**CASE STUDY**

**on**

# DISTRIBUTED DECENTRALISED GENERATION BASED BIOMASS GASIFIER SYSTEM

**at**

**JAMERA (District Korba), Chhattisgarh**

**Submitted to**

**The Energy & Resources Institute (TERI)**
**New Delhi**

**December 2007**

## Introduction

Energy is a key driver to sustain an impressive economic growth of 9-10% in the country. There is hardly any area where energy input is not required though in a varying measure. So, it is quite important to ensure a sustainable flow of all forms of energy. That is not all; as energy should also be used quite efficiently. Energy conservation is all the more needed in the present day scenario. As of now, around 75-80% of our population lives in the villages, where energy supplies are quite deficient in nature. As per census 2001, nearly 44% of the rural households do not have any access to electricity. Out of these some of the villages are situated in quite inhospitable terrains where taking grid power would either be quite difficult or un-economical. Thus it leaves due scope for alternate forms of energy to make their way into such remote rural areas.

Recently, the concept of rural electrification via Distributed Generation (DG) has come as a boon for the rural areas. This is in tune with the Govt. of India's initiative to provide electricity to all by the year 2012. The key objective is to ensure an integrated development of the villages accompanied by wholesome economic growth of the country.

## Concept of Distributed Generation

There is a sizeable number of un-electrified villages in the country. Extending grid power to such remote rural areas is a mix of technical, economic and social challenges. A way forward is to consider the option of Distributed Generation (DG), which is now deemed as a viable solution. The objective is to satisfy the bare minimum electricity needs of the generally deprived sections of the civil society. It is generally believed that the distributed generation can turn out to be more efficient, reliable and clean in contrast to the grid power. However, the sustainability of energy supply may still be dependent on the following few factors:

- fuel availability (at the site)
- appropriateness of the technology chosen
- trouble free operation of the system
- project management issues

There is no ownership issue associated with the delivery of grid power at an individual's level. However, same is not the case with the DG mode of power generation. The State utilities i.e. the State Electricity Boards (SEB's) are certainly not geared up to take this emerging power supply arrangement in their fold for one reason or the other. Perhaps the best possible option under the existing circumstances is to hand over the overall control of the DG based power generation systems to the Village community itself.

The present Case Study takes a close look at the holistic transformation of a tribal village in the Jamera village of Pali tehsil in district Korba of Chhattisgarh after having been adopted under the DG power supply mode.

**Origin of the Study**

Providing electricity to the rural areas is high on the priority of the Central government. The Ministry of Power (MOP) has put in place a mission known as REST, which stands for Rural Electrification Supply Technology Mission. Primary purpose of this mission is to speed up the electrification of all villages progressively by the year 2012 via use of renewable energy sources and similar other decentralized technologies. Accordingly, MOP made a specific request to National Thermal Power Corporation (NTPC) to get involved in the above mentioned programme for rural electrification. The essence being to set up De-centralised Distributed Generation (DDG) projects based on renewable energy technologies like biomass and solar etc.

NTPC has one of its major power plants in district Korba of Chhattisgarh under the name of Korba Super Thermal Power Station. There are quite a few villages in the Korba district awaiting grid power connection since long. With this in view, NTPC put forth a specific request to the Energy and Resources Institute (TERI) to undertake the techno-economic viability with a ready objective to identify the most suitable village (s) for the purpose of setting up a DDG project in those remote rural surroundings.

**Site Selection**

The thermal power major i.e. National Thermal Power Corporation consolidated the list of un-electrified villages in the district Korba of Chhattisgarh state with an active support from the Ministry of Power. Following which, preliminary survey was carried out in the following few villages coming under the jurisdiction of the Korba district:

- Khirti
- Kandi
- Uchalenga
- Arisiya
- Jemara
- Bagdara
- Bela

A well structured questionnaire was framed for each of these villages to collect the primary information. The study was based on an end use approach within which the existing energy use patterns as well as the projected demands of the individual village were evaluated. Accordingly, the collected data was thoroughly analysed to evolve a suitable design plan for village electrification. Due consideration was accorded to the local needs and there from to the demand and supply requirements of energy use in those areas. The participatory approach of managing the intended facility was given a proper recognition. In totality, the following few parameters were focused in the first instance through closely held discussions with the individual rural groups:

- technical feasibility (of the energy options)
- initial readiness to pay for better mode of lighting (traditional oil lamps in use)
- overall sustainability (of the intended project)

The village surveys thus carried out led to the preparation of pre-feasibility reports. Following which, NTPC and TERI jointly shortlisted Jamera a non-descript village in the Pali tehsil of Korba district to have the very first Distributed Generation (DG) power system. Figure 1 shows the schematic layout of Jamera.

**TERI's Participation**

The Energy and Resources Institute (TERI) based at New Delhi revisited Jemara village during the second week of November 2003. The sum total objective was to carry out a detailed assessment of the following few important parameters:

- load requirement (s)
- available local energy resources
- willingness to pay
- project implementation structure

Accordingly, a Detailed Project Report (DPR) was prepared by (TERI) for NTPC, the key outcome of which is detailed in the following section.

**Site accessibility**

Jemara is a picturesque village amidst a dense forest area. The village is accessible from Pali via a 25 kms. long, rough and narrow hilly road. It is at a distance of around 70 kms. from the NTPC power plant location at Korba. The TERI team had to wind its journey of about 1500 kms. from New Delhi to Bilaspur by train with important stations like Jhansi, Bhopal and Raipur falling enroute. From Bilaspur to the site, it meant traversing another 84 kms. by a jeepable taxi. On this route stands a widely frequented ancient temple of Hindu pilgrimage. Jamera is spread over 6 closely spaced hamlets and is a predominantly tribal dominated community. There are around 100 households at this site accommodating nearly 617 people of all age groups.

**Weather characteristics**

Jamera enjoys dry to moist tropical climate with clear summer months lasting between April to June. The rainy season sets in during July to September with winter months slated for November to February. The maximum temperature is about $48^0$C in May with it being minimum at $7^0$C in December. Average rainfall is around 1265 mm. On the whole, the site is accessible for most part of the year, though somewhat vulnerable to the flood like situation during the rainy season.

**Literacy rate**
The literacy rate in Jamera is a dismal 18.63% with just about 30 children making it to the primary education level at present.

**Occupation**
More than 90% of the village community is engaged in the area of agriculture for its basic sustenance. Some of the villagers also work on the construction sites of Panchayat, PWD and Forest department. There is just one person in the government employment worth the name and another one works for a village cooperative.

**Infrastructure availability**
Jamera does not score too low on the infrastructural availability considering the fact that it is a remotely located village. There is a primary school, panchayat bhawan, anganwadi Kendra, Cooperative, ration shop besides a kerosene oil depot. However, the nearest primary health centre is a good 16 km away in Lafa village. As far as a wholesome market is concerned, it is at Pali. There is no dedicated bus facility for the residents of Jamera, with just jeep transport being available for Pali twice a day.

**Agriculture produce**
This village is quite deficient in terms of irrigation facilities, which results in low productivity of around 5 quintals per acre. Major crops grown here are paddy, maize, arhar with few vegetables being grown for local consumption only.

**Types of fuel in use**
Jamera happens to be no different from a village elsewhere in the country. Every household in the village uses firewood and kerosene oil for cooking and lighting purposes. Wood is not a restricted commodity here being available in a large quantity from the neighbouring forest. Key tree species found here include saal, saja, dhaura etc. The average daily consumption for firewood is about 6.75 kg/day/household facilitating cooking of meals (mainly rice) twice a day. The average monthly consumption of kerosene oil totaled 4.25 liters per family per month. The oil wick lamps were quite visible at this location before in addition to limited use of firewood flame for lighting.

**Choice of Technology**

The Jamera village was extensively surveyed to arrive at the best possible technology option for basic electrification. Biogas based power plant was ruled out both on the basis of degree of difficulty in collecting the dung as well as the non-uniform distribution of cattle (often put for sale) amongst the community. There is a good sunshine (5.4 kWh/$m^2$/day) at the site, which would have made it an ideal choice for the use of a solar PV based village powers system. However, its high initial capital cost swung the balance in the favour of a biomass energy based power system commonly known as a biomass gasifier.

Accordingly, biomass gasifier technology was deemed as a best possible alternative for this village having a forest cover of nearly 5247.7 ha. There is a grazing land totaling around 124.7 ha, which has been encroached upon by the villagers for agricultural purposes. Jamera has an annual surplus availability of woody biomass in the range of 3567.46 tonnes enough to keep a biomass gasifier system of 10 kWe going on for a daily operation of 4-6 hours. The dry and fallen wood is found year round excepting during the rainy season.

However, to run the system on a long-term basis, unanimity was reached with the villagers to use 5 acres of village forest. The local forest department agreed to develop this forest for supply of fuel wood by a massive plantation drive. TERI agreed to bear the entire cost of tree plantation guided by its own initiative.

**The biomass gasifier technology**

Biomass gasification is a process of converting solid biomass fuel (like wood) into a combustible gas. It is commonly known as the producer gas, which results due to a series of thermo-chemical reactions. The gas is a low heating value fuel, with a calorific value of 1000-1200 kcal/$Nm^3$. Nearly 2.5-3.0 $Nm^3$ of gas can be derived via the gasification of about 1 kg. of air-dried biomass. It can then be used in an energy-efficient manner with a fairly good control mechanism to meet thermal energy demands in ovens/burners, boilers or kilns etc. However, the gas can be cooled, cleaned and fed to an engine to operate

either on dual fuel or in a 100% producer gas mode to produce some useful electricity. The biomass gasifier with 100% producer gas engine is a proven and eco-friendly technology and thus carbon neutral. Further, the ash content of biomass as wood blocks (5 cm cube) is less than 0.5 %. It is also possible to use the unburnt charcoal taken out from the gasifier for any commercial purpose.

**National programme on biomass gasifiers**

The Ministry of New and Renewable Energy (MNRE) is implementing a National Biomass Gasifier Programme for mechanical, electrical, thermal heating applications and village electrification since mid nineties. Various types of financial incentives are available for installation of gasifier systems under this programme. Biomass gasifiers in the capacity range of 5 kW to 1 MWe electric capacity have been developed indigenously and are being manufactured by around 15 manufacturers in the country.

The systems being proposed for village electrification applications are based on 100% producer gas, which is a recent technological development. The biomass gasification systems can be used for a diverse range of applications in the rural areas. Apart from use as a cooking fuel and for electricity generation, the gas can be used for heating applications in village industries.

The estimated cost of village electrification projects with biomass gasification systems is about Rs. 50,000/- to Rs. 80,000/- per kWe in capacity range of 5 KW to 50 KW including the cost of land, civil works, distribution lines etc. Biomass Gasifiers in India are being made in capacities ranging from a few kWs to MW. Table 1 shows the growth pattern of various biomass technologies.

**Table 1: Status of biopower from different technological routes in India**

| Technology | Estimated Potential | Installed Capacity as on December, 2006 | Growth Rate | Capacity Installed in 2005-06 | Growth Rate in 2005-06 |
|---|---|---|---|---|---|
| Bio Power (Woody Biomass) | 52000 MW | 500 MW | 36% | 87 MW | 30% |
| Biomass Gasifiers | 16000 MW | 76 MW | 13% | 6 MW | 9% |
| Bagasse Cogeneration | 5000 MW | 708 MW | 22% | 54 MW | 12% |
| Energy Recovery from Waste | 5000 MW | 46 MW | 28% | 0[b] | 0% |
| Biogas Plants | | 3.9 million | 4% | 0.02 million | 1% |

**TERI-a front runner in biomass gasifier technology**

Small capacity (10-20 kWe) biomass gasifier systems are ideally suited to provide remote rural electrification at an affordable cost. TERI has developed a 100% producer gas engine with good field performance reliability. Figure 2 shows a pictorial representation of such a system. In an effort to spread their use, it has so far commissioned four systems in the states of Chattisgarh, Orissa and Rajsthan. A few more systems are currently in the different stages of installation under the ambit of Village Energy Security Programme (VESP) of the Ministry of New and Renewable Energy (MNRE) and the recently envisaged renewable energy charter of NTPC.

It was on February 13, 2004 that TERI teamed up with NTPC to set up a 10 kWe biomass gasifier system for electrification of Jemara village. Thus Chhattisgarh got its very first biomass based power system, which is running satisfactorily excepting for just a few brief spells of shutdown. A unique feature of the project set up here is the creation of a village-level cooperative society by the all powerful name of Mahamaya Urja Utpadan Sahkari Samiti, Jemara.

**System capacity**

There are around 100 households availing the benefit of biomass based lighting. Two light bulbs of 40 W each are being used for indoor lighting in each household. These lights remain operational for about 4 hours (6-10 p.m.) on a daily basis. Five nos. of street lights also lit up a few vital entry and exit points within the village at night. Such lights also stay on for about 4 hours daily. The plant capacity is around 8.20 kWe as per the following breakup:

| | |
|---|---|
| **Number of households** | 100 |
| **Total domestic lighting load (@ 80 W per household)** | 8.0 kW |
| **Street lighting loads 5 No.s (40 W each)** | 0.2 kW |
| **Total connected load** | **8.20 kWe** |

The system capacity was scaled up to 10 kWe taking into account the near-term electricity demand as also the associated technical losses etc. A well performing producer gas engine offers a distinct cost advantage at Jamera, since it does not use diesel. However what is really needed is an assured supply of biomass.

Table 2 gives a bird's eye view of Jemara village from several important considerations:

***General***

| | |
|---|---|
| **Name of the Village** | Jemara, Pali Block, Korba district, Chhattisgarh State |
| **Distance from the nearest road-head** | 23 kms. |
| **Distance from block office** | 23 km. |
| **Distance from electrical sub-station/11 kV line** | 23 km. |
| **Distance from nearest powerhouse** | 70 km. |
| **Total number of households** | 100 |
| **Total population** | 617 |
| **Number of hamlets/dalit bastis** | 06 |
| **Community facilities available** | Primary school, primary health centre, Panchayat Bhawan, Anganbari Kendra |
| **Commercial establishments** | Ration shop, Kerosene oil shop |
| **Primary Occupation** | Agriculture |
| **Important crops** | Maize, Paddy, Arhar |

*Technical-Electric Demand*

| | |
|---|---|
| **Total Household load** | 8.0 Kw |
| **Total Street lighting load** | 0.32 kW |
| **Commercial load (proposed)** | 7.5 kW ( 7.5 hp rice huller+ battery charging) |
| **Industrial load** | Nil |
| **Community load** | Nil |
| **Daily hours of use (lighting)** | 4 hours |
| **Daily hours of use (commercial load)-proposed** | 2 hours |
| **Technology option considered** | Biomass gasifier (with 100 % Producer gas engine) |
| **Installed System capacity** | 10 kW |
| | |

*Management of Funds*

| | |
|---|---|
| **Total project cost** | Rs. 2.5 lacs -Detailed Project Report<br>Rs.- ?<br>(on equipment cost, civil work, distribution network, social engineering and Annual Maintenance Contract (AMC)<br>Total Cost-Rs. ? |
| **Sources of financing** | Central Financial Assistance: Rs.<br>State Share<br>Central Share<br>Other sources |
| **Revenue generation** | Rs. 250 initial charges<br>Rs. 25 per lighting point per month |

**Raw feedstock availability**

The wood collected for the purpose contains nearly 25-30% of moisture. It is removed prior to being loaded in the biomass gasifier system through a sun drying system. Total quantity of firewood used per day is around 60 kgs. to ensure 4 hours of daily operation. Specific fuel consumption is nearly 1.5 kgs of wood per unit of electricity generated at the site. Buffer stock of woody biomass is maintained for about 4-7 days at a time in a specially created shed at a distance of just 0.5 km. from the plant location. Wood is moved from that point to the system via a trolley mounted arrangement.

**Operation of TERI supplied biomass gasifier system**

The system was transported to the site by TERI in a fully dis-assembled form. Once it reached the site, TERI staff took just about 15 days to assemble it with a high degree of precision. Nearly a week or so was spent on installation and commissioning of the plant. A 3-feet boundary wall incorporating a wire mesh was found to be unsuitable for preventing the rainwater seepage. As a remedial measure, a thick shield was erected.

A wood cutting machine is available at the site, which cuts it to a uniform size of about 2x2 inches. It is then fed to the hopper of the gasifier via a door opening arrangement. The opening and closing of the door is carried out by using a manually operated chain pulley device. The reactor gets the air and solid fuel and changes them into a gaseous fuel known as the Producer gas.via a partial combustion process.

Gas thus obtained is drawn below the grate and made to pass through the cleaning system. The hot combustible gas coming out of the gasifier is filled with impurities like dust particles and tar, which are drained out in the cleaning train. Following which, the cooling and cleaning train cools as well as cleans the gas upto the prescribed standard. Finally, the clean combustible gas at around ambient temperature is available for operating the gas-generator set. The system is being used throughout the year excepting for any brief periods of malfunctioning. Nearly an hour or so is spent every evening to stabilize the operation of the power producing system.

**Key attributes of the gasifier system at Jamera**

- Upto 15 % moisture in the woody biomass (feedstock) is being tolerated by the existing system
- Wood pieces of 2 inches x 2 inches avoid the bridging problem thus leading to a smooth operational flow
- A rod is kept in place to shake wood prior to final loading
- Charcoal is present for quick ignition
- Sufficient water level is maintained

- A polypropylene filter is being used
- Blower paddle is in use at the time of ignition
- Proper venting arrangement is in place to increase the temperature of fire box for gas production
- Flame is visible to know the presence of producer gas. Any change in the colour of the flame points to presence of impurities
- Tar content is significantly reduced
- Gas finally passes through the paper filter before it is inside the engine
- A cutoff fuse is present as a safety measure

Initially, a diesel engine was being used to fire the blower. This practice was discontinued after a year or so mainly to bring down the system maintenance cost.

**Major problems witnessed**

These type of power producing units have just been around for a limited period of time. So, there is not enough field demonstration experience available, which leaves a definite room for system improvement especially vis-à-vis the following few parameters:

- uniformity in size (2x2 inches) of the woody biomass fed to the system is not always maintained, which leads to one problem or the other
- cleaning system still needs a fair amount of change to make the operation more clean
- system assembly and standardization procedures are not adequately documented for an easy understanding during the troubleshooting stages in particular

**System breakdown**

This village community based system has functioned more or less satisfactorily since the time of its installation excepting for some brief spells of troubled operation. The change of filters during those times accompanied by a through cleaning of the system restored the system operation to normal. Spares availability at the site was found to be up to the

mark. Table 3 gives the actual performance status of the biomass gasifier system at Jamera during the period January 2005 to May 2006.

| Period | Total hours of operation (as observed) | Total hours of operation (as desired @ 4 hours/day) |
|---|---|---|
| May 2006 | 120 | 124 |
| April 2006 | 73 | 120 |
| March 2006 | 86 | 124 |
| February 2006 | 83 | 112 |
| January 2006 | 73 | 124 |
| December 2005 | 109 | 120 |
| January 2005 | 79 | 124 |

It is clear from above that the system did not perform for almost half of the stipulated time in the months of January and April 2006. While as, it worked remarkably well in the month of May 2006 recording just % of down time. There are a variety of reasons due to which the plant failed to provide lighting for the desired duration of 4 hours per day. In fact, some of the most common reasons visualized at the site are given in Table 4:

| Problematic issue | % Contribution |
|---|---|
| Engine related | 12 |
| Social (related to collection) | 9 |
| Distribution network related | 3 |
| Non-availability of fuel wood (due to excessive rains at the site) | 1 |
| Non-availability of the Operator ?(at the site) | 1 |

Clearly, the engine specific operation has been the most problematic in comparison to the remaining issues followed up closely by social issues.

**Project performance indicators**

Jamera has suddenly transitioned from being a sleepy village to that buzzing with full scale activity during the evenings. Prior to the installation of the system here, the evenings used to be quite dull and boring. Community interaction of a desired measure is now quite visible due to presence of both the indoor and outdoor lighting systems. The school going students now enjoy reading under the bright light. The drudgery of tribal

housewives earlier cooking under the dimly lit smoky oil lamps is finally over. That is not all, as they need not take to cooking soon after returning from a tiring day's work outside their homes. Street lighting has now made the corner side gatherings more happening, as a good number of village youth in particular like to spend their evening hours discussing everything under the sun. However, there is a limited spread of such lights within the village, which means any emergency visit outside the immediate periphery of the village is incomplete without carrying an oil wick lamp. This still means a dependence of the villagers on the kerosene oil.

**System operation**

The system is rated at 10 kWe of power and has been functioning at the site since February 13, 2005. It is switched on by the operator at about 5 p.m. daily for initialization purposes. The supply of power to the village community begins from 6 p.m. every evening. Power is normally switched off at around 10 p.m. excepting when it is needed for some social gatherings within this closely knit village. The system operator adheres strictly to the switching ON and OFF operations on a daily basis. Figure 3 showcases the illuminated areas of the village during the evening hours

**Site Management**

The day to day care of the system is being taken by the two operators specially trained for the purpose. However, supervisory control is with the Village Energy Committee (VEC) namely Mahamaya Urja Utpadan Sahakari Samiti. This society was registered and brought into the forefront during the implementation stages of the project itself. It comprises of about 7-8 members from the user community itself. Incidentally, the committee seems to wield little or no influence at all over those members, who refuse to either pay up or cooperate with the smooth functioning of this distributed generation facility.

The committee is duly entrusted with the collection of monthly electricity charges from the user community. The money stands deposited in a VEC account, which is used to pay monthly emoluments to the operators apart from meeting the day to day maintenance

expenses. An exclusive account in the name of VEC was opened at the District Cooperative bank at Pali.

The VEC meeting is held at regular intervals to take stock of all matters related to overall sustainability of the plant from a variety of end use considerations. One of the very important initiatives has been the energy plantation in a 5 acre forest land in Jemara village so as to ensure a regular supply of the raw feedstock material i.e. biomass for the plant operation as well for ecological balance.

**System maintenance**

The Village Energy Committee (VEC) nominated two unemployed boys from the community itself. There were given practical training by TERI in assembly, testing and routine maintenance of the biomass power system. The operators specially trained for the purpose were found to be equipped with proper skills to ensure a proper upkeep of the system. Any problems with regard to the system operation are properly recorded by these operators in a notebook specially maintained for the purpose. Majority of the routinely occurring problems are redressed at the site itself without any external support.

However, in case of any further malfunctioning of the system beyond the operators ability, the skills of TERI resource person namely Mr. Vishnu Sharma come handy. He is able to resolve such problems to the best possible extent. The types of commonly observed problems relate to the tar specific choking, which needs cleaning. The end users too face some problems though not frequently, which are immediately reported to the operators at the site. In practice, most of the complaints made note of at the site are satisfactorily attended to during the day.

As per the agreement arrived at between NTPC and TERI, the monthly salaries for two operators along with the supervisor were met by TERI for a period of two years. Lately, NTPC has awarded a 3-year plant maintenance contract to TERI, which is going to last uptill 2010. In turn, TERI has given an engine specific Annual Maintenance Contract (AMC) to a local company. Its technicians rectify the defects within no time as and when

these happen thus ensuring a reasonably good field performance reliability of the biomass gasifier system as a whole.

.**Project financing**

Various schemes of the Government are available to fund the entire cost of village based electrification projects. The biomass gasifier facility at Jamera has matured due to total fund availability from the National Thermal Power Corporation (NTPC). The key components on which such funds have been utilized are as under:

- formulation of Detailed Project Report (DPR)
- civil works
- plant equipment & auxiliary systems
- transmission and distribution (T&D) network (house wiring included)
- annual maintenance contract (AMC) for a period of 5 years
- energy plantation (paid by TERI ) to ensure un-interrupted biomass supply
- payment of insurance premium for plant machinery to cover natural calamity and fire (after 5 years)
- professional charges of a consultant engaged for social engineering (during the stages of project implementation)
- project management

**Electricity Charges**

Prior to the installation of a DG biomass gasifier system at the site, an average village household used to spend a princely sum of Rs. 30 on buying of kerosene. It served to light up the oil based lamps during the evenings. Taking this into account, a monthly sum of Rs. 30 was fixed as the electricity consumption charges for availing of the domestic lighting facility. However, this sum was later reduced to just Rs. 25/ after due deliberations between the VEC and village community.

**Operation and maintenance expenses**

A feature unique to this type of system in Jamera is that Operation and Maintenance (O&M) expenses are to met out of the monthly collections by VEC. This makes the community responsible for a proper upkeep of the system at least in terms of avoiding its misuse in any manner. Here too, a fixed amount has been specially provisioned to take care of the monthly average maintenance expenditure. This amount is a small part of the revenue collected month after month from the end users.

**Revenue generation**

It has not been possible to set up an income generating facility at Jamera so far. Though in the initial stages of the project, some thought had been accorded to setting up a few small scale units directed at income generation for the village community as a whole. As of now, there is no commercial activity present at the site, which is facilitated by the power delivered from the biomass energy route. These could normally have been in the form of a flour mill, rice mill or an oil deriving unit etc.

The preliminary idea of obtaining bio-fuel for income supplementation purpose in the form of multi-purpose energy plantations has failed to take off for one reason or the other. Needless to say, the financial model in operation at Jamera does not rely on any return on investment for want of any solid resources with the village community.

**Payment terms**

The beneficiaries of two lighting points in each household shell out Rs. 25 on a monthly basis. Around 75% of them show their readiness to pay such charges on time. However, there is no denial of lighting facility to those defaulting month after month or in limited periods in-between. The operator and resource person are generally responsible for the monthly collection of electricity charges. Users have paid a one time deposit of Rs. 250 to get a lighting connection in their modest dwellings. Following two options are in operation at the site

- Pay less and get more wood
- Pay more and get no wood

**Revenue collection**

Around 79 connections existed in the month of February 2005, which dropped to mere 71 by June 2005 An amount of Rs. 6575 was collected in lieu of the first installment of one time project contribution @ Rs. 125 per household from 53 consumers. Additionally, a sum of Rs. 3425 was collected towards the second installment of one time project contribution @ Rs. 125 per household from 28 consumers.

***Capacity building and training***

TERI extended its role in the present project beyond the customary role of an equipment supplier. It put in place a set of administrative guidelines to ensure a smooth run of the project. Jemara being as it is located distantly; it was all the more necessary to impart desired set of skills and training to the members of the village community itself. VEC recommended the names of two unemployed youth from Jemara, who were given extensive hands on training supplemented by the classroom training too on diverse aspects of plant operation and importantly, routine maintenance. In fact, these operators were co-opted into the installation cum commissioning phase of the system. In all, TERI team organized about six training programmes vis-à-vis the following few aspects for an immediate benefit of consumers as well as the VEC members:

- accounting & book keeping
- management system
- safe practices in electricity use
- banking transactions
- sheer importance of income generating activities at the site

**Scope assessment for income generating activities at Jemara**

NTPC has lived up to its social responsibility charter by illuminating the otherwise desolate surroundings of a village like Jemara. However, that alone does not seem to be enough when making a fair assessment of this novel concept. The genesis lies in the fact that almost all the beneficiaries of such a facility are poverty ridden and need some

supplementary source of income. Having so is bound to give them a high sense of belonging with the power system put up for them. Taking a cue from this growing realization, TERI team has identified the below mentioned set of activities (in coordination with the villagers) with a definite scope of income generation for the village community as a whole.

**Oil expeller**

Inhabitants of Jamera village are somewhat lucky to find mahua seed in the adjoining forest. It is rich in edible oil content, which is derived manually. Women in particular are engaged in this activity. Any excess quantity of this oil is put up for sale in the nearby market. Nothing wrong in that excepting for the low productivity of oil from the seed. The gains can be manifold by extracting the oil via an oil expeller in return for a small amount. Additional advantage could be by way of reducing the physical drudgery for the village womenfolk and raising of some nominal income for the gasifier plant

***Making of leaf cup (dhona patha)***

There is nothing unusual in collecting the fallen leaves from a forest area. However, when the same leaves are a saleable commodity, a proper marketing approach is needed. At the moment, the villagers make leaf cups by hand for an open market sale. Here too, women undertake this activity partially supported by the young children. The volume of cups turned up this way is small, which can surely be enhanced many times by a machine based operation. The objective is to engage the services of the biomass gasifier based plant operator for large scale cup making on payment of nominal charges. The charges payable vis-à-vis the oil seed extraction and cup making may be decided in consultation with the Village Energy Committee or VEC.

The above said activities if, initiated could lead to a long term sustainability of distributed generation based power systems like a biomass gasifier system in the present case.

**The Business Model for Jamera system**

It is quite apt to enunciate a properly functional business model for this specific mode of power generation, which can translate into significant gains for all possible stakeholders. Following three of models make good business sense:

- technical
- financial
- social

**Technical Model**

Seemingly, it is the most vital component of a decentralized distributed generation system. Any inexactness in devising a site specific technical model can lead to plethora of operational problems. In the present case, a properly formulated technical model was put into action, the immediate consequence of which is a smoothly functioning biomass power system at Jamera. Following few are the key linkages of a successful technical model:

- ❖ identification of village (s)
- ❖ feasibility study
- ❖ choice of technology
- ❖ constitution of a VEC
- ❖ land allocation by VEC
- ❖ award of annual maintenance contract
- ❖ raising dedicated plantation
- ❖ upgradation of technology

**Social Model**

The empowerment of the village community is quite crucial to an overall success of a power system like at Jamera. It instills in them a sense of purpose and belonging to care for the system upkeep in no uncertain terms. Of special significance is the role intended/played by a designated body better known as the Village Energy Committee (VEC). VEC is as good as a cooperative society and exercises control over the following few parameters of immediate relevance to the community and system operation as a whole:

- monthly electricity charges

- initial contribution from the beneficiaries
- fuel supply arrangement
- security of the plant

Following few are the major linkages of a social model, which transforms a technical model into a feasible power solution alternative for the remote rural areas of the country:

- collective decision making (resting with the village community)
- overall charge of the system with the VEC
- Social engineering (via a qualified professional)
- Capacity building of the VEC
- Scope for income generation activities
- Monetary contributions by the end users
- Checks and balances

**Funding Model**

Jemara is a example of peoples' participation of a different kind. They are quite receptive to the idea of continuing with the system use for extended durations, but plead helplessness to pool together any substantial resources either for system purchase or any capacity augmentation as such. In this case, the capital costs have been entirely funded via GOI grants as available under various schemes. The running cost for the Operation and Maintenance (O&M) is being met by the Village Energy Committee (VEC) and a monthly payable electricity charge of Rs. 25 is being collected per household in this village. It is near equal to the amount spent by each family on the purchase of kerosene oil for lighting purpose. The self sustainability of a financial model rests on the need to create a commercial entity alongside. However, it has not largely happened in the case of Jamera. The principal linkages associated with such a model are given as under:

- capital cost via grant
- operation and maintenance cost by VEC
- payment of bare minimum monthly electricity charges
- provision of penalties (for any defaulters)

- income generating activities

**Segmentation of Project Cost**

The biomass gasifier system installed at Jamera comes much cheaper in comparison to the solar PV system for example. An indicative breakup of the project cost is tabulated below:

| **Detailed Project Report** |
|---|
| **Cost of Equipment** |
| **Distribution Network** |
| **Civil Works** |
| **Project Management cost (for 5 years)** |
| **AMC (for 5 years)** |
| **Social Engineering** |

**Key benefits of the DG system at Jemara**

The inhabitants of Jemara village are visibly happy with the change the biomass energy based lighting has brought forward in their day to day lives. Simultaneously though, they also admit that they could have very well lived without electricity as before. This is mainly due to the fact that a tribal community of this kind finds itself in close harmony with nature and thus far removed from the impact that electricity otherwise generates elsewhere.

However, a small percentage of people openly seemed to disagree with their contention. The fact is that Jemara is gradually going through the transformation phase and soon enough they would ask for additional supply of power. Few most important benefits that have accrued to the community as a whole are given as under:

- power availability for indoor lighting, street lighting and community lighting
- extended daily schedule with evening activity having picked up
- organisation of community functions like marriages and religious gatherings under the beaming light bulbs in the evenings
- reduced use of kerosene oil leading to less pollution and diminished threat of fire etc.

In essence, Jamera has gained prominence amongst the several clusters of villages around it. A positive fallout of this has been the painstaking initiative of the local authorities, who constructed a pucca road from Pali to Jamera thus leading to its extended outreach. However, a few more initiatives that are yet to see the light of the day are as follows:

- Change of diesel engine driven rice huller into an electrically operated engine with obvious savings for the villagers
- Installation of an oil expeller as an income generating mechanism
- Handing over of two desktop computers to the Village Energy Committee for creating a business hub-mainly to know the best attainable prices for the agriculture produce of the villagers

**Adequacy of lighting needs**

Most of the households in Jamera feel satisfied with the number of indoor lighting points at present. However, there is more need felt for having an additional number of streetlights. There is no demand on the part of village community for running fans etc. The thatched roofs on the mud houses provide the desired cooling effect during the hot days of summer. Indeed a time tested traditional building architecture with no use of electricity for heating or cooling needs.

**Summary observations & results**

***Routine activities***

- users pay a monthly amount of Rs.25 only in lieu of the electricity supplied to them each month
- operators are being paid a sum of Rs. 900 each as monthly remuneration by VEC from revenue collected for the purpose
- VEC has collected full one time connection charges of Rs. 250 as on 31.3.2006
- VEC has engaged a locally available tractor-trolley @ Rs. 250 per trip per month to collect about 25 quintals of fuel wood owing to reluctance of consumers to fetch wood individually (as kind)

- user community has expressed the need for a second connection

**Operation and maintenance**

- system is being run for about 4 hours on a daily basis
- operators log in the system operation in a notebook kept for the purpose
- annual maintenance contract (AMC) awarded to m/s pawan automobiles at Pali

**Few most recent developments**

- the rice huller owned by a member from village community was recently retrofitted with electrical motor given on a rental and returnable basis
- the state nodal agency i.e. chhattisgarh renewable energy development agency (CREDA) has approved a financial outlay of Rs. 2.5 lakhs to set up one oil expeller of 50kl/hr capacity at Jamera
- near to medium term provision is being made for setting up one dona patta making machine to switch from the existing manual operation to machine based

**The path forward**

The impact assessment studies carried out at Jamera brings out a clear need for initiating a few more steps (as given below) to make system installation of this kind more beneficial for the village community at large:

- system should be more resistant to the vagaries of nature and site specific conditions in particular
- system must be operational for longer durations than what was witnessed in the present case
- project management issues should be handled more skillfully