MITIGATION AND ADAPTATION INFORMATION NETWORK FOR SUSTAINABLE COMMUNITIES

DECENTRALIZED RENEWABLE ENERGY IN INDIA

A Compendium of Case Studies

UNEP GRID ARENDAL
Environmental Knowledge for Change

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Development Alternatives

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Preface

The perceived impacts of climate change on livelihood needs and activities of a single village community could be very small. However, the aggregate impact of many village communities with the same needs and activities can be significant at national, regional and global scales. To scale up renewable energy solutions that enhance access to energy for village communities while mitigating drivers of climate change requires a knowledge base that supports the context-specific implementation of packaged solutions in a large number of villages. The packages should include training, financing, technology and management systems, primarily based on off-grid solutions. But it should be adaptable to the local situation, taking into account the unique environmental, economic and social settings of different village communities.

The project "Developing a Knowledge Base for Energy Efficiency and Decentralized Renewable Energy in India" is a project under the umbrella of MAIN - Mitigation and Adaptation Information Network for Sustainable Livelihoods. MAIN is an Information & Communication Technology (ICT) based network designed for exchange of information and experience, promoting innovation, capacity building, and empowerment by and for local communities. The objective of MAIN is to bring together expertise, knowledge and local experiences in a common network that empowers communities across the globe to create, share, use and store knowledge to support sustainable living.

The present “Compendium of Case Studies” has been prepared by Development Alternatives (DA) in association with UNEP/GRID-Arendal. This compendium has been prepared as a part of project "Developing a Knowledge base for Energy Efficiency and Decentralized Renewable Energy in India" under the umbrella of MAIN - Mitigation and Adaptation Information Network for Sustainable Living. The compendium seeks to capture the essence of the community based projects addressing decentralized renewable energy projects, practices and opportunities. The projects have demonstrated, or are expected to facilitate sharing and learning through the unique expediences of innovative models for decentralized renewable energy. It is hoped that the lessons learnt will foster socio-economic development and more security for livelihoods in rural areas. The case-studies should be of equal interests for replication by academics, policy makers, development agencies and interested individuals.

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Development Alternatives

Development Alternatives (DA) is a 26 years old research and implementation focused not-for-profit organisation. The activities of DA broadly cover the areas that underlie any form of sustainable development process. The Climate Change Centre has been established in the organization since 1990. The Centre has made active contributions to research, advocacy and outreach programmes related to Climate Change Mitigation and Adaptation.

UNEP/GRID-Arendal

UNEP/GRID-Arendal is an official United Nations Environment Programme (UNEP) collaborating centre located in Arendal, Norway with an office in Ottawa. GRID-Arendal's mission is to provide environmental information, capacity building services and innovative communication tools, methodologies and products for information management and outreach. GRID-Arendal seeks to make credible, science-based knowledge understandable to the public and to decision-makers.

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INNOVATIVE SOLAR POWER MODEL

A Case Study of Village Rampura, District Jhansi, Uttar Pradesh

At A Glance

Location
Village Rampura, Panchayat Pahalguwan
Block Baragaon, District Jhansi
Uttar Pradesh, India

Beneficiary Households
70

Plant Operational Since
January 2009

Power Plant Design
Polycrystalline Solar Plant 8.7 kWp; Mini-grid 0.75 km;
Battery backup to secure 3 days of autonomy
(days with no sun)

Funding Agency
Scatec Solar

Implementing Agency
Development Alternatives, India

OVERVIEW

Rampura is a small village in the Bundelkhand region - a semi-arid region of district Jhansi, in Uttar Pradesh. Till the year 2008, there was no electricity in the village. But with the initiative of setting up of a Community Solar Power Plant (CSPP) by Development Alternatives along with Scatec Solar, Rampura is now reaping the fruits of increased economic activity which can be directly attributed to the electric supply.

The process of CSPP was started in 2008 and by January 2009 it started supplying electricity to the people of Rampura village. Prior to electrification, the villagers were using kerosene as the prime source of energy for household lighting, resulting in an annual kerosene consumption of approximately 2,400 litres. The main objective of the CSPP was to gain a first-hand experience about the design, construction and operation of stand-alone solar power plants and establish a community managed revenue model. The community solar power plant was commissioned as a pilot project and now, with its success at the community level, it can be replicated in other areas and context as well.

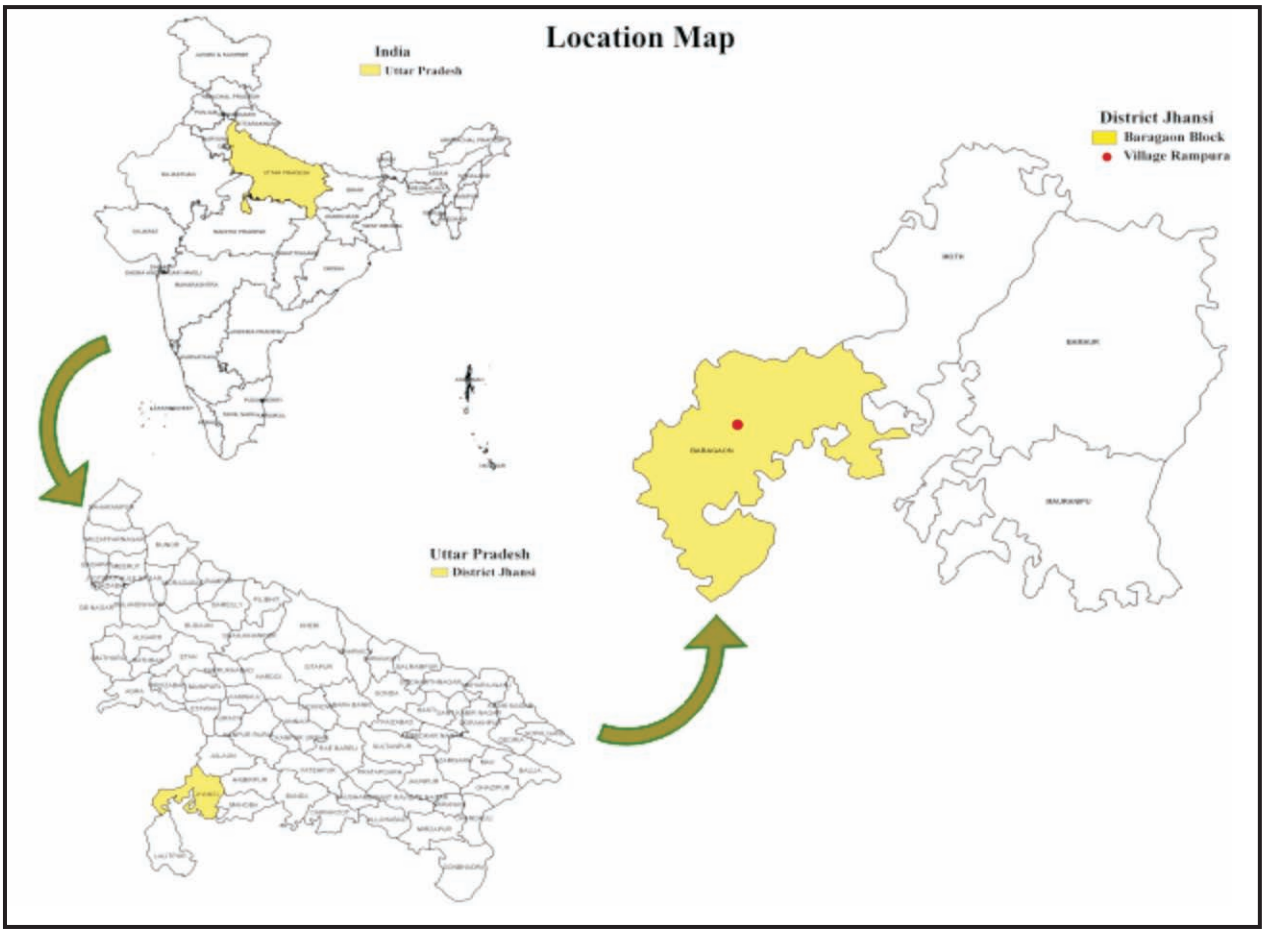
Partners

The Community Solar Power Plant at Rampura was initiated by Development Alternatives with technical and financial support from Scatec Solar. DD Solar 23 India (which works under the banner of Bergen Group) provided the technical support by donating one television and computer to Rampura. Along with this, Bergen Group is also paying for the salary of the computer teacher. Development Alternatives acted as a 'door- opener' for introducing the concept of solar power in the village and played a catalytic role in facilitating the implementation of solar power plant. One of the focus areas of the pilot solar energy generation project was decentralized energy generation. This was attained through community participation, along with social mobilization & capacity building of grassroot stakeholders, which included the local communities and members of Panchayati Raj institutions. A Village Energy Committee (VEC) was formed and assigned the responsibility of load management, revenue recovery and operation-maintenance on its own for sustainability.

Process and approach

The approach followed for setting up the solar power plant was 'Build-Own-Operate-Transfer' (BOOT), where the ultimate ownership of setting up and operating the plant rested with the village community itself. A work plan was developed by Scatec Solar for operation and maintenance of the solar plant for approximately 20 years. Development Alternatives took the role of engaging the village community and encouraged the villagers to utilize the electricity generated using solar power for new income generating activities. The concept of 'Pay for Energy' was introduced to the villagers to ensure financial sustainability of the plant.

Solar power generated from CSPP is now supplied for household lighting, fans and entertainment/educational purposes. Along with these facilities various other developmental activities have been carried out in the village, which include basic computer education, formation of self-help groups, land development and health and cleanliness activities. These developmental activities have helped in establishing a successful revenue model in the village.



Business model

A Community based solar power plant has polycrystalline solar panels with 3 strings that consist of 20 modules each. Each module consists of 50 cells. The total capacity of the solar power plant is about 8.7 kW. To secure 3 days of continuous power supply (days without sunlight), 24 batteries (2 Volt) of 2500 Amperes are used. The power station has two inverters of capacity 5 kW each supplying power of 42 Volt (DC) to 220 Volt (AC) and one 9 kW inverter charge controller.

For distribution of electricity, a mini-grid is supplying single phase 220 Volt (AC) power for household and community use and enterprise running. The project started with installation of 8 street lights and this number has now increased to 13 street lights for community use.

The plant has been oversized to meet the electricity demand for an enterprise load up to 2 horsepower (hp). The current tariff is structured in three slabs on the basis of monthly consumption of individual household. Consumption below 5 kW lies in Slab-1, between 5-10 kW in Slab-2 and more than 10 kW in Slab-3.

Current Tariff Structure			
	Slab-I	Slab-II	Slab-III
Types	0-5 kWh	5-10 kWh	10 kWh
Domestic			
Fixed Cost (INR)	20	90	160
Variable Cost (INR)	4.50 per kWh	5.5 per kWh	6.50 per kWh
Enterprise			
Fixed Cost (INR)	200		
Variable Cost (INR)	6.5 per kWh		

Revenue

- **Annual revenue from domestic load: INR 40, 843 *(including Rs. 4800 from street lights)***
- **Annual revenue from commercial load: INR 4,819**
- **Total annual revenue: INR 45,662**

Expenditure

- **Annual operator salary: INR 14,400**
- **Annual salary of security guard: INR 14,400**
- **Estimated annual expensive on maintenance: INR 4,000**
- **Annual insurance premium: INR 3,500**
- **Total annual expense: INR 36,300**
- **Annual saving: INR 9,362**

OUTCOME

The 8.7 kW plant generates an average energy of 950 kWh per month. The average energy consumption of the village is 840 units. Thus, the solar power plant is running at 90 per cent of its full utilization capacity. Out of the 69 households in this village, 44 households are connected to the solar power plant mini-grid supply. The solar power plant has not only provided assured energy supply to the people of Rampura, but has also made its impact in social, economical and environmental domains.

Socio-economic changes

Education and skill development

Presence of electricity in the village has enormously changed the lives of women and children. As per the field survey, 14 households have consented that electricity has made a positive impact on education.

Solar panels in village Rampura

School children engaged in learning computers

Flour mill as a small enterprise is established to generate local employment

Children are enjoying the benefits of electricity which include using computer, watching TV, flexible studying hours, etc. They are now being able to study for 1.5-2.0 hours extra every day. Advent of electricity has improved the quality of life in Rampura and has placed it amongst the few advanced villages in India. The village has been able to hold a successful computer training programme in the village school campus itself. At present, 42 children of Rampura (and nearby villages) are getting an opportunity to learn the basic functions of computer. Out of 42 children, 28 children are below ten years of age.

Gender concerns

Presence of electricity in the village has brought a positive change in the lifestyle of women. In fact, it has brought a shift in cooking timings for dinner. Provision of electricity throughout the day has given more time to women for indulging into various income generating activities like sewing, stitching, rope-making and sweater-weaving.

To educate villagers, especially children on the importance of renewable energy a "*Saanp-Seedi*" (snakes and ladders) game was invented, with energy efficiency component in it. It proved to be an effective method of information dissemination.

Renewable energy based enterprises

Rural electrification has also opened new avenues for employment generation and enterprise development in the village. A flour mill of 3 horsepower is operating on electricity generated from the solar power plant.

Meters are connected to save the theft of electricity

Mini-grid established to distribute electricity

Improved living standards

Provision of quality services (due to the continuous electricity supply) has raised the living standard of the villagers. This is visible from the quantity of electrical appliances purchased by them. Reportedly about 15 new TV sets, 9 coolers, 12 fans and a refrigerator has been purchased within the nine months of commencement of the plant, summing up to a total of Rs 64,000. Each household is paying an average of Rs 120 per month for electricity services.

Prior to the introduction of these electricity services, each household was spending Rs 60 per month on kerosene oil for lighting purposes only. This clearly demonstrates the willingness of rural people to pay extra money, provided they get quality services.

Improved health and sanitation

As per the results of household survey conducted keeping women in center, women agreed that non-usage of kerosene lamps has made a positive impact on their individual and family health. Presence of street lights is helping the villagers to change their age old habit of defecating in the open. Survey revealed that 17 households have already constructed new toilets in the past one year, after the inception of the solar plant.

Environmental changes

Reduction in the usage of kerosene oil by the villagers has reduced the environmental problems in the village.

Emission reduction

Prior to the inception of the solar power plant, the average household consumption of kerosene was 3 litres per month. At present, the average monthly consumption of kerosene has fallen to half of the initial consumption.

With 44 households subscribing to electricity services, 110 litres of kerosene is saved per month. Hence, Rampura villagers are successful in keeping in check around 3900 kg of carbon dioxide (CO_2) emissions annually.

LESSONS LEARNT

The pilot phase of the solar energy power generation project has provided valuable lessons, which can be used in formulating a general catalogue for the future roll-out of such projects.

Community needs and aspirations

While planning and designing any welfare and development activity, community needs and aspirations have to be considered. During the implementation of the solar energy generation project, the project team recognized the growing demand for extra energy by the villagers for irrigation purposes. For this, the project team introduced the concept of mobile irrigation in the village.

Community awareness

Though the villagers felt that there was a need to utilize alternative methods of energy development to cater to their requirements, there were some apprehensions regarding the solar energy at the initial stage. The common perception amongst villagers was that solar energy can be used only for lighting and it cannot cater the demands of domestic activities such as irrigation and running of appliances.

Therefore, a change in the mindset of the villagers was required, so that the Community Solar Power Plant model would appeal everyone and be replicated and applied to other villages as well. The villagers were also encouraged to invest in energy-efficient appliances like the CFL.

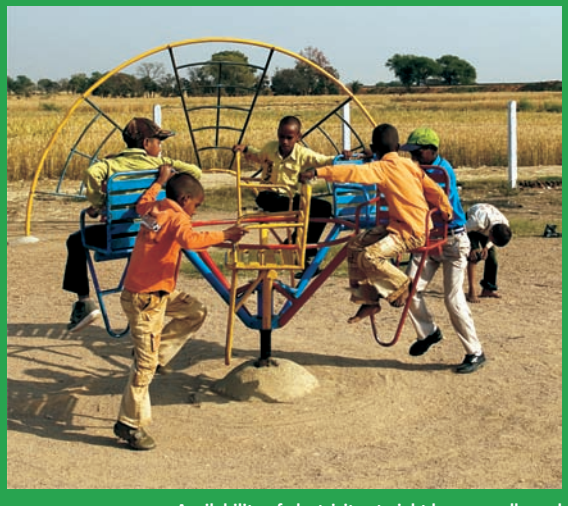
Various workshops were organised to educate and create awareness related to the environmental, economic and social benefits of decentralized energy generation in the village.

Community mobilization to secure ownership

For the sustainability of any community-based project, it is essential that the community should be able to take the ownership of the project. For this, community participation was sought from day one by involving local people in activities such as plant construction. After eight months of continuous training in accounting and management, Village Energy Committee has now become the owner of the solar power plant. Other developmental activities in Rampura like basic computer education, self-help group formation, land development, health and cleanliness activities have helped in establishing a successful revenue model.

Dialogue between local government and stakeholders

Development Alternatives not only initiated the dialogue process between local communities and the government but also influenced the local government to support the project. Support from the local Panchayat was required for procuring land for the solar power generation project. Permission from other Local



Availability of electricity at night has now allowed the kids to enjoy daytime activities

Community participation in action

District Administration departments (like Revenue Department and Sales Tax Department) was also sought for custom clearance and transportation of hardwares like solar panels, batteries and controls from one state to another state.

Deciding realistic power plant capacity

Although the capacity of a power plant varies along different geographical locations, a large part of northern and central India experience similar seasonal cycles. Hence, the results this pilot solar plant projects can be taken as the baseline for similar context.

Another important component for deciding the realistic capacity of a power plant is its load estimation and response to the fluctuating demand and supply. With the experience of running the pilot solar plant for more than a year, Village Energy Committee in Rampura is now in a position to take prudent decisions to meet every day challenges of load management.

Importance of explaining the tariff structure properly

To gain confidence of villagers it is important to explain each component of the project to the local communities. A locally acceptable tariff structure can certainly promote the usage of electricity in more efficient ways. For the ease of villagers, a chart can be prepared to explain the monthly consumption of electricity units (kWH) versus monthly bills that can be charged (INR).

HIGHLIGHTS

- Students are now able to study for 1.5-2 extra hours every day.
- The computer training programme in the village is attracting students from the nearby villages as well.
- Television has brought change in the living style of villagers with an upto date knowledge of the world.
- Rampura has become much safer and possess better sanitary conditions.
- The purchasing power of local communities has been enhanced and they are now better equipped with appliances like coolers, TVs, DVD players.
- The Pilot Solar Generation project at Rampura was implemented with the total cost of INR 29.5 lakh.

About the Partners

Development Alternatives (DA) is a 26 years old research and implementation focused not-for-profit organisation. The activities of DA broadly cover the areas that underline sustainable development process.
Website: www.devalt.org

Scatec Solar is a global turn-key supplier of solar PV solutions, with headquarters in Oslo, Norway. Scatec Solar is the first turnkey PV supplier with triple ISO certification for quality, environment and health.
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SOLAR POWER TO EMPOWER

A Case Study of Barefoot College
Village Tilonia, District Ajmer, Rajasthan

At A Glance

Location
Barefoot College, Village Tilonia
District Ajmer, Rajasthan, India

Number of Beneficiaries
0.9 Million People

Implementing Agency
Barefoot College

Funding Agencies
Ministry of New & Renewable Energy (MNRE) and Indian Renewable Energy Development Agency Limited (IREDA)

Technical Support
Indian Technical & Economical Cooperation (ITEC) with United Nations Economic & Social Commission for Asia & Pacific (UNESCAP)

The Barefoot College has been pioneering solar electrification in rural, remote, non-electrified villages, since 1972. The institute comes under Tilonia Gram Panchayat of Kishangarh Block in Ajmer District of Rajasthan.

Respecting the traditional knowledge and needs of the local population, Barefoot College adopted an innovative approach. The approach involved, using local skills to achieve people-centric and participatory development that is sustainable, rather than neglecting the local population by using knowledge external experts. The approach followed by Barefoot for rural solar electrification has been replicated across 751 villages in 16 states of India and 20 other underdeveloped countries. Nearly 2 Lakh (0.2 million), people have been provided with clean energy and electricity across the globe. Collective efforts have benefited at least 8,96,000 men, women and children worldwide.

OVERVIEW

The Barefoot college started with the modest beginning of 145 Watt mini solar power plant has now became first fully solar electrified campus (80,000 square feet area) located in rural India. What makes all the interventions unique is that all the installations are being carried out by "Barefoot Solar Engineers" who are either illiterate or semi-literate men and women. The college has demystified solar technology and is decentralizing its application by making it available to poor and neglected communities.

Partners

The main funding sources are the Ministry of New & Renewable Energy (MNRE) and Indian Renewable Energy Development Agency Limited (IREDA). The technical support is being provided by The Indian Technical and Economical Cooperation (ITEC) with United Nations Economic and Social Commission for Asia and Pacific. (UNESCAP).

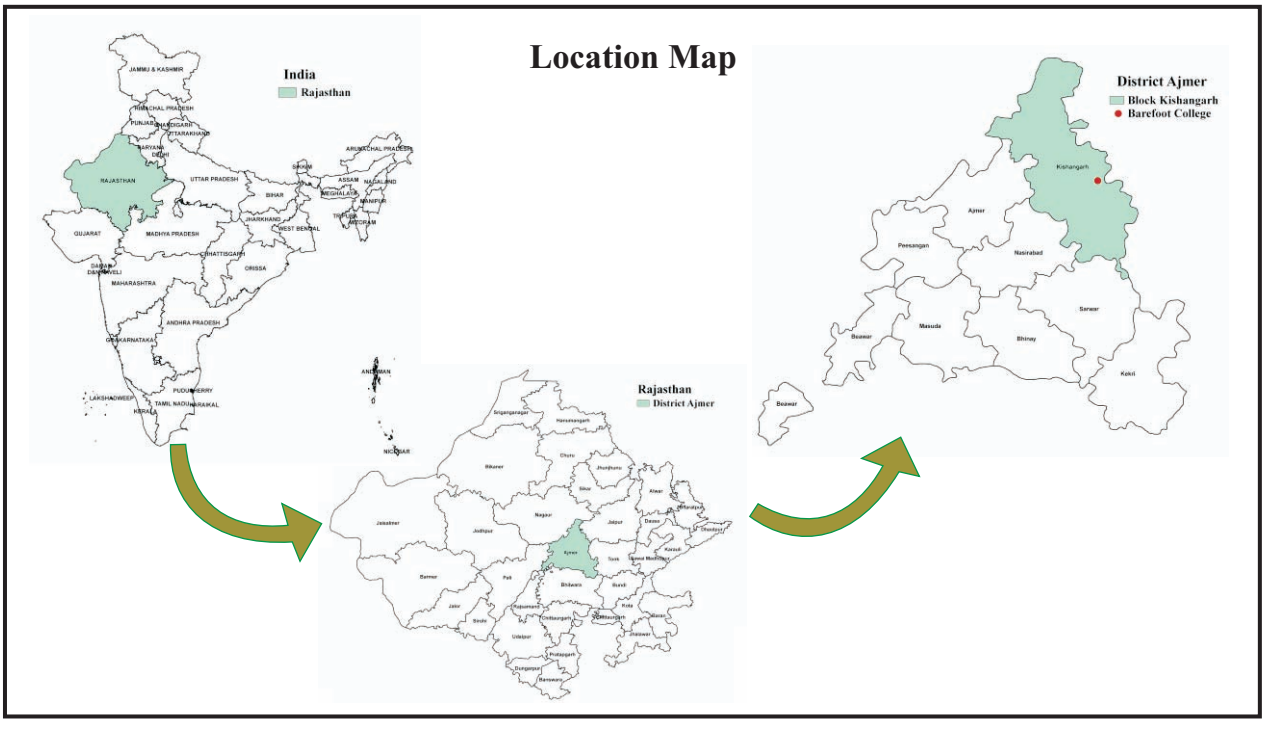
'Demystification' of solar technology is – putting the fabrication, installation, repair and maintenance in the hands of the semi-literate rural men and women thus making the solar electrified villages technically and financially self sufficient

Process and approach

The approach followed by the Barefoot College for rural solar electrification is unique. Only those villages that are inaccessible, remote and non-electrified are considered for solar electrification. The process starts with the orientation of community members on solar lighting and its benefits. A consultation takes place between the community members and 'Village Environment Energy Committee' (VEEC) to map needs, aspirations and willingness of the village community towards the responsibilities that need to be assumed during the project implementation.

The VECC essentially prepares the village community to take responsibility and ownership of solar units introduced in the village. It consults the village community to identify the households that are interested in acquiring solar lighting units. The institute provides a choice between two kinds of solar lighting units – Fixed Home Lighting Systems and Solar Lanterns.

As part of the decentralization and demystification process, the college imparts training on leadership qualities and willingness to work for the village as 'Barefoot Solar Engineers' (BSEs), to the community members, who essentially have a low economic status. A 'Rural Electronic Workshop (REW) is also set up by the trained BSEs in the village to install, repair, and maintain solar lighting units.



Business model

Each household that desires to obtain solar lighting system needs to pay an affordable contribution every month, irrespective of their economic status. This ensures that even the poorest of the poor can have a sense of ownership towards their unit and take care of it. The VEEC is responsible for making sure that the BSEs install, repair and maintain all the solar units properly.

The monthly fee to be paid by each electrified household is determined on the basis of the amount a family spends on kerosene, candles, torch batteries and wood for lighting every month.

OUTCOME

The Barefoot college has harnessed solar energy not only to provide electricity for domestic use but also to create employment, to save the environment by reducing carbon emission, to prevent millions of litres of kerosene from polluting the atmosphere and to conserve thousands of trees from being cut for energy generation purposes.

The college also provides the basic services and solutions to solve various problems of rural communities - like drinking water, education of women, health and sanitation, rural employment, income generation, electricity as well as social awareness and conservation of ecological systems.

Socio-economic changes

Education & skill development

Introduction of solar lighting units in rural communities has helped children to study even after dark. More than 50,000 children in India are attending Barefoot Night Schools after sunset (as they work at home and herd livestock during the day).

The very belief that educational qualification is not a barrier for picking up practical skills, and serving communities makes Barefoot college's every initiative unique. Infact, this is reflected in the selection of community members to be trained as Barefoot Solar Engineers.

Jobs created

The illiterate men and women irrespective of their age are being trained to work as school teachers, doctors, midwives, dentists, health workers, solar engineers, water drillers, hand pump mechanics, architects, artisans, designers, masons, communicators, water testers, phone operators, blacksmiths, carpenters, computer instructors and accountants.

As of May 2010, 480 people have been trained as Barefoot Solar Engineers (BSEs), of whom 230 are women. These BSEs have fabricated, installed, repaired and maintained nearly 16,000 fixed solar units and 9,762 solar lanterns across 16 states of India and 20 of the least developed countries like Afghanistan, Bhutan, Cameroon and Kenya etc.

Gender concerns

With the advent of the Barefoot movement, most of the village women have started studying and working, which has addressed the problem of the gender discrimination. Employment (after training) has made women financially independent.

Women who used to spend hours in fetching water and collecting fuel wood can now spend quality time doing other productive work with the installation of nearly 16,000 solar units and construction of more than 1500 rain water harvesting structures.

Environmental changes

Barefoot College has been applying solar energy as an alternative source of lighting (solar home lighting units), heating (solar water heaters), cooking (parabolic solar cookers) and drinking water (solar powered desalination plant) since its inception.

Preference to physically challenged people was given to boost confidence in them

Rural Electronic Workshop

The collective efforts of many illiterate and semi-literate rural men and women, have managed to save more than 30,000 litres of kerosene per month from polluting the atmosphere and have reduced the drudgery of women across 3 continents. The total carbon emissions reduction from 1986 to 2008 is estimated to be nearly 1.86 millions tonnes annually.

LESSONS LEARNT

- Difficult and varied social beliefs of the village communities posed a major challenge in terms of handling the dominating families of the big and powerful local politicians. Dominance of a few families was nullified by creating space for all the households to have their say on every social issue.
- Checking the migration to cities was handled by providing sustainable livelihood opportunities in the village itself, like repairing work, marble work and other local services.

Rural women serving as Barefoot solar engineers

WAY FORWARD

The Barefoot College has the vision of evolving a global solar village by creating sustainable livelihoods for the rural communities (especially for rural women) by converting renewable technologies into trades. The community managed, controlled and owned approach adopted by the Barefoot College is innovative and ensures the complete participation of the rural community and therefore can be replicated to other areas.

HIGHLIGHTS

- Barefoot College Campus meets its energy needs through 50 kilowatt solar modules with 5 battery banks.
- Estimated cost of one unit of power generation is INR 11.
- Nearly 16,000 solar units and 1500 rain water harvesting structures have been established.
- Total carbon emission reduction from 1986 to 2008 is 1.86 millions tones per year.
- A community radio and digital empowerment foundation have been established by the college.
- The college has set up the Women Barefoot Solar Cooker Engineers Society (WBSCES) in Tilonia. It is the first association of illiterate and semi-literate women who can independently fabricate, install and maintain 2.5 square metre parabolic solar cookers.
- In September 2006, college established India's first ever solar powered reverse osmosis plant for water desalination at a small voluntary organisation called 'Manthan' established in Kotri.

About the Partners

Barefoot College is a non-government organization established in 1972, to provide basic services and solutions to address the problems of the rural communities, with the objective of making them self-sufficient and sustainable. These 'Barefoot solutions' can be broadly categorized into solar energy, water, education, health care, rural handicrafts, people's action, communication, women's empowerment and wasteland development.

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WASTE TO ENERGY

A Case Study of Rice Husk Power Plant, Bihar

At A Glance

Location
Husk Power Systems, Patna
Bihar, India

Number of Rice Husk Power Plants Installed (October 2010)
57 Plants

Installed Capacity (each unit)
35 - 100 kW

Beneficiary Households (per plant)
450 - 500

Funding Agencies
Ministry of New and Renewable Energy (Government of India)
Shell Foundation, Draper fisher Jurvetson, Acumen Fund, Bamboo Finance, Cisco, LGT Venture Philanthropy, International Finance Corporation

Rice Husk Field, Bihar

The majority of population in the rural areas of Bihar lives below the poverty line and has no access to electricity. This has affected the development of the state to a large extent. The need of electrifying the villages in Bihar has been addressed by Husk Power Systems (HPS).

Husk Power Systems (HPS) came into existence in 2007 with the main goal to provide affordable, reliable and environmentally sustainable energy to rural India by using husk as the fuel. HPS follows the concept of three 'Rs' to provide electricity that is Reliable, Renewable and Rural. HPS builds, owns and operates 35-100 kW 'mini power-plants' that use waste rice husks to deliver electricity to off-grid villages in the Indian 'Rice Belt'.

Rice is the main crop of Bihar, which falls in the rice-belt of India. Bihar, on an average produces 47.14 lakh metric tonnes of rice per year and about 13.4 lakh metric tonnes of rice husk goes waste per year. Conventionally, after paddy rice is processed, a huge quantity of biomass is left as a residue in form of rice husks. This rice husk, when used in efficient gasification or combustion systems, has a considerable potential to generate energy.

OVERVIEW

Husk Power Systems started its operations with one plant in 2007. As on date, it has 57 plants in operation across 250 villages of Bihar and Uttar Pradesh impacting 2,00,000 lives. Scaling at the rate of electrifying 10 villages every week, HPS plans to install 6000 plants by year 2014, which would brighten upto 6 million lives. The HPS initiative saves 42,000 litres of kerosene and 18,000 litres of diesel per year.

Partners

The basic premise of the HPS initiative is to provide electricity to the agrarian rural communities in a cost-effective and environment-friendly manner. Husk Power System has a major financial contribution from two social venture capital funds, one is Switzerland-based Oasis Fund and another one is the Hyderabad based Acumen Fund.

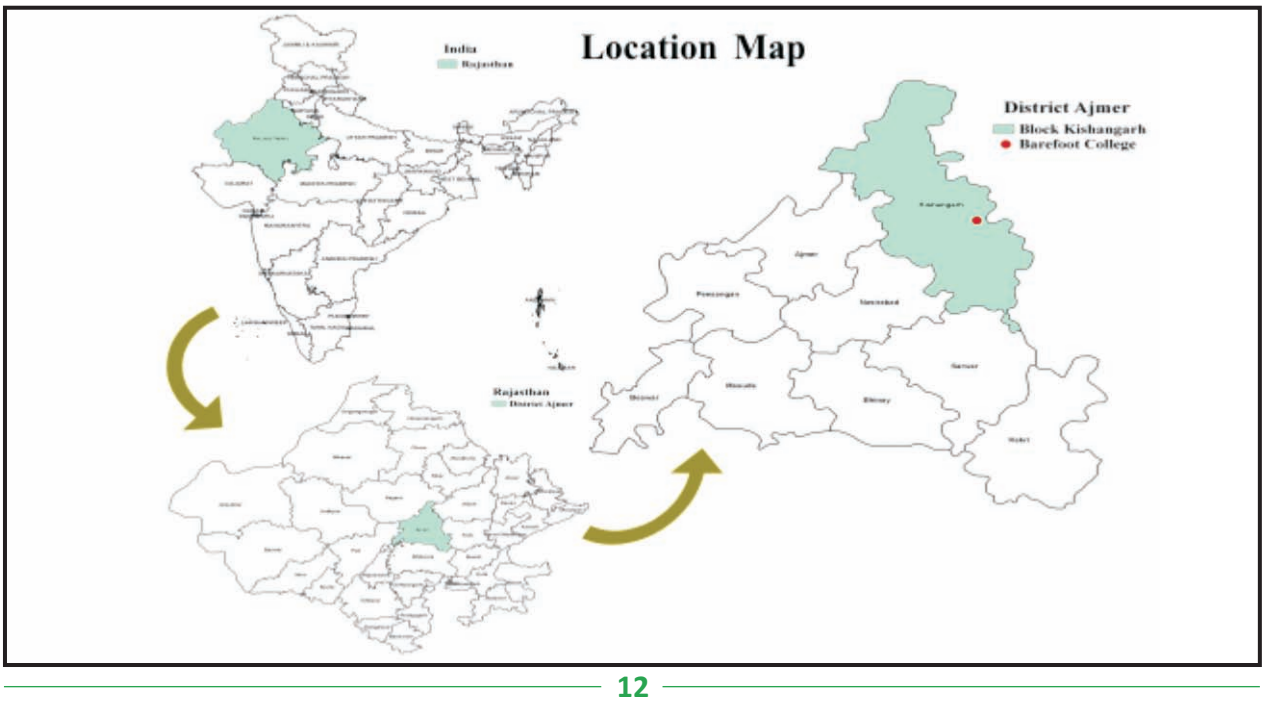
Process and approach

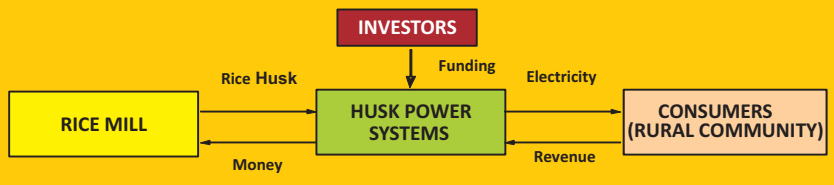
HPS supplies electricity to the villagers using environment-friendly biomass gasification technology. Electricity is supplied to only those villages that have demand of 15 kW and fall within the radius of 3 kilometres from the proposed HPS plant. HPS trains local villagers of the village in which the power plant is to be established. The duration of the training is two months and covers the operation and maintenance of the power plant. Thus, a job-platform has been created for unemployed literate/neo-literate villagers.

Business model

'Pay-for-Use' service approach is being followed by HPS for raising revenue and supplying electricity. The HPS business model is attractive and successful in the rural areas because of its low cost.

About 300 kg of rice husk is required as raw material to produce 40 kilowatt of energy, which is sufficient to supply energy to 500 households for 6-12 hours per day. Raw material (waste rice husk) is purchased for Rs. 1 per kg from rice mills. Generally, electricity is supplied to domestic and commercial consumers for fixed 6 - 8 hours in a day. Charge rates are Rs 80/month/2*15 Watt CFL`s and mobile recharge. Low cost pre-paid meters have been installed that can efficiently regulate the flow of low-watt electricity and reduce electricity theft to less than 5 per cent.





Inflows and outflows of matter and money

OUTCOME

Husk Power Systems has made a tremendous impact in the lives of rural people by supplying affordable electricity. HPS initiatives have helped in creating conducive environment for employment generation and enterprise development. Environmental benefits are also very much evident.

A Rice Husk Power Plant, Bihar

Socio-economic changes

Establishment of rice husk based power plants in rural areas has led to an enormous change in the lifestyle of the local communities.

Increased lighting has also indirectly helped the community by increasing the business hours in the market area, reducing thefts, improving health conditions and encouraging new business developments like computer shops and photo studios. Moreover, lighting has increased the possible number of study hours, as children are now able to study after dark.

Gender concerns

HPS initiative has provided employment opportunities to thousands of rural women by giving them training and raw material to manufacture incense sticks (using rice husk char). As of now, more than 1200 women have been trained (at 2 plant sites) for manufacturing incense sticks. This enables household to earn upto Rs. 1000 per month and save Rs. 150 on kerosene costs while paying only Rs. 80 for electricity.

Education & skill development

HPS has facilitated the education of children of local communities by paying school-fee of Rs 50 per month.

Jobs created

HPS ensures that jobs are created for local communities. To facilitate this, company hires local villagers for maintaining and operating the power plants. At each operating unit, atleast 3 personnel are employed, which include an operator, a lineman/electrician cum bill collector; and a husk loader.

HPS initiative has provided opportunities for local employment generation

Environmental conditions

Emission reduction

Each Megawatt of power generated from rice husk plant has resulted in reduction of carbon dioxide (CO_2) emissions by about 5800 every year. These reductions in emissions can be attained with the implementation of 32-33 rice husk plants. HPS is currently developing a Programme of Activities (PoA) for Clean Development Mechanism (CDM) to gain carbon credits.

Moreover, processed waste water and tar tank water is collected in a settling tank and recycled, which ensures that there is no water pollution. Rice husk char/tar and used filter media are mixed and stored on the ground.

LESSONS LEARNT

- Grid based power is not a competition to off-grid renewable energy systems because of high demand for modern energy services and low availability of power in the grid.
- An interstate tax policy on technologies and products is acting as an impediment for dissemination of renewable energy technologies.
- Locally available renewable energy sources provide sustainable models to be built around them.
- Availability of trained work force at the local level is critical for sustainability renewable energy systems.

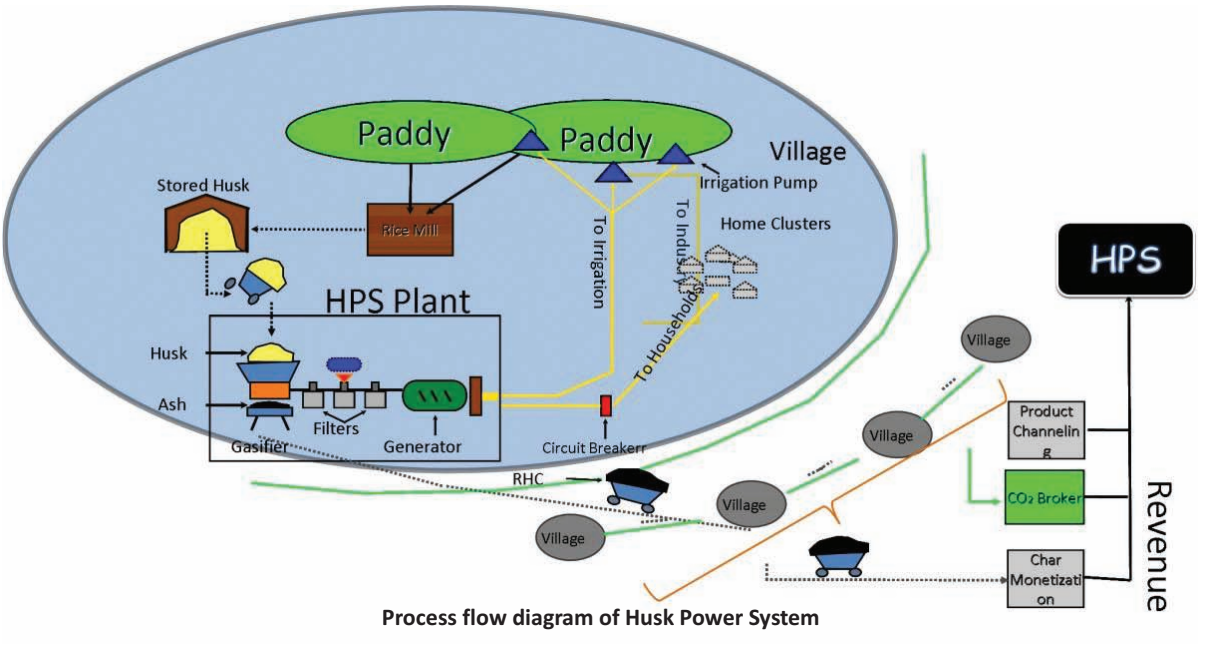
Income generation activities have initiated the gender empowerment

WAY FORWARD

Currently, only 50 per cent of total potential of generating electricity through rice husk is being exploited. There is an ardent need to penetrate the market. HPS has identified 25,000 villages as feasible sites within India's rice producing belt (Bihar and neighbouring states) for establishing rice husk based power plants. HPS has a goal of installing 6000 power plants till 2014 and has the vision of electrifying large sections of rural India.

HIGHLIGHTS

- Husk Power Systems has installed the first rice husk based power plant in India to generate electricity.
- Residual waste from the plant is used in making incense sticks, rubber and manure.
- About 1200 women have been employed in incense sticks manufacturing.
- For each Megawatt of power generated about 5800 tonnes of carbon dioxide emission reductions can be achieved every year.



Process flow diagram of Husk Power System

About the Partners

Husk Power Systems (HPS) is a company that aims to provide affordable, reliable and environmentally sustainable energy to rural India. HPS has enlightened the villages from 100 per cent biomass based power plant that uses discarded rice husks to generate electricity.

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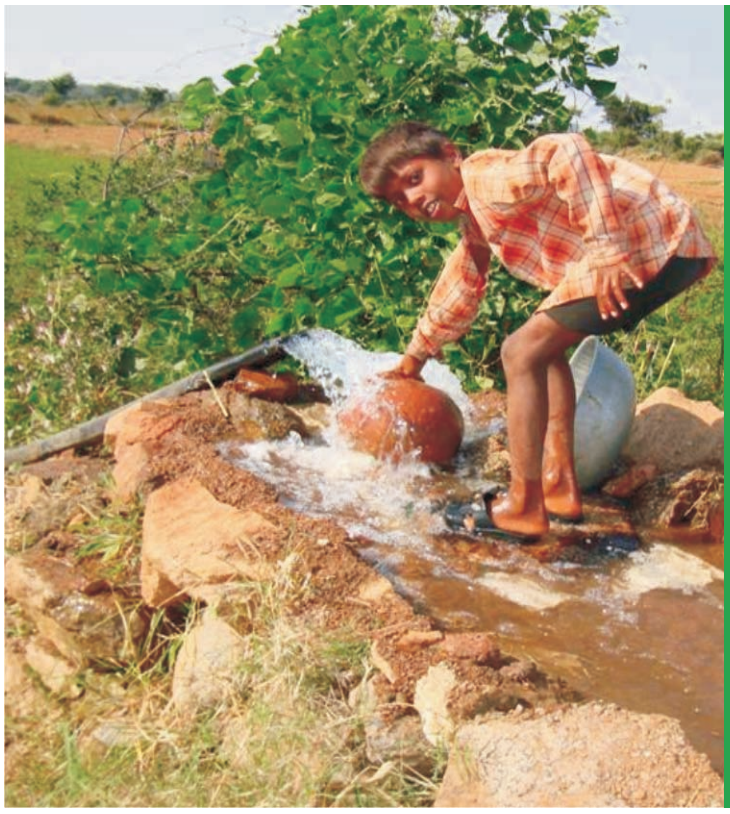


BIO-ENERGY TO LIVELIHOODS

A Case Study of Community Biomass Gasifier Village Radhapur, Madhya Pradesh

At A Glance

Location
Village Radhapur, Panchayat Badarkha, Block Pichore
District Shivpuri, Madhya Pradesh, India

Power Plant Design
Down drift biomass gasifier engine plant - 10 Kilowatt

Number of Beneficiary Households
87

Funding agency
Department of Science and Technology, Government of India

Implementing Agency
Development Alternatives, India

Wood is a major source of fuel in rural India, accounting for 50 per cent of the country's energy consumption. However with depleting forests resource base, it has become essential to consider an effective fuel mix for rural India. Biomass materials like lantana, ipomoea, agri-residues (mustard, rice) can be used for decentralized energy generation in rural areas.

Radhapur is a small village in Pichhore block of Shivpuri district of Madhya Pradesh. Agriculture and daily labour are the only sources of income for the villagers. The village has around 120 acres of fertile soil for cultivation, and uses 32 pumps for irrigation that consume more than 4000 litres of diesel. Like many other unelectrified villages, villagers of Radhapur were facing an energy crisis due to ever raising diesel prices. Increased diesel prices have forced the farmers to migrate to nearby cities to generate livelihoods. Also, continuous consumption of log woods for cooking and burning was contributing to deforestation and indoor air pollution.

Biomass gasifier

OVERVIEW

Development Alternatives took an initiative to resolve the environmental, socio-economical problems faced by the Radhapur village. In 2009, Development Alternatives established one down drift biomass gasifier of installed capacity of 10 kWe. The gasifier provides electricity to 87 households of the village.

Partners

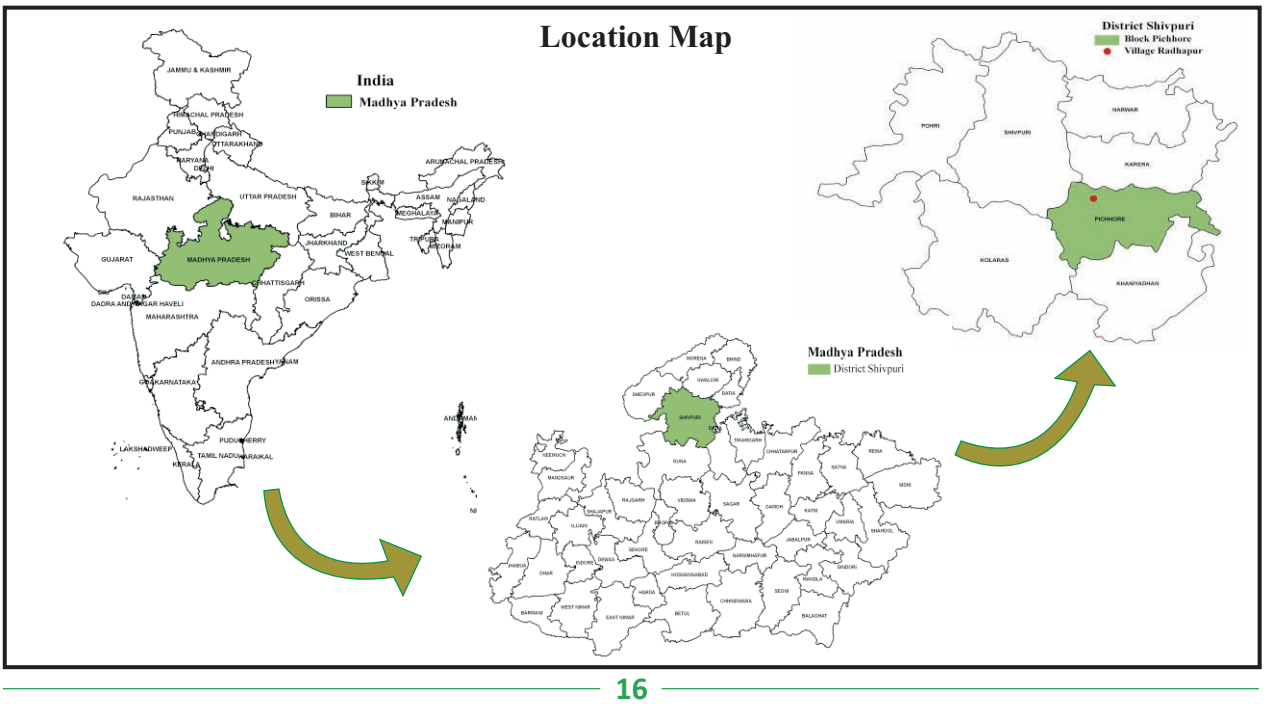
Partners in this initiative are Department of Science and Technology (DST), Government of India and Development Alternatives. Department of Science and Technology has funded the initiative, and Development Alternatives has facilitated the implementation of biomass gasifier plant in the village through community participation.

Development Alternatives has contributed to this programme through social mobilization of grassroot stakeholders and in building institutional, financial and technical capacity. It has also encouraged small scale entrepreneurs from the different communities of the village to set up micro-enterprises like flour mill, oil expeller etc. within the village.

Along with this, a community based service delivery model has been established through formulation of Village Energy Committee (VEC). VEC not only manages the production and distribution of energy but also initiates other sustainable development processes on its own.

Process and approach

The approach followed for setting up biomass gasifier in Radhapur village is 'Build-Own-Operate-Transfer' (BOOT), where local community takes the charge of the facility. The innovative components of the project include need-based load balancing mechanism, participatory planning and execution and value-added energy services for livelihood creation. To achieve this, a 16 member Village Energy Committee (VEC) was formed (with 4 women members) with its own bank account. Under the 'BOOT' model, the VEC monitors, manages and collects the revenues for the supplied power. The committee has also given a piece of land for the installation of a biomass gasifier plant and conducts regular meetings in the village. A plant operator from the village (on the payroll of VEC) has been identified to manage the plant.



Activities like biomass cutting and chopping is done by biomass cutter

Mini-grid established for distribution of electricity

Business model

The most crucial part of setting a biomass gasifier is to have a sustained supply of raw material. In the present context the raw material used is ipomea, a locally available weed. On direct combustion, it gives a very pungent odor and hence is not used by local communities as a fuel for cooking purposes.

For the purpose of gasification, ipomea needs to be harvested and chopped in to small pieces. Biomass harvesting, chopping and transportation are being done by local communities and thus, it is an additional source of income for them. While it was essential to consider the social interest, it was also important to keep the cost of ipomea within reasonable limits as this would have had a direct bearing on the cost of the power supplied.

The distribution of electricity is done through a 750 metre long transmission and distribution (T&D) line in 3 phases. Each phase supplies 220 volts as an alternate current power for domestic, irrigation and enterprises use. In the initial stages eight street lights were installed for community use now village has 12 street lights. Now, the village has 6 street lights. Different slabs for load usage have been formed for varied usage. The following tariff rates against various load categories have been formulated to enhance the plant load factor for the sustainability of the model.

Current Tariff Structure			
	Slab-I	Slab-II	Slab-III
Types	<5 kWh	5-10 kWh	>10 kWh
Domestic			
Fixed Cost (INR)	20	90	160
Variable Cost (INR)	4.50 **per kWh**	22.5+5.5 **per kWh** per unit for additional units above than 5 units	50.0+6.50 **per kWh** per unit for additional units above than 5 units

OUTCOMES

In Radhapur, about 18 households have paid connections for electricity that is being generated through the biomass gasifier. Apart from meeting the domestic energy needs, the power plant also fulfils the energy demand for irrigation (6 pumps) and enterprises (1 flour mill of 5 horsepower). Subsequently, 1 motor driven biomass cutter of 3 horsepower has also been installed. Local community member (villager) is engaged to ensure un-interrupted biomass supply on an enterprise mode.

Social-economic changes

Radhapur is a resource rich village but its economy was badly hit by high cost of energy. Non availability of electricity and dependency on fossil fuel had caused the villagers to suffer financial, agricultural, education and various other losses. With the implementation of biomass gasifier in the village, the conditions in the village have changed noticeably. Children are now able to study even in the evening hours after sunset. Villagers are actively taking part in weekly meetings and planning seasonal activities along with discussing and solving other issues.

Gender concern

Provision of electricity has brought positive change in the condition of women. Infact, the domestic meter connections have been issued in the name of women in many households. Women self help groups have been formed and trained for making leaf cups (to be sold in open markets).

Energy generation using locally available biomass to generate local employment

As members of Village Energy Committee, village women (four in number) are now actively participating in decision making processes related to the power plant.

Skills development

Trainings for making leaf cups and oil seed extraction have been undertaken as these activities can lead to a long term sustainability of distributed RE based generation power systems.

Renewable energy based enterprises

One flour mill of 5 horsepower capacity and one motor driven Biomass cutter of 3 horsepower have been installed in the village.

Jobs created

Two operators (for round the year) have been employed for the plant maintenance and 1 entrepreneur has been trained to manage the flour mill. Over 500 people at farm level and over 400 people at enterprise level have been benefitted directly or indirectly from the power plant.

Environmental conditions

Consumption of electricity through biomass gasifier has resulted into reduced indoor air pollution and has also reduced the dependence of villagers on forests resource base.

LESSONS LEARNT

- The creation of consumer-networks is important for the Radhapur gasifier technology market. This network includes development of micro enterprises and the interactions of these enterprises with local and national banks and the local government.
- Promotion strategy cannot neglect the intrinsic characteristics in the mindset of the society. The strategy involves identification of the role of key actors in each region while considering the specific mindset of the society.
- Adoption of innovative systems by the local people and developers will be easier, if VECs strengths are easily formed and revealed.
- Compatibility between the renewable energy technology and the existing infrastructure such as power for irrigation should be promoted.
- Procedures for implementation of technology are simple, ruled and commissioned. Dense and cohesive networks between the developer and the society helped in smooth of the power project.
- Enhancing the capacity of VEC to generate energy is very crucial for the sustainability of the project. The training programme includes collection and accounting of revenue from the villagers, managing the services and load management system, adoption of safety measures in use of electricity, execution of bank transactions (deposition and withdrawal).
- Identification of possible interventions for income generation activities are at the village level is useful for long term sustainability of the initiative.
- Additionally, effective sharing of responsibilities among the VEC members is crucial for the development of social structure.

WAY FORWARD

The prime objective of the initiative was to provide energy for irrigation and enterprise but later, the need for domestic energy supply was also identified. To fulfil the growing demand of energy, team is planning to upgrade the plant.

HIGHLIGHTS

- Waste water from the power plant is allowed to pass through filter beds. The treated water can be safely discharged or be re-circulated.
- Women self help groups have been constituted for making leaf cups and marketed to the near by markets.
- Reduced consumption of fuel-wood by villagers has led to reduced indoor air pollution and dependence on natural resources.

About the Partners

Development Alternatives (DA) is a 26 years old research and implementation focused not-for-profit organisation. The activities of DA broadly cover the areas that underline sustainable development process.
Website: www.devalt.org

The Department of Science & Technology (DST) was established in May 1971, with the objective of promoting new areas of Science & Technology and to play the role of a nodal department for organizing, coordinating and promoting S&T activities in the country.
Website: http://dst.gov.in

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BIO-ENERGY TO ENTERPRISE

A Case Study of Women Empowerment Bundelkhand, Madhya Pradesh

At A Glance

Location
Sri Ram Raja Gaushala, Orchha Town, Block Niwari
District Tikamgarh, Madhya Pradesh, India

Plant Operational Since
2003

Beneficiary Enterprises
8 livelihood enterprises has engaged 30-40 women

Power Plant Design
60 cubic meter digester, 5 pit slurry tankgas engine of 5 KVA with single phase generator

Funding Agencies
United States Agency for International Development (USAID), USDOS, DST, SDC, IGFRI, NRCAF, DBT, SBI, Arghyam, Madhya Pradesh Government

Implementing Agency
Development Alternatives, India

The Bundelkhand region in Madhya Pradesh State is lagging behind in terms of development, human, social, economic and environmental indicators as compared to other agro-ecological zones of the state. People have limited access to information on developmental plans, schemes and products. Lack of affordable and reliable energy supply is a major constraint in value addition and income generation in the region.

As gender inequalities are high in the region state of rural women in the region is also not good. Malnutrition is a common feature of the women in the region. The region has faced drought like conditions in last five years. In the drought-hit Bundelkhand region, livestock, other than agriculture, is a major source of income generation. The region has 1100 cattle per 1000 population. However, only 58 per cent of the cattle produce milk.

Development Alternatives perceives this as a huge potential to rejuvenate the entire value chain of livestock-based economy in an integrated manner with women in central role. Additionally, methane captured from the livestock waste can mitigate climate change by reducing green house gas (GHG) emissions and enhance the economy by fulfilling the energy demand. Prevailing condition has made people specifically rural women of Bundelkhand region more vulnerable to climate change impacts.

OVERVIEW

Based on the above observations Development Alternatives initiated a programme to empower women, institutionalize and build their capacities to stand and fight for their rights. Development Alternatives with support from United States Agency for International Development (USAID), started an initiative known as Gaushala (cow shelter) model. The main objective of the Gaushala model is to develop and establish community based enterprises with active participation of rural women while simultaneously empowering them.

The Gaushala model was first piloted in Orchha, Madhya Pradesh as 'Sri Ram Raja Gaushala' and then replicated to two other locations namely 'Dayoday Gaushala' in Lalitpur, 'Sri Raghav Gau Sambardhan Sala Gaushala' Mauranipur (both are in Uttar Pradesh State). The model has been termed as 'Community Managed Energy Services Model'.

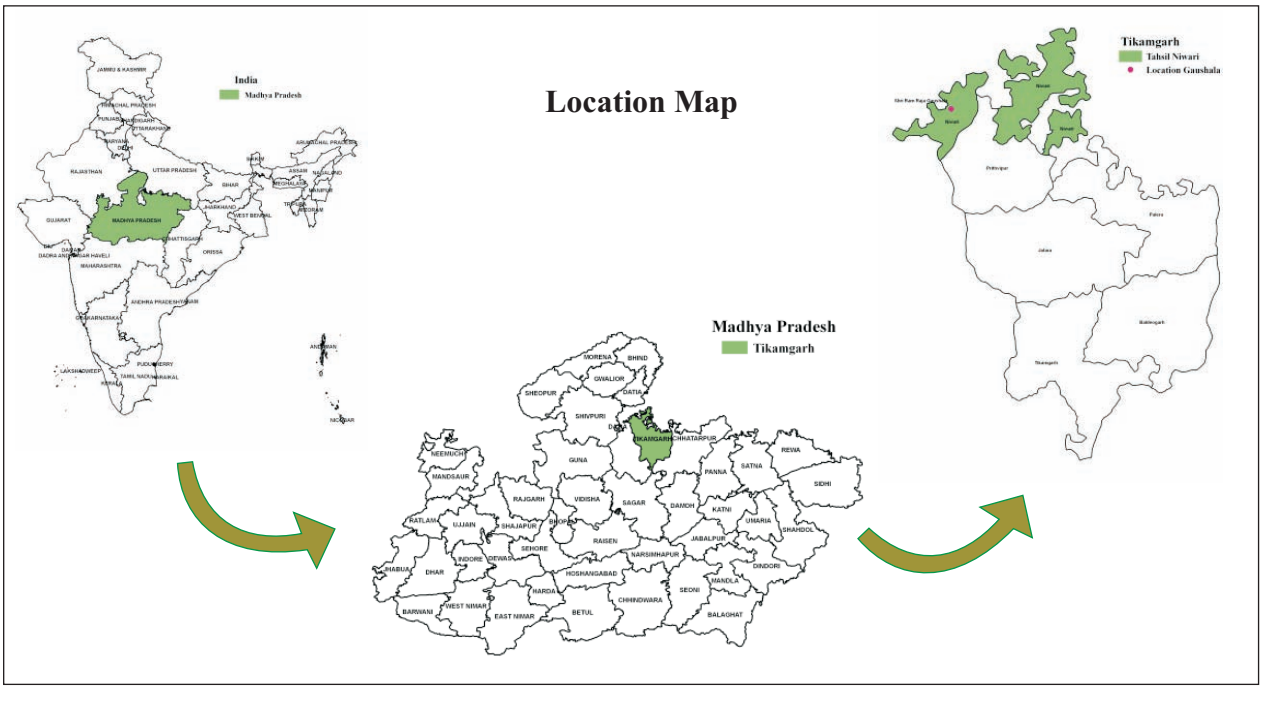
Partners

Development Alternatives provided technical assistance and service support for the initiative. The Madhya Pradesh Government and USAID provided the major financial support. Later as the programme progressed relevant agencies were contacted for funds.

Process and approach

The programme aims at empowering women so that they can acquire enhanced stake in natural resource management and economic value addition. For this, women have been clustered into different Self Help Groups (SHGs), which are referred to as the Women Energy Clusters (WEC).

About 50 groups of women were formed with each group consisting of 10-12 female members. These groups were imparted training to demonstrate technologically modern; environmental friendly and sustainable methods of livestock rearing and fodder cultivation. These groups of women then applied for a piece of Government wasteland to develop this land as a Gaushala (cattle shelter), where scrap cows could be kept and taken care of. Around eighteen acres of land was allotted to mahila mandal (Women Energy Clusters) out of which total land used for agriculture is around 5.3 acres and 1.5 acres for infrastructure development whereas rest of the land is used for grazing and fodder production. Along with this a biogas plant has been installed in the Gaushala campus with support of United States Agency for International Development (USAID).



Business model

The capacity of the bio-gas plant at 'Sri Ram Raja Gaushala' in Orchha is 5 kilo-volt ampere (single phase). The KVIC model forms the basis of biogas generation plant. An engine is attached with 60 cubic meter digester. Power generated from the biogas plant is used to run various enterprises like milk chilling plant, spice grinding, oil expeller, and water pump for irrigation. The slurry left in the digester is used as compost after vermin-composting.

OUTCOME

The Orchha gaushala is enjoying the energy services for different purposes, which includes lifting ground water for irrigation, running flour mills, spice grinding machines, oil expelling and milk chilling units. The members of the gaushala are also getting premium price by selling treated slurry in the form of enriched organic compost/vermicompost. The gaushala workers are also cultivating green fodder for their in-house cattle and potential business.

The financial status of the gaushala model helps the participants to understand the related linkages in the potential market. Demonstration of this biogas model at three different locations of Bundelkhand has already started inspiring potential takers.

Socio-economic changes

Skills development

The Gaushala workers primarily women have been trained to operate and maintain the biogas plant. Women have also been trained in fodder cultivation and management.

Gender concerns

Approximately 40 members of women SHGs representing 5 to 6 villages own and manage one women energy cluster ('Shri Ram Raja Gaushala') for which an institutional and financial model including leveraging of carbon finance is demonstrated, validated and made available for replication.

The Women Energy Cluster (WEC) provides energy for 6-8 livelihood enterprises engaging 30 to 40 women. This initiative of Development Alternatives to empower rural women has boosted the confidence of the women in Bundelkhand region.

Renewable energy based enterprises

The power generated from the biogas plant is used to provide energy services to supply drinking water, irrigation and running of micro-enterprises like milk chilling plant, flour mill, oil expeller and spice grinding which were otherwise operated by diesel/coal. Several other potential areas of livelihood generation, like organic farming, green energy based irrigation services, construction and operation of domestic biogas plant, repairing and maintenance of gas engine etc. are also introduced through this gaushala model.

Environmental changes

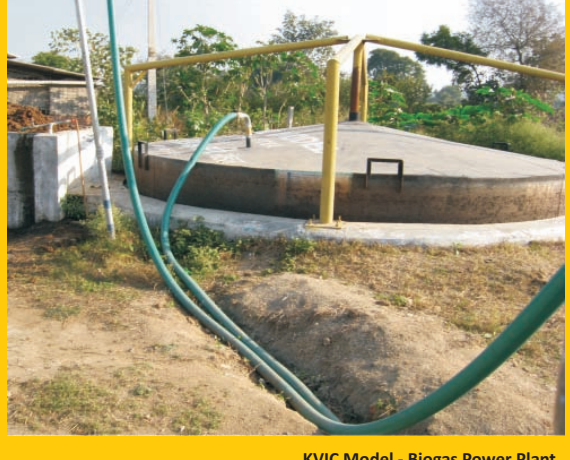
The most obvious environmental benefit from the initiative is mitigating methane emissions. Total methane captured and used so far is approx 32,000 cubic meter, generated over 9000 units of electricity. Besides, no waste is generated in usage of the biogas form of energy. Slurry, which is produced from the digester as a by product can be utilized as well. The slurry provides additional nutrients for bed technique for vermicomposting. The model has enhanced the use of treated slurry as organic manure thereby resulting in gradual reduction in the use of chemical fertilisers. 'Gaumutra' - cow urine is being used as a natural insecticide.

LESSONS LEARNT

- It's pertinent to map community needs and aspiration for setting community based enterprises to ensure project sustainability.
- To setup any community based micro-enterprises market availability and feasibility should be kept into consideration.
- Women were central to the present model and played very instrumental role in operation and maintenance too. Literacy, awareness and training programmes were run to mobilize and educate women.

WAY FORWARD

- Development Alternatives has analysed the complete value chain and is in a position to develop a customized techno-commercial detailed project report (DPR).
- For all three gaushalas, the energy team is now planning to set up small enterprises that utilize local resources e.g. natural pesticides (cow urine based), nursery, water supply, and organic vegetables.



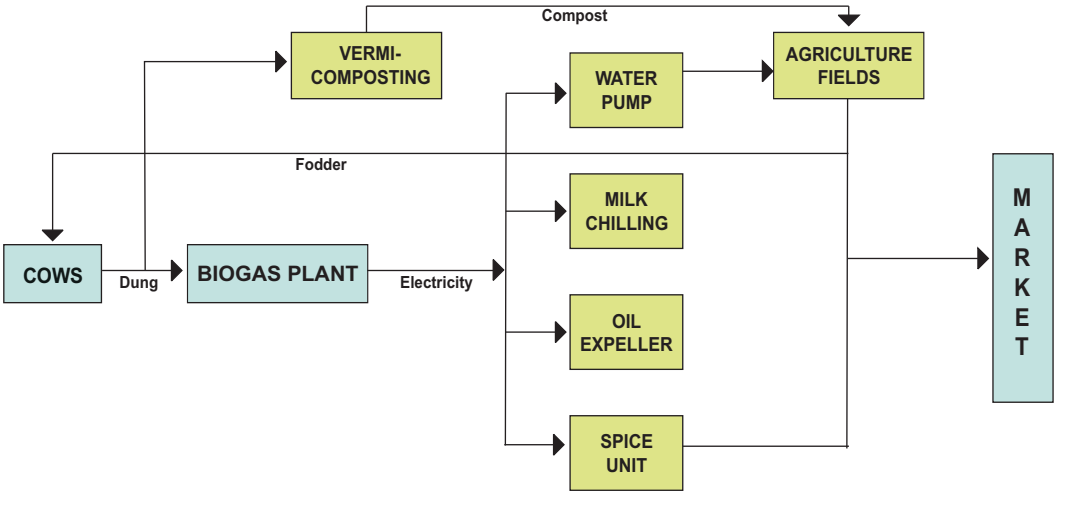
KVIC Model - Biogas Power Plant

Shri Ram Raja Gaushala, Orchha

- The electricity generated is currently being used for enterprise development but there is a need to upgrade the engine to 8-12 KVA so to serve domestic needs as well.
- According to estimates an investment of USD1.2 million towards the initiative over the next five years will be able to create 5000 jobs and reduce the emissions by 1200 tonnes per annum.
- The team is now in the process of developing a PoA (Programme of Activities) to avail benefits from reduced carbon emissions.

HIGHLIGHTS

- Gaushala is run by women of the Sankalp Swashakti Mahila Mandal.
- TARA Akshar a literacy programme was run in the intervention villages.
- Total methane captured and used so far is approx 32,000 cubic meter generated over 9000 units of electricity.
- One of the major indirect impact of Gaushala model is fodder security and protection for the scrap cows.
- Additional infrastructure developed includes vermicompost bed, two submersible pumps of 2 & 5 horsepower, a borewell and spice grinding unit.



Flow Diagram of Shri Ram Raja Gaushala Model

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