as funding agencies; the private company Scatec Solar AS, as the project implementer; and IREDA (Indian Renewable Energy Development Agency) as the monitoring agency.

The approach adopted for implementation of the project included the following.

- Worked with local NGOs as a door opener into villages. The NGOs organized a number of meetings (over several months) for raising awareness among the villagers to participate in the project under the PPPP model and explained to them the objectives and benefits of the project. The NGOs seemed to be very competent, with a lot of experience from the areas, and also dedicated with the long-term view of supporting the villages in development.
- The NGOs also carried out the needs assessment of the community – 'bottom-up approach' – and thus an estimation of the required load for different villages.
- The project attempted to secure proper operations and maintenance through local ownership. In all villages, VECs (village energy committees) have been formed, with varying number of members in total and varying number of female members. The VEC members were in general selected by the villagers. Similarly, the villagers appointed VO (village operators), having a minimum

educational qualification, and capability of understanding and operating the systems installed. The VOs were given basic training on topics like switching the battery charging systems on and off, and the electricity supply system to the households; taking required steps during low sunshine days, like switching off supply to the households; and in general monitoring of electricity supply as per the battery charging level.

The project led to several encouraging social outcomes/impact in most of the villages.

- The kerosene lamps used earlier caused respiratory and eye problems. Introduction of electricity has had a clear positive health effect on the household.
- Children are able to do their school homework and study in the evenings. This is claimed to have resulted in better marks in school examinations.
- The TV is bringing entertainment, news from the world, and educational programmes to the villagers, which is very positive. Following the commercials, some villagers now want more household appliances such as coolers and refrigerators. They have also become more aware of their own social standing as compared to people/societies seen on TV.
- Available electric light helps women to cook food in the evening, not during day as previously. The evening meals served are thus 'straight from the pot' meaning better quality 'fresher' food.
- Installation of fans makes heat more bearable and helps avoid insect and mosquitoes. The lights make it easier to spot insects inside the house at night.
- Streetlights have made walking outdoor after dark safer. Streetlights have also reduced the number of thefts.
- As electricity has enabled pumping of water, girls do not have walk long distances to collect water. Use of water will also inevitably increase with such systems, and thus hygiene standards in the households will evidently improve.
- In some villages, the value of land has increased, becoming more attractive to immigrants.

MNRE and Norad conducted a review of the project in late 2011 to assess the installation of projects as per plans. The review team observed that though the project contributed significantly to social outcomes, the business models were not financially viable and needed further introspection.

Learning from this pilot project will be very useful to be considered while developing such projects in future. Some of these are as follows.

- The local governments were not involved in the project in any way, so the implementation of the CSPPs was not coordinated with other electricity installation in the villages.

- Building the grid infrastructure as well as providing continuous system up-time, also after sundown, is excessively expensive with PV; a hybrid solution would be more cost effective.
- Striking the right supply/demand balance is complicated. Having stable, for example, commercial, offtake makes system dimensioning more predictable.
- Small systems are not bankable, hence business model innovation coupled with easily accessible support schemes is the prerequisite for success.
- The operation manuals and tool kits, where applicable, should be provided in vernacular language.

CASE STUDY 26

SOLAR ENERGY

Fresh vegetables in Ladakh*

Situated at an altitude of more than 3500 m above sea level, the Ladakh district of Jammu and Kashmir is one of the famous cold deserts of the world characterized by cold breeze and blazing sun. Ladakh receives very low rainfall. In winters, the temperature can be as low as –25 ºC.

The climate makes it difficult to grow fresh vegetables and other crops in the open for almost nine months in a year as plants die because of freezing cold. Airlifting the vegetables from the plains in winter and bringing them 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 and hence, many suffer from malnutrition. Being a rainshadow 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 10 years, GERES is working in this area in collaboration with LEHO (Ladakh Environmental Health Organization), LEDEG (Ladakh Ecological Development Group), the Leh Nutrition Project, and STAG (SKARCHEN and SPITI Trans-Himalayan Action Group/Ecosphere) .

A solar passive greenhouse

GERES developed an IGH (improved greenhouse) to maximize 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

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supplementary heating. Some of the salient features of the improved greenhouses are as follows.

- The greenhouse is oriented along an east–west axis with a long south-facing side.
- This long south side has a 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 are 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 the north, east, and west sides are constructed as cavity walls to help in minimizing heat 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.

Commercial greenhouse of Gulan Razul

- Vents are provided on the walls and on the roof to avoid excess humidity and heat and also to allow controlled natural ventilation.
- The 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, the entire greenhouse is constructed using locally available material. The main frame of the roof is made using local poplar wood, willows are used for struts, and straw or water-resistant local grass is used for the thatch. Rock, stone, mud bricks or rammed earth are used in the construction of walls. The polythene sheet has to be procured from places like Mumbai. Local masons were employed to construct the greenhouse by providing them with 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 approximately Rs 30,000. The owner of the domestic IGH has to either pay or collect

Construction of passive solar greenhouse at 14,000 feet

all the locally available material like wood for the roof frame, straw for thatch, mud bricks, and the material used for insulation. He has to provide the labour or pay for 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 it matches the agricultural cycle of Ladakh.

GERES monitors the IGH construction by providing the 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.

- Families should belong to the BPL (below the poverty line) category.
- They should have a site suitable for greenhouse construction.
- The family must be keen to use the greenhouse successfully and also willing to share the products with the community at large.

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.

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 a month. However, 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 vegetables to nine other families and barters with six other families, resulting in an improvement in their health. On an average, the villagers are able to save Rs 500 to Rs 1000 on vegetable purchases as locally grown fresh vegetables cost less when compared to imported vegetables.

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

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

The IGHs have increased income generation for their owners, as now they can earn additional income by selling vegetables and seedlings for cash. Surveys conducted have revealed that on an average an IGH owner earns Rs 8250 per year by selling their excess produce providing a 30% increase in their income levels.

The scale-up potential for IGHs in the high-altitude Himalayan states is very large.

In Ladakh, alone the potential demand for IGH to produce fresh vegetables for civilian consumption is about 3000 units. It may double up to 6000 units, if military requirement for fresh vegetables is included. At present, replacement of UV-resistant polythene sheet every five years and also lack of awareness among agricultural/horticulture departments at the 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 .

Passive solar greenhouse in a land

CASE STUDY 27

SOLAR ENERGY

Salty to sweet water*

solar shows the way

The villages around the Sambhar Salt Lake in Rajasthan face acute shortage of water. The region is drought-prone and over 80% of its ground water sources have unacceptable levels of fluoride, which is further exacerbated by the presence of salt. The ever-increasing number of salt production industries in the area that pump out more than 96 billion litres of water per year adds to this problem. Salt is produced by flooding the now almost-dry surface of the lake with the pumped-out water. Over the years, water has leaked into the sweet water sources and shortage of fresh water has become a critical issue in these villages.

The TDS (total dissolved solids) in the water can go beyond 10,000 ppm (parts per million), while the permissible limit, according to the BIS (Bureau of Indian Standards), is 2000 ppm. The recommended limit is even lower – 500 ppm.

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As there are only a few sources of sweet water, people are forced to drink from the same sources.

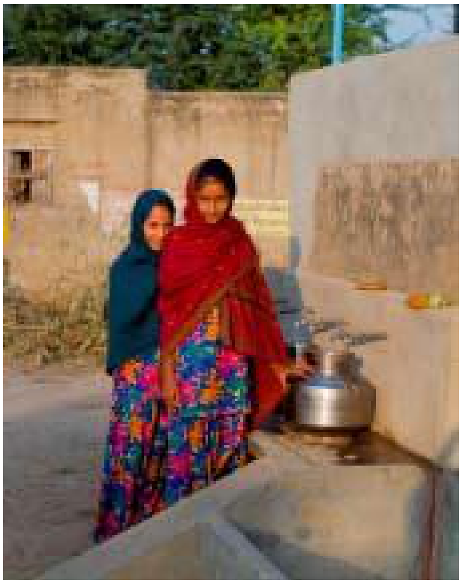
Solution

Taking all these factors into consideration, a local CBO (community-based organization), Manthan Sanstha, with the assistance of the Barefoot College, Tilonia, installed the first solar-powered RO (reverse osmosis) plant in their campus in village Kotri in 2006. The RO unit had been developed by the CSMCRI (Central Salt and Marine Chemicals Research Institute), a body of the CSIR (Council for Scientific and Industrial Research). The CSMCRI was the first to develop an RO plant capable of running on solar power, the first prototype of which was installed at Manthan. The rationale for using solar energy was that the plant required a steady and assured supply of energy in order to function optimally. The electricity supplied from the grid is erratic and irregular at best and several RO plants have failed in the area because of this reason. The plant installed at Manthan serves the drinking water needs of the campus and the village Kotri.

In 2010, taking this project out of the campus, Manthan and its Delhi-based partner FORRAD (Foundation for Rural Recovery and Development) designed a project to install such units in five villages. These villages are Sinodiya, Bhopa ki Dhani, and Jhag in Silora Block in Ajmer district and Solawata and Mordikala in Dudu Block in Jaipur district. The units were developed, assembled, and installed by CSMCRI.

Process

Pani Samitis were formed in each of the villages to plan, assist, and monitor the functioning of the units. These comprised representatives of the various community groups and equal representation by men and women from the village. It was



decided that every family using water from the unit would pay a one-time deposit of Rs 500 and a monthly fee of Rs 20 a month to get 20 litres of water a day per household.

The village panchayat offered the use of their community building to house the unit. The *Pani Samiti* identified two people for training on operation and maintenance of the plant. Of the 10 operators, 7 are women, though in terms of their literacy level they can only sign their name.

Parma Ram, a primary school graduate from a non-formal school, who was trained in the assembly of the solar unit and in the functioning of the RO plant, carried out the technical coordination of the project. He underwent training at CSMCRI and with their support trained these plant operators.

Technology

The RO system includes the following components.

- Booster pump
- Sand/bag filter to remove coarse particles, dirt, suspended matter, and other impurities
- Micron cartridge filters that remove fine particulates and colloidal and suspended particles
- High-pressure pump
- RO membrane system to remove dissolved solids/salts, fluorides, arsenic, nitrates, and bacteria

The RO units reduce the salt content of the water from 8000 ppm to 500 ppm and can process 400–800 litres of water per hour for eight hours a day.

These plants are driven by 5 kW of solar power generated by 96 panels mounted on the roof of the building. Tubular batteries are used to store this electricity. These batteries do not have to be serviced for five years and are not water-based, making them easier to maintain.

Impact of the project

- Reduction in water-borne diseases and other ailments caused by fluoride contamination: joint pain, digestive disorders, skin ailments, and so on

Economics

Reverse osmosis unit costs – Rs 13,50,000
Solar power (5 kW) – Rs 14,00,000
Housing and peripherals – Rs 1,00,000
Total cost: Rs 28,50,000

The operation cost also includes the cost of water testing, training, and administration for the first few years. Funds for this project were made available by the Coca-Cola India Foundation. The basic infrastructure, in terms of land and building, was provided by the gram panchayat.

- Reduction of drudgery amongst women and girls
- Demystification of renewable energy technology and handing these over to women and local community leading to their empowerment.

Scale-up potential

The intervention is required to be taken up on priority in 100 villages around Sambhar Salt Lake and in other villages across the country with similar constraints.

Sustainability aspects

- The deposit of Rs 500 per household and the monthly fee of Rs 20 ensure that the operators get a stipend and that the cost of minor repairs can be met.
- The importance of safe water for people will ensure that this project is sustained in the local areas.
- Technology has been transferred to the local community through training and capacity building of women on maintenance of the system.
- Decentralized and democratic process ensures collective ownership.

CASE STUDY 28

SOLAR ENERGY

Ending water woes in Kutch*

The Kutch region of Gujarat faces perennial drinking water problems. A small remote village called Hodko in Kutch has found a solution to this problem in an environment-friendly manner. WASMO (Water and Sanitation Management Organisation), an NGO (non-governmental organization) working in this area, initiated a programme in this village to encourage the utilization of solar energy at the rural level. Today, solar energy is responsible for a regular and equitable distribution of water to every household in the community. The initiative was taken up by the *Pani Samiti* of Hodko village, following the completion of the water supply system as part of the ERR (Earthquake Rehabilitation and Reconstruction) programme. Another reason for taking up this initiative was because of the erratic power supply from the existing grid. Therefore, the need for an alternative source of energy became absolutely necessary.

The first step was to install solar pumps in areas where the total lift of water was within the prescribed limits of a solar pump, that is, 70 m. Installation of these solar pumps has helped the women in these villages, who earlier had to walk for long distances to get water. Realizing the utility of solar PV (photovoltaic) pumps, many farmers have now started using it for irrigation purposes. As an added advantage, these pumps have low running and maintenance costs. This technology is now getting widely accepted for drinking water supply and irrigation purposes by the rural communities in the region.

Economics of the model

The expenditure on a solar pump including the SPV panels, a support structure, wiring, plumbing, and others, costs about Rs 4 lakh. This amount is for a pump with a pumping capacity of 20,000 litres of water per day. As compared to this, the cost of an electric pump with the same pumping capacity is about Rs 20,000. However, installation of these electric pumps is not practically feasible in this region. The installation of the power lines is a tedious process involving high expenses. The community in the village, with help from the *Pani Samiti*, carried out the installation of water supply systems throughout the village. They also took the responsibility of the O&M (operation and maintenance). However, the system could not be

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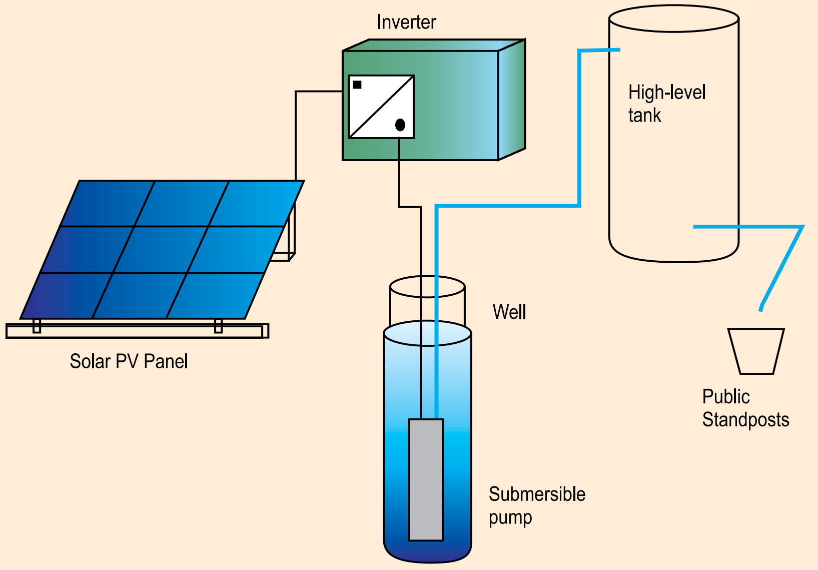
Technical Details

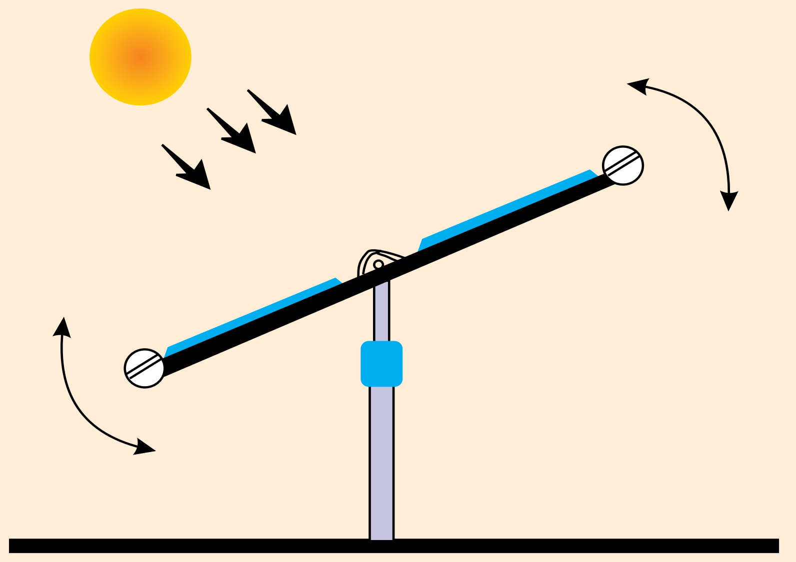
1) The civil works include
   - (a) 75,000 litres of underground sump (U/G sump)
   - (b) Pump house (2 m × 2 m)
   - (c) Wire fencing
2) Solar pump
   - (a) Solar PV module of 1440-Wp capacity
   - (b) AC submersible pump of 0.75 HP (horse power) capacity
   - (c) 20 panels
   - (d) Dynamic head of 13 m
3) Water supply management
   - (a) The water is supplied through a pipeline from the Banni RWSS (Regional Water Supply Scheme)
   - (b) Five to six *virdas* as an alternate source
   - (c) The village is divided into different *vandhs* where tanks of either 5000 litres or 10,000 litres are constructed for distribution of water on the basis of equity.

About 75,000 litres of water is pumped daily for approximately 5.5 hours to meet the requirement of the whole village including seven clusters (parts) situated far off to the village.



A diagrammatic sketch showing the working of an SPV pump

commissioned due to erratic power supply. Also, the running cost for pumping the water was cost intensive, which on many occasions became a deterrent in the recovery of the entire O&M charges. Solar energy is cheap and inexpensive, involves



A model showing the working of a PV panel

negligible maintenance cost, and provides assured power supply. The use of diesel pumps, on the other hand, is even more expensive compared to SPV pumps, and hence not financially feasible.

Sustainability

There is no uncertainty regarding the sustainability of the solar water supply plant. The village committee has been empowered, and with the active involvement of the people in decision-making, the sustainability issues have been properly addressed.

Impact of the project

Post installation, the water supply has been smooth in the Hodko village. The major change observed after the installation of solar pumps is that now the villagers have a regular water supply, with negligible O&M cost. Due to the splendid performance of the solar plant, the villagers have opted for solar cookers, solar lights, and solar water heaters. This is just another step towards acceptance of renewable energy by people living in remote areas in adverse climatic conditions.

Scale-up potential

This innovation has an immense scale-up potential across the entire Kutch region and in other remote locations of the country where grid connections are either erratic or not available at all.

ABOUT BOOK

India has considerable experience and is home to several innovations and successful examples of providing energy access to the remotest areas of the country. However, the challenges before us are to ensure that this access happens rapidly and in a sustained manner. This compendium titled Empowering rural India the RE way: inspiring success stories from different parts of the country are the living examples of the zeal to bring about a change, a determination to surpass the barriers, and an urge to adopt and promote renewable energy technologies to suit local requirements. The 28 success stories presented in this publication illustrate good practices and lessons learned in expanding energy access to rural and remote areas. The publication also carries information and knowledge on dissemination of low-emission technologies, innovative business and delivery models, entrepreneurship, institutional strengthening, and financing.

This publication, which is only a glimpse of a few successful attempts, will show the way to many organizations not only in India but also in other developing countries to replicate similar projects for meeting energy requirements of the rural folk, besides enhancing their livelihoods. At the same time, this would also be useful for local entrepreneurs and corporate organizations in exploring business opportunities in this area.

सत्यमेव जयते
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