

# **Study of Available Business Models of Biomass Gasification Power Projects in India**

**Under the project**

**“Removal of Barriers to Biomass Power Generation  
in India”**

**Supported by**

**United Nations Development Programme, New Delhi**

**Prepared by**

**The Energy and Resources Institute, New Delhi**

**&**

**The University of Petroleum and Energy Studies, Dehradun**

**October 2013**



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## Preface

After 66 years of Independence, some corners of our country are still in acute darkness. While the reasons behind this are many, a key potential solution to this problem is the promotion of decentralized power generation through renewable sources of energy. Harnessing these resources to generate off-grid power to supplement conventional energy sources is receiving increasing focus. A number of projects, particularly biomass-based small power projects that have been successfully implemented in villages by enterprising individuals and other organizations have shown great promise.

In the present study, various biomass gasification power-generation models from across the country are evaluated for their techno-economic viability for promotion and scaling up in other states. The case studies compiled here generally describe the decentralized model of electric power generation using biomass gasification technology, with 'agricultural waste' as feedstock. Globally, there are a few concerns over the use of biomass as a fuel, such as conversion of food crop into fuel, conversion of agricultural land under food crops to fuel crop cultivation and conversion of agricultural waste into fuel (as opposed to being converted into soil nutrients). All of these issues are critical with regard to sustainable agriculture, socio-economic development, and food security.

Almost all the case studies chosen for this study had to address various barriers and challenges at various stages of implementation such as access to finance, viability, tariff, and geographic locations. However, these projects have succeeded as standalone plants generating electricity using locally available raw materials. These case studies essentially promoted local socio-economic development, an integral component of the project, while demonstrating their financial viability.

The broader aim of presenting all the successful case studies together is to illustrate that gasification-based biomass power projects are possible and that obstacles can be overcome. All these projects have shown immense potential in scalability, technology demonstration, and sustainability. Overall, there is a need to take a much valuable conclusion and message from these case studies. One of the key lessons is that decentralized power generation projects from biomass must be highly localized in both its design and implementation, along with detailed assessment of local energy requirements and resources.

To make the renewable energy sector a success in India, projects have to be scaled up, replicated, and integrated in the mainstream development strategy to achieve the desired long-term objective.

We are confident that such studies will encourage many other entrepreneurs and organizations, not only in India but also in other countries, to execute similar innovative projects which will provide access to clean and affordable energy solutions for communities.

## Acknowledgements

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## Abbreviations

BERI	Biomass Energy Rural India
BESCOM	Bangalore Electricity Supply Company Limited
BM	Built and Maintain (Business model of HPS)
BOM	Built, Own and Maintain (Business model of HPS)
BOOM	Built, Own, Operate and Maintain (Business model of HPS)
BOVSS	Baharbari Odhygik Vikash Sahkari Samiti
DESI	Decentralized Energy Systems Private Limited
GEDA	Gujarat Energy Development Agency
GEF	Global Environment Facility
GoI	Government of India
GoK	Government of Karnataka
HPS	Husk Power Systems
ICEF	India – Canadian Environment Facility
IRPPs	Integrated Rural Power Producers
kWh	Kilo-Watt-hour
LSP	Local Service Provider

MNRE	Ministry of New and Renewable Energy
MW	Mega Watt
NGOs	Non-Governmental Organizations
PMU	Power Management Unit
PSC	Project Steering Committee
RECs	Renewable Energy Certificates
SRE	Saran Renewable Energy
UNDP	United Nations Development Programme
UPCL	Uttarakhand Power Corporation Limited
WBREDA	West Bengal Renewable Energy Development Agency
WBSEB	West Bengal State Electricity Board

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## Executive Summary

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In comparison to other renewable resources such as solar and wind, biomass presents an interesting proposition. Being an agrarian economy, a major segment of the population in India depends on agriculture. Thus, biomass in the form of agricultural residue is available in all parts of the country, thereby overcoming spatial limitations as in case of other renewable resources. Temporal limitations are also addressed as there cannot be total dependence on natural resources such as wind or the sun. In case of biomass power, fuel is either available throughout the year or can be transported, stored, and used the entire year to give high plant capacity utilization factors of up to 85%. Thus, biomass presents an ideal solution for powering all parts of the country, in particular rural areas, with highest efficiency.

In India, the overall market potential for clean, reliable and affordable energy is gradually expanding. New and innovative business opportunities are rapidly emerging in different parts of the country (in particular rural areas) to meet the increasing energy demand. There is also an increased interest by private players and social entrepreneurs to provide a range of energy services to the poor. Developing a suitable end-user model is an important criterion and one that is largely influenced by key aspects like the local context, business model and the nature of energy services provided.

With the above objective, UNDP-MNRE has awarded an assignment jointly to The Energy and Resources Institute (TERI) and University of Petroleum and Energy Studies (UPES) under their GEF funded project 'Removal of Barriers to Biomass Based Energy Solutions'. This project aims to address various technical, regulatory, and institutional barriers that have hitherto prevented the large-scale dissemination of biomass power in India at the megawatt & sub-megawatt level. Under the assignment, two sensitization workshops for potential investors and a skill enhancement workshop for operators were conducted to enhance their knowledge and capabilities towards small-scale biomass power projects.

The present study looks at different business models of gasification-based biomass power generation projects that are currently in operation in India. A strong social vision with a focus on rural development and a mission to bring electricity to poor rural households has been a common and underlined feature that binds all these organizations together. Case studies presented have been characterized on the basis of the following criteria: 1. Off Grid 2. Grid Connected 3. Captive

Biomass-based power projects aim to provide access to clean energy services, primarily focusing on productive load using locally available biomass feedstock. However, mainstream finance options are generally not available for small-scale biomass-based power projects in India and access to end-use finance is a key challenge for all these projects. With the increasing demand for energy services coupled with increasing number of projects, this study captures some of the key features of the successful business models already in operation and also highlights some key suggestions to facilitate up-scaling of the operation in different parts of the country.

**Key salient features of the study:**

- A strong social vision and a mission to bring energy to poor households has been an underlined feature across most of the off-grid projects.
- All the business models provide direct benefits to the poor households by providing access to clean and reliable energy.
- Proprietors and entrepreneurs operate on a combination of market and non-market mechanisms to have access to finance.
- The business models contribute to reduction of greenhouse gas emissions.
- All the business models have generated employment opportunities.

The study has identified a number of barriers such as financing of power projects, technology customization, biomass resource management, tariff structure, and lack of government policies on biomass, that need to be overcome, for the further replication of these business models and up-scaling of biomass power projects. The study concludes that the government should make efforts to create a conducive environment for biomass power projects ranging from policy framework to market development in order to ensure that entrepreneurs can come up with larger plant capacities, both in grid and off grid mode.

## Case Studies

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This section includes some successful case studies on small-scale biomass power projects in India.

### 1. Sub-Mega Watt Gasifier Projects (OFF-GRID)

#### Husk Power Systems in Bihar



**Figure 1:** Husk Power Biomass Gasifier plant

**Source:** HPS

#### Project at a Glance

S. No.	Particulars	Details
1	Project Proponent (NGO name with main office address) along with website address	Husk Power Systems Pvt. Ltd. Opposite. Shiv Mandir, Near National Seed Corporation, Shastri Nagar Market, Sheikhpura, Patna- 800 014, Bihar, India Website: <a href="http://www.huskpowersystems.com/">http://www.huskpowersystems.com/</a>
2	Contact details of responsible person	Gyan Ranjan E-mail: <a href="mailto:ranjan@huskpowersystems.com">ranjan@huskpowersystems.com</a> Phone: +256 754 250 786
3	System configuration	25-kW to 100-kW 'mini power plants', 100% producer gas based system, single fuel mode
4	MNRE contribution	Subsidy of Rs 15/W + Rs 1 lakh/Km (up to 3 Kms)

5	Other contribution	Shell foundation, CISCO, Oasis capital, LGT venture, IFC, Acumen fund, DFG
6	Beneficiary contribution	Local farmers give rice husk to the HPS people at competitive prices
7	Project location (name of village, panchayat name, taluk/block/district/state)	300 villages in Bihar (approx.)
8	Number of beneficiary	200,000 people benefitted
9	Type of tangible/direct benefits	Each plant serves around 400 households, saving approximately 42,000 litres of kerosene and 18,000 litres of diesel per year
10	Type of beneficiaries (men, women, children) and type of benefits	Employing 350 people operating across the State of Bihar
11	Cost–benefits (investment, monthly or yearly balance sheet of expenditure and revenues, product life time)	Cost economics of project implemented by HPS is provided in detailed information
12	Increase in income to the families (INR/percentage)	Local women involved in making incense sticks can from rice husk char can earn up to Rs 1000 per month.

**About the company:** Husk Power Systems (HPS) is a private organization run by Gyanesh Pandey, Ratnesh Yadav, and Manoj Sinha. HPS provides electricity to about 200,000 people, across 300 villages in Bihar. The company uses rice husk as the main raw material to produce electricity and has installed around 80 plants. Most of the plants are 25–100 kWe in capacity. Each of these biomass gasification plants uses about 330 kg/day or 50–60kg/hr of rice husk to generate power for six hours a day.

**Financing:** HPS was established with the help of international agencies and government subsidies. The initial capital funding came from the founders' savings and competition prize money. The other major source of capital includes strategic partners, such as Shell Foundation that helps the HPS both in its operations and financing<sup>1</sup>. They also get a subsidy of Rs 15/W + Rs 1 lakh per kilometre distribution (upto 3 kms) from the Ministry of New and Renewable Energy (MNRE).

The total landed cost of a 32 kW plant, including distribution system, is less than US\$ 1,000 per kW. HPS is paid a subsidy of up to Rs 320,000 for each plant, by the MNRE. The remainder of the capital comes from investment and sales revenue.

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<sup>1</sup> IFC, Acumen Fund, Oasis Funds, LGT VP, DFJ, CISCO, Shell Foundation, MNRE were investors for HPS



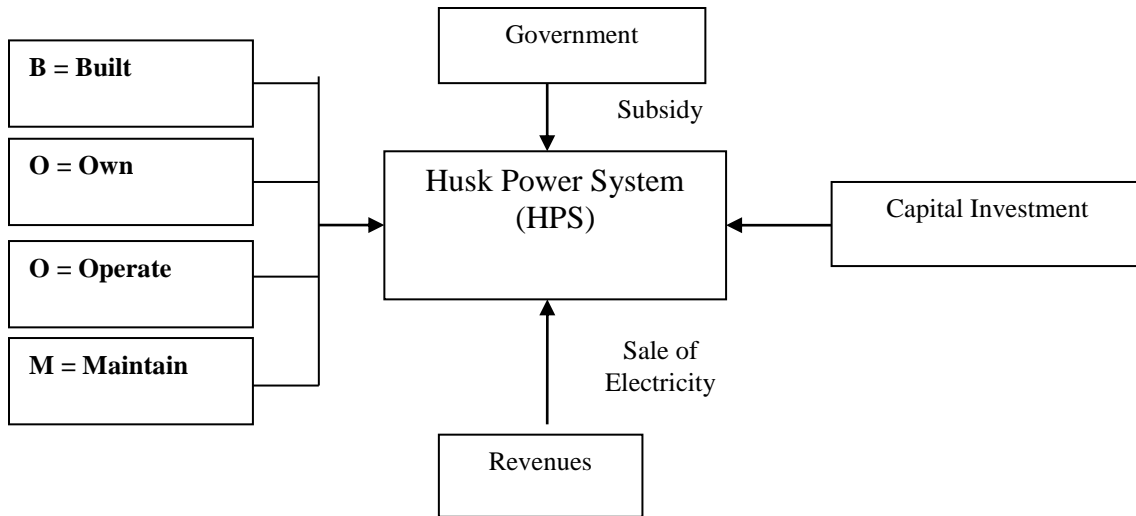


**Figure 2:** Gasifier plant with subcomponents

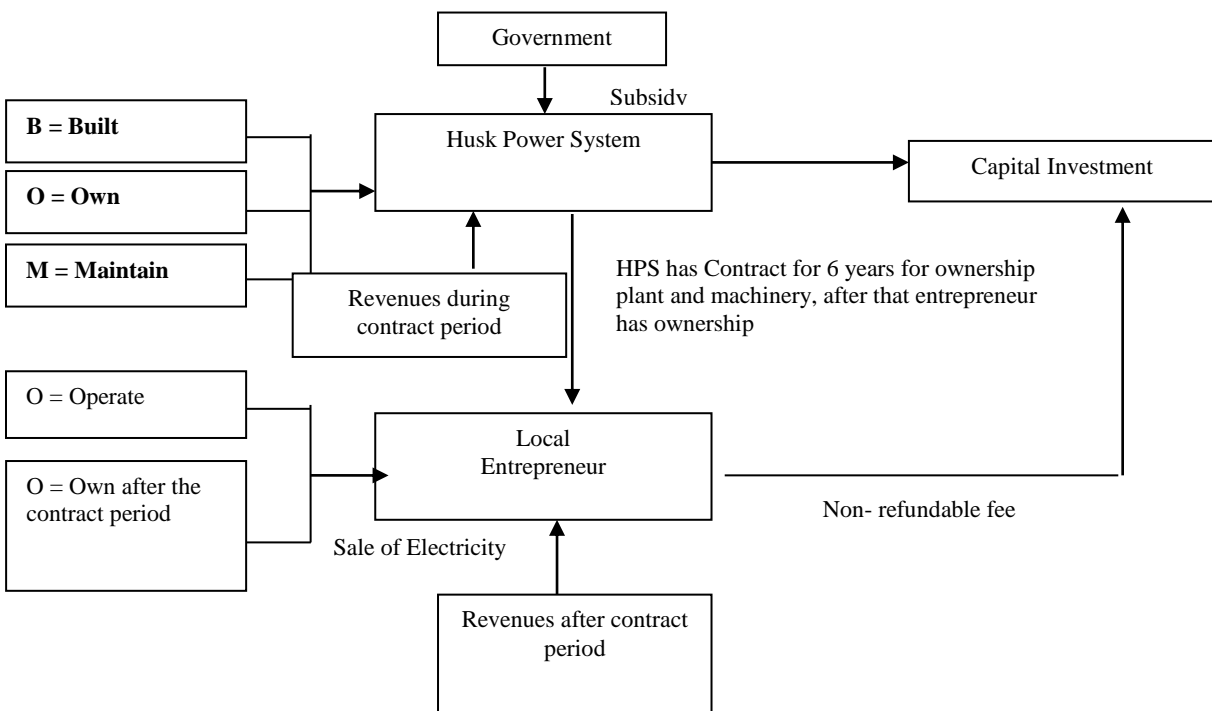
**Business model:** HPS operates on several innovative aspects and mechanisms as part of their overall business model. As rice husk is a natural waste found in various parts of the count, the model is replicable elsewhere. Using an agro residue such as rice husk as a feed, helps achieve cost -effective monthly operations. The proprietors own the entire system, i.e., from generation to revenue collection with virtually no dependence on government or outside support. HPS also promotes energy efficiency by encouraging rural customers to use energy-efficient CFL bulbs. As a by- product, they sell the ash residue and rice husk char to incense stick manufacturers and other customers.

HPS has three business models commonly referred as BOOM, BOM, and BM. These models are characterized on the basis of responsibility of HPS for any system.

- **BOOM (Build, Own, Operate, and Maintain):** Under this model, HPS builds, owns, operates and maintains the power generation and distribution systems, with revenues coming from subscriber fees. HPS has 100% ownership of the plant. Additional revenue streams come from the sales of silica and husk ash (to be mixed in cement or used to produce incense sticks). HPS also does carbon offsets, in 2012.
- **BOM (Build, Own and Maintain):** Under BOM model, HPS still has 100% ownership of the plant. HPS installs the plant and provide regular maintenance for the contract period of six years. The plant is operated by the local entrepreneur who has to pay a maintenance fee of Rs 15,000 per month for six years. After completion of the contract period, the plant will be owned by the local entrepreneur. In order to start this plant, the local entrepreneur has to deposit a non-refundable fee of Rs 2 lakh.

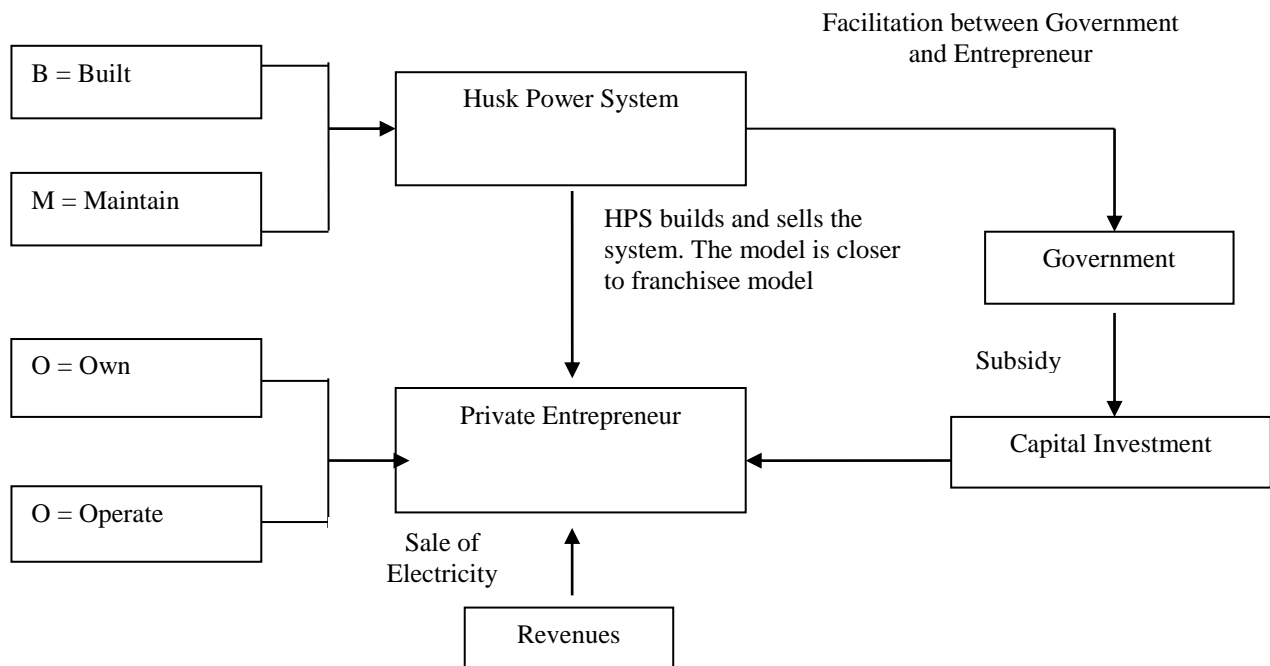


**Figure 3:** BOOM business model of HPS



**Figure 4** BOM business model of HPS

- **BM (Build and Maintain):** This latest business model is suitable for rapid scaling up. HPS installs the plant and provides maintenance service of the plant. The plant is fully owned and operated by the local entrepreneur who invests all the capital cost. Any financial assistance/subsidy on plant gets transferred to the local entrepreneur.



**Figure 5** BM business model of HPS

**Demand-driven business model:** HPS has adopted a demand-driven approach which ensures that only villages where people are eager to get the power connection can benefit from such a technology. At the outset, the HPS team surveys each household and estimates the potential demand in watt-hours. The households also pay a token installation charge of Rs 100 per household which not only ensures compliance by the users, but also covers a substantial cost of grid distribution. Overall, this reduces the fixed investment in infrastructure for the power plant shed and storage space, which is almost 5% of the total investment.

**Operation and maintenance of the system:** 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 persons are associated with each plant — while one person handles husk buying, ensures a regular supply of raw material, and is involved in the revenue collection activities, the other is an electrician for the cluster of villages. In addition, HPS has cluster-level managers who look after the plants in the range of 20–25 km or about 5–7 plants.

**Biomass supply:** As stated above, rice husk is the feedstock for the HPS power gasifiers. Accordingly, all HPS systems are located in the rice belt of northern India where rice husk is a plentiful agro residue. HPS procures the rice husk from the farmers and suppliers at competitive prices (approximately, Rs 1–2 per kilogram) and farmers have an incentive to supply them in order to ensure that electricity remains available in their

villages. The typical plant can serve two to four villages, approximately 500 households within a radius of 1.5 km, depending on size and population. To ensure the viability of the plant, HPS follows demand-driven approach. Selection of the villages to be supplied is based on the village having a demand of at least 15 kW/month and falling within maximum radius of 3 km from the plant site. The husk collected from the suppliers is transported by tractors in parallel to about 7–8 plants in one cluster. HPS has plans to have one rice mill in each operational region to ensure sustained fuel supply at reasonable price.

**Cost:** The cost of producing 32 kW of electricity per month is Rs 22,000, which includes cost of raw material, salaries, and maintenance. HPS loses only about 4% of revenue through default on payment or electricity theft, considerably lower than most power suppliers in India, who often lose 30%. HPS has set up its own distribution lines and each line has a fuse to so that no one draws power excess to what was informally agreed at the outset and to counter power theft. In general, the HPS model maximizes energy use and minimizes distribution and system losses by keeping an optimal mix of plant wattage and distance served.

**Tariff:** Generally, electricity is supplied to domestic and commercial consumers for a fixed 6–8 hours in a day. Basic connection supplies two 15 Watt CFL lights and mobile charging. Charge rates are US\$ 2.20 per month (1US\$ = Rs 45) for a 30-watt connection (2x15 Watt CFLs) and mobile recharge. Currently, in most of the cases, power supply is not metred and each customer is charged as per the number/wattage of equipment used in the daily supply. Monthly payment is collected in advance by HPS employees. However, a few low-cost pre-paid metres have also been installed that can efficiently regulate the flow of low-watt electricity and reduce electricity theft to less than 5 per cent.



**Figure 6:** Pre-paid metre at HPS

**Source:** HPS

**Services offered:** The HPS model aims at not only providing electricity but empowering the village community by providing energy, employment opportunities, training, women's empowerment, and health care.

- **Management information system:** Unique in-house management information systems have been developed that are customized for distributed operations. It interfaces data through multiple input sources such as cell phones, monitoring hardware, and computers.
- **Employment to the local:** HPS hires local villagers for O&M of the power plants thereby ensuring that jobs are created for local communities. At each operating unit, at least three personnel are employed, which include an operator, a lineman/electrician -bill collector, and a husk loader.
- **Low-cost and low-skill incense stick manufacturing process:** An initiative that has also provided employment opportunities to thousands of rural women. It gives them training and raw material for the manufacture of incense sticks that can be made from the rice husk char, enabling them to earn up to Rs 1,000 per month. They also save money by the use of renewable electricity at Rs 80 instead of kerosene that had cost Rs 150.

## Decentralised Energy Systems Pvt. Ltd (DESI Power)



**Figure 7:** Baharbari Village Power Plant, North Bihar

**Source:** DESI Power

### Project at a Glance

S. No.	Particulars	Details
1	Project Proponent (NGO name with main office address) along with website address	DESI Power, INDIA No. 4, 2nd Floor, Above Amanath Cooperative Bank, 4th Main, KHM Block R.T. Nagar Main Road Bangalore - 560080 India Ph: + 91-80-41328160/23431346/23431348 Fax: + 91-80-23431353 E-mail: <a href="mailto:desipower@airtelbroadband.in">desipower@airtelbroadband.in</a> / <a href="mailto:desipower@vsnl.com">desipower@vsnl.com</a> Website: <a href="http://www.desipower.com/">http://www.desipower.com/</a>
2	Contact details of responsible person	Dr Hari Sharan Birchstrasse 6, 8472 Seuzach Switzerland

		Phone: +41-52-335 3500 Fax: + 41-52-335 1442 Email: hari.sharan@bluewin.ch
3	System configuration	20–120 kWe capacity
4	MNRE contribution	Subsidies from MNRE
5	Other contribution	Loan from bank, promoters equity, women for sustainable development, Technology and Action for Rural Development (TARA), Baharbari Odyugic Vikas Swavalamvi Shakari Samiti (BOVSS), Ltd.
6	NGO contribution	Biomass supply agreement with the local group that manages the supply of biomass.
7	Project location (name of village, panchayat name, taluk / block / district/state)	15 plants in Madhya Pradesh, Orissa, Bangalore, Bihar, Karnataka, etc.
8	Number of beneficiary	200,000 people benefitted
9	Type of tangible/direct benefits	Cooking energy Domestic lighting Water supply for irrigation or drinking Cold storage for seasonal vegetables and agro-produce
10	Type of beneficiaries (men, women, children) and type of benefits	Employment generation, Promotion of micro-enterprises
10	Cost – benefits (investment, monthly or yearly balance sheet of expenditure and revenues, product life time)	Information provided in project summary

**About the Company:** DESI Power has an objective of providing power to rural society by means of renewable energy systems, and has built decentralized power stations for supplying electricity to industries and technical institutions. DESI Power has built 10 biomass gasification based plants and operates nine of them. The system capacity ranges from 20 to 120 kWe. DESI Power has successfully implemented biomass gasifier-based power projects in TARA Gram, Orchha, in Madhya Pradesh, and in Baharbari and Gayari villages of Bihar based on a similar model.

DESI Power first set up the plant and then created rural micro enterprises and energy services which provide demand for the plant. DESI Mantra and Baharbari Odhyogik Vikash Sahkari Samiti (BOVSS) are two sister organizations that promote and support micro-enterprises.

**Financing:** DESI Power model is also known as an 'Umbrella Model' because in their model, a rural enterprise gets partnered with many institutions. For example, DESI Power has four projects in Araria district in Bihar. The major sources of funding were subsidies from MNRE, a loan from ICICI Bank, promoter's equity, and revenue from sale of carbon credits.

**Business model:** The business model involves building and operating biomass gasification based power plants in direct association with local partners and later on transferring the plant to the partner under mutually agreed terms. DESI Power came into being to supply electricity and energy services to two distinct decentralized electricity markets:

- Captive power plants for small-scale industries which depend on diesel generators (due to unreliable grid supply).
- Independent Rural Power Producers (IRPPs) for villages and semi-urban areas

The local partner may be an NGO, a Panchayat, a co-operative body or an industry, actively involved in these projects right from the beginning. The building of IRPPs is integrated with the establishment of profitable local small scale industries, businesses and agro-forestry owned by the villagers. For commercial success, the power plant has to sell as much electricity as it can generate and the villagers have to produce and sell as much of their products as they can in the village and at neighbouring market places. The mutual dependence is further strengthened through, on the one hand, the generation of additional income from the supply of agro-residues and other biomass to the power plant and, on the other, DESI power cluster trains villagers, especially women for capacity building.

**Biomass supply:** DESI Power enters into a biomass supply agreement with a local group formed who in turn manages the supply of biomass. In Baharbari, DESI Power considers Ipomoea with hardwood as a feedstock. This was the second plant in the country using Ipomoea as feedstock. But, as the demand for electricity increased, search for an additional feedstock led to maize residue. To add additional substitutes, 'Dhaincha', a leguminous plant with low investment was identified as a possible raw material. The cost of feedstock ranges between Rs 0.40/kg – 0.75/kg (Ipomea) and Rs 1.4/kg – 1.6/kg.

But as demand for electricity increased, the search for additional feedstock led to maize residue. To add additional substitutes, Dhaincha — a leguminous plant with low investment — was identified as a possible raw material. The cost of feedstock ranges between Rs 0.40/kg – 0.75/kg (Ipomea) and Rs 1.4/kg – 1.6/kg.

Similarly, in Araria district, DESI Power has prepared a feedstock calendar for the entire year to ensure year-round supply. This reflects on the importance they attach to this vital link in the entire chain. The company is also thinking on the lines of captive forestry dedicated for the biomass production.



**Cost:** The capital cost is about Rs 3.4 million for 75 kWe per plant.

**Tariff:** Different slabs for load usage have been formed for varied usage. Domestic load is about 3-4 kWe peak for 4 to 12 hours per day; irrigation load: 8-25 peak for 2 to 14 hours per day and enterprise load upto 3.5 kWe to 8.5 kWe peak for 4 to 12 hours per day in the village. The tariff rates against various load categories have been formulated to enhance the plant load factor for the sustainability of the model. These rates are given in Table 2.1.

Entrepreneurs receive electricity from DESI Power and sell to households at a rate of Rs.5/day for a 60-watt bulb and pay Rs.3 to DESI Power. Unlike households, micro-enterprises normally pay for the services at a fixed price of usually Rs.60 for an hour of irrigation (from a 5 HP pump).

**Table 1:** Tariff rates for DESI Power

Slabs	Electricity cost	
	Fixed (Rs)	Unit rate (rs)
Less than 5kWh	Rs 20	Rs 4.50
5–10 kWh	Rs 90	Rs 22.5 for 5 units + Rs 5.5 per unit for additional units
More than 10 kWh	Rs 160	Rs 50 for 10 units + Rs 6.5 per unit for additional units above than 10 units

**Services offered:** The following services are provided by DESI Power:

- Providing energy services through 'EmPower Partnership Programs' which will supply 10 clusters of 10 villages each with a 50-kW biomass plant. Total power generation will be 500 kW per cluster and 5 MW for 100 villages.
- Energy services will be promoted and micro-enterprises would be built simultaneously with the power plant to the planned installation of 4,000–5,000 MW of generation capacity per year.
- DESI Power and its partners will ensure the training of local micro-entrepreneurs and staff for the use of energy for sustainable productive uses and income generation.
- DESI Power also ensures identification, organization, and training of local promoters/ owners of each village plant.
- A Management Training Centre (DESI MANTRA) has been set up to train local staff, especially women, for all levels of work and management.
- Women gain financial and personal independence and learn business skills they need to work in an administrative job or run their own micro-enterprises.

- DESI Mantra sets aside a portion of their tuition loan, if obtained from a village-based lending group, to pay them as a stipend throughout training.
- It has established the Vermiculture Demonstration Unit and is promoting vermiculture among farmers in the villages under DESI Power's 100-village project.

**Observations:** DESI Power's experience shows that it will be very difficult to implement the decentralized programme successfully and efficiently by any centralized organization, be it the government, the private sector or NGOs. A decentralized implementation jointly with villagers; local organizations and entrepreneurs; NGOs; plant promoters, suppliers and builders; financiers and corporate entities are the only sustainable route. They will be brought together to implement such projects in their own regions in with support from DESI Power and its partners. Local capacity building and training will be the starting point for each project.

Self-sustained growth can only take place if the rural electrification programme is linked to village micro-enterprises for local value addition and employment generation. The power generation based on local renewable energy resources can provide reliable and affordable electricity supply to make the micro-enterprises profitable and thus bankable and attractive for private entrepreneurs.

## Saran Renewable Energy (SRE) in Garkha, Bihar



**Figure 8:** Saran biomass gasifier power plant

**Source:** SRE

### Project at a glance

S. No.	Particulars	Details
1	Project Proponent (NGO name with main office address) along with website address	102, Bajrang Market, Mauna Gola Rd., Chapra, Saran, Bihar – 841301 Telephone: 06152-233049, +91-9431272861 E-mail: <a href="mailto:saranrenew@yahoo.co.in">saranrenew@yahoo.co.in</a> , <a href="mailto:sanjay@saranrenew.in">sanjay@saranrenew.in</a> Website: <a href="http://www.saranrenew.in">www.saranrenew.in</a>
2	Contact details of responsible person	Ramesh Kumar Managing Director
3	System configuration	128 kWe, downdraft, open top Gasifier, made by NETPRO under license from IISc Bangalore
4	Total project funds (INR)	Rs 83,00,000
5	MNRE contribution	25%
6	Other contribution	Directors of the company, Loan from banks
7	Beneficiary contribution	Farmers grow Dhaincha crop which is used as a Gasifier feedstock
8	Project location (name of village, panchayat name, taluk/block/district/state)	Garkha Bihar, another 5 MW plant is planned in Sitalpur, Bihar
9	Type of tangible/direct benefits	Rural electrification, Low-cost electricity
10	Type of beneficiaries (men, women, children) and type of benefits	Promotion of medical facilities Low-cost Irrigation facilities

11	Cost–benefits (investment, monthly or yearly balance sheet of expenditure and revenues, product life time)	Provided in Summary
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**About the Company:** Saran Renewable Energy Limited (SRE) is set up by Mr VK Gupta in 2006 who wanted to address the electricity problem in his home town in Saran District, Bihar. This social enterprise is run by a group of agriculturists and entrepreneurs and operates in two areas that are critical for rural development:

- Energy access using off-grid rural power plants.
- Rural livelihood programmes called ‘Village Development Programme’ which are involved in wastelands reclamation, improved agriculture, setting up micro industries, and so on.

The SRE model is community oriented and delivers social and economic benefits to the rural poor, enabling them to increase their income, have access to energy and improve their quality of life. The gasifier installed at village Garkha by SRE in 2008 is designed to supply 128 kW electricity at 240 V, a high voltage for a gasifier with two 3 kV transmission lines, each 1.25 km provide link to the customers. The plant is run for 10 hours every day using 35% of the total capacity. The gasifier used by SRE is down draft open-top gasifier made by Netpro under license from the Indian Institute of Science, Bangalore. Gas engines are used to generate electricity.

**Financing:** SRE was largely established with private equity along with 25 per cent of financial support from the Ministry of New and Renewable Energy (MNRE), under its various technology and commerce related schemes. The cost of the entire system was Rs. 83,00,000. The proportionate cost of the gasifier and generation plant was 90% of the total cost and the remaining 10% for the two 3 kV distribution lines.

For setting up the plant, finance was provided by the directors of the company, while ICICI Bank loaned Rs 20 lakh. In the break-up of the expenses incurred, the largest portion was towards paying off the investment, fuel cost and operation and maintenance.

**Business model:** Saran Renewable Energy Limited (SRE) is a build & operate model of decentralized electricity operations in three villages of Bihar. The electricity distribution is outsourced to local people, who had already been providing electricity to the village through diesel generators.

**Operating model:** The gasification plant operates daily for about 10 hours from 10:00 am to 09:00 pm (with one hour break in between) with a current peak demand of 90% of the capacity with an average demand of 65%. Twelve staff and five casual workers run the plant. But with such a continuous load on the plant, maintenance and proper running assumes significance. The plant is maintained by technicians who have been

trained in Bangalore. If maintained properly, the life of the machine can be up to 15 years.

**Biomass supply:** SRE used dhaincha as a biomass source for their plants. It typically grows on sizeable empty lands in and around Saran district.

Dhaincha requires low maintenance and has a short cropping cycle of 6-8 months. The gasifier at SRE uses about 70% dhaincha as raw material and the rest is from a variety of other sources like corn cobs, wood and other local plants similar to dhaincha. To maintain an uninterrupted supply of this marshy crop, SRE gave a beneficial offer to the farmers to grow dhaincha – free seeds and some incentive. For example, a farmer with a hectare of marshy land can hope to earn income from it. A dhaincha crop of about 5 tonnes a year can earn him an extra Rs. 7,500 to 10,000 per year.

This is a substantial amount in a region of low incomes. The power plant can sustain on about 75 acres of wasteland sown with Dhaincha. SRE purchase of feedstock ensures income to farmers and economic use of non-fertile lands. However many farmers have not shown enthusiasm to sow the seeds despite clear economic benefits.

**Cost:** SRE buys agricultural waste and dhaincha from nearly 100 farmers. The price varies in the market between Rs. 1.5 – 2 per kg depending on the moisture content. About 1.25 kg of Dhaincha produces one unit of electricity at the cost of Rs.8.

**Tariff:** The sale price of electricity to the consumer is Rs 10 per unit. The cost is calculated by taking into account the payback of the loan taken by SRE to set up the gasification plant. Although the cost by the state electricity board was around 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. Farmers are charged Rs 150 for irrigation water supply which is half of the amount of Rs 300 which they used to pay earlier for diesel run pumps.

#### **Observations**

In addition to selling power, the entrepreneur has to think beyond to build business in rural areas. For instance, the SARAN biomass gasification plants are designed for a particular biomass. According to the SARAN Power website, this dependability of SARAN on one kind of biomass poses problems.

A medical clinic can now run a nebulizer, which is used for respiratory problems, especially among children. 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.

In addition to medical clinic now over 1000 businesses (e.g., grain mill saw mill etc.), households, schools, etc., get electricity for 10 hours per day. Irrigation facilities in the area have improved and cost for water supply has reduced by half, thus increasing rural savings.

## AVANI in Uttarakhand (for Captive Use only)



**Figure 9:** AVANI pine needle based biomass gasifier power plan

**Source:** AVANI

### Project at a Glance

S. No.	Particulars	Details
1	Project Proponent (NGO name with main office address) along with website address	AVANI PO Tripuradevi, via Berinag Dist. Pithoragarh Kumaon 26253, Uttarakhand, India Telefax: (+91) 5964 244943 E-mail: <a href="mailto:info@avani-kumaon.org">info@avani-kumaon.org</a> Website: <a href="http://www.avani-kumaon.org">http://www.avani-kumaon.org</a>
2	Contact details of responsible person	Rajnish Jain
3	System configuration	Pine needle based 9 kWe gasification system, 7.5 kWe is available for productive use.
4	Total project funds (INR)	Rs 4.85 lakhs for 9 kWe gasifier and Rs 70 lakhs for 120 kWe gasifier.
5	Beneficiary contribution	Collect pine needles
6	Project location (name of village, panchayat name, taluk/block/district/state)	Kumaon, Uttarakhand
7	Operation hours till now	More than 1,500 hours
8	Type of tangible/direct benefits	Electrification
14	Type of beneficiaries (men, women, children) and type of benefits	Employment generation, use of charcoal as a cooking fuel

## About the Company

AVANI is a voluntary organization working in the Kumaon region of Uttarakhand, located in the middle ranges of the Central Himalayan region. It was in 1997 that AVANI started its journey as the Kumaon Chapter of 'The Social Work and Research Center', also known as the 'Barefoot College'. The Barefoot College focuses on capacity building of rural communities, enabling them to make sustainable and capable contributions to society. In November 1999, AVANI was formally registered, continuing the work initiated in 1997. Rajnish Jain founded AVANI, with a mission to improve the quality of life in far-flung villages. AVANI initiated work on developing and disseminating appropriate technologies for meeting energy and water requirements of the local villages, promoting craft-based (development of handmade naturally dyed textiles), and farm-based livelihood opportunities. Till date, AVANI projects include the dissemination of solar technology, water resource management, natural textiles and paints, and the social and economic development of rural communities with projects such as healthcare and micro-finance.

AVANI is also a founder member of the World Mountain Peoples' Association, which strives to develop solutions to development problems, influence policies in favour of the mountain communities and bring them together on a common platform.

**Business model:** The gasifier is for the captive use only. Over 5 years ago, a 9 kWe gasifier based on pine needle was installed at AVANI centre which has continued to generate electricity for the center. For that set up, about 1.5 kW is consumed for running the system and 7.5 kW available for productive use. The gasifier has worked for over 1500 hours and has largely supported the electricity needs of the centre.

AVANI aims to set up a 120 kWe village based power plant. They have signed agreements with Van Panchayats and aims to work with self-help groups to collect pine needles for this power plant (at Re 1 /Kg). The village has donated land for setting up the power plant. They have also signed a Power Purchase Agreement with Uttarakhand Power Corporation Limited (UPCL), the state electricity power company, to sell the generated power. Since it is still a captive project no revenue has been generated<sup>2</sup>

The gasifier has worked for over 1,500 hours and has largely supported the electricity needs of the centre. With that experience, AVANI aims to set up a 120 kWe village-based power plant though their progress has been slower than expected as they have faced difficulties on the funding front. They have signed agreements with Van Panchayats and aim to work with self-help groups to collect pine needles for this power plant (at Re 1/Kg). The village has donated land for setting up the power plant. They

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<sup>2</sup> Avani bio Energy has signed a power purchase agreement with the Uttarakhand Power Cooperation at a base price of Rs 3.70 a unit. The PPA stands valid for 20 years. (Source: Firing-Up-Dreams, Renewable Energy 01 Dec, 2012,<http://www.businessworld.in/news/null/firing-up-dreams/65>)

have also signed a Power Purchase Agreement with Uttarakhand Power Corporation Limited (UPCL), the state electricity power company, to sell the generated power. Since it is still a captive project, no revenue has been generated

**Cost:** The gasifier is The cost of the 9 kWe gasifier manufactured at Baroda, Gujarat, was approximately Rs. 4.85 lakhs. The capital expenditure for setting up 120 kW gasifier systems is over Rs. 70 lakh with an expected 17% return on investment.

The capital expenditure for setting up 120 KW gasifier systems is over Rs 70 lakh with an expected 17% return on investment. The AVANI project with its innovative business model proposes to address the interdependent issues of unemployment, health, and improvements in the overall quality of life of rural communities in the hilly region. The project also addresses one of the most energy-intensive and a vital household process, cooking by effectively utilizing bio charcoal, a by-product of the gasification process. This improved cooking energy solution will reduce fuel gathering time by 70% and simultaneously provide smoke-free cooking.

Residue from a 120 kW gasifier system will be sufficient to meet the cooking fuel needs of 100 households as typically the gasification process produces about 10% residue. Families pay for the charcoal, which is cheaper than LPG or kerosene, either by cash or by collecting pine needles in lieu for it. This improved cooking solution not only replaces fuel wood collection (for cooking), an activity typically carried out by women, but also promotes smoke-free households resulting in a reduction in respiratory-related diseases.

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 key shareholders. The company will set up more such power plants, generating profits, which in turn will be shared by the producers and pine-needle collectors.

There is a good potential to replicate this model in other parts of the central Himalayan region since pine needle is found in plenty. As per estimates typically, 1 sq. m of pine forest will yield 1.19 kg of pine needles. A 100 kW gasifier running for 24 hours will require around 4.5 tonnes of pine needles. A 115 ha of cleared forest every year which will give 1,350 tonnes of pine needles per year for electricity generation.<sup>3</sup> Particularly in the central and western Himalayan region, such a gasifier model has enormous potential of generating electricity.

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<sup>3</sup> Empowering rural India the RE way: inspiring success stories, Ministry of New and Renewable Energy, Government of India, 2012





**Figure 10:** Pine Needle Collection for gasifier plant

**Services Offered:** AVANI aims at addressing the socio-economic divide at the village level by monetizing the collection of pine needles and use of charcoal in households. The unemployed can earn by collecting pine needles for the gasifier and others can purchase the by-product, i.e., charcoal for cooking including relatively the well-off families in the village, who may not participate in collection. Further, the sale of electricity to the grid and other users will create a surplus that will further employ a larger number of people in the collection of pine needles, thus creating a sustainable livelihood model at the village level.

**Challenges and issues:**

Addressing both storage and collection challenges is key to the implementation of projects of this size. This is especially crucial because pine needles are available for only a few months annually.

Finances and the associated project costs are also barriers for a project of such a nature. The other major barriers have been the lack of availability of technical expertise and training and awareness programmes for plant operators.

## Gasification system in Tumkur district, Karnataka



**Figure 11:** Biomass gasifier system at Tumkur, Karnataka (BERI project)

**Source:** UNDP

### Project at a Glance

S. No.	Particulars	Details
1	Project Proponent (NGO name with main office address) along with website address	Project is started under the programme Biomass Energy for Rural India (BERI)
2	Contact details of responsible person	United Nations Development Programme
3	System configuration	500 kWe gasifier
4	Total project funds (INR)	Rs 40.96 crores
5	Main contribution	Global Environment Facility (GEF)
6	Other contribution	India Canada Environment Facility (ICEF), Government of Karnataka (GoK), and Ministry of New and Renewable Energy (MNRE).
7	Beneficiary contribution	Reduce GHG emissions from the primary use of fossil fuels that were used for various household purposes such as cooking, lighting, fans, irrigation pumps, and other power applications
8	NGO contribution	Capacity building, awareness
9	Project location (name of village, panchayat name, taluk/block/district/state)	28 Villages in Tumkur district, Karnataka
10	Date of operation	Project period was from April 2001 to December 2006. The project has undergone three extensions, first from January 2007 to December 2008, thereafter to December 2010 and finally up to December 2012
11	Number of households benefitted	2,500 households

12	Type of tangible/direct benefits	Electrification
13	Type of beneficiaries (men, women, children) and type of benefits	Promotion of biogas plants Irrigation facilities Employment generation through plantation and tree-based farming
14	Cost-benefits (investment, monthly or yearly balance sheet of expenditure and revenues, product life time)	cost economics provided in Summary
15	Increase in income to the families (INR/percentage)	Local people were employed in tree-based farming which resulted in an additional income for them
16	Units of power generated and estimated GHG reduced tCO <sub>2</sub>	The 500kWe plant have generated 1,520,000 kWh of electricity as of June 2012, resulting in reduction of 1,200 tonnes of CO <sub>2</sub>

**About the Project:** This project was implemented by the United Nations Development Programme (UNDP) with the financing support provided by the Global Environment Facility (GEF) and with the co-financing support of the India- Canada Environment Facility (ICEF) (now closed) , Government of Karnataka (GoK), and Ministry of New and Renewable Energy (MNRE). The project objective was to remove key barriers to the use of biomass for energy generation in rural communities.

**Background:** BERI was conceived as a project with GEF funding to create a decentralized and sustainable energy generation and distribution system to provide comprehensive and high quality rural energy services that are critical for promotion of rural development and improving the quality of life in rural communities. The project's aim was to provide a reliable high quality supply of energy for these services for rural populations. The original design of BERI envisaged sixty 20 kWe biomass gasifier units to supply electricity for 2,500 households in 24 villages belonging to five different talukas (Korategere, Madhugiri, Sira, Gubbi, and Tumkur) in Tumkur district of Karnataka. To ensure the sustainable supply of biomass fuel to these gasification units, the project also envisaged promoting energy efficient cook stoves and community biogas plants for biomass conservation as well as building of community capacity for irrigation, generation of cooking fuels and growing plantations. The intended impact of BERI was to reduce GHG emissions from the primary use of fossil fuels that were used for various household purposes such as cooking, lighting, fans, irrigation pumps and other power applications.

**Financing:** The original project period was from April 2001 to December 2006. The project has undergone three extensions, first from January 2007 to December 2008, thereafter to December 2010 and finally up to December 2012. BERI was planned as a 5-

year project; as such, GEF resources of USD 4,082,220 were managed by UNDP's Project Management Unit (PMU) under the management of the project Steering committee (PSC). The project co-financing amounts were estimated to be in the order of USD 1.137 million, roughly 28% of the GEF allocation. Prior to the commencement of the project, co-financing was already committed from ICEF, Gol, GoK and the private sector. During the course of the project, significant in-kind contributions were provided by GoK, Gol, NGOs and private sector stakeholders.

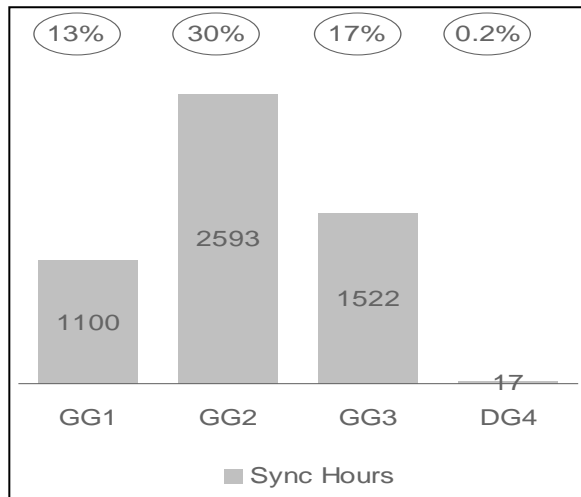
**Plant details:** The plant details for BERI project are provided in Table 2 below.<sup>4</sup>

**Table 2:** Plant details for BERI Project

S. No.	Parameters	Information
1	Technology	CGPL and IISc Bangalore
2	Installed capacity	1.05 MW cumulative capacity (11 gasifier systems) was installed in Kabbigere, Borigunte, and Seebanayanpalya clusters in Tumkur district, Karnataka. The 900 kW is 100% producer gas (two 100 kW systems, one 200 kW system, two 250 kW systems); the 100 kW one is dual fuel (diesel and gasifier) system; and 10 kW five dual fuel (diesel and gasifier) systems were implemented.
3	Electricity generation for 500 kW Kabbigere plant	The cumulative electricity generation was 1,140 MWh (as on 30 June 2012)
4	Biomass supply for Kabbigere plant	The Kabbigere plant received the biomass supplies from private contractors located more than 40 km from the plant. The price of biomass received was twice as of locally supplied biomass.
5	Weighted average PLF of the Kabbigere plant	15%

**Operation of the plant:** For Kabbigere 500 KW plant, which consists of one engine of 200 KW (represented as GG1), three engines of 100 KW each (as GG2, GG3 and DG4 respectively), and the operational performance was moderately satisfactory. Figure 12 shows the operational performance for the period of April 11 to March 12. The GG2 engine performed best out of the four and ran for around 2593 hours during the operational duration.

<sup>4</sup> Terminal Evaluation Report, UNDP/ GEF Project: Biomass Energy for Rural India, March 2013



**Figure 12:** Operation of Kabbigere 500 kW plant in Karnataka

**Cost:** As per the operational data of Kabbigere unit (May 2011 to April 2012) 5, the average cost of power exported per unit for the 12 months is Rs. 10.64, which is high against the industry benchmark. The operational cost includes the

- cost of biomass (Rs. 2.77/ kWh)
- biomass sizing cost (Rs. 0.58/ kWh)
- O & M cost (Rs. 2.58/ kWh) and
- cost of auxiliary consumption & losses (4.71/ kWh).

Primary causes of the high cost of production are traced as (Terminal Evaluation Report, UNDP, 2013)

- the operational inefficiencies of the plant including a high number of plant personnel;
- the high cost of biomass due its sourcing 40 km from Tumkur at twice the cost;
- low PLF; and
- a high plant parasitic load

**Revenue:** The electricity was sold to Bescom at a rate of Rs 2.85 per unit. Hence, in terms of financial viability, the selling to Bescom at the rates mentioned was not profitable. Since the cost per unit exported even in better performing biomass gasification operations are in the range of Rs 6.50 Rs–7.00, it is clear that the Bescom rate needs to be increased substantially. BESCO rates are stipulated by State Renewable Energy Cooperation (SERC). Therefore there is need to pay attention towards low tariff of biomass related power projects.

**Key learning:** The revenue received from the project is very low and thus the project is not viable. Therefore, the BERI project needs to be approached in the following direction for future growth.

- Continue the existing model. Negotiate better rate with discoms (Bescom currently)
- Explore alternative markets (corporate/industrial users, viz., Wipro, Infosys) that will pay higher rates.
- Earn Renewable Energy Certificates (RECs)<sup>6</sup> for the biomass project (Details provided in Annexure).
- Go for an off-grid model; sell power directly to end-users in rural areas
  - Look for markets to sell electricity directly to users, instead of KPTCL. Forming a rural electric cooperative under BERI may help achieve this objective. The cooperative can distribute power directly to the adjoining areas and collect revenue directly. It may even be eligible to get a subsidy for its operations from the Rural Development and Panchayat Raj Department.
- Go for an off-grid model and sell power to wholesalers
  - Outsource the entire operation to a third party, giving him the right to sell electricity to whoever he wants, and asking the bidder for the maximum amount he will give to BERI for use of assets; this should be given on a lease basis.

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<sup>6</sup> Internationally, purchase of REC is deemed as purchase of power generated from Renewable Energy (RE) sources. It is acknowledged that renewable energy generation entails production of certain environmental attributes apart from electricity generation per se. Thus, RE generator can sell two different products on account of renewable energy generation. These products are the electricity and the environmental attributes associated in the form of RE Certificate.

## Gasification System at Sunderbans



**Figure 13:** Biomass gasifier system in Sunderbans

### Project at a Glance

S. No.	Particulars	Details
1	Project Proponent (NGO name with main office address) along with website address	West Bengal Renewable Energy Development Agency (WBREDA) initiative in collaboration with MNRE, Sunderban Development Department, Forest Department, and South 24 Paragans Zilla Parishad
3	System configuration	500 kWe gasifier
4	Main contribution	MNRE
5	Other contribution	State funds
6	Project location (name of village, panchayat name, taluk/block/district/state)	Chotamukakalli, West Bengal
7	Number of households benefitted	15,000 families
8	Type of tangible/direct benefits	Power generation
9	Type of beneficiaries (men, women, children) and type of benefits	Small-scale industries Government health centre Employment offered through energy plantation and power plant operation and maintenance Refrigeration facilities, etc.
10	Increase in income to the families (INR/ percentage)	Local people were employed

**About the Project:** The West Bengal Renewable Energy Development Agency (WBREDA) in collaboration with MNES (presently MNRE), Sunderban Development Department,

Forest Department, and South 24 Parganas Zilla Parisad had installed a 500 kW (5x 100 kW) dual fuel mode biomass based power plant and Chotamulakalli was identified as a probable location for setting up the woody biomass based power plant. Gosaba Rural Energy Co-Operative was formed in the year 1996 for the operation of the system. Gosaba Island installation has been a successful case study for the reason that the energy generated from gasifier has turned the socio economic status of the island along with community development. Even when the cost of energy generation is high, the energy generated from gasifier has played a pivotal role in improving the life style of the rural masses of Sunderbans, where grid penetration is impossible in the near future.

**Financing:** The project was carried out by WBREDA. For the project, loan was taken from MNRE under the Remote Village Electrification Programme and the remaining from the State funds.

- 75% - Loan from MNRE
- 25% - State funds

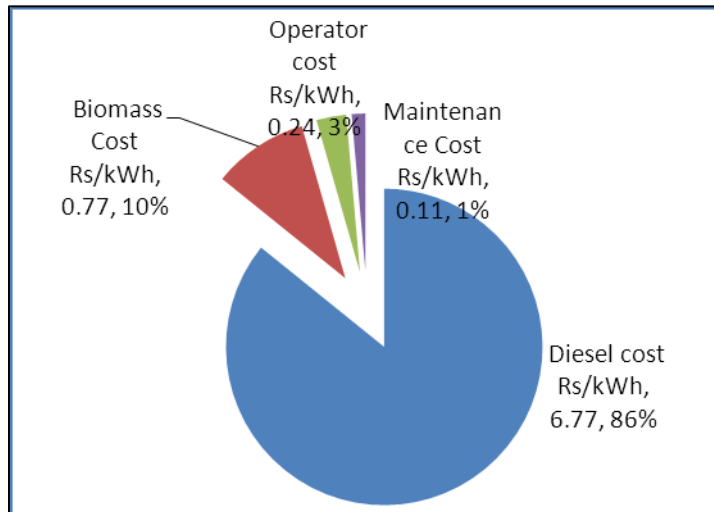
**Business Model:** The plant was setup by the Gosaba Rural Energy Development Cooperative Society Ltd in the year 1996. There were 13 board members: six elected members and seven nominated members. The society comprised of consumers representatives, WBREDA, West Bengal State Electricity Board (WBSEB), Sunderbans Development Board, Forest co-operative department and officials from Government of West Bengal. The entire operation and maintenance of the plant was the responsibility of the Co-operative Society. This cooperative was responsible for ensuring biomass supply, daily plant operation and maintenance, and financial record keeping. For undertaking renovation, repair and maintenance of plants, around 75% of the financing was taken from the co-operative and the rest from MNRE. Ankur Scientific Energy Technologies Private Limited undertook turnkey operation for the project and performed major maintenance and retrofitting functions. The company trained the local unemployed people for gasifier operation. The state nodal agency, WBREDA had functions as the Technical Backup Unit for the project. Also, periodically tests were conducted for the plant operators to monitor their performance.

**Biomass Supply:** Gosaba Biomass Gasifier plant operates on woody biomass. As such, supply of woody biomass is to be ensured for sustainability of the power plant. At Gosaba, energy plantation work was taken up right from the planning stage of the power plant. Generally, it takes three to five years for harvesting of captive energy plantations. The initial three years is the load growth period. Biomass consumption during that period is comparatively low and has to be arranged locally. In subsequent years, biomass is available from the captive energy plantation.

**Cost:** As per data available for the system, for three consecutive years (2002-2004) the electricity generation cost was increased from Rs. 4.20 to Rs. 7.20/kWh. The increase in



cost of electricity generation is a result of increase in diesel prices. The total expenditure in running a plant was around Rs. 10 lakh/ annum and total revenue generated was only Rs. 7.20 lakhs/annum approximately. The cost break- up for the project is provided in Figure 14.



**Figure 14:** Break-up of Gosaba gasifier project costs

**Revenue:** The average daily generation was 950 units over the period of 16 operating hours.

- Domestic consumers - Rs 5/kWh
- Commercial shops and establishments - Rs 5.50/kWh
- Industrial consumers - Rs 6/kWh.

The average household consumption was in the range of 1 to 3 units per day. The households with electricity supply connection had to pay a fixed charge of Rs 75 per month in addition to the variable charges for the units consumed.

#### **Services Offered:**

- Power generation is the only core service offered by the plant apart from the employment offered through the energy plantations and power plant operation and maintenance.
- Small-scale industries – lathe machine units, boat-repairing works, grill welding, domestic iron implements, sharpening machines and machines to grind spices like chilli and turmeric, using automated electricity operated machinery have been established in the region.
- An operation theatre has been made functional in the government health centre in the island. With the availability of refrigerators, it has become possible to store life-

saving vaccines or medicines. Electricity operated pump motors for the purpose of irrigation and cultivation of crops.

- Electricity operated pump motors for the purpose of irrigation and cultivation of crops.

### **Success of the Project**

- *Locals involved in decision making:* One of the reasons for the project's success was that locals were involved in decision-making from the very start. A series of public meetings was held to raise awareness of the technology, its limitations, advantages, and the need for an energy plantation.
- *Community Campaign for Setting up Biomass Plants:* Concerned by the threat to their incomes, the local diesel operators initially opposed the setting up of the power plant. But other members of the community undertook a vigorous campaign to sell the benefits of the new approach (which included the health benefit of cutting the toxic fumes from the diesel generators). This dissipated the opposition to a large extent and some of the diesel operators were later employed in the plant.
- *No instances of electricity theft:* There has been no reported evidence of electricity 'theft' or of defaulting on bills since the people are very co-operative with the cooperative society that sets the tariff, advises WBREDA on where the power line should go, and is responsible for collecting electricity bills from each household.
- *Good Level of community ownership:* The boards of directors are the members of the village panchayats are on the board, which is one of the ways of ensuring a good level of community ownership.

### **Challenges and issues:**

- There was resistance from local diesel suppliers. Apprehending the discontinuation of their meagre income, the local diesel operators initially opposed the setting up of the power plant. Later, the experienced among them were employed as operators in the gasifier power plant.
- The issue of continued supply of biomass for the plant was resolved by energy plantation of 71 ha of low-line river bank silt beds (char land) under the tutelage of the local Panchayat Samiti, Block Development Officer, and the Chairman of the cooperative so that no scarcity occurred in securing the stock of the main fuel ingredient (wood). Generally, it takes five years for harvesting of captive energy plantation. The initial three years are the load growth period as the number of consumers is less. Biomass consumption during that period is comparatively low. However, this has to be arranged locally.

## 2. Sub-Mega Watt Gasifier Projects (GRID-BASED)

### Grid Connected Gasifier Project in Kothara, Gujarat

#### Project at a Glance

S. No.	Particulars	Details
1	Project Proponent (NGO name with main office address) along with website address	Gujarat Energy Development Authority (GEDA)
3	System configuration	500 kWe gasifier
4	Total project funds (INR)	200 lakh
5	Main contribution	MNRE sanctioned Rs 121 lakhs to GEDA for setting up a 500 kWe grid connected gasifier plant
6	Other contribution	GEDA
9	Project location (name of village, panchayat name, taluk/block/district/state)	Kothara, Kutch district
10	Date of operation	June 2002
13	Type of tangible/direct benefits	Power generation

**About Project:** The project objective is to feed a minimum of 500 kW electric powers into the grid at Kothara sub-station. The Gujarat Energy Development Authority (GEDA) took up Energy Plantation Programmes in the wastelands of Kutch in a major way since the early 1980s. The programmes are multi-dimensional in nature with linkages to energy supply, food and fodder, soil regeneration, ecological development and local employment generation.

GEDA's energy plantation in Kuch district cover an area of 1450 hecatres and has been at different agro-climatic locations developed in villages Moti Sindhodi, Lathedi, Vingabe and Kosha in taluka Abdasa.

**Financing:** The total project cost is Rs 200 lakhs as per project cost break up given in Table 2 below, with plant and machinery at Rs 160 lakhs and civil work at Rs 30 lakhs. Ministry of New and Renewable Energy (MNRE), sanctioned funds to Gujarat Energy Development Agency (GEDA) for setting up of 500 KW Grid connected Biomass gasifier-based Power Project (Project) at Kothara village in Kutch district. The project was mainly aimed to demonstrate technical feasibility and economic viability of medium scale power generation based on gasification of naturally growing energy tree species like *Prosopis juliflora* and/or fuel wood from energy plantations raised specifically for the purpose. The project was finally commissioned in June 2002, incurring a total expenditure of Rs 2.07 crore.

**Table 3:** Break up of project cost

Organization	Amount sanction out of Rs 200 lakh (in Rs)	Percentage share
Government of India through the Ministry of New and Renewable Energy	121 lakh	58.5%
Gujarat Energy Development Authority	84 lakh	40.5%

**Business Model:** The project was developed to generate power from biomass through gasifier based plant and feed power of 500 kW to the grid. The model utilized by GEDA here is OOM (Owned, Operate and Maintained). The power supplied to the grid is charged at a rate of Rs 2.25 per unit from the Gujarat Electricity Board.

**Biomass Supply:** The gando bawal is a highly aggressive tree. It coppices well – its annual average growth has been recorded to be up to 3–5 metres. It thrives in difficult physical conditions, and due to its ability to strike root and flourish in highly degraded soils. The consumption of biomass per kWh was 1.2 kg.

**Cost:** The total cost of project was around Rs 200 lakhs, that include cost of plant and machinery (Rs 149 lakhs), civil works (Rs 27.15 lakhs), and plantation expenditure (Rs 22.87 lakhs) etc. The fuel cost for project was Rs 1.5/kWh.

**Tariff:** The charges for the electricity to Gujarat Electricity Board were Rs 2.25/unit.

**Issues and Challenges:** The major problems observed during the gasifier operation time were:

- The project attained an annual generation of electricity of 1,66,928 kWh against the projected capacity of 13,20,000 kWh (13%). Incurring an operational expenditure of Rs 89 lakh, GEDA in all generated 3.89 lakh units power (2002-04) and earned an income of Rs 7.63 lakh by its sales to Gujarat Electricity Board.
- Supplies received from Singhodi site were erratic and inadequate as the wood logs received were requiring resizing at high expenses; relatively green/high moisture wood were supplied.
- There were no biomass supplies for the project from Lakhara-Velara plantation when the plant was commissioned. The present biomass gasifier-based power project was implemented based on the non-existent plantation and unavailable input material.
- The economic viability has suffered due to manifold increase in diesel price by the time it is implemented.
- Cost of transportation of fuel wood from Singhodi site was prohibitive due to not meeting the government regulations.
- The project was finally closed down in March 2004.

### 3. Mega Watt Gasifier Projects

#### Gasifier Project Vadodara

##### Project at a Glance

S. No.	Particulars	Details
1	Project Proponent (NGO name with main office address) along with website address	Ankur Scientific
3	System configuration	500 kWe gasifier
4	Total project funds (INR)	Rs 640.67 lakh
5	Main contribution	MNRE-UNDP
9	Project location (name of village, panchayat name, taluk/block/district/state)	Sankheda Taluka, Vadodara, Gujarat
13	Type of tangible/direct benefits	Power generation

**About the Project:** Ankur Scientific Energy Technologies Pvt. Ltd. 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<sup>7</sup>’ implemented under a project by MNRE-UNDP funded by GEF. The project was commissioned in a short duration of 6 months with the help of local villagers and farmers, panchayats, the taluka offices, the collectorate and departments of land conversion and town planning, the District Industries Centre (DIC), the pollution control board, the Gujarat Energy Development Agency (GEDA), the Madhya Gujarat Vij Company Ltd, the Gujarat Energy Transmission Corporation Ltd, and MNRE.

**Financing:** The project cost was Rs 640.67 lakh. The cost break up is

- Cost of land: 16.94 lakhs
- Civil and Construction: 100.70 lakhs
- Plant and machinery: 517.61 lakhs
- Other assets: 5.42 lakhs

The project was funded under the MNRE- UNDP implemented project, and received partial financial assistance along with the bank loan.

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<sup>7</sup> MNRE has implemented a MNRE - UNDP / GEF assisted Project on “Removal of Barriers to Biomass Power Generation in India to accelerate the adoption of environmentally sustainable biomass power technologies by removing the barriers identified, thereby laying the foundation for the large scale commercialization of biomass power through increased access to financing. As part of this Project, the Ministry is contemplating establishment of a few Model Investment Projects (MIPs) in different parts of the country with a view to focus removal of barriers related to technology, Size and Sustainability and would like to provide financial support to grid interactive, MW capacity projects based on Biomass Gasification Technology. The aim of establishing these model projects is to standardize the technology package in this capacity range and also to generate information / data to develop benchmark norms related to Capex, O&M, PLF etc. which are essential inputs for determination of separate tariff for such projects. The developed financial models would facilitate in mainstreaming of the gasification technology in the biomass power sector and for its faster replication in the country.

**Business Model:** It is a grid based model that is owned operated and maintained by Ankur Scientific Energy Technologies Pvt. Ltd. The overall system designed has two woody biomass based gasifiers which are coupled to three units of 400 kWe each running on 100% producer gas engine gensets.

**Biomass Supply:** The biomass for the project is based on crop residues of the common crops available near the project site, mainly cotton, tur, and sorghum stalks, mango seeds, and corn cobs. The surrounding area of the project site is rich in cotton, tur, and maize cultivation. The agri-residues are willingly sold by farmers and villagers to the project developers for some added revenues. A few young villagers and farmers have been identified and trained to manage the supply chain. The purchase price of biomass is approx. Rs 2 per Kg.

**Cost:** The project cost comes to Rs. 640.67 lakh including cost of land, civil and construction, plant and machinery etc. The O & M cost for gasifier is 3.5% of the gasifier cost and O & M cost of gas engine is Rs 0.25/kWh. The purchase price of biomass is approx. Rs 2 per kg.

**Tariff:** The developer signed the project purchase agreement with third party buyer for the duration of 10 years with affixed tariff rate of Rs 4.10 per kWh for 10 year. As per the selling agreement, the seller is responsible for payment of applicable transmission, wheeling and other charges including the electricity duty.

**Uniqueness:** The waste heat from the exhaust of two engines is being used for biomass drying.

- Char produced has high calorific value and is used as a fuel for small scale industry requiring thermal energy.
- Char of sizes below 1 mm would be given to the local farmers as biochar for soil addition as it increases the fertility of the soil and thereby the yield.
- 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 would initially be sold to industries for their thermal application and thereafter in the long run , the company intends to give part of the briquette / charcoal to the local villagers for smokeless cooking.

# Recommendations and Conclusion

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## Recommendations

1. **Financing:** During the study, it is observed that, the funding for biomass power projects is mainly through self-funding and grants (from different funding agencies). Very few commercial banks had shown interest in funding these projects.

While interacting with various stakeholders, it was revealed that financing institutions, such as banks, consider biomass as the best resource for power generation in comparison to other renewable sources. However, they have been concerned about the availability of adequate biomass, pricing of biomass, gaps at the policy level, etc. As the Government of India is looking for megawatt-scale biomass power generation through entrepreneurs, a robust biomass policy is a must regarding financing of bigger projects.

2. **Technology:** While gasifier technology has been amply demonstrated in thermal and small-scale power generation applications, at the sub-megawatt scale, significant challenges remain to be resolved. The gasifier technology being used in India is the conventional fixed bed, and capacity ranges are still at the small and sub-MW scale. The stability and long-term continuous operation of these gasifiers is still not proven. The energy and environmental performance of the current technology need further improvements, particularly in reduction of impurities in raw gas, water usage, and wastewater disposal.

Further, generally in India, engines manufactured for use of natural gas or biogas are used for producer gas. While for smaller-scale systems such an arrangement is suitable for larger sub-megawatt scale systems, engines manufactured exclusively for producer gas might be required to provide the efficiency and reliability needed for operations on this scale. Further, even the engines available are generally available only in smaller sizes, up to 250 kW. This necessitates the use of multiple engines, which in turn increases the system complexity.

Grid-connectivity is another major issue. Most of the case studies discussed in this report are for off-grid systems. While, as mentioned elsewhere in the report, such systems are useful for small scale deployment in areas where grid-connectivity is not possible, for larger sub-megawatt systems, grid connectivity enables the system to be operated at close to its full capacity for longer durations, increasing system efficiency. For non-grid connected systems on the other hand, the system has to be run as per the requirements at that point of time, with shutdowns and restarts becoming more.

3. **Biomass supply:** Biomass supply is the most critical component of biomass power projects as all other components ranging from financing to technology to tariff are the function of it.

Financial institutions consider biomass as a potential resource for power generation, but still they are not very enthusiastic about these projects. This is because of uncertainty in biomass supply, its pricing and logistics.

Biomass gasification technology is biomass dependent. Gasifier designs are heavily dependent on biomass characteristics i.e. a biomass gasifier designed for woody biomass cannot run on loose biomass and visa-versa. This technological constraint is a barrier in ensuring the biomass availability round the year. In the absence of a strong biomass policy, the pricing of biomass is not regulated and therefore erratic in nature. This affects the cost of power generation and finally the tariff.

As the above discussed components are dependent on biomass supply, and to ensure smooth and continuous supply of biomass the following recommendation are:

- Technology of biomass gasifiers has to be improved/ changed so that biomass of varying nature can be used. In this biomass processing Briquetting or pellet technology can play a pivotal role provided the cost of final fuel for gasifier remains competitive. The technological improvement will further ensure the availability of biomass irrespective of seasonality.
- Second most critical challenge is consistent biomass availability. For sustainable operation of the biomass-based power plant, both for short and long term basis, the following biomass supply arrangement can be made.
- Collection from nearby areas: Collection of biomass with the help of local people (villagers) from the nearby areas (forest waste/agriculture waste) for meeting the requirement of the power plant on commercial basis.
- Agreements with state forest department will also ensure the biomass supply either from depot, forest (weeds) or through providing forest waste lands for energy plantation.
- Agreements with village authorities for allocating village waste lands for energy plantation.
- Government should make efforts to develop a strong policy for biomass trading in line with the agro product policy for announcing minimum support price. This brings the focus on providing better market linkages based on product cluster



formation and effective strengthening of the credit and marketing links for financial security of the developer and entrepreneur.

- Capacity building programmes on biomass supply chain mainly focusing towards backward integration, for local people (especially youths) can also be a useful in ensuring biomass supply throughout the year.

#### **4. Peripheral services:**

- During the study, it is observed that the entrepreneurs have also provided additional services to enhance the livelihood opportunities for the local people. For example EmPower Partnership Programmes of DESI power which identified peripheral activities along with energy services those services can be categorized as capacity building, services offered for providing additional livelihood opportunities for the local people.
- While developing the business model of power generation through biomass gasification (especially in case of off grid power projects), it is recommended that an integrated business model should be conceptualized for such projects. This should include livelihood opportunities identification, training for the local people, and also to facilitate the interested local people for accessing financing facilities.
- This model will ensure self-sustainability of the plant operations for the long term; will create spin-off benefits in the area in terms of enhanced working hours, increased incomes, improved lifestyle, better paying capacities, etc.

**Tariff:** There is a need to restructure the tariff support by central and state governments to further facilitate the uptake of this technology by developers and entrepreneurs.

It is recommended that the efforts are made to carry out price discovery of unit generation (kWh) for biomass power projects to facilitate independent power producers/ entrepreneurs.

#### **Conclusions**

Assessment of case studies concludes that the electrification through biomass power projects has simplified the life of millions of rural people. The case studies have been categorized as grid, off-grid, and captive power projects. The studies have shown that the projects were started with a self-sustainability approach but they are facing various barriers in the plant operations. The barriers have been identified such as financing of

power projects, technology customization, biomass resource management, tariff structure, and lack of government policies on biomass. At the end, it can be concluded that governments should make efforts towards creating a conducive environment for biomass power projects ranging from policy framework to the market development so that entrepreneurs can come up with larger plant capacities (grid and off-grid mode).

## Bibliography

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Access to Clean Energy: A Glimpse of Off Grid Projects in India (UNDP document) from [http://www.in.undp.org/content/dam/india/docs/access\\_to\\_clean\\_energy.pdf](http://www.in.undp.org/content/dam/india/docs/access_to_clean_energy.pdf), Retrieved 29 December 2012.

BERI Project, See website Biomass\_energy\_for\_rural\_india\_factsheet\_project, September 2012.

Debyani Ghosh, A. S, 2003. *Scaling up biomass gasifier use: Applications, barriers and interventions*. New Delhi (India) and Harvard (USA): The Energy and Resources Institute and John F Kennedy School of Government.

Desipower (2003).

Empowering rural India the RE way: inspiring success stories, Ministry of New and Renewable Energy, Government of India, 2012

<http://www.desipower.com/100Village/writeUp100Village.htm>. Retrieved 12 26, 2012, from <http://www.desipower.com>.

Desipower (2012, 12 26). [http://www.desipower.com/economics/cost\\_electricity.htm](http://www.desipower.com/economics/cost_electricity.htm). Retrieved from <http://www.desipower.com>.

Desipower (2012, 12 26 [http://www.desipower.com/economics/triple\\_bottomline.htm](http://www.desipower.com/economics/triple_bottomline.htm). Retrieved 12 26, 2012, from <http://www.desipower.com>.

Desipower. (2012, 12 26). [http://www.desipower.com/how/business\\_model.htm](http://www.desipower.com/how/business_model.htm). Retrieved 2012, from <http://www.desipower.com>.

Devalt. (n.d.). (<http://www.devalt.org/knowledgebase/pdf/Case%20Study-3.pdf>). Retrieved 12 27, 2012, from <http://www.devalt.org>.

Final Report On Policy and Regulatory Interventions to Support Community Level Off-Grid Projects, November 2011, prepared by ABPS Infrastructure Advisory Pvt. Ltd.

<http://designpublic.in/blog/a-conversation-with-ratnesh-yadav-from-husk-power-systems/>. Retrieved 12 27, 2012, from <http://designpublic.in>.

[http://ganashakti.tripod.com/981207/bengal\\_News2.htm](http://ganashakti.tripod.com/981207/bengal_News2.htm). (n.d.).

<http://www.ankurscientific.com/company.htm>.

<http://www.ashden.org/files/Husk%20winner.pdf>. Retrieved 12 27, 2012, from <http://www.ashden.org>.

[http://www.cepe.ethz.ch/education/CompletedThesis/Validation\\_Report\\_Grande\\_Final\\_e.pdf](http://www.cepe.ethz.ch/education/CompletedThesis/Validation_Report_Grande_Final_e.pdf). Retrieved 12 26, 2012, from <http://www.cepe.ethz.ch>.

<http://www.dealcurry.com/20121025-Power-Producer-From-Agri-waste-Husk-Power-Systems-Raises-Funds.htm>. Retrieved 12 26, 2012, from <http://www.dealcurry.com>.

<http://www.desipower.com>.

<http://www.desipower.com/100village/writeup100village.htm>, 2003

[http://www.desipower.com/how/business\\_model.htm](http://www.desipower.com/how/business_model.htm),2012

<http://www.desipower.com/MANTRA/BusiPlan/BusiPlan.htm>. Retrieved 12 26, 2012

<http://www.devalt.org>. (2012, 12 26)

<http://www.devalt.org/newsletter/jan06/lead.htm>. Retrieved 12 26, 2012, from <http://www.devalt.org>.

<http://www.findthatpdf.com>. (2012, 12 26). [http://www.findthatpdf.com/search-780787-hPDF/download-documents-statusreport\\_100villageempowerpartnershipprogram-dec08.pdf.pdf.htm](http://www.findthatpdf.com/search-780787-hPDF/download-documents-statusreport_100villageempowerpartnershipprogram-dec08.pdf.pdf.htm). Retrieved 12 26, 2012, from <http://www.findthatpdf.com>.

[http://www.huskpowersystems.com/innerpagedata.php?pageT=Background&page\\_id=76&pagesub\\_id=119](http://www.huskpowersystems.com/innerpagedata.php?pageT=Background&page_id=76&pagesub_id=119). Retrieved 12 27, 2012, from <http://www.huskpowersystems.com>.

IFMR Research, Centre for Development Finance, 2010. Empowering Villages: A Comparative Analysis of DESI Power and Husk Power Systems: Small-scale biomass power generators in India. Chennai: Institute for Financial Management & Research.

Inclusive Business Models, Guide to the Inclusive Business Models in IFC's Portfolio, September 2011.

[netprorenewable](http://www.netprorenewable.com). (2012, 12 26). <http://www.netprorenewable.com/aboutus.html>. Retrieved 12 26, 2012, from <http://www.netprorenewable.com>.

[sesec](http://www.sesec.org). (2012, 12 26). [http://www.sesec.org/pdf/8/sesec8\\_sharan.pdf](http://www.sesec.org/pdf/8/sesec8_sharan.pdf). Retrieved from <http://www.sesec.org>.

Terminal Evaluation Report, UNDP/ GEF Project: Biomass Energy for Rural India, March 2013

V Ranganathan and syed Haque Cost Benefit Analysis of Biomass Gasifier Based Electrification for BERI, October 2012.

Waste to Energy- A case study of Rice Husk Power Plant, Bihar, prepared by Husk Power Systems Private Limited

[www.eai.in/green-communities/gosaba-island-west-bengal-biomass-for-electricity/](http://www.eai.in/green-communities/gosaba-island-west-bengal-biomass-for-electricity/)



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