

CASE STUDY

**FOR A 10 kWe BIOMASS GASIFIER POWER SYSTEM
INSTALLED AT DEODHARA, ORISSA**

BY

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Background

Electricity is the basic driver of all round change. It enables so many things for us. So, why should Deodarah be an exception? With this realization, it was handpicked for the electrification purposes. Nothing seemed to be new in this objective, until the TERI team gained a first hand experience of its all round remoteness. The initiative did not stop at that, but carried over fruitfully to several new vistas of this amazing remoteness. Today, Deodhara is basking in the glory of a woody biomass gasifier system happily placed in its fold on October 18, 2004. Since then, our endeavour has been to gauge its holistic impact under the actual field operating conditions.

Deodhara has lived to tell its own story of system successes and failures alike as unfolded here without a tinge of intentional holdup

1.0 Introduction

Energy supply is a paramount issue not only in India, but worldwide too. A mind-boggling number of 2 billion people rely on biomass in one-way or the other. There is nothing wrong in that barring the fact that it's use is often in-efficient moreso in a developing country scenario. The resultant effect is on health, environment and social well-being. So, the call is loud and clear to make a clean and efficient use of biomass. The immediate perspective is to make available at least bare minimum energy services to the rural poor. The technology, which does this trick convincingly in the remote rural environs, is the biomass gasification.

Presently, biomass gasifiers are turning out to be a ready solution to the small energy needs of the sparsely populated rural households located away from the hustle and bustle of big cities and towns. However, gasifier technology is yet to enlarge its canvas of wider outreach for a variety of end use considerations.

It is not as if, the biomass gasifiers have emerged out of blue just today. These systems have been around for more than a decade now. However, technology alone is not a sure indicator to take gasifiers deep inside the rural landscapes for electrification. This case study takes a close look at the issues that go hand in hand in making the gasifier system a dream generator of sorts.

Biomass gasifiers are still waiting in the wings to take off far and wide

1.1 Origin of the Case Study

Orissa has always been generous in offering itself as a living example of acute backwardness and one of the lowest electrification levels. It has caught the fancy of both the national and international organizations for poverty alleviation and allied programmes from time to time. UNDP-DESI project is one such prime initiative targeted at setting up decentralized rural energy systems for an integrated development. Under the ambit of which, 25 villages in remote rural India were adopted for a variety of renewable energy technology uses. Thus came into limelight a one of the most difficult to reach tribal villages, **Deodhara** in the Komna block of Nuapara district in Orissa. In fact, it was the lone village to be endowed with a biomass gasifier system.

1.2 Key Objectives

Biomass energy based projects are no longer counted amongst the demonstration type of projects. However, what sets these apart is an upcoming pattern of making users as virtual masters of these captive power installations. Deodhara finds itself on the same pedestal in view of the following few distinct yet interwoven objectives:

- **disseminate community managed, community owned decentralized energy interventions**
- **institutionalize the operation and maintenance network within the community**

2.0 Initializing the Case Study

Detailed Project Report (DPR) is a vital ingredient of deciding on the suitability or otherwise of a specific technology use more so at a remote rural site. This practice was followed up in the present case too with OREDA giving the go-ahead to TERI to make a DPR. So, our team took the first hand opportunity to make an on-the-spot assessment of Deodarah on numerous fronts. Following few aspects of significance were adequately focused on:

- **site characteristics (general)**
- **raw feedstock availability**
- **logistic support**
- **existing energy use**
- **load profiling**

Today, Deodhara showcases a sustainable model for generation and supply of electricity-all with local support and resources

2.1 Mapping Project Area

Deodhara is a minuscule village situated on the western part of the Komna block and southern part of Nuapara district. Amongst five blocks of Nuapara is the Komna block. It is located on north-western side of Nuapara district between parallels of latitude 20° - 30° N and longitude 82° - 40° E. Komna is easily one of the most backward blocks, which brings it within the purview of the Integrated Rural Energy Program (IREP) of the Ministry of New and Renewable Sources of Energy. Nearly half of Komna block is still awaiting electrification. **Table 1** sums up the basic indicators of Komna block depicted in the map (**Figure 1**) alongside.

Number of Gram Panchayats	24
Number of revenue villages	143
Total geographical area (in sq. km)	652
Total cultivable area (in ha)	49,100
Total Population	104,514
Number of households	21,079
Number of rural families	21,616
% of rural families below the poverty line	89
% of un-electrified villages	47
Literacy rate	19%

Komna is essentially a tribal dominated area with an even population of males and females.

2.2 Deodarah at a glance

A typical village administrative system is in place here too. Deodarah is one of the five villages under the jurisdiction of Rajana Gram Panchayat. It is almost 6 kms. away from the Gram Panchayat Headquarters (GHPQ). **Figure 2** shows the location of Deodarah within Rajana. Komna block headquarters and Deodarah are separated by a kaccha road stretch of around 19 kms. While, komna is easily accessible by bus from Nuapara, it is a troublesome affair to reach Deodarah. We now present a first hand account of what our field teams observed right from the project inception to post system installation stages.

2.3 Observations of significance

To begin with, TERI team carried out a preliminary questionnaire based survey. The simple yet all important idea was to gain foothold over the following few parameters:

- **existing energy consumption pattern**
- **electricity needs of the community**
- **existing biomass availability**

The village community was quite receptive to our surveying needs and displayed a keen sense of curiosity and cooperation. Needless to say, it readied us well for the challenges ahead during the actual process of system installation. Our subsequent visits to the site allowed us a deeper insight into their day-to-day sundries etc. We now try to bring alive those experiences of ours with the curious readers of this case study. Deodarah is virtually sitting in the lap of a neighbouring forest, which to its residents is nothing short of a deity.

Demography

The average family size is about 4 members each in a cluster of 65 households. Out of these, 62% belong to the scheduled tribe, nearly 23% to scheduled caste and rest 15% to other categories. A unique demographical character is its high percentage of youth and small children. Old and infirm people can easily be counted on the fingertips here.

People

They are quite modest like adivasi people with little or no inkling of life outside their bamboo hutments. By and large, we found them to be a friendly lot. Most of them were

ever ready to offer help knowing fully well as to what brought us to their fold. So much so that people over here took it upon themselves to guard us against any lurking danger of animals in those desolate surroundings.

Climate

Climate in Nuapara district is more or less representative of Deodarah too. In fact, it closely resembles the conditions existing in the main Deccan plateau. May and June are the hottest months here with mercury normally shooting beyond 40⁰C. Temperature levels are surely subdued during December and January at around 28-30 ⁰C. This is the time when north India shivers for certain. However, Deodarah records an average monthly minimum temperature of about 12⁰C in January. The rainy season usually lasts here for nearly 4 months and measures upto a yearly average of about 1144 mm. So, Deodarah remains on the boil for most part of the year.

Education

The lone symbol of education here is a primary school in a pleasingly good condition. It draws a good number of village children to its fold. This is not out of an intense urge for learning the 3 R's, but more out of fending for themselves under a mid day meal scheme of the government. In fact, the daily course of meals served at the school turns out to be a hugely awaited opportunity for the under nourished children here. One anganwari center is also keeping its flag high even under very trying circumstances.

There are about 75% literate households here, out of which a lowly 15% possess more than a middle class qualification. Just two teachers manage the daily grind of the school at their sweet will. The villagers take pride in having about 5-6 students making it to 10th and 12th grade examinations. **Figure 4** shows the distribution of households in Deodarah in terms of varying education levels.

Occupation

Majority of people in Deodhara find favour with rice cultivation-a plentiful source of livelihood here. Just a marginal number of people rear oxen and goats so as to meet their bare minimum needs. They nourish no hope of finding any surplus from any type of

income generating opportunity. Instead, they themselves live in an abject poverty. There is no employed person in the entire village worth its name, who can be a torchbearer to the community at large. For namesake only, a chowkidar is attached to a distant police outpost.

The most underprivileged group

It sent shivers down our spine to see some people finding shelter under the tree in all seasons of the year. They are the most miserable of the lot and do not have even the mud dwelling. This 15% segment of the local population does not have even an inch of rice fields under its belt. So, they have a total dependence on the surrounding forest. The early sunrise sees them making their way into the dense forest for multiple purposes. Ironically, they are endowed with good skills in honey cultivation. Not only that they also have a strong nose for judging the worthiness of medicinal herbs from amongst a large number of plants sitting unawares in the forest area.

Sale of forest produce

The bounty of honey so painstakingly produced by them together with the ailment curing herbs fetch them some money. They use it to buy some food items for themselves. Those with good agricultural land holdings use the barter system, wherein some quantity of rice is exchanged for some honey and herbs. Once free from their ordeal in the jungles, they find refuge yet again under those trees i.e. their homely nests facing the wrath of weather the year round.

Income levels

The villagers are employed as petty labourers at princely sums of Rs. 25 each. Basically, there are just small land holdings present. Occasionally, these people resort to the novel practice of group farming. This simply means working on each other's farms so as to save the drudgery of eking out Rs. 25 as labour charges to others. At times, two and half kgs. of rice is bartered for a full days work at other's fields. This speaks of their hard-pressed circumstances even in the modern times of change.

Land use

The total village land remains heavily under cultivated at around 45%. Trees line up nearly 90% of the village forest area. A quarter of land holding refuses to be farmed, as it is simply barren. However, trees of different species find themselves firmly rooted on this large patch of land. Paddy is the main crop grown here. The irrigation needs are largely met through the dug wells only.

Forest-the ownership of a different kind

Deodhara is located amidst the forest surroundings. Its people share an intimate connection with the forest. So, they have taken it upon themselves to prevent its misuse. This concept has flown from the govt. itself thus reinforcing a strong need for community participation in safeguarding the forests too. In lieu of this, they are permitted to take home dry/fallen twigs, leaves, wild fruits and importantly, the medicinal herbs. Additional incentive comes to them in the form of getting fodder grass at throwaway rates.

Entrepreneurship

A saving grace for the entire village is the presence of a rice mill. It draws people from the neighbouring villages to grind their crop. Thus, it serves as a nerve centre of some activity in this otherwise hush hush surroundings.

Well for irrigation

It is quite a pleasing sight to watch vegetables growing here in abundance. Nearly, all types of vegetables are found here. The watery needs of such a produce come from a village well, which is bubbling with water for most of the time.

Housing

There is hardly a structure worth its name, which is pucca by any means. Nearly all the houses have thatched tile roofs symbolizing extreme poverty.

Dress

A unique trait of their dress is their bare footed nature. No shoes and chappals are ever worn by them. They cover their bodies just by a small saree like cloth even during rare sojourns outside their village territory. A stream flowing nearby wets their bodies during the hot summer months.

Energy Consumption

Deodhara is scarce in many things, but not the fuel wood. So, it is largely used for cooking here. Every household uses about 6 kgs of wood on a daily basis. These people are accustomed to cooking their meals twice a day. To see the darkness through, kerosene oil lamps were lit up every night before biomass power landed on the scene. Nearly 2-3 liters of oil was used per household per month.

Self-sufficiency is the hallmark of the Deodarah people despite the vagaries of nature thrown at them

3.0 Field experiences-general

Seemingly, it is of interest to know the experiences of our field teams at the following few levels:

- **Site accessibility**
- **Logistics at the site**
- **Site vulnerability**

3.1 Site Accessibility

The TERI team made its first visit to Deodahara on (). Makhan Lal Sharma, our field technician was the first amongst us to plan for this rather arduous journey (kms.) . He sounded quite determined to fight the odds from the very first go and proved it right too. In fact, he stayed at the site for long periods of time. () hours Journey by train took him up to Raipur-an industrial hub. Staying overnight at Raipur made him think hard about his onward journey to Khaliyar-a good 175 kms. away. From there, he moved ahead by around 30 kms. to reach Komna.

Now began the ordeal for him, as he had to cross two streams minus any proper river transport worth it. Surely, a field staff of Orissa Renewable Energy Development Agency (OREDA) joined him in. So, the small team of 2 people had to put its act together by using a makeshift raft of bamboo. An early part of the stream was seen through on a Rajdoot motorbike wading through the knee-deep water. It was a daunting task for the pillion rider to keep the mechanical spares of the biomass gasifier system tightly gripped. Failing which, everything else ran the risk of being buried in a watery grave below. This was how Makhan Lal made it to the site fighting all odds enroute. Subsequently, Sunil Dhingra (P.I. of this project) and other team members too experienced similar situations during their site visits on and off.

The base facility

Being now at the village was quite reassuring for Makhan Lal. However, it was now the turn to settle down to make things happen. Deodhara has a primary school building, within one room of which, Makhan Lal set up the TERI's operations on the very first day.

3.2 So, how was the very first day?

Makhan Lal has the memories of the very first day at the site firmly etched in his mind. Basically, he was welcomed with a heavy downpour soon after his arrival in Deodarah at around 4 p.m. He was quick to sense the festive atmosphere that time in the village-it being Dusshera. With rain drenching everyone outside, it was the time to step inside. Within a few minutes or so, he spotted some movement close to a battery housed in the office room. The guest other than himself turned out to be a snake terrifying even a few villagers so much so that they ran out of the room there and then. So, it was left to our technician to rid himself of this menace, which he did so convincingly.

Cleaning act

He had to plan his stay at the site not just for a day or two, but also for much longer periods. He was quick to realise the fact of snakes and large insects choosing safe hideouts behind some unused things in the room. So, he lost no time to make a clean sweep of the room all by himself. This exercise lasted for a good three hours before he

could even attend to anything else. Next morning, it was a sense of delight for all those, who thronged the room. Perhaps, they too took a lesson or two to keep their indoors clean.

Language

It took a few days of acustomization by the TERI staff to know the nuances of the local dialect. Basically, villagers here speak oriya with a fair sprinkling of bangla and a few more dialects.

3.3 The wayward youth

The team watched in sheer dismay the shocking habit of few villagers selling their bare minimum produce of rice to buy life-threatening items like beedis and gutka. It pointed to their growing addiction towards such things at the cost of enjoying even a simple meal at home. No amount of counseling made sense to those people, who seemed hooked on to such things for rest of their life. The village manages with two kiosks selling such items.

3.4 Wild life Intrusions

Quite close proximity of this village to the forest brings its own malady. This is very much evident in the form of wild animals making unchallenged entry in the village at times. It was a life threatening experience of sorts for the TERI team to see two wild bears fighting each other close to their room. The choice was limited to forcing themselves indoors, till the animals retreated into their natural habitat. Sensing our helplessness, wisdom dawned on the community to give us the company of a fellow villager in our room all the time. In a way, he served as the most trusted escort during our movement both within and outside the village boundary.

The terrifying experience

A few days later, a youth from the village community came knocking on the door to warn the team about the intrusion of a cheetah nearby. The stony silence in the village that time was giving way to the thunderous sounds produced by a cheetah. The team learnt thereafter that cheetah was in the habit of forcing its tail under great impact against the

bark of the trees. Actually, it is a clever ploy adopted by the cheetah to get people out of their rooms and thus fall as easy preys. This was surely a nerve chilling experience for the TERI team at least for a few days.

3.5 The cooking experiences

The team had its last laugh always while cooking its food at the site. Insects occupied every bit of space and posed as big irritants. So, while cooking, mosquito net was also put to use, but of little respite. It was a real hair raising experience every day to keep many different types of insects at bay. On their part, the villagers seemed to care little for such things as expected of such remote rural communities. As time progressed, the team learnt to live with the menace of having insects all over the place. This revealed their grit and determination to stick to that place despite such odds.

Staying amongst the villagers at Deodarah tantamounted to living in virtual captivity of their tradition, culture and way of life at least for some time

4.0 Key project parameters- technical

TERI has a closely-knit team of professionals and technicians working on varied aspects of the biomass gasifier technology. In fact, it is aptly named as Biomass Energy Technology Applications (BETA) group. It worked out its way for this specific project by detailing a point specific line of action. This primarily took into account the following few issues of immediate, short term and long term importance. So, it meant a holistic planning with an ultimate objective of electrifying the hopes of this remotely located community:

- **organisational support**
- **estimation of biomass resources**
- **collection mechanism for raw feedstock**
- **design of a biomass gasifier system**
- **initial testing at TERI field campus (in Gwal Pahari, Haryana)**
- **assembly of system components at site**
- **testing cum evaluation**

- **installation and commissioning**
- **operation and maintenance**

It is of interest here to go through a vivid account of how all of this materialized in actual terms.

4.1 Organisational support

TERI-the Technology Developer

The Energy and Resources Institute (TERI) has been in the forefront of mission oriented, target driven and socially committed research on various design configurations of biomass gasifiers. It is amongst the first few research centers in the country to successfully demonstrate a fully in-house conceptualized and designed system. In fact, one of our unique system designs was a mobile power station of sorts installed quite early on in village Dhanwas of Haryana. Our team spearheaded by Dr. V.V.N.Kishore is a glaring example of sheer passion and technology acumen for serving the interests of industry and remote rural communities alike.

Technology upgradation is a well-adopted mantra at TERI. This is very much evident in terms of scaled up capacities of earlier designs at much improved field efficiency levels. Its field staff is fully trained to assemble, install, test and maintain the biomass gasifier systems at the site itself. Following are the major accomplishments of TERI in the fast upcoming area of biomass gasification so far:

- **nearly 10 biomass gasifier specific packages developed**
 - 6 patents
 - 6 licensed manufacturers
- **more than 250 systems across various geographical regions in India**
 - systems exported to Nepal, Myanmar, Thailand
 - cumulative capacity> 11 MWth
- **Dual fuel systems (70% gas+30% diesel) developed in the capacity range of 10-100 kWe**
- **100% gas systems developed**
 - 10 kW (modifying diesel engines into SI gas engines)
 - 50-100 kW (using natural gas engine)

4.2 Orissa Renewable Energy Development Agency (OREDA)

OREDA is a state nodal agency set up to promote the use of renewable energy programmes amongst the remote rural communities in particular. It is fully geared to work in close coordination with both the national and international programme implementation agencies. This is reinforced by a strong vision to create its field offices across the state. TERI team had an opportunity to work in tandem with OREDA for setting up a biomass gasifier system at Deodarah. Janardan Mehr, a field technician with OREDA and one of his colleagues were placed at the services of TERI team all along this project. OREDA has a field office at Komna ably managed by these two people.

4.3 Ranjana Gram Panchayat

As is customary in the rural context, Ranjana is a Gram Panchayat. It is located in the Komna block and has a mandate to involve itself fully in the affairs of village Deodhara too. This includes its overseeing role in the biomass gasifier project as well.

4.4 Village Energy Management Committee

The end user community here is the people of village Deodarah itself. They also have a say of their own much to their satisfaction and immense delight. It is a core group of about 9 members chosen for a one-year period at a time.

4.5 Energy Management Committee

It is a group of people drawn mostly from outside Deodarah village. In fact, Deodarah has just a sole representative to keep abreast of the decision making process in the said committee.

4.6 Divisional Forest Officer (DFO)

It is a vital link in the chain of command and control systems. The importance of the divisional forest office stems from the fact of the forest resource i.e. the woody biomass being the workhorse of the present biomass gasifier system at Deodarah.

Technology though a virgin territory for the villagers was not misplaced here due to a range of local interventions beginning from wood itself

4.6.1 Estimation of Biomass

The raw feedstock material for the present biomass gasifier system is the woody biomass. So, TERI team had to gauge its long-term availability in more than one way. For this purpose, tree species of various types were identified. Standard methods of calculation to know the sustainable yield of woody biomass were used. Basically, following few types of biomass sources were identified at Deodhara.

- **forest**
- **barren land**
- **cultivation land**
- **homestead**
- **pastureland**

The girth at the breast height (GBH) for the sample trees was measured along with their height using Abney's hand level. Both these measurements helped us to know the volume of trees. Estimations pointed to gross surplus reserve of woody biomass in the range of 370.96 tones per annum. This stimulated the intervention of a biomass based gasifier system at Deodhara much to everybody's delight.

Deodhara lives in close harmony with the nature using it to the maximum possible levels

5.0 Biomass gasifier system design

Surely, Deodhara was a test case for the TERI team on various counts. It had a village community finding solace for its day-to-day energy needs from its immediate environs i.e. the forest wood. So, caution and optimism to introduce a hitherto unknown power system for them was the catchword. This is what finally paved the way forward for all

those involved. However, it was not without its stock of lows and highs witnessed all along the initiation of this project. In fact, the trouble free functionality of the system matured in the domain of the village setting itself. Unlike a solar PV system relying on a freely flowing fuel i.e. sunlight, the present system threw its lot with the freely available wood gathered so painstakingly by the innocent looking villagers.

5.1 Biomass Gasification Technology

Gasification process

Gasification is by now a well-understood concept of changing the solid biomass fuel into a gaseous fuel. It is not the purpose of this case study to delve deep into the technicalities of system operation. However, points of significance are reported here. The producer gas released in this specific system is a combustible gas having a heating value of around 1000-1200 kcal/m³. Following is its composition on a volumetric basis:

Carbon monoxide	CO	18-24%
Carbon Dioxide	CO ₂	12%
Hydrogen	H ₂	13-20%
Methane	CH ₄	12%
Nitrogen	N ₂	Balance

5.2 Technology at work

Figure shows the block diagram of a biomass gasifier system set up for electrifying village Deodarah. The process takes off with hopper of the gasifier receiving the biomass supply. It has a door opening schematics based on the water seal concept. A manually operated chain pulley device enables the opening and closing of the door. As observed, it takes an hour or so for the cold starting as well as system to stabilise. The fed biomass changes into a gaseous fuel known as the producer gas via the partial combustion route in the gasifier reactor.

The gas is drawn below the grate and made to pass through a cleaning system. The ash from the gasifier deposits in the ash pit, which contains the water. This way, it functions

as a water seal. At this stage, the emitted gas is contaminated and filled with dust particles and tar vapours. These are cleaned in the cleaning train prior to being supplied to the engine. However to clean the larger size particles, use of a cooling and cleaning train enabled with a gravity filter/heat exchanger cum SS mesh filter is made. For elimination of tar and fine particles, packed bed scrubber and centrifugal scrubber are put to an effective use.

Likewise, a mist separator is utilized to take out the particulate carried away by the gases during their cleaning within the wet scrubber. Also, we have used a paper filter to serve as a safety filter to keep the clean gas within the allowed range of tar and dust particulate. Importantly, the gas and air mixture is introduced at the air intake of the engine to supply it via the manifold. Finally, valves are in place for air and gas both to change their proportion so as to get hold of an optimum mixture. **Figure** shows a schematic operation of a 100% biomass gasifier based decentralized power generation system. Key operational features of this system are:

average calorific value	1000-1200 kcal/Nm ³
Biomass gasification	1.4 kg/kWh (woody biomass)
Interval of cleaning process	50 hours (minimum)

5.2.1 Key system components

Our gasifier system is made of mild steel lined with refractory castable. It uses a water-cooled engine having a rated power of 26 BHP at 1500 RPM. The engine allows a manual control using a battery for startup in an automatic battery-charging mode. A standard make alternator provides a stable 3-phase AC power supply at 415 V, 50 Hz. The pump has a capacity of 750 Watts and a RPM of 2800. It uses a user-friendly control panel of high precision.

The panel is equipped with the voltmeter, ammeter, frequency metre along with protective devices/functions like MCB and earthing etc. There are multi-level indicators for sensing the operation of blower, pumps, vibrator motors and importantly, the

temperature. A hand fed, hand operated woodcutter is in place at the site to shape wood to its desired size for gasifier operation. It is designed to handle about 100 kgs of wood per hour in sizes upto 100 mm.

Table: Key performance indicators

Raw feedstock consumption per hour

Average power generation per day

Average power generation per year

Capacity utilization factor

Plant shutdown days per year

5.2.2 Civil work for the Biomass gasifier and engine

A pucca shed occupying around 36-m² area has been built to accommodate a 20 kVA generating set besides a biomass gasifier and accompanying equipment. The structure has a steel truss roof with a GCI sheet cover supported on the RCC columns. The outer wall is made of GCI sheet fitted on a suitable frame minus any surrounding wall. The underlying idea is to enable free passage of air to eliminate the risk of carbon monoxide on human health. A feature unique to this design has been to site the gasifier building in the immediate vicinity of the main plant building. This is primarily to use the gas near the point of generation itself. Both the cooling and cleaning operation of the gas are well taken care of in this captive mode of power generation.

Deodarah is sitting pretty in the lap of a forest area. So, it was not a difficult issue to tackle in terms of the raw feedstock availability i.e. woody biomass. We now take a close look at how this important resource was collected, stocked, managed and used at the plant site.

**TERI and Biomass
gasifier technology go
hand in hand with an
everlasting bond of high
hopes and reliability**

6.0 System of biomass collection

The villagers tread the jungle twice a week in search of fuel wood for cooking. Interestingly, one member of each family comes home with booty of around 12-15 kgs. of firewood. It finds its way in their traditional cookstoves nearly twice every day. TERI team evolved the concept of offering them improved cookstoves, which could lessen their drudgery of cooking apart from saving one kg. of wood too every day. This idea found ready takers, as it also meant twin benefits for them. One kg. of wood saved per household per day was all that a plant operation needed. So, it totalled about 30 kgs. of firewood per household every month as an end user contribution to smooth running of the plant. Following few points are of significance here:

- **village forest contributes a maximum sustainable yield of around 399.5 tones-roughly 42% per year**
- **non-forest land (agricultural as well as barren land) contribute equally good amount of biomass**

6.1 Surplus availability of biomass

Deodarah is flush with huge biomass reserves poised to ensure a long-term operation of the present system. Villagers use wood for their cooking needs. So, the cumulative usage of wood for this important end use application is subtracted from the wholesome availability of biomass.

6.2 Management cum utilization of raw material

Biomass enshrined in the village forest is in a yearly surplus of about 370 tones. Out of which, the biomass gasifier system utilises a lowly 20 tones per year. This large surplus prompted TERI to design a system much beyond the existing electricity needs of the village community. These needs pivoted around the thought of putting in place some small-scale unit for income generation at the site. In that case, the existing wood consumption could simply double to 30-40 tones per year.

6.2.1 The hassle free delivery

Size of firewood delivered at the plant did not matter to the villagers. This was taken care of by a mechanical cutter put up at the site by us. Instead, what mattered was that every

household was bound by a simple rule of supplying one kg. of firewood per day. The village is receiving power for 2 light points per household between 6-10 p.m. every day.

6.2.2 Storage for biomass

The system uses fuel wood procured from the forest area. So, its continuous availability on the site is a pre-requisite to running the system smoothly. Stocking of the wood well before the onset of rainy season is also needed. That is why a covered warehouse was put in place to take care of at least a month's fuel supplies in advance.

6.2.3 The occasional reluctance

A few villagers at times discontinued the already agreed upon practice of delivering 1 kg. of wood per day at the plant site. They seemed to take refuge in the fact that our storage area had enough stock of wood at times. So, we had to impress upon them the need to stick to the schedule without fail. It took them sometime to realize the essence of stocking the wood to ensure an uninterrupted operation of the system.

6.2.4 Drying of the wood

Wood delivered at the plant was by and large dry. However, any moist wood was subjected to heat produced by burning of buradi. It is a fairly common method practiced by the villagers of Deodarah.

**Humans and wood share
an intimate relationship
with each other right
from birth till our death,
irrespective of the way it
is consumed**

7.0 Energy Consumption

Deodarah is scarce in many things, but not the fuel wood. So, it is largely used for cooking here. Every household has an average use of about 6 kgs of wood per day. These people

are accustomed to cooking their meals twice a day. Normally they finish their daily chores before the sunset to take advantage of sunlight as well as to save themselves from the volley of insets during evening. To see the darkness through, kerosene oil lamps were lit up every night here before biomass power landed on the scene. Nearly 2-3 liters of oil was used per household per month. **Table** summarises the fuel use at the plant site:

Energy source	Cooking		Lighting	
	Wood (ton/day)	Wood (ton/year)	(liters/month)	(liters/year)
Fuel wood	1.62	592.21		
Dung cake				
Kerosene			632.5	7590

7.1 Electricity-a better bet

The poverty ridden villagers echoed unanimity with regard to having electricity connections in their homes. They showed promise of paying for that as well in the following order:

Single light point for 6 hrs. per day @ Rs. 15 per month

Two light points for 6 hrs. per day @ Rs. 35 per month

The intention of charging them for the electricity used was not a misplaced one. It was not a charge for the electricity used as such, but as a means to take care of the operation and maintenance needs at the site.

7.1.1 Load actually connected to the system

The thatched mud houses come alive with biomass power every day. Each household is using two lamps of 11 W each. That is not all, dark and desolate streets too are rejoicing now that villagers tread on them at night too. It has offered them an added security against the unwanted intrusion of wild animals from the neighbouring forest. The total connected load of the plant is as under:

Total number of households 65

Total domestic lighting load @ 22 W per household

Total Street lighting load 10 nos. @ W/point

Power for woodcutter

1 kW

Total connected load

7.2 Immediate gains from system operation

Evening hours used to be utterly dull for these villagers. That is no longer the case now with biomass power on the village horizon. The plant is run between 5-10 p.m. every day. However, there are quite a few occasions when the lights stay on for the whole night. This is so during the time of observance of certain traditional festivals in the village. Marriage occasions too place an additional demand for power. Villagers feel a sense of pride during such times in particular, moreso when their surrounding villages are just reeling in dark. They not only rejoice at indoor lighting, but at outdoor lighting too. The woodcutter is put into action during 6-8 a.m. every day. The annual energy generation as measured from the plant adds up to the following:

**Biomass lighting signaled
a real change without
actually changing their lot
for the better**

8.0 Organizational Support actually materialized at the site

Let us now look at how we implemented this project vis-à-vis the supporting role of all those involved.

8.1 Sustainable Operation of the biomass gasifier plant

Deodarah is a glaring example of how a few organizations/groups partnered together to make it a runaway success. It has the shades of blurring the fine divisions between urban, semi-urban and rural thought processes and accompanying actions. We now look at the role fulfillment and inadequacies (if any) of both the man and machine from a variety of end use considerations

8.1.1 TERI

TERI put in place a multi-pronged strategy right from the project inception stage itself. It encompassed scheduling of site visits to addressing capacity building and training needs too. On the technology front, it customized the operation of a diesel engine to run on the gas alone mode. The cue was taken from almost a similar system in test mode at its field station in Gwal Pahari. Prime concern hinged around a concrete need to design a robust system much to the working comfort of a typical village community. We met our ever-passionate objective of delivering the quality borne systems for remote rural electrification yet again. The biomass gasifier system prior to being delivered to Deodarah was extensively tested at Gwal Pahari for no less than 250 hours. However, following few issues still weighed heavily on our minds:

- **remoteness of Deodarah proved a definite handicap at times**
- **lack of any communication link between TERI office and Deodarah**
- **occasional shutdown of the system on account of poor fund collection dampened the first hand initiative of maintaining a 100% functional rate**

8.1.2 OREDA

It was not just a funding partner in this key remote rural electrification project. Instead, it shouldered the following few responsibilities in a thoroughly professional and time bound manner:

- **site preparation**
- **construction of shed**
- **laying of local grid & distribution system**
- **construction of a biogas plant (for initial charging of gasifier)**

Dampeners

- **small scale unit intended for income generating purposes of village community failed to take off so far due to one reason or the other**

8.1.3 Ranjana Gram Panchayat

The Energy Management Committee (EMC) set up by the Ranjana Gram Panchayat more or less facilitated the flow of funds for regular upkeep of the system. It has been instrumental in motivating the plant operators to ensure a smooth and un-interrupted operation of the plant.

Dampener

- user contribution of Rs. 25 per month has been found wanting at times thus affecting the revenue generation stream of the EMC

8.1.4 Village Energy Committee

Village Energy Management Committee (VEMC) has been effective in propagating the gain (s) from the biomass plant amongst its community. It has led from the front in gearing the village to cultivate a sense of belonging for the biomass system.

Dampener

at times lagged behind in the effort to ensure timely and regular delivery of the raw feedstock material at the plant site

Urban, semi-urban and remote rural mindsets are not at cross-purposes here, but await further sense of purpose in different ways

9.0 Funding pattern

The requisite funds for this specific project actually originated from the United Nations Development Programme (UNDP).

9.1 Project Finance

Lately, biomass energy has got a big impetus under an overall framework of country cooperation. Along this line of support, UNDP sanctioned a project concerning, “

Decentralized Rural Energy Systems for the integrated development of Komna block, district Nuapara district” to OREDA in 2003. In turn, OREDA selected TERI from amongst several other key players to supply a 10 kWe biomass gasifier system at a total outlay of Rs. 17, 20,000 as per the following major breakup:

Capital equipment	Rs. 11, 45,000
Trial test run at Gwal Pahari (for 2 months)	Rs. 75000
Training cost (both at TERI campus and at Deodarah)	Rs. 150000
Annual Maintenance Cost (for 3 yrs.)	Rs. 150000

9.2 Revenue management

It has been more or less a troublesome affair for the VEMC to collect and record the monthly payments as well as the feedstock i.e. firewood from the Deodhara residents-its immediate beneficiaries. Amount thus drawn into an exclusively used VEMC account has been gainfully used so far for the routine operation and maintenance needs. It is a clear example of how the user community has been made a party to the transparent mode of system management in actual terms.

Biomass power sticks to the temptation of being a cost effective solution, no matter how far the surroundings are

10.0 Key economic and social issues post system installation

Life used to come to a grinding halt in this isolated village till biomass power fired its activity beyond the dusk. Now, villagers crowd around selective few points to deliberate

at whatever happened to them during the day. No less appreciation is seen in their conversation for this novel mode of lighting. After all, it has turned their darkness and gloom filled days upside down. However, the system has yet to score on improving the lot of the villagers in actual money terms.

This is because, no income generating activity driven by the biomass power has really materialized so far at Deodhara. The sheer irony is that every one involved in this project so far has rallied strongly around the need for setting up one or two money income-garnering units. But, that alone has not helped to put the idea in real practice. Nonetheless, the user community is pretty happy in knowing for itself how wood could even facilitate a push button operation of light in their homes- an idea not even remotely thought of before for sure.

10.1 Capacity building and training

The biomass gasifier plant was entrusted to the routine care of VEMC after successful commissioning. Supplementing this effort earlier on was the training of OREDA representatives as well as the operators nominated by VEMC itself. A two-tier training module encompassing training at TERI campus and hands-on training on a functional system at Deodhara reaped good results. Today, those trained for the purpose by TERI are turning out to be the true problem solvers and not as simple bystanders. This has reposed an unfailing faith of the end user community in this woody but rock solid technology.

It is a core group of about nine members chosen from the village community itself. VEMC has hinged around the concept of infusing, “sense of belonging” in the end user community. Operators specially trained for the regular system upkeep have displayed a high sense of purpose and associated responsibility. The VEMC has been meeting at quite regular intervals to bring to the fore any type of operational problems. This approach is the culmination of a community driven sensitivity towards adopting an altogether new yet somewhat familiar to use woody biomass. OREDA has not side stepped its brief to act as an overall custodian of this biomass gasifier system in more

than one-way. TERI's advanced support at system repair level beyond the existing capabilities at the site has come in handy on quite a few occasions.

11.0 Key Operation and maintenance issues

Mere installation of biomass energy systems for village electrification does not pay the expected dividends. The challenge is not merely to provide the power, but much more importantly to speedily spring back to action in case of any problems. Our biomass system too had to pass through these stringent requirements all along.

11.1 Initial system rundown

The biomass gasifier system installed at Doedarah has not been without its dose of problems. In fact, it failed to deliver power for a good 15 days and that too within a week or so of its commissioning. Understandably, the initial optimism that had been so well nourished by all those concerned waned fast. Timely rejoinder from OREDA saved the day with quick intervention from TERI. Two of its staff lost no time to reach the site and set the problem right after an exhaustive troubleshooting exercise. This type of elongated system breakdown served as a wakeup call to investigate the causes and effects in great detail. The conclusive inference pointed to the presence of a few unwanted engine-choking materials. So, it necessitated cleaning of the engine at regular intervals by the field staff. Nonetheless, the system did not face any major hiccups reported to us thereafter.

11.2 The alluring grid power connection

Grid power is naturally alluring to all of us. People of Deodarah were no exception when it came knocking on their doors. Many villagers seemed to be fascinated with its power. Perhaps, they had seen it at work somewhere outside their confines. Now was the question of choosing between a biomass gasifier system and the surely conventional grid power. Sensing a strong liking of villagers for the later, OREDA officials dissuaded them from falling as easy preys to it on the following two counts:

- a. grid power is never reliable, while as biomass power will in any case be available to them for 3-4 hours every day without fail**
- b. grid power is surely costly, so a drain on their already empty pockets**

Soon after, the villager's choice swung in favour of the biomass power. Following which, the grid power connection was snapped at least for the near future.

11.3 Lack of performance quality

Unlike other renewable energy systems, biomass systems are till now self-certified only. This means the absence of any independent testing agency at present. The sheer irony is that testing agency now happens to be the same as a technology developer/supplier. Till date, there is no Bureau of Indian Standard (BIS) standard available vis-à-vis the use of biomass power. The resultant effect is an unchecked entry of low quality systems into the field much to the dismay of quality conscious players like TERI.

**Biomass power can even
throw sunshine to the
wind, if, it keeps the hopes
of its beneficiaries lighted
up all the time without fail**

12.0 Summary assessment of the Biomass gasifier system at Deodarah

Sun shines fairly bright at Deodarah. So does woody biomass stand dense and erect in its immediate surroundings. The die has rightly been cast in favour of choosing a biomass gasifier system for a variety of reasons. We found the sheer logic of the same acceptable to an extent of using the locally available resource to the hilt. After all, they have been so much habituated to deriving energy from wood for cooking etc. So, what was really different in this case was not an open burning of the wood, but a technology induced consumption in an enclosed and efficient manner.

The TERI team put the heavy odds behind it and led the technology march from the front. OREDA paved the way forward with all the resources available at hand. This reinforced a strong working relationship between us. The village community did not lag behind in its initiative of rallying behind our joint efforts to a good extent. However, their response ranged from a lukewarm to full blown appreciation all along the duration of this project.

There are a few important issues of significance here. Tribals as they are seem to be hooked on to their traditional way of living for ever. They acknowledge their liking for new form of lighting in clear terms. Seemingly lighting alone is not what they would have expected from the gasifier system. After all, word had gone around much before we made it to Deodarah that biomass power could supplement their income levels too.

The day-to-day operation of the system has been ably handled by the manpower trained by us for the purpose. Just a few major technical holdups have sought our intervention at the site. This clearly affirms our belief in the biomass power systems being akin to any other renewable energy system in terms of its outdoor performance reliability.

The formation of EMC and VEMC was a calculated move to manage the affairs of the biomass mode of power generation on several counts. However, it has not fulfilled its mandate in toto.

The Path forward

Biomass power is poised for a long drawn innings on the village landscape in particular. It is deep rooted to the immediate surroundings of the potential user communities and so not an alien in real terms. However, what is largely alien to them are the winds of economic change that has swept the urban and semi-urban areas so far. Lighting alone is not a gurantee to hook their interest to a biomass system. They need something more to tread on a path of prosperity. So, the path forward is to lay the foundation of a biomass generator and a money-spinning unit together and surely not as a long drawn awaited opportunity.