OFF-GRID AND GRID CONNECTION IN SRI LANKA

Sri Lanka energy sector is dominated by conventional energy sources with more than 50% of the total consumption coming from biomass, 11.4% from hydro 31.6% from petroleum and rest from renewables like solar and wind. Only around 60% of the house holds in Sri Lanka have been electrified with the figure varying from 90% in Colombo to less than 40% in Monaragala district.

Main renewable sources capable of offering a sustainable contribution to the Sri Lanka electricity generation sector are: micro-hydro, wind, biomass and solar. Penetration of renewable energy in the electricity generation sector has been extremely limited by the constraints in financing mechanism and financial availability. The only exception has been the mini-hydro due to its relatively low capital investment and greater opportunities for grid connection, but overall its future expansion is limited as there are now few potential sources of fast moving water which are not already being utilised. Energy has been obtained from biomass for many years, initially for small scale operations such as cooking, but nowadays it has also found an outlet for larger scale use within industry for power and heat applications..

The Government has been reviewing the overall energy policy and this year (2006) is producing a revised policy document.. The new policy has recognised the need for a greater diversity in the source of fuel and in particular the need for a key third fuel source to support the role of hydro-power and oil. The third fuel is to be coal, but the need for renewables is accepted. The intention being that coal and renewables provide 20% of the power needs of the country by 2010 and 80% by 2025.

Electrification of Households

Electricity will be made available to all possible areas using the national grid extension projects and a focussed rural energy initiative using off-grid technologies.

- Medium-term targets for electrification of households through grid extension

Year	Total Households to be provided access to the grid
2010	80%

- Medium-term Targets for off-grid electrification of households

Year	Total Households using off-grid electricity systems
2010	6%

The Institutional responsibility for implementation of this expansion programme rests with the Ministry of Power and Energy which shall be required to prepare a long-term electrification plan, updated every year, and will be responsible for its implementation, with the support of the electricity supply utilities, Energy Conservation Fund, Provincial Councils, NGOs and appropriate financial institutions.

Table 1 Proposed mix of energy resources

Year	Conventional Hydroelectric	Oil	Coal and NRE	Comments
1995	94%	6%	0%	-
2000	45%	54%	1%	-
2005	51%	47%	2%	Moratorium on power plants burning oil or similarly priced oil/gas products
2010	40%	40%	20%	Progressive diversification into coal and NRE
2015	28%	8%	64%	Moratorium on power plants burning oil or similarly priced oil / gas products may be lifted
2020	19%	4%	77%	Caution on possible over-dominance by coal
2025	13%	7%	80%	- do -

CEB Power Plants

Sri Lanka initially developed the hydroelectric potential available in the catchments of two major river basins - Kelani and Mahaweli Rivers, and operated an entirely hydroelectric-based generating system until about 1995, with minimal thermal backup during dry periods. The hydroelectric generating capacity presently in operation in various river catchments, and their energy capability is given in Table 2 below (extracted from the Draft Energy Sector Master Plan of 2004) . Thus, Sri Lanka has 1,185 MW of major hydroelectric generating capacity, delivering about 4,193 GWh/year under average hydrological conditions. Operation of the 20 MW small hydroelectric capacity developed by CEB is highly dependent on water releases for irrigation. The availability of hydro electricity varies significantly, owing to the vagaries of rainfall. This along with the growing demand for electricity necessitated the development of thermal power plants, whose contribution has been steadily increasing, as see in Figure 1.

Figure 1 The changing mix of the source of electrical energy

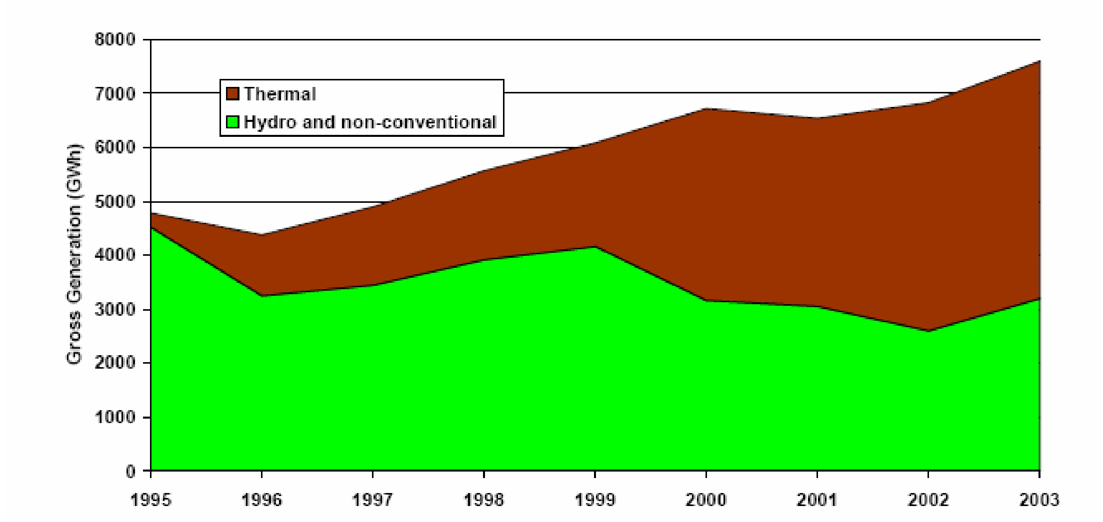


Table 2 CEB Hydro Power Units (ESMAP 2004)

Plant Name	Units x Capacity	Capacity (MW)	Annual Avg. Energy (GWh)	Storage (MCM)	Commissioning
Laxapana (KM) Complex					
Canyon	2 x 30	60	163	123.4 (Moussakelle)	Unit 1 Mar 1983 Unit 2 1988
Wimalasurendra	2 x 25	50	114	44.8 (Castlereigh)	Jan 1965
Old Laxapana	3 x 8.33+2 x 12.5	50	279	0.4 (Norton)	Dec 1950 Dec 1958
New Laxapana	2 x 50	100	467	1.2 (Canyon)	Unit 1 Feb 1974 Unit 2 Mar 1974
Polpitiya	2 x 37.5	75	409	0.4 (Laxapana)	Apr 1969
Laxapana Total		**335**	**1432**		
Mahaweli Complex					
Victoria	3 x 70	210	769	721.2	Unit 1 Jan 1985 Unit 2 Oct 1984 Unit 3 Feb 1986
Kotmale	3 x 67	201	494	172.6	Unit 1 Apr 1985 Unit 2 Feb 1988 Unit 3 Feb 1988
Randenigala	2 x 61	122	392	875.0	Jul 1986
Ukuwela	2 x 19	38	172	1.2	Unit 1 Jul 1976 Unit2 Aug 1976
Bowatenna	1 x 40	40	54	49.9	Jun 1981
Rantambe	2 x 24.5	49	219	21.0	Jan 1990
Mahaweli Total		**660**	**2100**		
Other Hydro					
Samanalawewa	2 x 60	120	361	278.0	Oct 1992
Kukule	2 x 35	70	303		
Other Hydro Total		**190**	**664**		
CEB Small Hydro Plants					
Inginiyagala	2x2.475+2x	11	-	-	Jun 1963
Uda Walawe	3 x 2	6	-	-	April 1969
Nilambe	2 x 1.6	3	-	-	July 1988
CEB Small Hydro Total		**20**	-		
		1205	**4196**		

Status as of end 2003.
Source: Adapted from CEB Report on Generation Expansion Planning Studies, June 2003.

Figure 1 (also extracted from the ESMAP) provides a clear view of how the importance of hydro power has been slowly diminished as ceiling to extensive expansion of this type of energy was reached and thermal plants had to be introduced.

Both the CEB and the Private Sector have been involved in the establishment of thermal units

Table 3 CEB Thermal Power Plants (source: ESMAP 2004)

Plant Name	Units x Capacity	Capacity (MW)	Annual Max. Energy (GWh)	Commissioning
Kelanitissa Power Station				
Gas turbine (Old)	6 x 20	120	748.8	Nov 80, Mar 81, Apr 81, Dec 81, Mar 82, Apr 82,
Gas turbine (New)	1 x 115	115	850.6	Aug-97
Steam (Fuel oil)	2 x 22	Retired 44 MW	0	Jun 62, Sep 63
Combined Cycle (Naphtha/diesel)	1 x 105, 1 x 60	165	1202	Dec 2002
Kelanitissa Total		**400**	**2801.4**	
Sapugaskanda Power Station				
Diesel	4 x 18	72	505.4	May 84, May 84, Sep 84, Oct 84
Diesel (Ext.)	8 x 10	80	546.6	4 Units Sept 97 4 Units Oct 99
Sapugaskanda Total		**152**	**1052**	
Small Thermal Plants				
Chunnakam	1 x 8	8	-	
Small Thermal Total		**8**	-	
Existing Total Thermal		**560**	**2652.7**	

Table 4 Private Sector Thermal Plants

Plant Name	Capacity (MW)	Annual Avg. Energy (GWh)	Commissioning
Independent Power Producers			
Lakdanavi Ltd.	22.5	156	1997
Asia Power Ltd.	50.8	330	1998
Colombo Power Ltd. (Barge)	60	420	Jun 2000
ACE Power Matara	20	167	Mar 2002
ACE Power Horana	20	167	Dec 2002
AES Kelanitissa	165	1200	Aug 2003
Total IPP	**338.3**	**2440**	

The following table (Table 5) provides a clear analysis of how electrical energy has been provided over the period 1995-2003

Table 5 The source of electrical power in Sri Lanka for 1995-2003

	1995	1996	1997	1998	1999	2000	2001	2002	2003
CEB HYDRO	4514.0	3249.2	3443.0	3908.7	4152.2	3153.8	3044.9	2588.6	3188.5
CEB NON-CONVENTIONAL					3.5	3.4	3.5	3.6	3.4
CEB THERMAL	269.1	972.1	1050.5	1245.7	1390.2	2205.3	1895.5	1952.6	2193.2
IPP THERMAL				382.7	489.3	822.4	1057.8	1243.3	1710.8
SPP HYDRO		2.7	4.5	6.3	17.8	43.1	64.7	103.5	112.8
SPP THERMAL		0.0	0.0	0.0	0.0	0.1	0.1	0.4	0.0
HIRED THERMAL		152.0	398.0	18.0	34.0	484.6	471.1	939.2	390.3
GROSS GENERATION TO CEB GRID	**4783.1**	**4375.9**	**4895.9**	**5561.4**	**6087.0**	**6712.9**	**6537.5**	**6831.3**	**7599.0**
Hydro and non-conventional	4514.0	3249.2	3443.0	3908.7	4155.7	3157.2	3048.3	2592.3	3191.8
Thermal	269.1	1126.8	1452.9	1652.7	1931.3	3555.7	3489.1	4239.0	4407.2
Hydro and non-conventional	94.4%	74.3%	70.3%	70.3%	68.3%	47.0%	46.6%	37.9%	42.0%
Thermal	5.6%	25.7%	29.7%	29.7%	31.7%	53.0%	53.4%	62.1%	58.0%

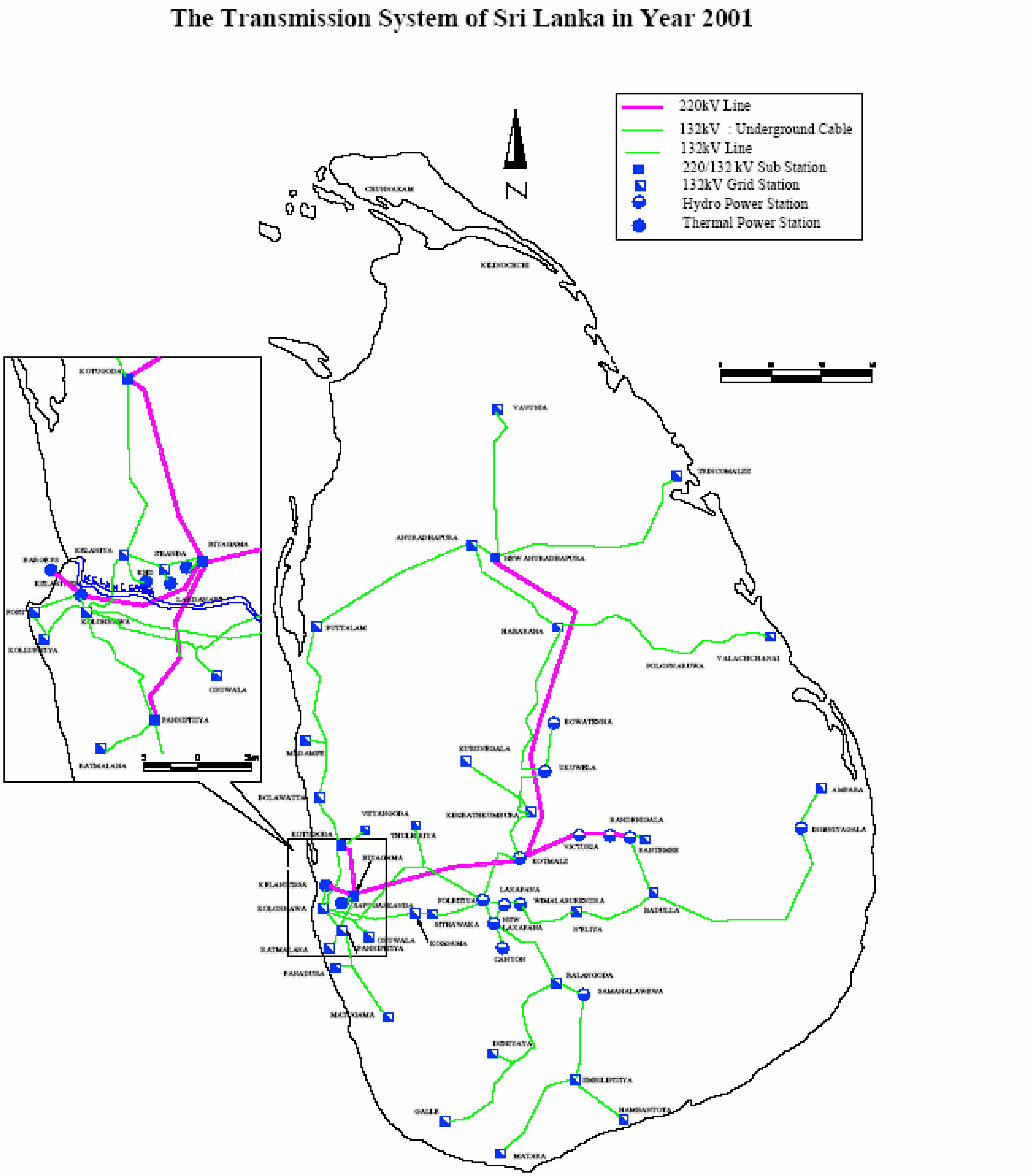


Figure 2 National Grid (2001) , Source ESMAP (2004)

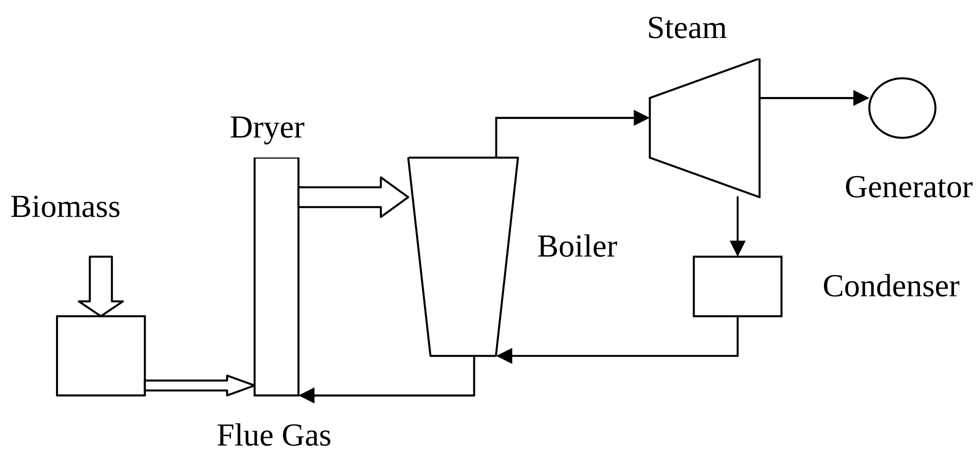
TECHNICAL ASPECTS OF GRID CONNECTED BIOMASS POWER PLANTS

First of all looking at the broad classification of ways in which biomass can be used to provide electricity, we have: -

1. Direct Combustion Systems (Steam Turbine Technology)
2. Gasification (Internal Combustion Engine technology)
3. Integrated gasification Combined cycle Technology.

1. Direct Combustion System

Wood in the appropriate form (chipped, hogged) and moisture content (preferably less than 20% of wet weight) is fed in to the furnace section of the boiler where it is burnt. The wood firing boilers (bulkier in size including large combustion chambers and have more auxiliary components) must be designed for higher excess air, higher fuel moisture content and the removal of ash. So the direct combustion involves large capital costs with compared to equivalent thermal capacity.

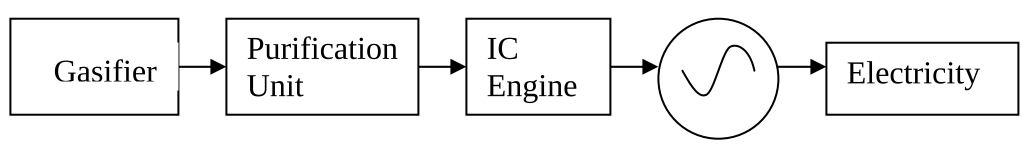


Conventional Steam Cycle

2. Gasification

The gas from the Gasifier is first washed, cooled and filtered and this combustible gas can be used as the fuel in the conventional internal combustion engine (‘IC engine), which is converted in to heat. The application of this method is suitable for small (Micro) scale power plants with few kilo Watts up to 2 or 3 MW systems.

Gasification (Internal Combustion Engine technology)



3. Integrated Gasification Combined Cycle Technology (IGCC)

The bio fuel is first gasified, and the combustible gas fuels a gas turbine to generate shaft power. Steam is also generated from the hot exhaust of the gas turbine with a heat recovery steam generator and then this steam is used to generate additional shaft power from a steam turbine. Though the cost is high compared to the other two technologies, overall efficiency too is higher. This option is suitable for large-scale systems of above 10 MWe

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Gasification

Gasifier technology has undergone many improvements in the last 50 years because of increased fuel prices and environmental concerns. The basic process of gasification is separately described **BUTTON INSERT HERE**

The process will have an efficiency which will vary around 16% to 24% in present systems. This will be the overall efficiency in production of electricity, but using flue gas to dry the fuel wood we can increase the usage of energy in fuel wood.

Overall efficiency of plant

Unit	**Efficiency (%)**
Gasifier unit	75
Engine	33
Generator	92
Overall	**22.5%**

(Material to be written) --- **I think all these technical aspects are probably variously covered elsewhere ????**

Organic Rankine cycle

. Gas turbine (Direct/Indirect)

Boiler technology

Combustion systems

Cross comparison and selection guidelines

performance enhancement

Air pre-heater

Steam re-heat

Heat recovery

Turbine

Types & Classification

Cross comparison and selection guidelines
Alternator

LOCAL SITE FACTORS

Water Requirements

Large quantities of water are used in the process of electricity generation, particularly for cooling in condensing exhaust steam from the turbines. Provision of an adequate supply of cool water for this duty will be a key issue in siting any dendropower unit.

Another water related issue is the requirement for high-purity feed water for the boiler to prevent deposit and corrosion of boiler equipment.

Water-Cooling Technology

Large power stations are frequently located on coastal or estuarine locations with cooling through extraction and direct discharge, but in other locations systems of recirculation with water-cooling technology may be required.

In a once-through cooling water system, the cool water is pumped continuously from the sea, river or other resource to the condensers and other equipment and then after use the heated water is discharged at an appropriate location to avoid re-intake. When the cooling capacity of such natural water resources is insufficient some type of circulating cooling-water system must be adopted to enable repeated use of the water such that it undergoes some artificial cooling before re-use.

With circulating cooling-water systems the heated water is cooled through partial evaporation in cooling ponds or cooling towers and then re-used. The design and operation of these will depend upon the particular duty and the ambient conditions at the site. Spray-type or atmospheric cooling towers can supply cooling water effectively for inland located power systems. Flow of air up through these cooling towers may be by either natural draught or induced draught. Induced draught implies the use of fans to promote air flow.

Cooling towers used in large power stations are often tall parabolic shaped structures that induce a natural draught flow of air up through streams of sprayed hot water that is pumped into the lower part of the tower. The hot water is sprayed and atomized and flows downwards over different types of packing. In this downward flow it is cooled evaporatively by the counter-current upward passage of air. With smaller-scale power plant such as apply for dendropower in Sri Lanka, other designs with more intensive packing and/or forced draught airflow may be more applicable.

Cooling-water requirements can be substantially reduced with use of cooling towers, though some make-up water will always be required. This is to needed to replenish the water loss by evaporation, but also there will be some drain off or purge from the circulating water to avoid build up of too high levels of dissolved salts, etc. The make-up could be around 5% of the water that would be required with a once-through system, so this technology will greatly reduce water requirements. The capital and running cost of cooling equipment have to be provided for in the overall economics of operating the power plant. Power requirements for pumps, blowers, etc. will reduce the net power export potential of any plant.

Specification and estimates for the cost and water make-up requirement of cooling systems will need to be obtained with any quotation. Consent agreements may need to be obtained for extraction of water. This matter and the cost of any water supply from the service utility should be negotiated and agreed at the design stage of any project.

Widen this here to include air cooling systems

Boiler Feed Water

Whilst relatively small quantities of water are needed for boiler feed water, dependable and economic operation of steam power plant requires high-purity feed water to prevent deposit of solids on the walls of heating surfaces and their intensive corrosion.

In regular operation of the boiler, feed water will be mainly derived from recirculation of the turbine condensate, but there are losses in any system and water must be added. Natural water will need treatment using ion exchange systems to remove impurities. The extent and cost of plant for this treatment will be a function of the quality of the available water supply and any potential source of make-up water for the boiler will require prior analysis. Establishing that a good quality water supply can be sustained from the treatment plant is an important part of plant specification and quotations.

Grid Connection Issues

In contrast to the relatively large power units currently supplying the grid, dendropower generation will be supplied from lower capacity stations, say around 10 MW and below. These stations will be at dispersed locations and will represent embedded generation within the existing network. They will most probably need to be connected into the grid at 33 kV and lower voltages. A combination of smaller capacity units would put less stress on the network.

There are no firm definitions for what capacity can be connected at what voltage. In any specific instance it will be necessary to make a local network study to establish the feasibility and cost of connection to the grid. Factors that will be relevant to this are:

- Design and voltage of the local network
- Nature of loads presently on network (size and load profile)
- Existing local substation arrangements
- Present fault levels and fault rating of equipment on network
- Number and type of generating units to be installed
- Likely output profile and fault contribution of new generator
- Details of any transformers to be connected

It is possible for smaller generators of around 100 kW to be connected at low voltage. The power exported could be metered and transformed up to 11 kV, and this would involve minimal connection cost. The network operator when accepting power supplied in this way would need to cater for any instability such connection creates to other users.

This issue of network stability gains importance, as the scale of power generation increases and above 100 kW connection will almost certainly be to 11 kV. Total additional embedded power generation within any local network of say 10 MW might be tolerated in these circumstances if connected directly to 11 kV switchgear at one of the 126 primary 33/11 kV sub station. A significant aspect for any power plant will be its location in relation to a primary substation. There will be less voltage control problems in making connection to the substation end of a well loaded 11 kV line feeder than to the far end of a lightly loaded 11 kV line feeding dispersed rural customers.

If 11 kV connection is not feasible and connection to the 33 kV system is required, then proximity of the generating unit to one of the 35 existing 132/33 kV substations may be desirable. The capacity of the network at such points will need to be reviewed but it is important to note that, since there is a rolling programme of upgrading and augmentation, the existing capacity of the network in specific locations may be subject to change.

It should be added that the network stability at the point of connection is also an important consideration for the power generator due to problems that arise for maintaining plant operation when the grid fails. In general, local network circumstances must be fully addressed when making grid connection and this will need to be done in close collaboration with the network operator. The recent publication 'CEB Guide for Grid Interconnection of Embedded Generators' addresses this matter.

1 MWe Biomass-Fired Boiler-Steam Turbine System feeding the National Grid

SOCIAL & ENVIRONMENTAL ASPECTS

Environment Impacts of Biomass Production

(a) Positive Environmental effects

- Protection of water quality due to the cultivation of energy crops
- Reduction of floods during wet seasons and maintenance of water supplies during dry seasons
- Erosion prevention due to the cultivation of energy crops
- Improvement of local microclimate through evaporative cooling and humidification
- Wind breaks and shelters that reduce erosion and conserve water, particularly in dry regions
- Improvement of soil properties
- There will be a considerable reduction in net CO_2 emissions that contribute to the greenhouse effect
- Protection of wildlife and other components of biodiversity

(b) Negative environmental effects

- Possible competition with agricultural crops through water use
- Increased chemical pollution from fertilizers and pesticides
- Reduction of biodiversity through alteration of forest structure, creation of tree monocultures, and use of non-native tree species which local wildlife are unable to use

Environmental Impacts of Power Generation

(a) Solid Wastes

The main solid waste produced from biomass generation, fuel-wood ash, may be treated, or disposed off as fertilizer, back to the land. In case of village dendro-power plants, part of the produced ash is returned back to the plantation. Ash improves the quality of the soil, adds nitrogen to the soil, and reduces the acidity of the soil as well.

(b) Prime Movers

The main environmental concerns as far as actual power generation is concerned relate to gaseous emissions, thermal pollution from cooling water and noise. The noise levels have to be restricted to 63dB in day time and 49dB in night time to comply with environmental regulations. Emissions can be controlled by tuning the engine and adjusting air to fuel ratios and fitting of catalytic converters and incinerators. The wastewater resulted from the plant operation are also to be sent to the same waterway. The most important issue is the management of cooling water. The water used for the cooling purposes of the plant is treated and the temperature of that water has been brought to the normal water temperature before it has been diverted to the waterway. An adequate means of treatment/cooling arrangements are being designed within the Power Plant itself. It is very important to accompany these treatment/cooling arrangements for the power plant as the heat water diverted directly to the natural waterways is ultimately harmful for the flora and fauna related with those waterways.

(c) Visual Impact

Large biomass plantations will affect the look of the landscape. As with most systems it is a case of thought, environmental impact analysis, planning, regulatory compliance, economics, and human interest, which tips the balance between an environmentally sound facility and an environmentally damaging system.

(d) Gaseous Emissions

The airborne emissions from thermal systems include internal combustion engines, typified by the products of combustion: particulates (fly ash), hydrocarbons and other organic products of partial combustion and oxides of nitrogen (NO_X), gasification, pyrolysis and catalytic systems may also produce such products, the extent of which depends on the design of the system. Combustion in the engine also produces CO_2 and to a varying extent, depending on combustion efficiency of CO. Estimated emission of pollutants from wood-based and coal –based power generation is given in following table

Pollutant	**Emissions(tones/GWh)**	
	Dendro Thermal	**Fluidized Bed Coal**
Carbon dioxide(CO_2)	0	739.52
Carbon Monoxide(CO)	30.31	0.08
Hydrocarbons(HC)	0.15	0.01
Nitrogen Oxides(NO_x)	3.32	5.3
Sulpher Oxides(SO_x)	None	11.18
Particulate Matter	0.51	4.58

Table xx: Emission of pollutants from wood-based and coal –based power generation Source: VIT Research Notes 1648-Feasibility of Electricity Production from Biomass by Gasification Systems

Flue gas treatment include a particle trap, heat exchanger to cool flue gas or the use of exhaust flue gas to remove the moisture level in energy crops, a wet scrubber to remove particulates, an induced draught fan to send flue gases to the atmosphere, treatment of scrubber water including settling and separation of fine fly-ash particles.

(e) Residue and Waste Utilization

The environmental impacts of over-utilization of organic wastes lie in loss of soil humus, reduction of fertility, increased erosion and loss of water holding capacity.
Residues associated with biomass use can be used as fertilizer. The ash from wood is a valuable source of potash, whilst both liquid and solid digestate from anaerobic processes have

value as fertilizer or soil conditioner. The digestion process is also effective in destroying pathogenic micro-organisms and eggs of parasitic worms. Plantation residues may contain 40% of the nitrogen, 10% of the phosphorous and potassium applied as fertilizer. However, conversely there is a limit to the amount of sludges, manures and fibrous crop residues, which can be incorporated into agricultural and management systems.

(f) Sound Pollution

Moving and rotating mechanical components which are installed inside the powerhouse definitely leads to generate a much noise. It may cause the villagers living closer to the powerhouse to become discomfort. Yet housing generation plant in the building can reduce impact on noise and further, sound proof panels could be built to lower the sound to an acceptable level.

Environmental Impacts of Energy Plantation

(a) Plantation Factors

The type of trees grown is a decisive variable in predicting environmental impacts from fuel-wood production; trees have different effects on erosion, water availability and quality, wildlife habitat, and air quality. The types and amounts of pesticides and fertilizers applied and the timing of applications will affect water quality.

(b) Plantation Site factors

Soil type, climate, and topography will affect erosion and runoff. Soil erosion will become a problem when it comes to wet zones. The soil type will influence the need for fertilizers and the rate at which pesticides and fertilizers leach to groundwater. High organic matter content increases the soil's retention of pesticides and nutrients. In the dry zone where temperatures are higher, pesticides break down and volatilize more rapidly.

Woody energy crops are not a substitute for natural forests. Producing energy plantations can harm wildlife if the crops displace a food source in the original land use. If the energy plantation displaced large areas of feeding land, food source for fauna would disappear.

(c) Water Consumption by Fast Growing Tree Species

Trees use water for the production of biomass and in the process, water is lost to the atmosphere through transportation. Fast growing trees accumulate biomass faster and cause higher water consumption irrespective of the species. Therefore, water consumption of a fuel wood plantation is directly related to biomass produced per unit area. Following table shows the most non-forest species consumes more water for the production of unit weight of biomass compared with the species recommended for biomass plantations.

Species	**Water use per total biomass (liters/kg)**	**Harvest Index**	**Water use per harvested biomass(liters/kg)**
Cotton/Coffee/Bananas	3200	0.25	800
Pongomia	2600	0.50	1300
Sunflower	2400	0.25	600
Paddy Rice	2000	0.30	600
Conifers	1540	0.65	1000
Dalbergia	1490	0.60	890
Acacia	1330	0..65	860
Sorghum	1000	0.25	250
Gliricidia	970	0.60	580
Eucalyptus	790	0.65	510

Table xx: Water use by plants through Evapotranspiration (Liters/kg of total biomass or harvested commodity produced) *(Source: CRI annual report 2001)*

(d) Reduction of Atmospheric Carbon Dioxide

Dendro Power is neutral of CO_2. Therefore, replacement of fossil fuels with biomass-derived fuels will not decrease the level of CO_2. However, increased used of biomass could, through reduction of dependence on fossil fuels, reduce the rate of increase in level of atmospheric CO_2.

SOCIAL ANALYSIS

Introduction

In comparison with other electricity generation technologies available, the small-scale fuel wood fired gasification IC engine based electricity generation plant requires major involvement from local resources. Participation of the local community, not only in plantation establishment but also in harvesting, transport, and fuel preparation can create useful work and high involvement. Small-scale stand-alone power plants are very suitable for electrification of rural villages and tend to attract funding support from a range of sources including the villagers themselves.

With the medium sized plants (1MW+), the fuelwood requirement can be considerable (around 50 tonnes/day) and reliability of supply is critical. The dendropower plant established at Walapane has provided some valuable lessons that can affect the success of such projects.

Reference should be made to the study that has been made on this project, which has indicated the importance of careful assessment of the needs of the communities and attention to the arrangement for collection of biomass and setting an acceptable payment. **Insert button here**

Energy Consumption Patterns of the Society

The initial question to be answered is the total energy demand of the village and the plant generation capacity that will be required Consideration needs to be given to the cost of energy production from current resources and the cost that can be bourne by the villagers..
The villagers must have a positive frame of mind about the project, since success depends upon the active attendance of all the villagers.

RISKS ASSOCIATED WITH BIOMASS POWER PLANTS

The major factors that determines the sustainability of the project is the continuity of the fuel wood supply, the issue of loan repayment. The risks involved in a village based off grid Dendro project stem from an over-estimate of the potential production from the plantation (possibly accentuated due to drought or other unfavourable growing conditions outside the control of the project), pressure from the need to repay the loan and mechanical breakdown of the Gasifier .

(a) Continuity of the fuel wood supply

The fuel wood supply is very critical. The possible difficulties to maintain the continuity of the supply would be,

- When villagers fail to supply the fuel wood
- When the fuel wood plantation is destroyed for some reason
- Limitations of storage facilities
- Fuel wood transportation difficulties
- Difficulties of finding substitutes for fuel wood

Occasions where villagers fail to supply the fuel wood

Once the power plant is commissioned, during first few years, there won't be any difficulties to maintain the continuity of the supply chain, because of the good impression and the motivation of the villagers. After this situation might change owing to factor like;

- Interpersonal conflicts
- Sluggishness of the villagers to supply fuel wood
- Land availability
- Demand increase in the price of fuel wood

Political influences

Unstable political atmosphere greatly influences the off grid power projects. While the construction is gong on, one candidate might visit the village and promise grid electricity. Subsequently the villagers' interest on the off-grid project disappears and the project comes to a hold.

On the other hand, if the political establishments can be convinced over the benefits, they may even promote the project providing facilities and removing bureaucratic red tapes.

CEB influences

The project implementers have to come to an agreement with the CEB that it is not providing grid electricity to this particular village at least for next 15 years, till the project is fully implemented, tested, and established as a well-running community project.