TECHNOLOGY FACTSHEET

CO-FIRING OF BIOMASS WITH COAL FOR ELECTRICITY GENERATION[1]

1. **Sector:** Energy Supply

2. **Introduction**

In this technology biomass is used as the fuel along with coal for the generation of electricity. Presently, only coal is used as the fuel in the 300 MW coal power plant at Norachcholai, in Sri Lanka. It is proposed to install 2 more units each of 300 MW capacity in the same location. Furthermore another power plant operating only on coal is planned at different location in Sri Lanka. In the proposed technology, it is intended to use biomass and coal as fuels.

3. **Technology Name**: Co-Firing of Biomass with Coal in Steam Boilers for the Generation of Electricity.

4. **Technology Characteristics: (Feasibility of technology and operational necessities)**

Feasibility of Technology:

As both coal and biomass are both solid fuels and their calorific values on weight basis do not differ much, it may appear easy to use biomass in a boiler designed for coal. However, combusting coal and biomass together encounters the following problems:

(a) **Fuel preparation, processing and handling issues**: In pulverized fuel boilers, the solid fuel need to be made into a powder before burning. Coal is a very brittle material. It is easy to grind it into powder form. On the other hand, biomass is very fibrous and flexible. It is not easy to grind. Biomass could be cut or sheared. Hence the type of equipment used to powder these two fuels are different. In other words if we the the same equipment to powder coal and biomass, then there will some restrictions. For this reason, if biomass and coal are mixed prior to powdering, then the maximum share of biomass in energy terms cannot exceed 10% of the energy content in the mixture.

(b) **Combustion related issues**: As the proximate analysis of coal and biomass are different, the bahaviour of the flame with and without biomass would be different. With higher percentage of biomass in the fuel mix, the stability of flame is very much affected. The likelihood of slagging in the combustion chamber is also high with higher share of biomass.

(c) **Ash related issues:** The physical and chemical properties of coal ash and biomass ash are different. Hence the ash handling equipment has limitations in simultaneous handling of

[1] **This fact sheet has been extracted from TNA Report – Mitigation for Sri Lanka. You can access the complete report from the TNA project website** http://tech-action.org/

coal ash wood ash. Ash from biomass combustion has a tendency of getting deposited in the heat exchanger region.

(d) **High Temperature Corrosion issues:** The presence of certain elements such as potassium in biomass leads to high temperature corrosion the superheater region. This aspect should be monitored.

(e) **Emission control issues:** The pollution control equipment such as de- NOx, de-Sox and electrostatic precipitator etc. has limitations when biomass and coal are simultaneously combusted.

(f) **Residue Utilization issues:** The operation of a coal power plant produces residues such as ash, desulphurization residue etc. A high share of biomass in the fuel mix significantly changes the characteristics of these residues. If not controlled, it might create problems in the utilization of these residues.

(g) **Capacity Reduction:** Biomass burns at a temperature lower than the temperature of combustion of coal. This results in some degree of capacity reduction.

Bearing in mind the above issues, the following technology options have been developed:

(a) **Use of Common Comminution Facility:** In this option, biomass is introduced upstream of the comminution facility. Hence biomass and coal are jointly pulverized in the same facility and the mixed fuel is handled jointly in the combustion process.

(b) **Use of Separate Metering and Comminution:** In this option, the fuels are handled separately until they are pulverized. Thereafter the two fuels are mixed and injected into the pulverized fuel pipework upstream of the burners.

(c) **Use of Separate Burners:** In this method pulverized fuels are prepared as per method (b) above and the two fuels are burnt using dedicated burners taking into account the characteristics of the two fuels.

(d) **Use of Biomass Gasifiers:** In this method biomass is separately pretreated, and converted into a low calorific value fuel gas (Producer gas) in a gasifier. The fuel gas is cleaned and combusted using suitably designed gas burners in the coal boiler. The share of biomass based fuel in the total fuel usage could be significantly higher in this process. However, higher share of biomass based fuel would result in some de-rating the boiler steam output.

(e) **Parallel Co-firing:** In this method, a separate boiler designed to use only biomass as the fuel is used to generate steam at the same temperature and pressure as that of the steam generated by the coal fired boiler. Steam generated from the coal boiler and biomass boiler are connected to a common steam header. Steam requirement of turbines are supplied from this common header. This last method, though the most expensive option, it has the following advantageous:

- This process does not encounter any of the problems enumerated earlier in co-firing.

- The share of biomass could be varied in the range almost zero to 100%.
- This method does not interfere with the operation of the coal fired facility. All guarantees applicable for the equipment initially provided for the coal firing facility could be continued as the use of biomass does not interfere with such equipment.

A number of co-firing facilities have been successfully installed and operated in many parts of the world. Following are some of such facilities:

(1) Gelderland Power Station, Nijmegen, The Netherlands:
- Total capacity: 635 MWe.
- Share of biomass: 20 MWe.
- Technology Option: Option (b) - Use of Separate Metering and Comminution.

(2) Wallerawang Power Station, NSW, Australia:
- Total capacity: 500 MWe.
- Share of biomass: 7% by weight.
- Technology Option: Option (a) - Use of Common Comminution Facility.

(3) Studstrp Power Plant, Jutland, Denmark:
- Total capacity: 350 MWe.
- Share of biomass: 10% by weight.
- Technology Option: Option (c) - Use of Separate Burners.

(4) St. Andra Power Plant, Carinthia, Austria:
- Total capacity: 124 MWe.
- Share of biomass: 3% by weight.
- Technology Option: Option (c) - Use of Separate Burners.

(5) Zeltweg Power Plant, Styria, Austria:
- Total capacity: 137 MWe.
- Share of biomass: 3% by weight.
- Technology Option: Option (d) - Use of Biomass Gasifiers.

(6) Amer Power Plant, Geertruidenberg, The Netherlands
- Total capacity: 600 MWe.
- Share of biomass: 5% by weight.
- Technology Option: Option (d) - Use of Biomass Gasifiers.

(7) Avedore Power Plant, Copenhagen, Denmark
- Total capacity: 430 MWe.
- Share of biomass: 40MWe.
- Technology Option: Option (e) – Parallel Co-firing.

Operational Necessity

The necessity to substitute at least a part of the coal fuel used for electricity generation is as follows:

- All the countries in the world, including developing countries are likely to be expected to reduce GHG emissions from 2015-2020.
- The carbon footprints of goods manufactured in Sri Lanka would play an important role in the international market.
- In the recent past countries such as China and India have started importing large quantities of coal. This has resulted in an increase in the price of coal. Moreover, with such increase in demand, the amount of coal available for purchase in this region has become an issue.

5. Country Specific Applicability:

Electrical Energy Supply Sector

The data provided by the Sri Lanka Sustainable Energy Authority (SEA) in their web: www.energy.gov.lk show that at present the national peak electricity demand is 2033 MW (28th September 2011) and the corresponding daily electrical energy consumption is 33.35 GWh/ day. The same data published during this year (2011) also show that the annual electricity peak demand growth is growing at about 400 MW per year and the daily electrical energy demand is growing at around 8 GWh/day/year.

In order to meet the above mentioned growth, the Ceylon Electricity Board (CEB), the sole utility responsible for the generation and distributing most of the electricity generated to the final consumers have been annually preparing and releasing their Long Term Generation Plan (LTGP). According to the last published LTGP, most of the future generation of electricity would be generated from coal based power plants as shown in figure 2.

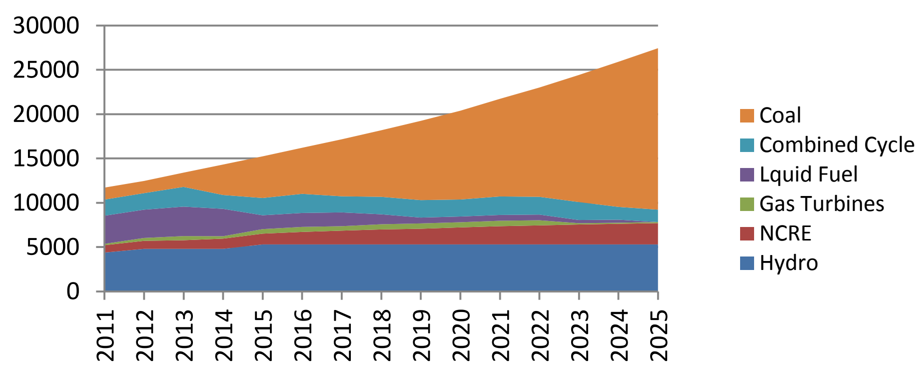

Figure 2: Annual Energy Generation (GWh/y)

In fact as per the above plan, EB has already commissioned and operating a 300 MW coal based power plant. The second phase of coal based power plant with a capacity of 2x300MW is under construction. Action has been initiated to construct another 2 x 500 MW coal based power plant in the country.

While the state owned utility CEB is planning to commission as many coal based power plants as necessary to meet the growing demand for electricity, the Ministry of Power and Energy, through the SEA is encouraging the private investors to develop renewable energy based power plants. In an attempt to generate at least 10% of the electrical energy requirements by the 2015, the SEA has offered an incentive scheme for the private sector to harness renewable energy resources and generate electrical energy and feed the national grid. A concessionary tariff based on the estimated cost of generation has been offered for each of the following technologies:

- Small Hydro: Rs. 13.04 / kWh
- Wind: Rs. 19.43 / kWh
- Biomass: Rs. 20.77 / kWh
- Agro/Industrial Waste: Rs. 14.60 / kWh
- Municipal Waste: Rs. 19.73 / kWh

In spite of the attractive tariff offered for biomass based electricity generation, only one power plant with a capacity of 0.5 MW has been commissioned a month ago. On the other hand by the end of 2010, a total of 86 small hydro power plants with a total capacity o 175.8 MW and 4 wind power plants with a total capacity of 30.15 MW and 2 agro residue based power plants with a total capacity of 11 MW have been commissioned.

A number of reasons have been attributed to the reluctance of investors to engage in biomass based energy generation. One important reason is that the difficulty in getting the desired energy output levels due to the high moisture levels prevailing in the biomass fuels. The development of this technology to dry the biomass fuels using waste energy available in the flue gas would resolve this issue.

Location of Coal Power Plant

The 3 x 300 MW coal power plants are located in a place called Nurachcholai, in Puttalum District. This is located in the Western coast of the island. With the intention of reducing cost, a breakwater has not been constructed. Instead, ships carrying coal are anchored in the deep sea at a distance of about 12 kilometers and coal from the ships is unloaded and transferred into barges. These barges shuttle between the ship and a jetty constructed at the coast thus moving the coal from the ships to the coast. A serious difficulty is encountered in this operation due to the stormy weather prevailing in this location most of the time of the year. Hence, the availability of adequate quantities of coal at this power plant is not assured.

On the other hand, plenty of suitable lands are available in the vicinity of the coal power plant for the production of sustainable biomass as fuel for use in electricity generation. Hence the proposal to substitute at least a part of the coal used for electricity generation with biomass would be very beneficial.

6. Status of the technology in the country and its future market potential:

Status of Technology in Sri Lanka

The cultivation and use of biomass fuel for energy generation have been extensively practiced in Sri Lanka for a very long period. In fact at present nearly 50% of the national primary energy is derived from biomass. Moreover, in the industrial sector, nearly 75% of the energy is derived from biomass fuel. However, there is plenty of room for technological improvements in these areas. The proposed technologies would be very much appreciated by this sector.

7. Future Market Potential

Electricity Generation Sector

At present a 300 MW coal plant is in operation. According to the Long Term Generation Expansion Plan of the CEB, the capacity of coal based electricity generation would be gradually increased to reach a value of 3600 MW by the year 2022. According to the study done by the Ministry of Science and technology, the potential for biomass based electricity generation in Sri Lanka is over 4000 MW. Hence the proposed technology of co-firing biomass with coal has clear potential at least till the year 2022.

8. **Barriers:** This section will be covered later.

9. **Benefits:** (How the technology could contribute to socio-economic development and environmental protection)

Social Benefits

The implementation of this technology would result in the cultivation, harvesting and transporting of biomass fuel. This would provide ample opportunities for the rural communities residing around the coal power plants.

In addition to the wood, these farmers will be in possession of Gliricidia leaves. This could be used to enhance the rural dairy industry and increase the production of organic fertilizer. All these mean that the introduction of this technology will provide productive employment to the under-employed poverty driven rural farming communities.

In addition the implementation of this technology also would provide opportunities for skilled and semi skilled workforce in the areas of installation high pressure steam boilers and ancillary equipment.

Economic Benefits

Electricity Generation Sector

As Sri Lanka does not possess any proven fossil fuel reserves and as the LTGP of the CEB is heavily depending on imported fossil fuels to meet the growing demand for electricity (see figure 2), the Ministry of Power Energy has formulated a policy to ensure that at least 10% of our electrical energy is generated from indigenous renewable energy resources by the year 2015. This share is to be increased to 20% by 2020. It is very unfortunate that those responsible for implementing this policy are promoting wind and solar PV. Wind and Solar PV do not contribute directly to any national economic benefits. Wind and Solar PV technologies depend entirely on foreign inputs for the import of necessary equipment and installation and commissioning staff.

On the other hand Sustainable Biomass based electricity generation results in significant local national input in the generation of electricity. All the fuel required for biomass based electricity generation is generated locally within the national boundary.

Moreover, on a level playing field, and if all costs including environmental, agricultural, health aspects are internalized, it can be proved that biomass based electricity generation is in fact the cheapest way of generating electricity.

Based on a net calorific value of 26,000 kJ/kg for coal and a landed cost of US$150/tone of coal and 15,000 kJ/kg for wood and a local price of Rs. 3.50 per kg, on an energy equivalent basis energy from coal is 2.77 times as expensive as the energy from locally available wood.

For the proposed 30 MW of biomass power plants, the savings in fuel cost would amount Rs. 0.68 billion per year and for the 3600 MW plant it would be 82 billion/ year.

Environmental Benefits

The increase in the use of biomass as an alternative to fossil fuels for industrial heat and electricity generation would result in the following environmental benefits:

- Less SOX and NOX emissions.
- Less GHG emissions: The 30 MWe project would result in 258,826 tCO_2/y.
- Additional Gliricidia plantations increasing the green cover in the country.

10. Operations: This will be written later.

11. Costs

Discussions held with local engineering companies who handle this type of equipment have indicated that to construct and commission a 30 MWe steam boiler with the capacity of 100 tonne of steam per hour would be Rs. 1026 million.

12. References

1. Calorific Values for Wood and Bark and Bibiliography for Fuelwood. A.P.Harker, A. Sandels and J.Burley. August 1982. Tropical Products Institute.
2. Standardized Power Purchase Tariff, 2011. Sri Lanka sustainable Energy Authority.
3. Long Term Generation Expansion Plan, 2009-2022. Ceylon Electricity Board. December 2008.
4. Long Term Transmission Development Plan 2005-2014. Ceylon Electricity Board. 2005.
5. Energy Sector Master Plan, Sri Lanka. Interim Report. Asian Development Bank, April 2004.
6. National Energy Policies and Strategies of Sri Lanka. Ministry of Power and Energy. October 2006.
7. Statistical Digest 2010. Ceylon Electricity Board, 2011.
8. Mahinda Chinthanaya: Vision for a New Sri Lanka. A 10 Year Horizon Development Framework, 2006 -2016, Department of National Planning, Ministry of finance and Planning.
9. http://www.energyservices.lk/statistics/esd_rered.htm
10. Mr. Justine Seneviratne, General Manager, Lalan Engineering Co. (Pvt) Ltd.
11. Introduction of Natural Gas to Meet Energy Needs of Sri Lanka, Department of National Planning, May 2011.
12.

The Hanbook of Biomass Combustion and Co-firing, edited by S Jakl van Loo and Jaap Koppeajn, Earthscan, 2008.