BIOMASS ENERGY FOR RURAL INDIA

Final Report

COST BENEFIT ANALYSIS

of

BIOMASS GASIFIER BASED ELECTRIFICATION

for

BERI

Submitted to

सत्यमेव जयते
Government of India

gef

UNDP
Empowered lives.
Resilient nations.

By
V Ranganathan | Syed Haque

31st October, 2012

Acknowledgements

We thank Shri G.S. Prabhu, IFS, who was the Coordinator of BERI for assigning this interesting project to us. His commitment for biomass Energy in general and for the BERI project in particular was singularly high. He saw great possibilities in biomass gasifier electricity for application in rural areas to relieve the chronic power cuts they have been suffering. Though the project itself had many infirmities and had encountered many difficulties, most of which may be attributed to Government department running a system that should essentially be run by a private entrepreneur, the purpose of the study and its Terms of Reference were clearly drawn to see beyond the project, to examine if the biomass gasifier based electricity is a viable option for addressing rural energy needs. That is why the study has been done in a Cost Benefit Analysis framework, rather than as a review of the BERI project itself, by looking at other successful projects and upcoming ones.

We also would like to thank Dr.S.N. Srinivas, and his team, who was handholding throughout the project and providing valuable inputs and comments on the draft reports and helping refine the report.

We are also grateful to Dr. Dasappa, Professor, Indian Institute of Science and Shri Sivanna, and Ms. Deepa Cholan, who succeeded Shri G.S. Prabhu in BERI as Coordinator for their valuable inputs and suggestions. Last but not the least, our thanks are due to Shri Rangaraju, who was running the BERI plants who participated in all the discussions. The errors are our own.

V. Ranganathan

Syed Haque

Table of Contents

Chapter 1
Introduction: Biomass Gasification Technology

1.1 Introduction

Over the years, several decentralized technologies like energy plantations, bio-gas, solar, wind, micro-hydro etc. are being experimented in India for possible adoption on a large scale. One feature of the so called decentralized energy options was that in most cases these energy sources, be it bio-gas, solar, wind or micro-hydro, were all driven by subsidy and hence their adoption at present is rather extremely limited to the funds provided by the Central and State Governments as a dole out for these programmes. The target orientation which underlines these programmes have also lead to the achievement of the 'numbers' rather than ensuring the efficacy of their use. Government audit reports have pointed out that in many cases, regrettably, even these numbers are overstated and do not stand the scrutiny of physical verification. In some cases, the subsidy in these technologies –like the solar lantern—has induced the distributing departments to restrict their distribution predominantly to Government institutions and departments. Apart from capital subsidy, where the Ministry bore a part of the capital cost, a fiscal subsidy of accelerated depreciation was also given. While capital subsidy was a supply push strategy, tax break was a demand pull strategy, incentivizing operators/users to go in for renewable energy, to avail the tax break. A large capacity of Wind Energy plants came into being through these incentives. However, while a capacity subsidy lead to a liberal capacity of renewable energy being created, ouput wise they were small while running, with a typical capacity factor of around 20% in the best of places like Kayatharu in Tirunelveli district of Tamilnadu; in many other places the plants ceased to function, like the Karnataka Power Corporation's wind energy plants at Kappadagudda, Tala Cauvery etc.

To overcome this, the incentives were changed to generation based incentives. They attracted international investment and improved efficiencies of plants.

Then came Renewable Purchase Obligations (RPO). Here each State has a different RPO and it is expected to increase from around 7% now to about 15% by 2014. One is not clear whether it has been State Policy or Regulator's preferences. At any rate, RPOs have been implemented by Regulators.

In addition to the RPO scheme, there is an option of trading Renewable Energy Certificates (RECs). There is a floor price of Rs.2 per kwh and the market prices have been around Rs.2.5 per kwh. However, in Europe, the same certificate has been trading at €3 to 6 per unit, amounting to Paise 35 to 70 per kwh*. In view of this, both the floor and the RPO obligations set in India appear to be more zealous than in Europe. With the Telecom Regulator imposing reduction in carbon footprint for the mobile tower industry, with towers in Rural areas reeling under erratic grid supply, even supplying with diesel has ceased to be an option, with biomass based electricity producers selling to them electricity at Rs.25 per kwh, which is higher than the cost of diesel based electricity. With the clamour for removal of diesel subsidy, such biomass based electricity producers have a bright future, in this segment.

**Assuming an SFC of 0.7 kg and a carbon content of 70% in coal, per kwh CO_2 emission = 0.7*70%*3.67 (kg of CO_2 emission per kg of carbon combustion) = 1.8 kg. At 3Euros (exchange rate Rs 65) per Ton, it translates to 35p per Kwh.*

Spain, Portugal, Italy and Ireland hit by financial crisis have rolled back incentives for Carbon reduction, while developing countries like India are pushing ahead with more incentives, to the delight of Renewable Energy investors.

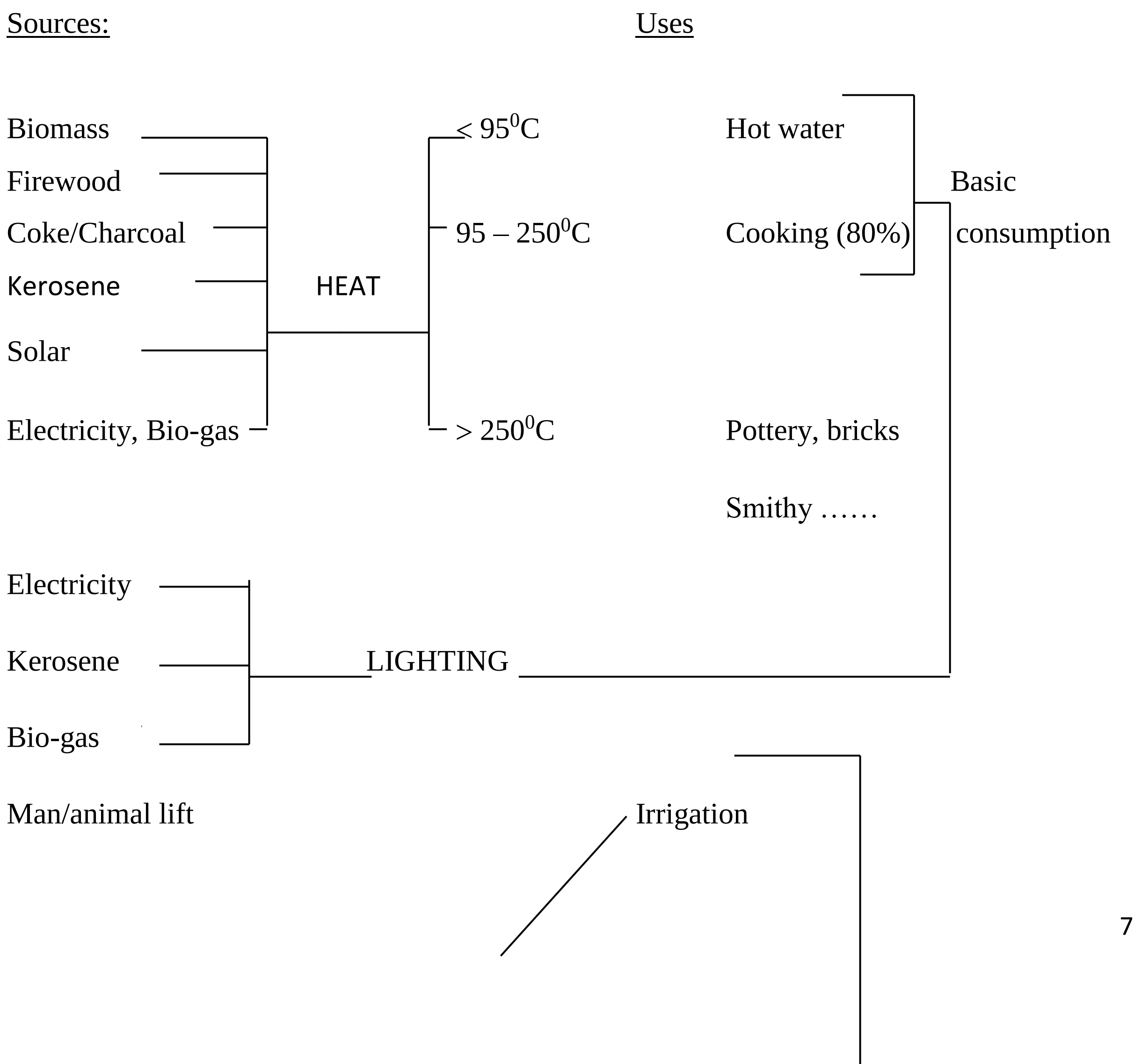
Then came the concept of Regulators giving a ‘feed in’ tariff, i.e. a higher rate than competitive coal-Hydro conventional electricity tariffs. This rate has also been a differentiated one, with a higher rate for solar than thermal, as an incentive to encourage different green options. From an economics and resource utilization perspective, feed in tariff with differentiated rates for electricity from different sources is allocationally inefficient, as it effectively supports higher cost electricity to coexist with lower cost electricity. The inefficiency of this system of feed in tariffs became evident when it was put to competitive bidding: the winning bidder sought considerably lower rate than the officially contemplated rate. At this juncture one must remind oneself that a reliable grid supply itself is green enough, as frequent failures of grid supply have encouraged a huge industry of diesel based captive generation.

In the current study we focus on Biomass gasifier based electricity generation, started by BERI (Biomass Energy for Rural India) and *assess its performance and potential of this form of electricity generation—which can be either fed to the grid, sold to an* *industrial consumer or distributed in rural areas which have either no access to grid or access is there but supply is unreliable—in terms of financial, economic and environmental viability and project replicability, scalability and sustainability, both as an option by itself and in comparison with other forms.*

When the Indian Institute of Science (IISc) started this project, it was conceived as to give relief to villages from the incessant power failures, and as a means of distributed power generation, using local resources, like locally available biomass, agricultural residue etc. With connecting to the grid, this objective is now completely lost, as grid electricity is mostly used in urban areas, irrespective of the source of generation. Fig. 1 gives the rural energy sources and uses.

Fig. 1

RURAL ENERGY: SOURCES AND USES



Diesel			
Electricity	Stationery		Income
Solar (PV)	-Mechanical-		Generating
Wind			(Productive)
Bio-gas		Industry	
Producer-Gas			
Diesel	Mobile –		
Animal/man	Mechanical	Ploughing	
Electricity	Electrical	Appliances, TV	Luxury Consumption

From the figure while it is clear that the dominant energy need is for cooking, there is also a critical need of electricity for both for basic necessity like lighting, and for entertainment through Television and for charging the mobile phone. The biomass gasifier based electricity would fulfil these needs which the grid electricity is not doing at present because of the poor quality of supply in rural areas, and in off grid areas where the electricity grid is still to reach.

1.2 Biomass Gasification Technology

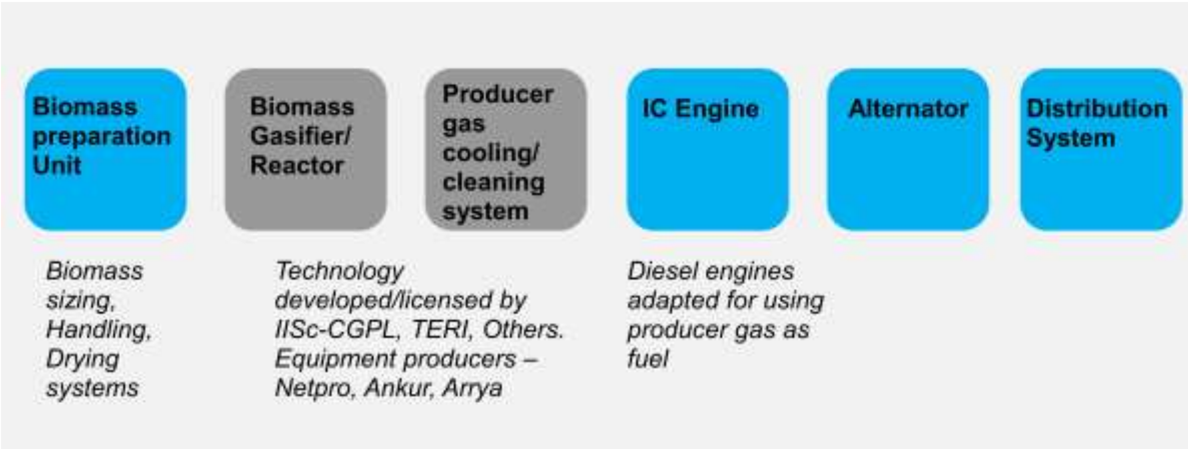
Biomass gasification is a century old technology, involving conversion of carbonaceous material into a mixture of Carbon Monoxide, Hydrogen, Methane and traces of inert gas (**Producer Gas**) through a series of thermo-chemical reactions. Today it is being looked upon as an alternative to conventional fuels. It was quite popular in pre and during World War II period. An estimated 9 million vehicles operated on gasifier technology during the war years. Post-war, with easier availability of liquid hydrocarbons, the interest in the technology waned.

Over the past two decades, the interest in the technology has revived on account of two reasons:

- Environmental concerns (carbon foot prints)
- Increased fuel prices

The essential components of a biomass gasifier based power plant are as indicated in the figure below

Figure 1.1 – Components of a biomass gasifier based power plant



This technology has been used to create generation capacities from demo scale (1-5 KW) to commercial scale (750 KW). With multiple engine and gasifier units operating in tandem, there are capacities of over 2MW under development at single site. However, creation of large capacities (above 5MW) at a single site has not been seen so far. The limitation is in procurement of the requisite volume of biomass at a site (1 MW capacity would require 25-30 tons of biomass per day).

1.3 Advantages of the Technology

- Environmentally benign – The closed loop process (planting, growing, harvesting/gathering, transportation, gasification, generation) results in a near zero net release of greenhouse gases. However, if the charcoal generated in the process is charged back to earth, it is carbon sequestering*.
- Round the clock operation – This technology scores over renewable like solar on this aspect. Mini-hydel—of the run of the river variety and wind power also suffer from seasonality in generation. But capital cost for Mini-hydel would be lower than that of biomass gasifier based electricity plant, and certainly the running cost would be very low.
- Distributed generation possibility – The technology is amenable to creation of small distributed capacities which in turn can reduce Transmission losses and generate local employment opportunities. A wide range of output ratings possible (10 KW to 2 MW).
- High overall conversion efficiencies. Calorific value of fuel to electricity conversion efficiency of upto 40% attainable.
- No site specificity unlike wind or mini-hydel. Provision of electricity at off-grid locations – In difficult terrains where setting up transmission infrastructure is

difficult, this technology can be useful. But cheap biomass availability near the site is a factor.

- Low gestation period.
- Cost of operation – Higher compared to large capacity coal based units, but substantially lower than diesel. Cost of diesel generated power in India is ~ Rs 16/Kwh (Diesel cost – Rs 13.5 (at Rs 45 per litre), assuming a specific fuel consumption of 0.3 lit per Kwh. would increase further to ~ Rs 18 if the subsidy is removed). Through biomass gasification route, the cost will be ~Rs 7 per Kwh (Assuming biomass cost of Rs 2500 per ton). Including capital cost, it will be higher.
- Wide variety of feedstock can be used., eg. Rice husk, agriculture residue (corn cob, mango seed) etc.

**Assuming 6% of biomass by weight is converted to charcoal which has 80% carbon content, the sequestration benefit at 6 Euros/ton carbon dioxide will be ~ 9p per kwh*

1.4 Disadvantages of the Technology

- Gasifier technology is workable and proven, but still does not lend itself to "fill it-shut it-forget it" mode like a diesel engine. This is primarily because unlike a specific fuel (gasoline, diesel, furnace oil etc) where the feedstock properties are always uniform, biomass cannot be standardized. In all likelihood, different batches of biomass will have different composition, moisture content, ash generation etc. Hence the operations will always require a closer monitoring of parameters and an absolutely uniform performance will not be the norm.
- Unlike a ubiquitous technology like diesel engine, trained manpower is not easily available.
- The cost of power generation is higher compared to coal based thermal. (Rs 7 per Kwh compared to ~ Rs 3/Kwh).
- The size at a location cannot be large. Difficult to have capacity beyond 2MW at a particular location. In case of biomass based units operating on direct combustion route, larger capacities exist as there is higher flexibility in biomass use. This however is not a disadvantage in so far as distributed generation is concerned.

- Steady availability of biomass – Continuous availability of biomass at viable price has been a challenge in many projects.

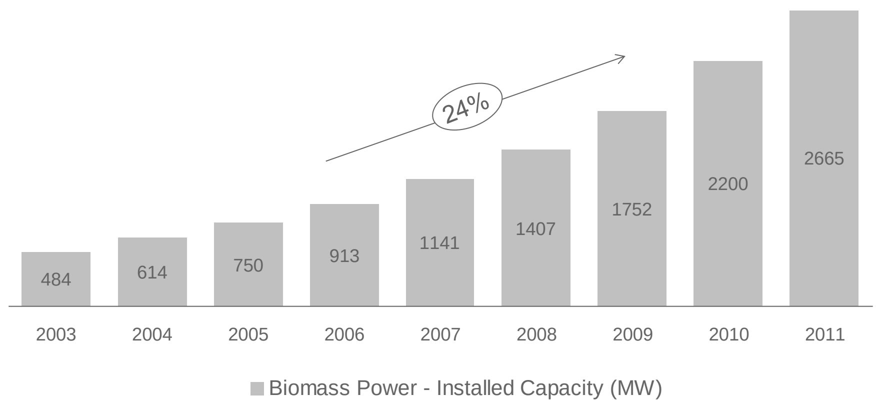
1.5 Critical Success Factors

- Availability of biomass – Steady and cost effective biomass sourcing is the most important determinant of the success of a project. In many projects, escalation in biomass procurement cost has rendered the project unviable. Projects with dedicated energy plantation may be ideal, but not always possible. In such a scenario, the biomass used can also be standardized and the gasifier control can be sharply tuned.

- Biomass Management – If the size and moisture content in the biomass is managed properly, there will be a lot fewer issues in operations.
- Availability of labour – Though the operation is not labour intensive as such (a 1 MW installation may need ~ 35 people(~ 25 persons in biomass sizing/handling and ~10 persons in operations and maintenance of equipments), availability of manpower becomes an issue in industrialized belts.

Chapter 2
Biomass Gasification Based Power Generation – Indian Experience

Fig 2.1 – Growth in biomass based power generation capacity in India



Source: Ministry of New and Renewable Energy

Biomass based power generation capacities have grown at a high rate (24% over the period 2003-2011) in India, but still lags far behind other renewable like wind (13,000+ MW capacity). However, a large part of this capacity is on account of sugar cane bagasse cogeneration units (1,666 MW). Of the balance 1000 MW capacity, a substantial part is based on combustion technology. According to Energy Alternatives India (EAI) estimates, total installed capacity of biomass gasification-based power production is only 10% of the overall biomass based capacities, ie. ~ **260 MW**). This is a little surprising considering the fact that India has a large agrarian economy. Studies have estimated a surplus biomass availability of 125-150 Million Tons annually (Source – MNRE). This is theoretically sufficient to generate 18,000 MW of green power, apart from 5000 MW that can be generated from bagasse generated by over 550 sugar mills in the country. (SFC – 1 to 1.3 kg per Kwh for dry woody biomass, and 1.5 kg per Kwh for non-woody biomass).

Sharp increase in cost of biomass may explain the tardy rate of capacity addition (apart from bagasse based cogen capacities). Price of rice husk escalated from Rs 600/ton to Rs 1800/ton in 2 years (2008 end to 2010 end). A large part of available biomass got diverted to heating application (It is 30-40% cheaper than furnace oil, the commonly used fuel for heating applications). Increase in biomass cost despite available surplus may seem inconsistent. However, this happens over a particular geography where there are competing uses of same biomass. For economic viability, biomass needs to be procured from a shorter distance (Logistically sensitive commodity). Hence, what is important is proper capacity planning across geographies.

2.1 Gasifier Based Power Generation – A field assessment

During the course of the study, we have directly interacted with numerous operators of plants as well as companies engaged in production and installation of gasifiers in power generation and heating applications.

We have studied 15 different companies/installations. They are:

1. Commercial Operators having multiple installations –
   I. Desi Power
   II. Saran Renewables
   III. Husk Power Systems
2. Commercial operators with single installation –
   I. Ankur Power, Sankheda, Gujarat.
3. Captive installations at:
   I. VIT, Vellore
   II. Pointec Writing Instruments, Attibele, Karnataka.
   III. PSG College of Technology, Coimbatore
   IV. Sir MV Institute of Technology, Bangalore.
   V. AIMS, Karnataka (Educational Campus), Mandya.
   VI. Beach Minerals Pvt. Ltd, Kuttam, Tamil Nadu
   VII. Nath Motors, Haryana
   VIII. NIE, Mysore
   IX. Edathala Polymers, Kochi, Kerala
   X. GB Food Oils Pvt Ltd, Tanjore

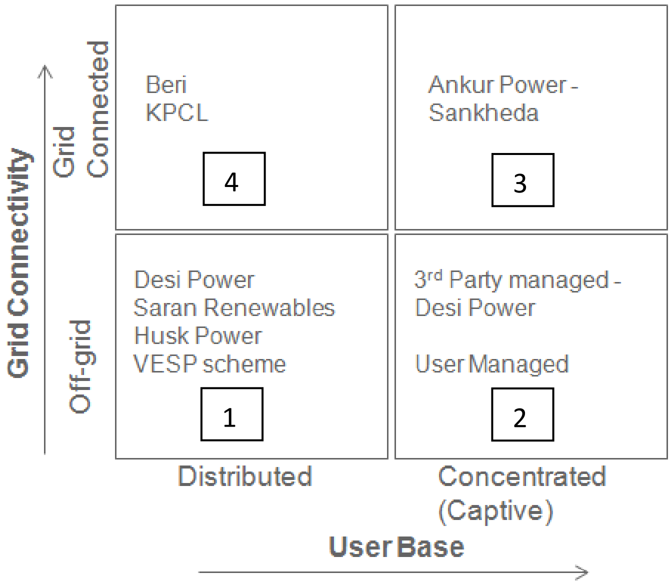
4. State sector projects at:
   I. KPCL, Kushalnagar
   II. KPCL, Bethmangala, Kolar Dist.

The installations marked in italics are not operational currently.

Technical issues, planning errors and escalation in cost of feedstock have been the major reasons for discontinuation/failure of operations. **Amongst these, non-availability of and escalation in biomass cost have been the most common reason. Even the commercial operations have cited managing availability of biomass as the most important challenge in their operations.**

2.2 Operating Models

Figure 2.1



1. Off Grid-Distributed Model

Commercial operators like Desi Power, Saran Renewables, Husk Power sytems have been operating small capacity plants in vicinity of village cluster. Such stand alone systems are free of licensing obligations and regulatory oversight. Retail tariffs are determined by market forces (Based on diesel power cost, kerosene used in lighting).

Husk Power Systems

It started in 2007 and has been able to rapidly scale up to 83 plants covering a few districts in Bihar and UP. Each plant is 35-50KW capacity (uses rice husk as fuel) and serves ~ 400 households in a cluster of villages. Provides electricity for 6-8 hours each day for lighting up 2 CFLs and a mobile phone charging station. It is a subscription based model (monthly subscription costs Rs 100-125, (approximately the amount spent by a rural household in procuring kerosene, firewood). Subscription is collected in advance. CFL lamps are provided as a part of subscription. The company has a tie-up with a CFL lamp manufacturer.

Their cost of generation is ~ Rs 7 per KwH.

This has been one of the successful models of its kind. It has attracted substantial funding and has won accolades globally. (Won Ashden award for sustainable energy development in 2011, Partnership with Shell Foundation). Managed by a passionate team, it has ambitious growth plans. It has been able to demonstrate a workable business and has managed to scale up at a brisk pace introducing numerous innovations along the way. However, its attempt to proliferate the model even faster through franchising has not been successful so far. Others like Saran Renewables, Desi Power have not been able to scale up as rapidly. In our assessment, the key reasons for Husk Power's success are:

Strong biomass supply linkage – They use rice husk, which is available in all the locations they operate in. Procurement distances are short. In most cases, they have annual supply contracts. In many instances, rice mills also are their customers for power.

This model holds promise in parts of the country where electrification is either still to reach, or power supply for rural areas is highly erratic. On the downside, availability and cost of feedstock has been an issue in some projects.

2. Off Grid-Captive Model (Biomass electricity as a standby, instead of diesel standby):

Use of biomass power as a back-up has been attempted by industrial users, educational institutions. Some third party operators like Desi Power have also tried to offer on a pay as you use basis. They have invested in equipment and have deployed manpower at consumer premises with an agreed rate for selling the generated power. This model has been tried by Desi Power in a number of locations – MVIT Bangalore, VIT Vellore, GB Food Oils Tanjore. Most of these installations however have not been successful. In some cases, there have been technical glitches but in a larger number of cases, biomass availability at remunerative price has been as issue. With an electricity output price realization of Rs 5 per Kwh, the operator will need to procure biomass at cost not exceeding Rs 1.60/kg to break-even (Biomass cost- Rs 2.75,

Sizing – 30 p, Maintenance/fixed expenses apportioned – Rs 1, Capital cost – Rs 1.20. Adds up to Rs 5.25. Assuming 25 p recovery from sale of charcoal, break-even at Rs 5.00)

Table – 2.1 – Field assessment of off-grid installations

Installation	Year of Installation	Status	Operating Model	Biomass Procurement Cost (Rs/kg)	Cost of Generation (Rs/Kwh)	Reason for Not Working
VIT, Vellore	2001	Working	Self-Operated			
Pointec Writing Instruments, Anekal, Bangalore	2008	Working	Self-Operated	2.5	6.5	
Beach Minerals Pvt Ltd, Tanjore	2010	Working	Self-Operated	2.25-2.50	6.5	
PSG College of Technology, Coimbatore	2001	Not working	Self-Operated			Increase in biomass cost.
Sir MVIT, Bangalore	2002	Not working	Third Party installed and operated (Desi Power)			Increase in biomass cost. Availability of more reliable HT power
NIE, Mysore	2005	Not working	Self-Operated			Sharp increase in biomass cost (went upto Rs10/kg. Switched to diesel for back up.
GB Food Oils Pvt Ltd, Tanjore	2007	Not working	Third Party installed and operated (Desi Power)			Technical issues (issues in gasifier operation)
AIMS Institution, Karnataka		Not working				Availability and cost of biomass

In MVIT Bangalore Desi Power installed a 100 KW plant at their campus in2002. They operated the plant for 4-5 years and were getting ~ Rs 5 per Kwh. Owing to increase in biomass procurement cost, Desi power wanted a substantial hike which led to disagreement between the two parties and eventually shutting down of service. Desi power later re-deployed the equipments at another site.

User managed installations have shown better results. In such cases, it is used as a back-up (hence the comparison is with diesel). Better control over operations (hence better operating metrics and cost) and a passion for contributing to a cleaner environment have been the reason for successful operation in our view. Installations at **Pointec Writing Instruments (Anekal**, Bangalore), Beach Mineral Corporation, Tanjore are some of the instances of successfully running operation.

3. On Grid-Captive Model

Installations like Ankur Power, Sankheda are operating on this model. The power generated is evacuated via grid and sold to an industrial user, with the state transmission utility receiving the wheeling charges. Unlike the off-grid models, these are larger capacity installations (1-2 MW as opposed to 50-100 kW range).

4. On Grid-Distributed Model

Installations like Beri, Kabbigere would fall under this category. In-effect, they are similar to On Grid-Captive model, except that the customer in this case being is the distribution utility. Units operating under this model also face transmission related disruptions like voltage fluctuations, grid supply failure etc. In the Beri case, one of the reasons for low PLF was the frequent power cuts which prevented injection of biomass gasifier electricity into the grid, during the power cut period. Ironically, at the time when the grid wanted more power, it could not be supplied though the biomass gasifier plant was working, because it could not be connected to the grid. Though the duration is relatively small (~4.2%) with 4 interruptions per day, its externality effect is vast.

Table 2.2

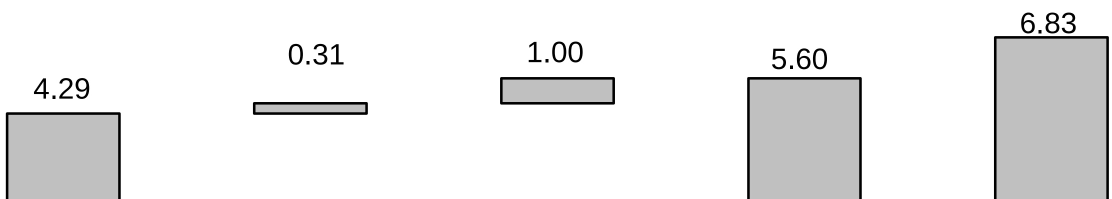
No. of interruptions and duration of interruption for 3 months in BERI's Kabbigere Plant:

2012	**Interruptions**	
	No.	**Duration (hour)**
January	102 (3.4)	30 (~1)
February	110 (3.8)	29 (~1)
March	114 (3.7)	55 (~2)

Figs. in brackets indicate average per day

2.3 Operating Cost Build-up

a. Industry average operating cost – Biomass gasification route



As can be observed from the above exhibit, biomass cost accounts for the largest part of overall cost of power generation. The average biomass cost in the projects we have studied comes to Rs 2.50/kg (Moisture content 40%). Hence on a dried basis assuming 1.2 kg requirement of dry biomass per Kwh, this accounts for Rs 4.29 per unit of power generated (corresponding to 10% moisture content, allowed to be fired in).

Assuming the export/generated ratio of 82%, the cost per unit of power exported works out to Rs 6.83. With an additional Rs 1.20/ Kwh for capital cost (**assuming 70% PLF and Capex of Rs 5.50 per MW capacity, the total cost works out to Rs. 8.03 per Kwh**).

b. Operating Cost – Beri, Kabbigere

Beri operations at Kabbigere has been dogged with technical and industrial relation problems (details in chapter 3. The cost structure is significantly higher than industry benchmark. Based on the data received from Beri for period April 2011 to March 2012, the unit had generated 5.2 lac Kwh of energy and exported 2.9 lacs kwh. The costs (per Kwh) work out to:

- Biomass cost – Rs 2.77
- Sizing cost – Rs 0.58
- Labour/Maintenance- Rs 2.79

The above adds up to Rs 5.93 per Kwh. Auxiliaries consumption/losses however, are far higher compared to industry benchmarks (export/generation ratio of only 56%). Hence, for per Kwh energy exported, the cost works out to Rs 10.64 per kwh. The PLF achieved is low (Below 20%). At 20% PLF, assuming a capex Rs 5.5 cr per MW capacity, the capital cost works out to Rs 4.20 per Kwh.

Therefore, including capital cost, the cost per Kwh of exported power works out to Rs 14.84 (10.64+4.20).

c. Operating cost recorded in 1000 hour IISc supervised operation at Beri, Kabbigere

Between 26th May and 8th July, 2010, the operations in one of the gasifier-engine units (100 kw) at the Kabbigere unit was run under the supervision of IISc (CGPL) team. The performance during this period is shown below. In 1035 hours of continuous operation under the team's supervision:

- Engine operation hours achieved - 1022 hours
- Grid synchronized hours – 951 hours
- Total energy generated – 80.6 MWh
- Total energy exported – 56.5 Mwh
- Internal energy consumption 30%
- Biomass consumed (on dry basis) – 111 Tons

The PLF achieved therefore is 78%. The per kwh cost achieved:

- Biomass cost – Rs 4.00 (Assuming a moisture loss of 25% and delivered cost per kg of Rs 2.50).
- Biomass sizing cost – Rs 0.31
- Maintenance/Overheads – Rs 1.00

Therefore,

- Cost per Kwh generated – Rs 5.31 [4+.31+1]
- Cost per Kwh exported – Rs 7.15 [{4.31x(1/.7)}+1
- capital cost at Rs 1.08/kwh, the cost per Kwh of exported power =Rs 8.23.

d. *Operating cost through biomass combustion route*.

From field assessment reports of UNDP (SN Srinivas et al), the operating cost build up (per Kwh) is:

- Fuel Cost – Rs 3.80
- Other operations and maintenance cost – Rs 0.77

Resulting in total operations and maintenance cost of Rs 4.57 per Kwh. **After taking into account the auxiliary load, cost of power exported will be Rs 4.96 per kwh. Including, capital cost, it will work out to Rs 5.87 per kwh.**

2.4 Renewable Energy Credits

Renewable Purchase Obligations (RPO) as well as preferential tariff for procurement of such power has been specified by various State Electricity Regulatory Commissions (SERCs). Across states, the discoms are obligated to procure a certain minimum quantum of power from renewable sources. However, as the distribution of renewable sources is not uniform across states, a mechanism of "Renewable Energy Certificates" (RECs) has been instituted in 2010. RE generators have the option of selling to discoms at preferential rates or selling power to discoms at their pooled cost of purchase and earning RECs. A generator will have claim to RECs also if the sale is to an open access consumer at a mutually agreed price or through power exchanges at market determined prices.

In many countries (UK, US, Australia, Japan, Netherlands, Poland), the concept has been used to develop a robust market for trading of green attributes of electricity. For non-solar, CERC has set floor and forbearance price limits at Rs 1500 & Rs 3900 per MwH respectively (Rs 1.50 to Rs 3.90 per unit for non-solar and Rs. 12,000 and 15,000 for solar. Over past 2 years the average price on the designated exchanges has been ~ Rs2,000/MwH. http://admis.hp.nic.in/doe/pdf/REC_india.pdf

Taking the REC benefit into account, an efficient producer through biomass gasification route will have a break even cost of ~ Rs 4.75 (considering just operating costs and not the capital cost), per unit (Rs 2.00 less the cost of generation ~ Rs 6.75 per unit).

2.5 Other sources of revenue

Depending upon the feedstock used, 5-7% (by weight) charcoal is generated as a bi-product in the gasification process. This can fetch ~ Rs 8-10/kg. Minor revenue can also be expected from disposal of sawdust generated while sizing of biomass. Hence, taking into account these benefits, an efficient operation can compress the cost further to ~ Rs 4.50 per unit.

2.6 Generation Cost: Non-Renewable Sources

2.61 Coal based thermal power

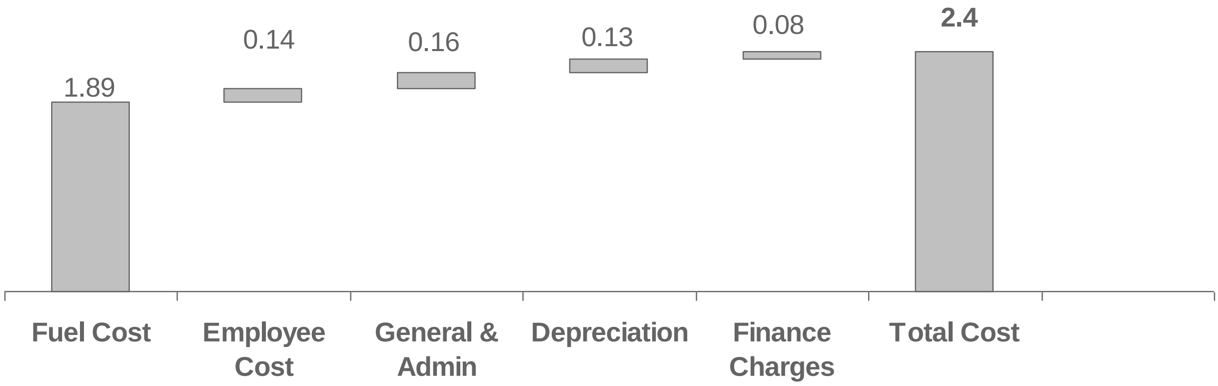
The generation cost in this case is impacted by a host of factors such as Location of the plant (Pithead based plants have lower freight cost and therefore lower cost of generation), Source of coal (Local/Imported), Size of the unit etc. Therefore the costs vary. In case of larger capacities, the costs will drop further down.

NTPC

Figure 2.3

NTPC - Average cost of power generation Rs /Kwh

(For coal based thermal – including fixed costs)



Source : NTPC Annual Report FY 2012

Competitively bid power:

In case of UMPPs with favourable coal linkage (Pithead based), the costs drop further down as is evident from their PPAs:

- Tilaiya UMPP, Jharkhand – Rs 1.77 per Kwh
- Sasan UMPP, MP – Rs 1.19 per Kwh

We present the following cases for arriving at operating cost in coal fired thermal power plants.

a. Units operating on domestic (CIL) coal supplies.

Fuel Cost per Kwh – Rs 1.74 (Based on landed price of Rs 2,381 per ton and SFC of 0.73 kg – All India average as per CEA based on operational review of 385 coal/lignite based thermal units above 25MW capacity adding up to 70,569 MW – year 2007-08). Landed cost per ton (Rs 2,381) calculated as:

Ex-Pit head cost – Rs 1811 per ton (Based on CIL's revenue from coal and dispatches -2011-12. This includes cesses, royalties, tax).

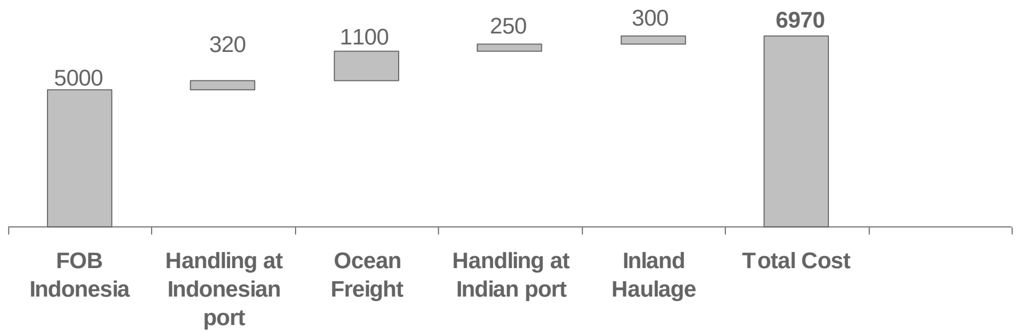
Add:

Average freight cost – Rs 570 per ton (Based on railways' freight earning from coal haulage)

Other overheads – Rs0.30 (assumed at NTPC's overheads). **Therefore, total operating cost works out to Rs. 2.04 per kwh.**

b. ***Units operating on imported coal.***

Import from Indonesia



All figs in Rs/Ton. Based on FOB rate of USD100/ton and exchange rate of Rs 50/USD.

The GCV is higher (6300 Kcal/kg), hence SFC would be ~ 0.46 kg per kwh. Therefore, fuel cost would be Rs 3.23 per kwh. Assuming other overheads at the same level as earlier case, **the total operating cost per Kwh works out to Rs 3.53**

Environmental cost/Impact of Carbon Credit – Coal Thermal

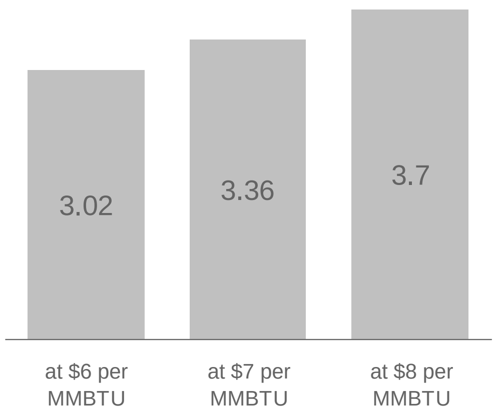
Assuming Certified Emission Reduction (CER), price of 6 Euros, the environmental cost of coal based thermal power generation will be ~ Rs 0.70 per Kwh (explained in Chapter 1, Pg3). On the lower side, at 3 Euros per CER, the environmental cost will be ~Rs0.35 per Kwh. Hence, at the current levels of CER price, the environmental cost is not a game changer.

2.62 Natural gas based

The cost of generation is impacted strongly by gas prices.

NTPC projects with long term fuel supply arrangements, under APM procure gas at \$4.2/MMBTU. At net heat rate of 2075 Kcal per Kwh (as per CEA estimates for combined cycle gas operated units in India), it translates to Rs 1.80 per Kwh (Nearly same as their overall fuel cost in which coal is the dominant part). (1mmbtu=252,000 Kcal). The spot RLNG prices however have been higher. They have been in the range (\$10-\$16) over past year in India. At \$14 per MMBTU, the fuel price will be Rs 6 per Kwh.

Figure 2.4 –Cost of power generation (Natural Gas) – Rs /Kwh



Source : Crisil Infrastructure Advisory

Most of the recent bids (gas based generation) have been won in Rs 3-3.30 range.

Indraprastha Gas Limited sells natural gas at around Rs.30 per scm (standard cubic meter) in 2012. One cum of natural gas produces 11 kwh of electricity. Thus variable cost of generation is around Rs.3. Adding Rs.1 for capital cost, total cost of electricity at the margin, would be around Rs.4 per kwh. But for large thermal power stations, the costs would come down due to economies of scale.

In the competitive bids, with natural gas, private firms quoted the following rates and secured contracts:

- Adani – Maharashtra (FY 2009) : Rs 3.29/Kwh
- Indiabulls – Maharashtra (FY 2009) : Rs 3.27/Kwh

Environmental cost/Impact of Carbon Credit – Gas

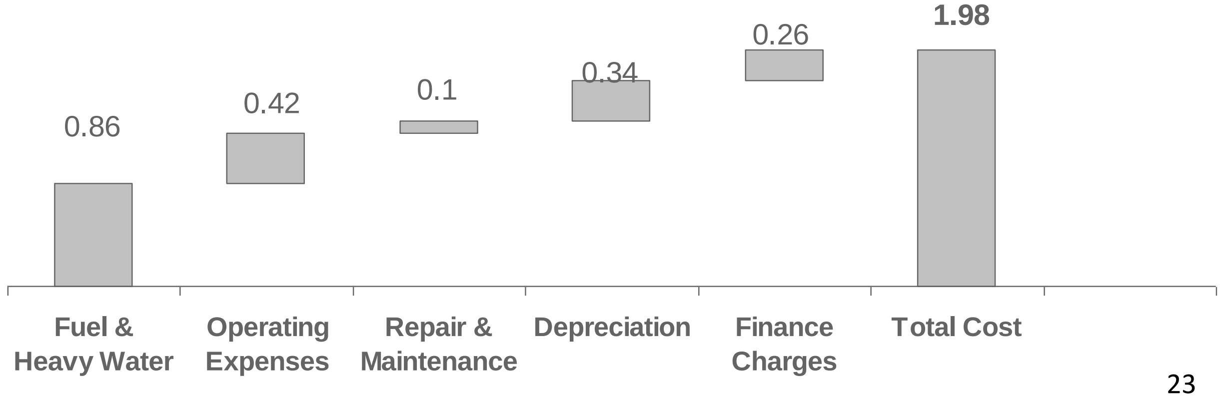
The specific carbon dioxide emission in combined cycle gas based units is 0.43 Tons per Mwh. (Less than half of coal based units. Therefore at CER price of 6 Euros, the environmental cost of gas based power generation will be ~ Rs 0.21 per Kwh.

2.63 Diesel Based

In India, the cost of diesel based generation works out to ~ Rs 16/ Kwh. At the current diesel price of Rs.50 per litre and diesel usage at ~ 0.30 Litre per Kwh, the fuel cost is Rs.15 per kwh. Adding a Rupee for capital and maintenance, the cost of diesel power would be around the amount mentioned. This rate would be very near its economic value, considering that 60% of the cost component in petrol price is that of Central and State taxes.

2.64 Nuclear Power

Figure 2.5 – NPCL - Average cost of power generation – Rs /Kwh



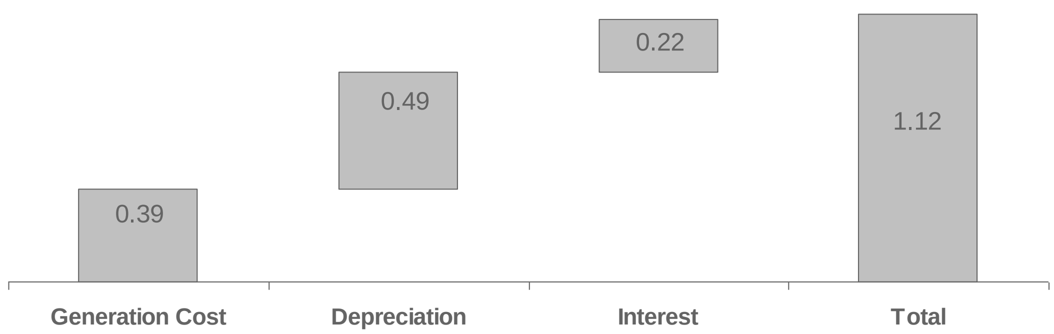
Source : NPCL Annual Report FY 2011

But NPCIL's figures cannot be trusted, for (i) their method of costing is opaque, (ii) most of their inputs are not got from the market, but from their own sister organizations, like ECIL, Uranium Corporation of India, etc, which are all PSUs and whose losses may forever be underwritten from the public purse and (iii) the future liabilities relating to nuclear burial costs of irradiated rods are most often not taken into the books of account. At nearly double the capital cost that of coal thermal, at around Rs.10 crores per MW, the capital component at 60 paise per kwh appears highly fudged. A reasonable guesstimate of nuclear power cost would be around Rs.5 per kwh. Nuclear electricity is a byproduct of India's strategic nuclear power programme and should not be confused with generating it on economic or financial merits.

2.7 Generation Cost: Renewable Sources

2.71 Hydro-Power

Figure 2.6 – NHPC - Average cost of power generation – Rs /Kwh



Source : NHPC Annual Report FY 2011

The generation cost obviously is low in case of hydro-power, however there is high capex per unit capacity and longer gestation period leading to significantly higher depreciation and interest burden. In case of new capacity they may be considerably higher than NHPC (older depreciated units). We recognize that this is the average cost of NHPC's total portfolio of electricity. Hence we need to compute the marginal cost, i.e. the likely present cost, and this comes to Rs.2.47, with capital cost component of Rs.2.17 and maintenance component of 30 paise. This is arrived at using a capital cost of Rs.15 crore per MW for storage hydro, with 95% availability factor, and 50 years life (see table 3.1). The economic and environmental cost adder is another 43 paise, mainly towards a liberal rehabilitation, making the total economic cost to Rs. 2.9 per kwh.

2.72 Solar Power

The cost of solar power generation (Solar PV) is strongly linked to the PV panel prices. PV panel prices have off-late seen a sharp crash (80% drop in last 5 years, 30% in last 1 year alone). Capital costs have now dropped down to Rs 10 Cr/ MW. This has led to a sudden spurt in capacity addition (Capacity increase from 20 MW to 940 MW in FY 2011-12). Jawahalal Nehru National Solar Mission (JNNSM) has a target of adding 20,000 MW capacity by 2020.

Average tariff bid for 350 MW capacity under the mission – Rs 8.80/ kwh. Lowest bid ~ Rs 7.50/ kwh. Though aggressive price bidding in some cases may be linked to specific situation allowing lower capital cost, which may not be available always.

Since solar power, like the wind, is also only an intermittent source of energy (Average PLF ~ 18%) , the capital cost will be significantly higher. Assuming a capex of Rs 10 Cr./MW, the capital cost per MW works out to Rs. 7.87 per MW, overall economic cost Rs. 8.07 per kwh (computation illustrated in next chapter).

In October 2012, it was announced that a 5 MW solar plant by Moser Bayer in Sivaganga in Tamilnadu has been in operation since 2011 at a capital cost of Rs.100 crores, yielding a capital cost of Rs.20 crores per MW (4 to 5 times the coal thermal cost with 20% capacity factor, against 80% PLF of coal thermal plants). In addition it occupied 65 acres of land which was not costed, claiming it was barren. Using a 20 year life, and a discount factor of 10%, the annuity factor is 0.112, and this with a capacity factor of 50%, gives a capital cost of Rs.5.11 per kwh. Even assuming a maintenance cost of ~90 paise per kwh, Solar energy’s total cost comes to Rs.6 per kwh. On the revenue side, while TNEB paid a tariff of Rs.4.5 per kwh, which itself was a TNERC mandated green tariff, MNES paid a Generation based incentive of Rs.10.5 kwh, making a total of Rs.15 per kwh to the firm, as revenue. According to the article covering the feature in The Hindu (Oct 29,2012)[1] the Solar Energy Policy 2012 (State or Centre?) mandates large energy buyers to buy 6% of their requirements from solar energy producers or equivalently buy solar energy certificates. Such an irrational exuberance for the Sun’s energy must be seen in the context of the enormously high 4000 MW deficit in the State, apart from the existential problem of MNES whose survival itself seems to depend on its giving subsidies. The capacity factor of 20%, with an announced average production of 24,500 kwh is too close to the mandated 19% PLF required by CERC with the average for the month given but not the average for the year. No one seems to question the rationale of MNRE giving a GBI of Rs.10.5 in addition to the TNEB tariff, when solar energy bidders themselves in other cases have asked only around Rs.7, our estimated cost even for a Rs.20 crore per MW plant is only around Rs.6 per kwh, and another

[1] R. Sairam, “A shining example of the hinterland” The Hindu Oct 29, 2012.

renewable source of energy large hydro at Rs.1 to 2 is languishing due to opposition from environmental extremists.

2.73 Wind Power

Wind power capacity capex costs are ~ 7.5 Cr/ MW. Assuming a 21% PLF and a costs for capacity handicap, operations, the economic cost will work out to ~ Rs 5.75 per Kwh. The costs for capacity handicap are meant to make apple to apple comparison, between wind, which is an intermittent source of energy with coal based electricity which is a continuous source of electricity.

Chapter 3

Cost Benefit Analysis

Energy sources vary in terms of factors such as:

- Investment intensiveness (Capex per unit capacity creation)
- Load Factor/Availability factor (in the extreme case whether intermittent like solar, wind or continuous)
- Life span of asset (hydro plants may require desilting)
- Environmental impact
- Cost of operation

We have evaluated both economic cost & benefit and also financial cost and benefit. Thereafter compared the respective cost and benefit ratio to obtain a more objective assessment of the sources.

Financial Cost This is the cost which the firm actually incurs. If there is a subsidy, the cost is after the subsidy.

Economic Cost: This is the opportunity cost to the economy as a whole. The cost includes subsidy, since that is the cost incurred by Government. To this is added the external cost, if any, like environmental cost of Carbon emission, full cost of rehabilitation in case of storage hydro, in case rehabilitation is not done satisfactorily and the economic cost of the resource used, instead of the possibly distorted domestic market price. For instance, for coal and gas, domestic price may be lower, but if it is imported at the margin, what is relevant is the world price.

Financial benefit: This is the actual revenue the firm would receive by selling the electricity. In the case of biomass gasifier based electricity, this would be at the level of the feed in tariffs, set by SERCs, or if no concessional tariff is taken, then market price + carbon credit at the international CER rates (Rs.0.70 per kwh).

Economic benefit: This should be evaluated at the opportunity cost of the electricity that this displaces (benefit = cost of the next best alternative). We can take two scenarios, for the next best alternative, viz. at the cost of diesel based electricity and at the cost of electricity bought in the market at spot prices, which is around Rs.5 per kwh.

Cost Effectiveness Analysis: Since all forms of electricity would produce the same economic benefit, and since economic valuation of benefits leads to ambiguities as to which would be the right next best alternative, one can keep the benefit side common for all forms of electricity and compare only the costs, both financial and economic, and do the final comparison based on economic costs only.

For biomass gasification, we have considered three different cases:

a. Off-grid operations like Husk Power Systems (discussed in earlier chapter).
b. On-grid operations which sell to industrial users like Anku Power, Sankheda.
c. On-grid Beri operations.
d. Beri operations under supervision of IISc (1000 hr operation over May-Aug 2010).

   Additionally biomass based operations on combustion technology also considered.

Table 3.1: Energy Sources – Base Parameter Comparison

Source Type	Energy Source	Capex (Rs Cr./MW)	Subsidy	PLF/AF/ CF	Useful Life of Asset (Yrs)	Capital Cost Factor	Average Tariff earned (Rs/Kwh)
Renewable	Biomass Gasification						
	Biomass - Husk Power	5.5	50%	29%	20	0.1338	18.00
	Biomass - Industry	5.5	50%	70%	20	0.1338	5.50
	Biomass - Beri	5.5	50%	20%	20	0.1338	2.85
	Biomass - Beri (CGPL, IISc supervised)	5.5	50%	78%	20	0.1338	2.85
	Biomass - Combustion route	5		78%	30	0.1241	4.42
	Hydro - Large*	15	-	60%	50	0.1204	2.17
	Wind	7.5	-	21%	20	0.1338	4.00
	Solar	10	-	18%	30	0.1241	8.00
Non-Renewable	Coal - CIL	5	-	74%	30	0.1241	2.83
	Coal - Imported	5		74%	30	0.1241	2.83
	Gas - APM rate ($4.2/ MMBTU)	5	-	90%	30	0.1241	3.30
	Gas - Spot RLNG rate ($14/MMBTU)	5		90%	30	0.1241	3.30
	Nuclear	10	-	90%	25	0.1275	2.62
	Diesel/FO	5	-	70%	20	0.1338	20.00

In evaluating economic cost, we have considered the capital cost (cost of capital / discount factor is assumed to be 12%. The initial capex, useful life of asset, PLF/Capacity factor/Availability Factor factored-in) as well as the running cost. The average per Kwh sales realization, running cost for sources have been obtained from various sources.

- Coal – NTPC (Annual Report 2011-12), Team analysis

- Hydro- NHPC (Annual Report 2010-11). We have loaded another 20% on capex as cost attributable to relocation and other impacts associated with large hydro projects.
- Nuclear – NPCIL (Annual Report 2010-11)
- Biomass – Interviews conducted with various operators, 1000 hour operations report from IISc, Combustion based operations (BTOR – SN Srinivas et al)
- Gas – Recent bids/PPAs, Team Analysis
- Solar – Recent bids
- Wind – Interview with operator
- Diesel/FO – Interviews

This is the cost from a financial/business perspective. Capital subsidies available, CER benefits available have been captured here. We have considered CER benefit at 70 p per Kwh for coal based thermal. (computation explained earlier in chapter 1). This corresponds to a price per CER of 6 Euros.

In renewables, On-grid operators can avail of either preferential tariff with discoms or sell in open market and avail REC benefits. Beri project has a prefential tariff (though at Rs 2.85 per Kwh it is low), hence does qualify for REC and therefore no financial benefit on this count considered.

Table 3.2: Cost Effectiveness Analysis

Source Type	Energy Source	Economic Cost (Rs per Kwh)				Financial Cost (Rs per Kwh)		
		Capital Cost	Running Cost	Env'tal Cost	Total Cost	Capital Cost	Running Cost	Total Cost
Renewable	Biomass Gasification							
	Biomass - Husk Power	2.88	6.20	-	**9.08**	1.44	6.20	7.64
	Biomass - Industry	1.20	6.80	-	**8.00**	0.60	6.80	7.40
	Biomass - Beri	4.20	10.64	-	**14.84**	2.10	10.64	12.74
	Biomass - Beri (CGPL, IISc supervised)	1.08	7.15	-	**8.23**	0.54	7.15	7.69
	Biomass - Combustion route	0.91	4.96	-	**5.87**	0.91	4.96	5.87
	Hydro - Large*	2.17	0.30	0.43	**2.90**	2.17	0.30	2.47
	Wind	3.82	0.30	-	**4.12**	3.82	0.30	4.12
	Solar	4.72	0.20	-	**4.92**	4.72	0.20	4.92
Non-Renewable	Coal - CIL	0.96	2.04	0.70	**3.70**	0.96	2.04	3.00
	Coal - Imported	0.96	3.53	0.70	**5.19**	0.96	3.53	4.49
	Gas - APM rate ($4.2/ MMBTU)	0.79	2.10	0.21	**3.10**	0.79	2.10	2.89
	Gas - Spot RLNG rate ($14/MMBTU)	0.79	6.30	0.21	**7.30**	0.79	6.30	7.09
	Nuclear	1.62	1.38		**3.00**	1.62	1.38	3.00
	Diesel/FO	1.09	14.50	0.60	**16.19**	1.09	14.50	15.59

**Hydro-Large – Cost of rehabilitation under Environmental Cost*

Illustrative computations

Capital Cost (Per Kwh) – economic = (Capital cost factor*Capex per KW)/(No of Kwh generated annually)

No of Kwh generated annually per KW capacity = (365*24*PLF or Availability Factor or Capacity Factor).

Capital cost factor – Based on cost of capital (assumed at 12%) and useful life of the asset.

Capital cost (per kwh) for wind power = (0.1338*75000)/(365*24*30%)= Rs 3.82.

Capital Cost –financial = Capital cost economic * capex subsidy (%)

Running Cost (per kwh) – All operating costs (Fuel, maintenance, overheads) – Financial costs like depreciation, interest not included.

The levelized capital cost for off-grid biomass gasifier operators (like husk power) is high because of limited period operation in a day. Typically, they operate their plant 7 hours a day (evening-night hours for rural subscribers). In case of Beri also it is high on account of low PLF. Higher capital cost for wind, solar also is on account of their low availability factor.

As can be observed from the above cost effectiveness analysis table, if we consider the economic cost amongst renewables, hydro and wind score substantially over biomass and solar. Combustion technology based biomass scores better (Although it is not as environmentally benign as gasifier based system, as it requires substantial amount of water. However, for our analysis we have not attached an environmental cost to it). Non-renewables like coal/gas owing to their low cost, PLF score higher.

In benefit-cost analysis, vis-à-vis diesel/furnace oil, biomass (gasification route) is clearly a better choice. So from a holistic perspective, wherever the replaced energy source is diesel, biomass is useful to deploy (Unelectrified villages, places where grid power cannot reach, places with erratic grid supply, heating applications where furnace oil is used). We reject the solar bench mark of Rs.15 per kwh, as even its own cost does not amount to this largess given to this energy source liberally by the MNRE.

Chapter 4
BERI Operations

Biomass Energy for Rural India (BERI) project was launched in 2007 with support from GEF (Global Environment Facility) through UNDP, ICEF (India Canada Environment Facility), Govt of Karnataka and Govt of India. The objective of the project is to promote decentralized renewable energy production to address the rural energy needs, empower local communities in a significant way.

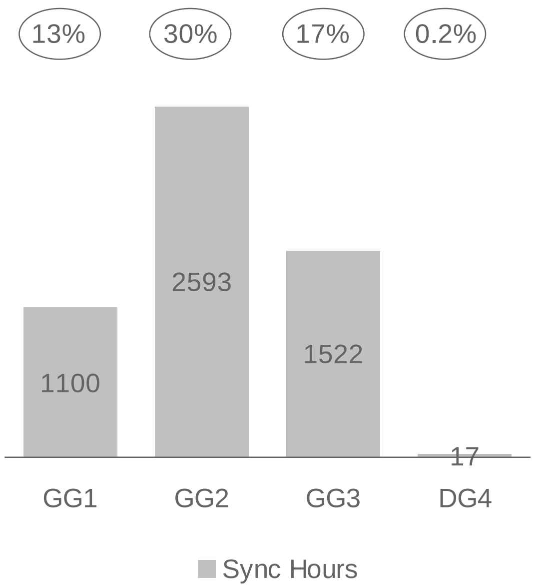
A dedicated Project Management Unit has been managing the project with generation facilities at:

- Kabbigere – 500 KW (1 Engine of 200 KW - GG1, 3 Engines of 100 KW each – GG2, GG3 and DG4)
- Seebinayana Palaya – 250 KW
- Borigunte – 250 KW

Kabbigere site went operational in July 2007. The other two sites are still to start commercial operation.

4.1 Kabbigere Unit Operations

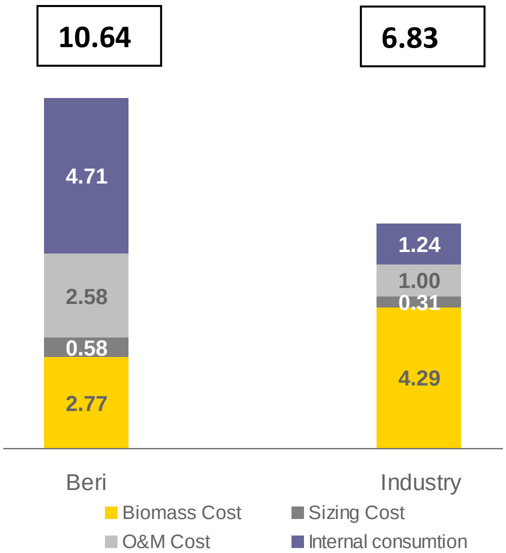
Figure 4.1 – Operational Performance of Kabbigere (Apr'11- Mar' 12)



The unit has been affected by technical and Industrial Relations problems for a long time. As can be seen in the above exhibit, the uptime of the engines has been low. **The weighted average PLF for the unit as a whole has been only 15%.**

Kabbigere unit's cost of generation is substantially higher compared to industry benchmarks. While the biomass cost seems to be than industry, it is way beyond industry benchmarks in biomass sizing/handling and O&M. Internal consumption (auxiliaries, lighting load etc) is substantially higher than industry benchmarks. Lower export percentage of power attributable to frequent transmission related disruptions (Voltage fluctuations, Grid supply failure). Thus it appears, in the case of a grid with frequent power outages, connecting to the grid becomes double whammy; it significantly lowers the capacity factor and increases the internal consumption of biomass; and it negates the advantage of decentralized generation and making electricity available exclusively to the local area.

Figure 4.2 – Operational Cost Comparison (Beri v/s Industry Benchmark operations)

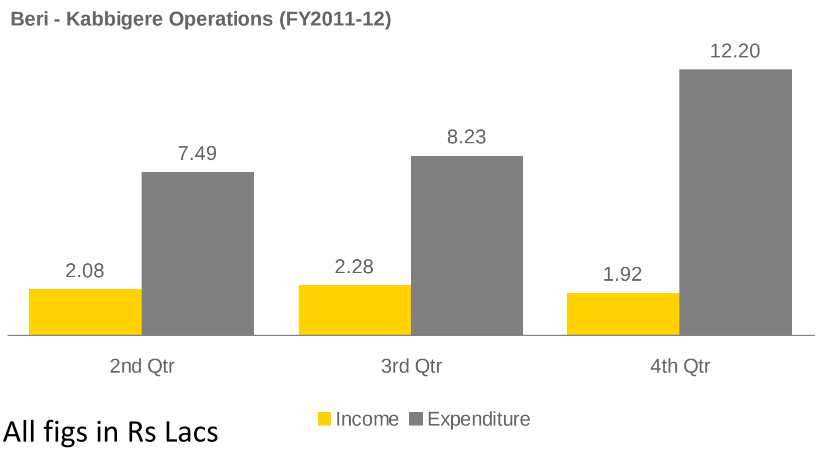


All costs in Rs/Kwh

Source: Team Analysis, Beri

The operational cost achieved during 1000 hours operation conducted under the supervision of CGPL, IISc was closer to industry benchmarks (Rs 7.15 per Kwh). Generation cost achieved was in-line with industry benchmarks, high auxiliary consumtion/losses though was still high (30% against industry benchmark of 12%).

Figure 4.3 – Quarter wise financial Performance Beri - Kabbigere



All figs in Rs Lacs

The above figures do not include deputationist's salary and other costs related to him.

The operations have been under severe losses. Operational losses for the period in consideration exceed Rs.21 Lacs. The average cost of power exported per unit for the 12 month period (May 2011 to April 2012) works out to Rs 10.64 (Best performance in March 2008, Rs 8.28 per unit exported). On the revenue side, it earns Rs 2.85 per unit from Bescom.

Cost per unit exported in better performing biomass gasification operations also are in the range of Rs 6.50 to Rs 7.00. **Hence, in terms of financial feasibility, selling to Bescom at the current rates, the operation will not be viable.**

4.2 Options for Beri

Improving operations and attaining industry benchmarks in efficiency is critical. Without this, the reason for existence will be questionable. The operation must set itself a quarter by quarter target of PLF improvement and cost reduction. Sub-Projects can be instituted with clear responsibility for improvement. The sub-projects may be:

- Increase in uptime of Gasifiers – May be broken gasifier wise further. Gasifier operation has been a bigger bottleneck compared to engine operation.
- Increase in uptime of Engines
- Reduction in cost of biomass procurement – Explore the possibility of getting more of locally available biomass (coconut husk, rice husk)
- Reduction in biomass cutting and handling cost – This may require some investment in handling systems.
- Improvement in power export ratio.
- Improvement in realizations from charcoal generated – The price of charcoal in urban areas is substantially higher ~ Rs10/kg. Better still, if the contract manufacturing for an agarbathi brand can be undertaken in the premises, it will

generate further job opportunities (particularly for women) and increase realizations further.

Each of these sub-projects, will need to pursued with clearly defined objective, timelines, approach/steps/milestones and accountability (Below is an illustration for planning/monitoring a sub-project).

Fig 4.4 – Sub-Project Plan (Illustrative)

Objective:
Improve realizations from charcoal sale

Project Team
-Mr. Ranga Raju

Pre-requisite:
- None
-

Approach / Steps / Mile Stones:
1. Identify wholesale markets for charcoal in Tumkur, Banaglore.
2. Identify industries requiring charcoal – Agarbathi makers.
3. Negotiate rates, delivery and payment modalities.
4. Conduct a pilot.
5. Operationalize & Review.

Illustrative Only

Schedule:
Status:

Start of Project: 20/08/2012
End of Project: 05/12/2012

1st Review: 28.08.2012

Potential:
-At a PLF of 60%, additional 1Rs/kg realization will lead to an earning of Rs 2 lacs per annum

Additionally, some niggling IR issues also may need to be addressed. Minor wage gap in relation to local industry, if it is affecting retention of people may be addressed. Additionally, a component of the compensation for the supervisors may be plant performance linked.

4.3 Long Terms Approach

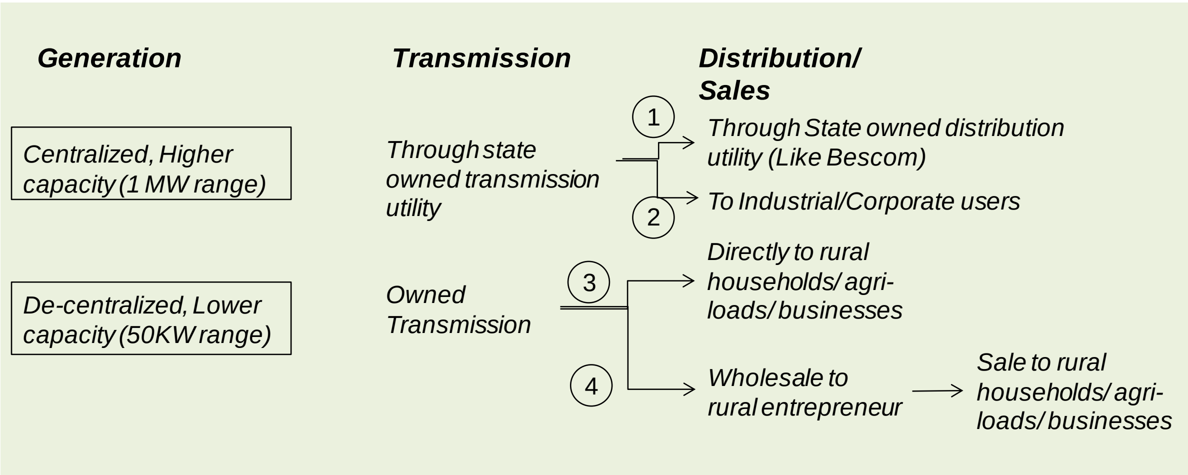
Apart from efficiency enhancements and improvement in operational health of the existing installations, the organization will also have to develop a medium/long term approach for further growth. The options for Beri could be

1. Continue the existing model. Negotiate better rate with discoms (Bescom currently).
2. Explore alternative markets (Corporate/Industrial users, viz. Wipro, Infosys..) who will pay higher rates. Earn RECs also.
3. Go for off-grid model, sell power directly to end users in rural areas.
   Look for markets to sell electricity directly to users, instead of to KPTCL. Forming a rural electric cooperative under BERI may help achieve this objective. The cooperative can distribute power directly to the adjoining areas and collect revenue

direct. It may even be eligible to get subsidy for its operations from the Rural Development and Panchayat Raj department.

4. Go for off-grid model, sell power to wholesalers.
5. Outsource entire operation to third party, giving him the right to sell electricity to whoever he wants, and asking the bidder maximum amount he will give to BERI for use of assets; it is given on a lease basis.

Fig 4.5 Option Summary - Beri



Going forward, the options for Beri could be:

1. Have centralized, higher capacity units (1 MW and above), wheel power through state owned transmission utilities and sell to state owned distribution utility. This is close to the current operating model. To operate on this model successfully, apart from operating at industry benchmark efficiency, the following also will be important:
   a. Tariff to have some link with market price of biomass, like high volume freight businesses (cement) offer contracts to their transporters – linked to diesel prices.
   b. Invest in load shifting mechanism so that power can be evacuated also when the grid is not live.
2. Have centralized, higher capacity units (1 MW and above), wheel power through state owned transmission utilities and sell to industrial/Corporate users. Selling to industrial users however may not be consistent with Beri's charter. Hence this option may not be a realistic possibility.

3. Have smaller de-centralized units servicing a cluster of villages having own transmission. The generating units would be located in close proximity to village clusters, a basic transmission system to connect to the villages clusters would be a part of the project. This kind of a system can be a boon for un-electrified villages (large parts Bihar, Jharkhand, Orissa, North-East). However, it can also be of high utility in areas with high power outage. Owing to low tariffs, even state owned distribution utilities tend to neglect rural areas. Such systems can act as a back-up to expensive diesel power. However, managing the commercial aspects (subscriber addition, billing, collection etc) can be a difficult task for a government sponsored agency. Government sponsored services are often prone to be assumed as "free for all", enforcing commercial discipline can become an issue.

4. Same as Option 3, but sale of power is on a wholesale basis to rural entrepreneurs.

   The option of selling power on a wholesale basis to rural entrepreneurs who in turn would manage retail subscribers can be a more workable proposition. The modalities for retail subscription charges may still be under the purview of Beri. In our opinion, this can be better model for Beri to expand its operation.

   With over a lakh villages in the country still to be electrified, nearly 18,000 villages which cannot be grid-connected and large swathes of rural areas with erratic supply and consequent dependence on high cost diesel and kerosene, this technology potentially has a large space to grow into. Beri over a period of time should look at playing a facilitator/catalyst role in expansion of its application through:

   - Developing a large pool of trained manpower for such operations.
   - Developing a strong pool of project implementation and maintenance manpower – It may not be possible to deploy high quality/skilled manpower at each site. Beri can develop a pool of such resources at its bases.
   - Reducing consumables cost in on-going operations and capex in new projects through higher volume procurement.
   - Developing low cost metering system.
   - Conducting field audit, estimating requirements and sizing the plants appropriately.
   - Developing feedstock linkages – Feedstock cost will be a key factor in successfully operating the technology. Escalation in biomass cost and consequent unviability has been the most common reason for project failure. Beri can take lead and work towards having dedicated energy plantation. MNRE has a separate group working in this area. Private biotechnology groups also claim breakthrough in the field (Beema bamboo claims to have developed a species of bamboo that can yield over 50 T per acre from year 4 onwards, at an operating cost of Rs 500/Ton).

Conclusion: The BERI operations of biomass gasification at Kabbigere in Tumkur district have established that the plant can be run, but the operations have been beset with problems of high labour turn over, frequent breakdowns of machines, increasing cost of biomass raw materials, the intended biomass energy plantation not providing sufficient input for the project, forcing the management to contracting for input biomass from far off places, the nonideal location of the plant itself—Tumkur is not rich in biomass—but for the fact that it was close to IISc for their experimentation, dependence on quality supervision (as evidenced by IISc's better operation of the same plant), the agency problem that is inherent in the Government's running such a plant, with the people expecting more than market prices both for their labour and for input materials, without corresponding accountability towards job, etc. have all made the project a sick child. The other two plants each of 250 kw in Seebinayana palya and Borigunte, have been stuck with the suppliers not honouring their contract obligations in ensuring the machines running the initial number of hours as per the contract and forfeiting the balance money, but resulting in the loss of nearly 80% of the capital cost becoming unproductive. The cost figures that we have shown for BERI operation, are exclusive of the cost allocations for the Coordinator, deputed by the Government, and thus are an underestimate of true costs.

There are 3 issues to be addressed:

1. What is to be done with the Kabbigere plant?
2. What is to be done with the Borigunte and Seebinayana palya plants?
3. What is to be the strategy of RDRP with respect to biomass gasification learning the lessons from the BERI operations?

Combining 1 and 2, all plants with their locations could be auctioned, with the condition that they must run the plant for a minimum period of 3 years with a minimum output in terms of kwh exported. This will help to prove the concept. No more money should be spent, even if bidders ask for restoring the health of the plants. We recognize that at present there is no great interest from bidders. With proper information to various parties who are at present in business, generating interest may not be impossible. As regards 3, it seems fair to say that the major lesson is that it should not be operating these plants. Should they be patronizing them?

The Cost Benefit Analysis reveals that Biomass gasifier based electricity is still in the same class as diesel, but for the carbon reduction benefit. The best option for electricity is still the grid based coal thermal and large hydro. Connecting to the grid not only negates the purpose of biomass gasifer based electricity, in terms of providing electricity for rural areas mainly, but also sharply reduced performance when the grid itself is unreliable; at the time when rural areas need most, even if biomass electricity is available, it cannot be connected, unless through extra investment of a load switch or by separate distribution lines duplication. The Electricity utility is not interested in making this investment. The best option seems to be to keep the ownership with BERI and outsource operation, distribution, marketing and collection of revenue to private sector, and collect from private sector a fixed amount of money for use of the existing assets, wait for some time for private sector to establish the benefits of this form of electricity through market based mechanisms and thus establish an alternative local source of electricity to the grid.