

## 2009 Ashden Awards case study Saran Renewable Energy Pvt Ltd

**Finalist's work:** Replacing diesel generators with biomass gasification systems

**Organisation:** Private company, established in 2006. Annual turnover US\$66,000, 12 staff (2009)

**Location:** Bihar, India

### Summary

Bihar is one of the poorest states in India. Mains electric power is available erratically and black-outs can last for days. Rainfall is high because of the monsoon, but there is frequent flooding. In the dry season, it is possible to pump water from boreholes to irrigate crops, but reliable electricity is needed to do this. Saran Renewable Energy (SRE) was set up by a family-owned grain-trading business, because of concern about the lack of electricity in Bihar. SRE has built a plant to gasify biomass bought from local farmers, and use the gas to generate electricity, which is sold locally, mainly to small businesses.

- Gasification plant uses a dual-fuel generator, to supply 128 kW of electricity at 240 V.
- Most biomass used is 'dhaincha', a local woody plant which grows on uncultivated waterlogged land, or can be added in the existing crop rotation during the monsoon.
- Two 3 kV transmission lines, each 1.25 km long, link to the customers.
- Most of the customers previously used diesel generators for businesses including grain mills, cold stores, a sawmill and welding. Some customers are 'generators' who sell electricity for lighting or charge batteries for other customers.
- A school and clinic are also supplied.
- The gasification plant runs irrigation pumps connected to the transmission lines and a pipe to supply to farms close to the plant.
- Plant runs for 11 hours per day. Currently runs at about 35% capacity and supplies about 220 MWh per year.
- Allowing for 10-15% use of diesel for ignition, the plant saves an estimated 0.35 litres of diesel per kWh, or about 77,000 litres of diesel per year.
- Greenhouse gas emissions reduced by about 206 tonnes/year CO<sub>2</sub>.
- Farmers are paid about US\$0.04 per kg for supplying biomass to the plant.
- Customers are charged about US\$0.15/kWh for electricity, compared with about US\$0.28/kWh for diesel generators and US\$0.12/kWh for (unreliable) grid supply.
- Plant cost about US\$170,000 to construct, financed by investment from the directors, a bank loan and an anticipated government subsidy (currently financed by directors).
- Capital cost expected to be recovered in about six years.

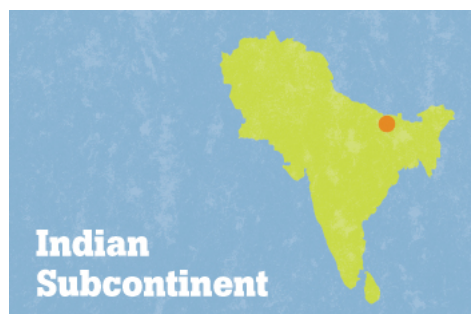
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## Context

Bihar is one of the poorest states in India, located in the east of the country. Saran District is in a rural part of the state. Most people live in brick built homes with basic infrastructure: grid electricity, water supply and sanitation all exist but have often not been well maintained. There is a shortfall in the electricity generation capacity, so power is available erratically and black-outs can last for days.

Rainfall is high because of the monsoon, which feeds several important permanent rivers, but frequently causes flooding. In the dry season, it is possible to extract water via boreholes to irrigate crops. However, reliable electricity is needed to pump this water for irrigation. A significant proportion of the land stays waterlogged, and has limited value for growing crops.

Saran Renewable Energy (SRE) was set up by a family-owned grain-trading business, because of concern about the lack of electricity in Bihar. SRE has built a biomass gasification plant at Garkha to gasify biomass bought from local farmers, and use the gas to generate electricity, which is sold to small, local businesses.

<b>Statistical information, India</b>	
Population (2005) million	1134
Urban Population % of total	29%
GDP per capita US\$ (2005)	US\$736
- at purchasing power parity	US\$3452
Population living on less than \$1 a day (2005)	34%
Population living on less than \$2 a day (2005)	80%
Population with access to grid electricity (2005)	56%
Annual electricity consumption per person (2004)	618 kWh
Annual CO <sub>2</sub> emissions per person (2004)	1.2 tonnes
Population % undernourished (2002 -2004)	20%
Population with access to improved water supply (2004)	86%

Source: *UNDP Human Development Report, 2007/08*

## Technology and use

### Biomass supply

Locally supplied biomass is used as the fuel for the gasifier. The main source (about 70%) is from a native woody plant called 'dhaincha' which grows rapidly in swampy areas, and also on uncultivated land beside roads and rivers. The remainder is from a variety of sources like corn cobs, wood, and other local plants similar to dhaincha.

Biomass is sold to SRE by the farmers who produce it. SRE staff chop the long stems of dhaincha and logs of wood into pieces 50mm long, and these are dried in the sun to a moisture content of approximately 15%. The biomass is stored under cover in the building housing the gasifier. This building is well ventilated to prevent the build up of poisonous or explosive gases.

## **Gasification**

After careful research, SRE chose a down-draught open-top gasifier, manufactured by Netpro under licence from the Indian Institute of Science (IISc) in Bangalore. In this design, the biomass is fed into the top of the reaction vessel every 15 minutes. Air is drawn through at a controlled rate, to provide oxygen for the gasification process and dry the biomass. The biomass gradually falls down the gasifier chamber as it burns at the bottom. As it falls down, the temperature increases and the biomass is broken down by pyrolysis, producing tar and volatile hydrocarbons. These gases are drawn down through the narrow combustion zone and through the hot charcoal below it, and are broken down into a mixture of hydrogen carbon monoxide, carbon dioxide and a small amount of methane. This mixture is called wood gas or producer gas. The combustion chamber is lined with three layers of firebrick, for insulation.

Ash and charcoal drop into the grate at the bottom of and are removed by a screw feed. The charcoal is separated and can be sold, as can the tar. The gas stream is taken off at the side and goes through a number of cleaning processes. Initially, a cyclone separator spins out solid particles and a water scrubber absorbs other impurities. Then the gas is cooled to below 100°C so that it does not overheat the engine. A fabric filter removes any remaining particles prior to the engine. The IISc gasifier design produces very low levels of tar and particulates, which has the dual benefit of low emissions and low plant maintenance. The cleaning water is initially taken from a borehole. After use, it is pumped into a large tank and treated chemically before being reused.

## **Electricity generation and distribution**

A dual-fuel Kirloskar engine, made in Pune, is used to generate electricity. It is rated at 160 kVA and supplies up to 128 kW of electricity at 240 V. Between 10 and 15% diesel is needed for ignition. The engine is housed in a purpose-made enclosure, which minimises noise. The plant itself uses about 15 kVA, mainly for pumps and fans. At present electricity is generated and supplied to customers for eight hours per day, from 10:00 to 21:00.

The generator is connected to a low voltage line (240 V, 3-phase) to supply customers in the immediate vicinity of the plant. Because this demand is limited, a transformer is used to step up the voltage to 3 kV, for transmission via two 3 kV lines to a groups of customers about 1.25 km away. At the other end of these lines, another transformer steps down the voltage, and power is taken to a distribution room with a meter for each customer. The transformers to provide this facility had to be made specially, because they are not usually available at such low power levels. Installations were carried out by contractors who have executing contracts for the Bihar State Electricity Board. The first customers in the immediate vicinity of the plant were connected 2007, and the first 3kV line was completed in 2008. A second 3kV line has recently been completed and new customers are being connected.

Several of the ten main customers are 'generators' – people who were previously running diesel generators and selling the electricity to their own customers. The 'generators' continue their existing business, but they sell on electricity from SRE rather than running their own diesel generators.

## **How users pay**

£1 = Rs 73 (Indian Rupees). US\$1 = Rs 50 (April 2009)

The power supplied to each customer from the gasifier plant is metered, and customers are supposed to settle up each day. Some customers pay late, but if they do not pay within a week they are cut off. SRE has taken out a loan to construct the gasification plant, and the sale price for electricity is therefore set at a level to pay back the loan. Contracts are negotiated with individual customers, and the current price is around Rs 7.5 per kWh (US\$0.15 per kWh). Now that the new transmission line is completed and extra customers are being connected, more of the available plant capacity will be used and the price can decrease.

The state electricity price is only Rs 6 per kWh, but customers are prepared to pay more for the reliability of the gasifier supply. Also, many customers had already given up with grid supply and were using diesel generators to provide their own power, or buying from others who had diesel generators. Typical charges for buying electricity from diesel generators are about Rs 12 to 16 per kWh, so even at current prices the gasifier supply is considerably cheaper, and gives a more stable voltage and frequency.

### **Training, support and quality control**

The plant is maintained by technicians trained in Bangalore. SRE also engage an engineering company based in Gurgaon, Haryana for heavy maintenance. Both the gasifier and the engine used by SRE have been reliable, and the electricity generated has a stable voltage and frequency, which are particular important for some of the small industrial users. The plant operates for about 85% of the time during scheduled hours of supply, but down time can usually be scheduled for quiet periods so the availability for most users is higher. During the first two years of operation, the plant had to be shut down for only two days for emergency maintenance. With proper maintenance the life should be 15 years. Customers were already familiar with using electricity, so did not require much training to convert to SRE supply.

An adequate stock-pile of fuel is stored on site to prevent shortages but fuel is always available locally at very short notice since the plant is in a rural area.

### **Benefits**

#### **Numbers**

SRE sold an average of about 300 kWh/day of electricity in 2008, but demand has now doubled. Sixteen customers are supplied, and in addition ten water pumps. The gasification plant operates for eleven hours per day, from 10:00 to 21:00, and the peak demand is currently about 60% of the capacity, with average demand about 35%. An estimated 200 users benefit directly from the electricity supply to businesses and shops, and a further 125 farmers benefit from irrigation water or from selling dhaincha to SRE.

#### **Environmental benefits**

SRE estimates that, taking into account the diesel which is still used for ignition, about 0.35 litres of diesel are saved per kWh of electricity generated by the gasifier. The 110MWh generated during 2008 therefore replaced about 38,500 litres of diesel, and avoided the production of about 103 tonnes of CO<sub>2</sub>. At the current level of demand, the savings would be 77,000 litres/year of diesel and 206 tonnes/year of CO<sub>2</sub>. The gasification plant also reduces the emission of other pollutants, such as nitrous oxide, sulphur dioxide and particulates. The plant is very quiet compared with diesel generators.

The use of dhaincha as a fuel has been introduced carefully to minimise competition for land with food crops. About 80% is grown on land which was previously uncultivated because it was waterlogged. Some of the dhaincha was already growing, and SRE provided seeds and advice to farmers to establish new plantations. Dhaincha sprouts at the beginning of the

monsoon, grows rapidly and fixes nitrogen, so some farmers grow it as an additional short-season crop in the monsoon, on land which they are already cultivating. It can be fitted between the normal 'wet season' and 'dry season' crops, in June and July, and harvested for biomass whilst still immature.

### **Social benefits**

Electricity customers include grain and oil mills, a sawmill, a welder, a battery charging station and 'generators' supplying village lighting. All benefit from a more reliable supply of electricity, without the hassle of running a diesel generator during the time when SRE supplies. The use of diesel generators has almost been eliminated.

Electricity from the SRE plant is used to operate about ten irrigation pumps by farmers living close to the transmission lines. SRE also runs an irrigation pump close to the plant. This pumps water through a long plastic pipe, which can be moved from farm to farm. About eight hectares of land are irrigated in the vicinity of the plant, and about 30 hectares in total.

Water for irrigation is supplied more cheaply by SRE-powered pumps than diesel pumps. One farmer who talked to the visiting Ashden assessor used to pay about Rs 300 once or twice per month to use a diesel pump, and now pays Rs 150 for the same water supply from the gasifier-powered pump.

A nursing station in Garkha needs electricity for run its services of collecting blood and other samples. The availability of reliable gasifier power is suitable for this day-time need, and costs only Rs 200/day, compared with Rs 300/day for the same supply from a diesel generator. SRE set up a study centre with free electricity, where children can come to study in the evenings. It also subsidises the supply of electricity to a computer training centre, to support education.

### **Economic and employment benefits**

SRE worked with local farmers for about three years before the gasifier plant was built, to build relationships and establish the planting of dhaincha. SRE buys agricultural waste and dhaincha from about 100 farmers, giving farmers an additional income stream. In addition, the nitrogen-fixing property of dhaincha may reduce the need for fertilisers: SRE is currently studying this in detail. Because dhaincha can survive excessive rain and water-logging, it can be more reliable than some cash crops. SRE guarantees to buy the dhaincha, at a price of between Rs 1.5 and Rs 2.0 per kg (US\$0.03 and 0.04) depending on moisture content. A farmer with a hectare of marshy land can produce about 5 tonnes/year of dhaincha and thus earn an extra Rs 7,500 to Rs 10,000 per year (US\$150 to 200 per year), less transport costs. This is significant in a region of generally low incomes. For comparison, the pay for unskilled labour is only about Rs 100/day.

SRE employs 12 staff and 10 casual workers at the plant. A local manager at the far end of the 3 kV line maintains this part of the system by taking meter readings at the start and end of each day, monitoring the power supply and checking for faults on the line (which are usually caused by monkeys!). All the temporary construction workers for the plant came from the local village.

SRE staff have discussed the availability of cheaper and more reliable electricity with the owners of local enterprises, encouraging them to set up manufacturing units in the area or to increase output. SRE has also talked to banks to encourage them to support these businesses.

## **Potential for growth and replication**

In the state of Bihar, the electricity generation capacity has not kept pace with demand. The result is an unreliable supply, especially in rural areas, or no supply at all. Several commercial businesses, such as tyre manufacturing and pharmaceuticals, have abandoned operations in the area because the power is so unreliable. Other businesses still use diesel generators. Government-led initiatives to encourage irrigation using electrically driven pumps have also failed because of lack of power.

There is therefore considerable potential for expanding the current gasification plant, which was deliberately set up with space to double its capacity. There is also the potential to set up similar plants in other areas where clusters of small businesses are close to farms which could supply the biomass. SRE has already identified several other locations, and has started dhaincha cultivation in two of them. There is a lot of interest in this project in both India and Nepal. SRE is actively involved in setting up a similar plant in Bharatpur in Nepal. If plants were also set up to supply the many households who have never been connected to the grid, then demand would grow rapidly. Several similar rural gasification projects have started elsewhere in India, and the demand for electricity is such that there is plenty of potential business. The main constraint, for SRE and others, is the availability of investment finance.

## **Management, finance and partnerships**

SRE was set up by a family-owned grain-trading business, because of concern about the lack of electricity in Bihar. The availability of the gasifier technology provided an opportunity for electricity generation, providing a gasifier plant could be located close to farms which were able to supply suitable biomass. SRE carried out a thorough survey and found that Garkha is in a rural area with a poor electricity supply and plenty of small businesses which all needed power. For each cluster of businesses, SRE carefully mapped the locations of the users, using questionnaires to establish the likely demand from each one.

SRE is led by a board of four directors: Yogendra Prasad (Chairman), Janardan Prasad, Ramesh Kumar and Vivek Gupta. Subodh Kumar and his team are responsible for the distribution of electricity. Relationship building with the farmers and establishing the dhaincha supply chain is the responsibility of Sanjay Singh and his team. Two staff are responsible for plant operation and electricity distribution.

The whole system cost about Rs 8.3 million (US\$170,000) to construct, about 90% for the gasifier and generation plant, and 10% for the first 3 kV distribution line. It was financed by investments from the directors and a loan of Rs 2 million from ICICI Bank. A further Rs 1.8 million was promised by the Government as a subsidy, although only 30% of this has been received so far, and the shortfall is being covered by the directors. SRE operated at a loss in the first year of generating (2007), but made a small profit of Rs 0.6 million in 2008, and expects to increase the profit this year. Although the initial business plan was to recover the capital costs in four years, this is now expected to be six years. The largest proportion of the running costs is paying off the investment (55%), followed by fuel costs (35%) and operation and maintenance (15%).

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This report is based on information provided to the Ashden Awards judges by Saran, and findings from a visit by one of the judging team to see their work in India.

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