CHAPTER 6

RESULT - THE INTEGRATED ENERGY PLAN

6.1 INTEGRATED ENERGY PLAN FOR THE VILLAGE

In spite of the government of India’s ambitious target of providing electricity to all by the end of 2012, there are about 18,000 remote villages in India that are yet to be electrified. According to a Tata Energy Research Institute, TERI, estimate of 2007, The Electricity Act (EA) 2003, Integrated Energy Policy (IEP) of the government of India aims to electrify all these villages especially those that are Below Poverty Line (BPL) and are inaccessible through the central grid for electrification. The Government plans to provide up to 90% subsidy under the various schemes. But sadly, even those areas under electrified zones, often get low quality electricity supply, dotted by 10-12 hours blackouts. According to the EA 2003 decentralized renewable energy (DRE) sources could be used to electrify these remote village. The government of India is in favor of DRE for rural communities. Greenpeace is one of the most active international environmental NGO in India promoting DRE for electricity supply and has been very much active in many states of India. Thus it may be concluded that with increased oil prices, climate change, increasing greenhouse gas emission, the DRE option has been seen as a favorable one.

Therefore, on this basis, an integrated system has been designed for Bichithur-Borgang village, as already explained in details in chapter 5, using locally available resources and
involving community participation for sustainable, ecological, economical and sound development of the area.

The integral plan includes a 1.8MW Small Hydro project for electricity generation a part of which will be used in the village itself, for setting up small scale industries, while a part of the generated electricity will be sold at the nearest central grid and the money utilized for welfare schemes within the village. Another 50 kW electrical energy generated from Biomass gasification process, will be used for electrification of the village households and community areas. The cooking problem of the village will be solved by Community Biogas plant of a total of 100 m$^3$/ day from 5 digesters each of capacity 20 m$^3$/ day. A total of 80 households will be connected to the biogas plant while 120 houses will be provided with Improved Chulhas. The street lighting problem of the entire village will be solved by 20 numbers of Solar street lighting system for the entire village. Drinking water for the village will be provided from the river Sunani by pumping water by pump sets run by electricity generated by Biomass gasification. There will also be a biomass plantation of locally grown trees in 32 hectare land, for fund generation, to augment the costs of the biomass gasification unit. The design of the Integrated System has already been explained in chapter 5. The economics, cost and revenue generation of the integrated project has been incorporated in this chapter.

6.2 TOTAL COST ESTIMATE OF THE INTEGRATED PLAN

The cost estimates of each the different plants under the Integrated System, is shown in Table 6.1
### Table 6.1 Total Cost Estimate of the Integrated Plan

<table>
<thead>
<tr>
<th>Sl no:</th>
<th>Total cost estimates of-</th>
<th>Rupees in lakhs</th>
<th>Rupees in lakhs</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>with subsidy</td>
<td>without subsidy</td>
</tr>
<tr>
<td>1</td>
<td>Biogas plant (including vermi-compost plant)</td>
<td>10.96</td>
<td>17.03</td>
</tr>
<tr>
<td>2</td>
<td>Biomass gasification plant</td>
<td>80.40</td>
<td>87.90</td>
</tr>
<tr>
<td>3</td>
<td>Small hydropower plant</td>
<td>997.00</td>
<td>1547.00</td>
</tr>
<tr>
<td>4</td>
<td>Cost of evacuation and transmission of electricity from small hydro plant</td>
<td>276.13 (no subsidy)</td>
<td>276.13</td>
</tr>
<tr>
<td>5</td>
<td>New improved chulhas</td>
<td>0.12</td>
<td>0.24</td>
</tr>
<tr>
<td>6</td>
<td>Solar street-light system</td>
<td>0.4444</td>
<td>4.444</td>
</tr>
<tr>
<td>7</td>
<td>Commercial biomass plantation</td>
<td>14.4 (no subsidy)</td>
<td>14.4</td>
</tr>
<tr>
<td><strong>Total cost estimate of the integrated plan</strong></td>
<td><strong>1379.45</strong></td>
<td><strong>1947.14</strong></td>
<td></td>
</tr>
</tbody>
</table>

### 6.3 ECONOMICS OF THE INTEGRATED PLAN

The integrated plant consists of the following units:

- Small hydro power plant of capacity 1.8MW generating 4.24 MU per year
- Bio mass gasification unit of 2×25 kilowatts
- 100 m$^3$ bio gas plant for 80 households
- Solar street light system of 20 street lights for the village
- New improved Chulhas for 120 households
- It is proposed to set up a bamboo based industry in the village which will use 500 KW of energy at 50% load factor. Thus, out of 4.24 MU energy generated by the
small hydro power project, 2.24 MU will be used within the village itself for the bamboo based industry manufacturing bamboo sticks for curtains, partitions and decorative items and other bamboo products. The rest 2.00 MU will be evacuated to power utility at Amsoi gate about 25 km away from the village.

6.3.1 COST OF EVACUATION OF POWER FROM THE SMALL HYDRO PLANT

33 KV Substation:

Cost of substation = 107.13Lakhs (Annexure 8, Table1)

Taking salvage value of 10%, depreciation per year= 107.13×0.9=96.4

Taking plant life=35 years, 96.4/35=2.75 lakhs

Interest on capital=12% on 7% equity = 107.13×0.7×0.12=8.99 lakhs

O&M charge per year = 1 lakh

Total= 2.75+8.99+1=12.74 lakhs

Cost of 33KV transmission line

Cost of line = 169 lakhs (for 25 km @ Rs.6.76 lakhs per km. (Annexure 8, Table2)

Taking salvage value of 10%, depreciation per year = 169×0.9=152.1 lakhs

Taking unit life=35 years, 152.1/35=4.34 lakhs

Interest on capital=12% on 7% equity = 169×0.7×0.12=14.19 lakhs

O&M charge per year = 2 lakh

Total= 4.34+14.19+2=20.53 lakhs
Thus, total cost/charge per year for the substation and transmission
= 2.74 lakhs +20.53 lakhs=33.27 lakhs.

Now. Units generated by the small hydro plant= 4.24 MU per year
Units used by bamboo based industry = 2.24 MU per year
Therefore, energy evacuated and transmitted will be 2.00 MU per year
Therefore, cost/charge per unit for evacuation and transmission
= 33.27 lakhs/ 2.00 MU = Rs 1.66 per unit.

6.3.2 REVENUE GENERATED FROM THE SMALL HYDRO PLANT

From the bamboo based industry:

Power requirement = 500 KW
Energy requirement per year @ 50% load factor = 2.24 MU
Cost of generation = Rs6.98 per unit
Add 5% overhead charge = Rs7.32 per unit
Extra revenue to be generated = Rs.7.32 ×2.2 × 10^6
= Rs.161 lakhs per year

From sale to power utility:

Power transmitted= 2 MU
Loss in transmission and transformer @ 4% = 0.8 MU
Power sold = 1.92 MU
Cost/charge of power = Rs. 8.64 (cost of generation at Rs. 6.98 per unit + cost of transmission and evacuation at Rs. 1.66 per unit)

Add 5% overhead charge = Rs. 0.34

Total cost/charge of power = Rs. 8.94

Therefore, expected revenue to be generated = 1.92×10^6 × 8.94 = 172 lakhs per year

Thus, expected total revenue generated from the Small Hydro power Plant will be equal to

161 lakhs + 172 lakhs = 333.00 lakhs.

6.3.3 EXPECTED REVENUE GENERATED FROM THE BIO MASS GASIFICATION PLANT

From domestic consumers

Let energy consumed = 30 units per household per month = 30×200×12

= 72000 units per year.

Cost of generation = Rs. 4.9 per unit

Overhead charge @ 5% = 0.245

Total cost of generation = Rs. 5.14 per unit

Money to be collected from each household @ Rs. 155 /month

Expected revenue = Rs. 5.14×72000

= Rs. 3.70 lakhs per year
**Revenue from sources other than domestic**

Other consumers includes commercial, small industry, community consumption like festivals etc.

Energy consumed = 6000 units

Cost of generation = Rs. 4.9 per unit

Overhead cost @ 10% = Rs. 0.49

Total cost of generation = Rs. 5.39 per unit

Expected revenue = Rs. 5.39*6000

= Rs. 32,340

**The revenue generated from selling of excess of Kodom trees from 4 hectares of land**

=Rs10.24 Lakhs (approx.)

**Total revenue earned from the biomass gasification plant**

= Rs. 3,70,000 + Rs. 32,340 +Rs 10.24lakhs = Rs. 14.2 lakhs per year

Revenue generated maybe used for operational cost, to pay the number of employees, kept in savings account of the village energy committee, etc.

- One manager @ Rs 4000 per month
- Two Operational staff @ Rs 2000 per month
- Four laborers @ Rs.100 per month
6.3.4 EXPECTED REVENUE GENERATED FROM S.S.L SYSTEM

From domestic consumers: Money to be collected from each household@ Rs. 10 /month

= Rs. 2000 /month.

One employee kept at Rs. 500 per month.

Money kept in the savings account of village energy committee = Rs. 1500 per month

In five years, saving will be Rs. 1 lakh which will cover maintenance and replacement of battery cost of the system.

6.3.5 REVENUE GENERATION FROM THE COMMUNITY BIO GAS (CBG) PLANT INCLUDING VERMICOMPOST UNIT

From domestic consumers: Money to be collected from each household per month @ Rs 100/ month = Rs100 × 80×12 HH =Rs 96000

The revenue generated from the CBP unit including vermi-compost = Rs.983532

Total Revenue generated =Rs. 10,79,532

Revenue generated maybe used to pay the number of employees: Revenue generated maybe used for operational cost, to pay the number of employees, kept in savings account of the village energy committee, etc.

Number of employees in the biogas plant includes.
- One Supervisor paid @ Rs3000/month
- One Workers paid @ Rs 2000/month
- Four laborers paid @ Rs 100/day

Table 6.2 Shows the Cost and Revenue generated from each unit of the Integrated Plant.

Table 6.2 Cost and Revenue generated from each unit of the Integrated Plant

<table>
<thead>
<tr>
<th>Sl.no</th>
<th>System</th>
<th>Size</th>
<th>Cost (Rs in lakhs)</th>
<th>Capital subsidy</th>
<th>Cost after subsidy (Rs.)</th>
<th>Unit generation per year</th>
<th>Cost of generation per unit</th>
<th>Total revenue generated from the plant per year</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Small Hydro</td>
<td>1.8 MW</td>
<td>1547</td>
<td></td>
<td>997 lakhs</td>
<td>4.24 MU</td>
<td>Rs. 6.98</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Evacuation 33KV substation</td>
<td>1.5 MV</td>
<td>107.13</td>
<td></td>
<td>107.13 lakhs</td>
<td>2.0 MU</td>
<td>Rs. 1.66 cost of evacuation and transmission</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>3KV</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>outgoing</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Transmission 33 KV line</td>
<td>25 km</td>
<td>169</td>
<td></td>
<td>169 lakhs</td>
<td></td>
<td></td>
<td>Rs. 8.64 Total cost of evacuation and transmission</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Rs. 333.00 lakhs</td>
</tr>
<tr>
<td>2</td>
<td>Bio mass gasification unit</td>
<td>2×25=50 KW</td>
<td>87.9</td>
<td></td>
<td>80.4 lakhs</td>
<td>0.1022 MU</td>
<td>Rs. 4.9</td>
<td>Rs. 14.2 lakhs</td>
</tr>
<tr>
<td></td>
<td>Biomass plantation</td>
<td>in 32Ha</td>
<td>14.4</td>
<td></td>
<td>14.4 lakhs</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Table 6.3 shows the amount of money to be collected from each household / month for electricity and cooking gas, and Table 6.4 indicates the One-time expense of each household towards the Integrated Plant. Table 6.5 shows the Savings in Firewood and Kerosene due to Biogas units & Improved Chulha.

### Table 6.3 Total Amount of Money to be collected from each HH

<table>
<thead>
<tr>
<th>Item</th>
<th>Description</th>
<th>For sale</th>
<th>land</th>
<th>10.96 lakhs</th>
<th>Rs. 10.8 lakhs</th>
</tr>
</thead>
<tbody>
<tr>
<td>3</td>
<td>Bio gas plant (including vermi-compost unit)</td>
<td>5×20=100 m³</td>
<td>17.03</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>Solar street light system</td>
<td>20 street lights</td>
<td>4.4</td>
<td>Rs0.444 4 lakhs</td>
<td>Rs. 1.00</td>
</tr>
<tr>
<td>5</td>
<td>New improved chulhas</td>
<td>120 numbers</td>
<td>0.24</td>
<td>0.12 lakhs</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>358.24 lakhs</td>
</tr>
</tbody>
</table>

For bio mass gasification plant: Rs. 205 per household per month

For solar street light system: Rs. 10 per household per month

For bio gas plant: Rs. 100 per household per month

Total monthly expense per household: Rs. 315 per month/ HH
Table 6.4 Onetime Expense or each H.H towards the Integrated Plant.

<p>| | | | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>For bio mass gasification plant</td>
<td>Rs. 1000 per household</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>For solar street light system</td>
<td>Rs. 50 per household</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>For bio gas plant</td>
<td>Rs. 1000 per household</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>For small hydro power plant Rs.</td>
<td>---------</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total amount</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Total onetime expense</strong></td>
<td><strong>Rs 2050/HH</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 6.5  Savings in Firewood and Kerosene due to Biogas

**Biomass gasification units & Improved Chulhas**

<table>
<thead>
<tr>
<th>Sl.No.</th>
<th>System</th>
<th>Capacity</th>
<th>Total Project Cost Rs (lakh)</th>
<th>Annual saving of firewood,/ kerosene / electricity</th>
<th>Annual saving in monetary terms Rs in Lakhs approx.</th>
<th>Monthly saving /HH/ month</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Biogas Plant</td>
<td>20m³</td>
<td>12.26 Lakh</td>
<td>12x80HH×200kg firewood =192,000 kg</td>
<td>192,000 kg ×Rs 3.00= Rs 5.8 lakhs</td>
<td>Rs 242</td>
</tr>
<tr>
<td>2</td>
<td>Biomass gasifier</td>
<td>25KW</td>
<td>87.90 Lakhs</td>
<td>10litresx12x200 HH =24,000 liters Kerosene</td>
<td>Rs45×24.00 0= Rs 10.8 lakhs</td>
<td>Rs 450</td>
</tr>
<tr>
<td>4</td>
<td>Improved Chulhas</td>
<td>0.240 Lakhs</td>
<td>0.5(12×120HH×200 kg firewood) =144,000 kg</td>
<td>144,000 kg Rs 3.00= Rs 4.32 lakhs</td>
<td></td>
<td>Rs 300</td>
</tr>
</tbody>
</table>

Taking, Present cost of firewood =Rs 3.00/ kg (Rs 3000 /ton), Cost of kerosene = Rs 45/ litre
6.4 SOCIAL BENEFITS FROM THE PROJECT

- Production of energy.
- Improvement of hygienic conditions of the villagers.
- Transformation of renewables into valuable electrical energy and heat energy.
- Transformation of wastes into fertilizers.
- Reduction of work load mainly for women.
- Improvement in health of villagers.
- Reduction of work time spent by women in cooking, gathering firewood, making dung cakes.
- Improvement in economic conditions/standard of the villagers.
- Environmental advantage by protection of forests, air, water. Soil.
- Global Environmental Benefits
  - Street lights will promote safety in the village and extend fruitful working hours which is otherwise wasted in activities like drinking, gambling etc., due to lack of electricity.
  - Will encourage setting up of new industries in the area and this will lead to employment of local Youths.
  - Promote co-operation among the villagers.
6.5 CALCULATION OF CARBON CREDIT EARNING POTENTIAL OF THE PROJECT

Carbon Reduction Potential calculated as per (ICGSEE Hybrid Solar PV and Biomass System for Rural Electrification) [39]

\[
\text{CO}_2 \text{ emission from biomass per unit generation} = 6 \text{ g/kWh}
\]

\[
\text{CO}_2 \text{ emission from solar PV plant per unit generation} = 68 \text{ g/kWh}
\]

\[
\text{CO}_2 \text{ emission from small hydropower plant per unit generation} = 10 \text{ g/kWh}
\]

Per year we can generate power from 50 kW biomass gasification plant = \(50 \times 7 \times 365\) = 127,750.00 kWh

Per year we can generate power from solar PV plant, considering 70\% efficiency, = \(8.4 \text{ kWh} \times 365 = 3066.00 \text{kWh}\)

Per year we can generate power from small hydropower plant- =4.24 MU

= 4240000.00 KWh

Carbon emission from solar PV plant per year = \(3066.00 \times 0.068 = 208.5 \text{kg/year}\)

= .2085 tons/year

= .2085 carbon credits

Carbon emission from biomass plant per year- = \(127,750.00 \times 0.006\)

= 766.5 kg

= 0.766 tons/year

=0.766 carbon credits

Carbon emission from Small hydropower plant per year- = .010 \(\times 4240000.00\)
From total integrated system, the carbon emitted per year $\ = 0.2085 + 0.766 + 42.400$
$\ = 43.37 \text{ tons/year} \$

If the same energy is generated through conventional (coal), then carbon emitted per year

$\ = 1.5 \times (3066.00 + 127,750 + 4240000.00) = 6556224.00 \text{ kg/year} \ = 6556.20 \text{ tons/year} \$

So by installing the integrated renewable system, the carbon emission reduction

$\ = 6556.20 - 43.37$
$\ = 6512.80 \text{ tons/year} \$
$\ = 6512.80 \text{ Carbon-Credits.} \$

Total money earned through carbon credits $\ = 6512.80 \times 30 = 1,95,384.00 \ $ (USD)
$\ = Rs \ 1,15,08,117.6 = \textbf{Rs 115.08 lakhs/annum}$

(Taking 1 USD = 58.9 Indian rupees)

6.6 ANNEXURES

Schedule of 33 kV substation and Cost schedule A - 3 of 1 km of 33 kV line on rails with maximum span of 100 meters using dog conductor, 2009-10, Source Assam State Electricity Board, is given in Annexure 8.
6.7 MAPS

Figure 6.1 and 6.2 shows the Map of the area (Development Block) and Satellite map of Bichithur-Borgang village.

Figure 6.1 Map of the Bichithur-Borgang area, development block.
Figure 6.2 satellite map of bichithur-borgang village. (inserts showing the integrated energy plan.) Source...Google Maps. Longitude 92 degree 22’ E and latitude 26 degree 03’ N