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## Alternative fuel for biomass boilers in Sri Lanka

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### Abstract

The use of industrial biomass boilers in Sri Lanka is important to fulfill the energy requirement in production processes. The largest number of biomass boilers are leading to several environmental problems today. The fuel source for those boilers is well-grown trees, especially rubber. The main idea behind this study was to evaluate the total amount of biomass required for the biomass boilers and propose environmentally friendly fuel replacements to protect the environments while keeping the industrial processes. There are around 400 bio mass boilers operating around Sri Lanka and it uses approximately 3200 metric tons of biomass to produce the daily steam demand. Therefore, most of the industries are currently using rubber wood as the biomass source. However, in this study, it has been calculated and shown that annual rice straw energy potential can be used to fulfill the 257 days of steam demand and annual energy potential of rice husk can be used to fulfill the 246 days of steam demand in Sri Lanka. However, it is identified Most suitable plantation is Dendro as it has several side benefits. To overcome annual steam demand from biomass boilers, it is required to maintain around 13000 hectares of Dendro plantation annually.

**Keywords:** Bio mass, boilers, alternative fuel, energy, rubber and dendro plantation

### Introduction

The small island Sri Lanka is located in the Indian Ocean with a total land area of 65, 525 km<sup>2</sup>. Sri Lanka is considered as one of the high bio diversity countries. Sri Lanka was under controlled over 400 years by foreign nations. During the colonial period, deforestation is started by cultivating commercial crops such as tea, rubber, clove so on. Not only colonization but also Mahaweli development project and 1977 free trade economic policy implemented the development projects in the jungles and highly dense forests <sup>[1]</sup>.

According to the fact that Sri Lanka's natural forest cover has significantly dropped off from 80% to less than 16% over the last 100 years <sup>[2]</sup>. Most of the development projects have been accelerated the deforestations in Sri Lanka and it has a bad impact to reduce the forest cover up to 20% in 2007. Dole and CIC farming multinational companies had deforested 65000 ha of forest area in the regions of Buttala, Lunugamwehera, and Somawathiya National Park and Chunnakkadu sanctuary. Both agriculture companies were involved in cultivated Cavendish banana after clearing forest cover in those most sensitive areas <sup>[3,4]</sup>.

In this study, it has been studied industrial biomass boilers effect on deforestation. Sri Lanka is a developing nation and a fast developing nation in the south Asian region. There are around 21.5 Million people living in this Island. The economy of Sri Lanka is mainly based on agriculture. However, after 1972, several industries have been established all around the country. According to the 2016 statistics, there are 20571 industries have been registered in the Department of Census and Statistics in Sri Lanka <sup>[5]</sup>.

Until the late 1970s, the manufacturing economy in Sri Lanka was dominated by state-owned large scale industries. However, in late 1970, with the liberalization policies adopted brought significant changes to the economy <sup>[6]</sup>.

At the same time, Export Processing Zones (EPZ) also introduced by the government. Currently, there are 12 EPZ zones are operating in Sri Lanka <sup>[7]</sup>.

Sri Lanka is a developing nation and it should continue its industrial processes. There are several industries which use steam for the manufacturing process. Most of the industries produced steam from bio mass boilers and furnace oil boilers. Other than steam, some of the industries are using hot water which also generated by hot water generators. Those industries can be categorized as,

- Plantation (Tea, Rubber, Coconut, Palm oil)

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- Food and beverage (Rice, confectionary, soft drinks, alcohol, meat, desiccated coconut, sugar, milk powder)
- Rubber and plastic (Tire, leather products, plastic household manufacturing, carpets, Styrofoam, water tanks, PVC products, nylon ropes)
- Pulp and Paper (Paper, corrugated, printing)
- Cement and concrete (cement, cement products, tiles)
- Wood and timber
- Textile (garment, elastic, yarn, buttons and zippers, yarn and fabric dyeing)
- Hotels and Hospitals
- Metal and steel
- Health care and cosmetics
- Medicine and Ayurveda drugs

It is clear that all of the above-listed industries are strongly support the economy. They provide a large number of job opportunities for the citizens, produced household goods, support for the development process, and most importantly the backbone of the Sri Lankan foreign trade economy. Most of the above industries are using steam boilers and hot water generates for their production processes. Some of them are biomass boilers, furnace oil, and diesel boilers. A large number of biomass boilers are leading environmental pollution problem today.

There are approximately 400 biomass boilers operating daily all around the country. The fuel source for those boilers are well-grown trees, especially rubber. Most of the biomass boilers are over 3 tons of steam capacity (3 tons per hour). Some of the industries are operating 24 hours daily while the majority is around 12 hours daily routine. Therefore, they consumed an enormous amount of firewood to maintain their process for generating high-pressure steam or hot water. The main idea behind this study is to evaluate the total amount of biomass required for the biomass boilers, environmental pollution attached with those biomass boilers and propose environmentally friendly fuel replacements to protect the environments while keeping the industrial processes.

### Discussion

When selecting wood for burning there are three main factors which have an effect on the calorific value (CV). The amount of heat generated per unit fuel amount strongly depend on, Species choice, wood density and moisture content of the wood [8].

There is a little variation in the CV according to the species choice. There is a different CV for different wood types. If it is considered for the rubberwood, it is around 18.4 MJ/kg [9].

Rubberwood (*Hevea brasiliensis*) has become significantly important crop source for biomass production in Sri Lanka. From the perspective of using rubberwood as fuel, it is clear that rubberwood is the most promising source of biomass in Sri Lanka. In fact, some of the scientists have identified that energy content in the rubberwood is 40 GJ/ ha per year. However, there are some other firewood sources also available. Some of them are paddy husk, sawdust, coconut shells, coconut leaves, coconut husks, plywood residuals, logging residuals. When it is compared with the rubber wood, energy availability is almost equal but the moisture content is relatively high.

Some of the widely used biomass crops are summarized with their scientific information in the Table 1 [10].

**Table 1:** Details of moisture content and the Calorific value [10]

Crop	Moisture content (%)	Average calorific value (MJ/kg)
Rubber wood	5	18
Oil palm	20	18.84
Paddy husk	13	14.93
Coconut husk	11.5	19.6
Logging residuals	12	18.41
Wood residuals	12	18.41

Due to the high demand for rubberwood from the biomass boiler operating industries, the amount of rubber plantation has significantly reduced. Furthermore, that directly cause for the lack of water source availability due to deforestation.

Wood density also play an important role as denser woods will take less volume than softwood when consider about same amount of weight. If you measure the energy generating per volume, denser wood will generally receive more heat.

### Rubber wood and industrial steam generation

Approximately, 200 kgs to 250 kgs of fire-wood will be necessary for boiling 1 Ton water at 20-degree centigrade initial temperature to 100-degree centigrade at boiling point under normal temperature and pressure. It can be calculated that to produce 1 ton of steam, it is required to burn 200 kg of wood.

If we consider as 400 biomass boilers in Sri Lanka, and average operating hours as 10, and the average capacity of steam production per boiler as 4 MT/hr, then it will be required around 3200 tons of wood. If 1 rubber tree can be produced around 1 ton of wood, it will require at least 3200 rubber trees per day to fulfill the energy requirement in biomass boilers in Sri Lanka. Therefore around 15 ha of trees are daily cut down to fulfill the demand.

### Problems with biomass boilers

The main problems with biomass industrial boilers can be listed as follows.

- Deforestation to collect the amount of biomass demand.
- CO<sub>2</sub> emission to the atmosphere
- Water sources depleted
- Atmospheric temperature increased
- High amount of ash generated
- As it comes with bigger sizes, shredding and convert it to small pieces will take time and labour hours.
- Expensive and finally lead for the many environmental pollution problems.

The total area cultivated with rubber for 2006 was estimated at 118,000 ha. Similarly, in the energy sector, the use of rubber as fuel wood will increase due to the increasing prices of LP gas and other petroleum products.

### Why rubber is famous as a firewood?

Rubber trees are widely available in Sri Lanka all around the country. After taking the latex, after around 25 years of production trees are cutdown of the wood purpose. However, to fulfill the current biomass demand, most of the rubber plantations are selling as firewood supply to biomass boilers and finally clean the plantation and sell the land for real estate companies. Therefore, last decade rubber plantation areas are significantly decreased all around the country. Some of the important scientific values of rubberwood are given below [11].

Rubber has following characteristics.

Moisture 4.13 wt%

Volatile matter 86.30 wt%

Ash content 0.6 wt%

High heating value 22 MJ/ kg

Sulphur content is very low.

Therefore, rubberwood is a famous and widely used firewood for the biomass boiler. Because of that, deforestation is widely implementing to fulfill biomass demand. It is really important to introduce other possible biomass to replace the high demand of rubberwood. That can be suggested as coconut husk, coconut shell, saw dust, paddy husk, rice hulls (husks), rubber seeds, bagasse, and last Dendro. Energy potential from these sources is given below.

### Rice husks and Straw

The importance of rice straw (Fig. 1) and rice husk (Fig. 2) for bioenergy are interesting. However, the use of rice husks for energy is currently negligible. It has calorific value around 13-19 MJ/kg. Currently, only in rice mills in the Polonnaruwa area are using some amount of rice husk as a biomass for their biomass boilers. At the same time, rural villages' people are still using rice husk for their daily cooking in special homemade stove. At the cement kiln in Puttalam also using a limited amount of rice husk to minimize their fuel energy by replacing part of the coal requirement. Nonetheless, rice husks could prove to be a valuable source with 910500 ha of rice cultivation and it produces around 3.2 millions of tons of rice

every year <sup>[12]</sup>. The importance of rice husk and rice straw can be summarized with important statistics: <sup>[13]</sup>. According to the literature <sup>[13]</sup>, 1 ton of Rice paddy produces 290 kg, Rice Straw. The Calorific value of rice straw is 2400 kcal/kg or 10 MJ/kg. Similarly, 1 ton of Rice paddy produces 220 kg, Rice Husk. The Calorific value is 3000 kcal/kg or 12.5MJ/kg. The moisture content is around 5-12%.

Based on the given statistics, it is clear that 30% of rice straw and 20% of rice husk by rice production is generating at the end of the harvesting. Therefore, rice straw is around 930,000 tons per year and rice husk is around 700,000 tons per year. Approximately there is an energy potential of  $9.3 \times 10^9$  MJ from rice straw and  $8.75 \times 10^9$  MJ from rice husks per year. If we consider specific heat capacity of water as 4.184 kJ/kg and latent heat of vaporization as 2260 kJ/kg, then the heat required for making 1kg of saturated steam at 100 °C can be calculated as 2.26 MJ.

Therefore, only by using rice straw as a biomass fuel, it can be used to produce 4.12 millions of tons of steam per year. There is a production of 16000 MT/day steam production in Sri Lanka with the biomass boilers. Therefore, annual rice straw energy potential can be used to fulfill the 257 days of steam demand.

Similarly, it can be used to produce 3.87 million tons of steam per year by using rice husk as a biomass fuel. The annual energy potential of rice husk can be used to fulfill the 246 days of steam demand in Sri Lanka (steam demand from biomass boilers).



**Fig 1:** Rice husk



**Fig. 2:** Rice straw

### Bagasse

Bagasse is a byproduct of the sugar industry after extracted the juice from sugarcanes (Fig. 3). It has an energy potential of 9.6MJ/kg and is utilized for combined heat and power generation within the sugar factories. Annual bagasse generation in Sri Lanka is around 213,000 MT <sup>[14]</sup>. However, that is not available to replace as a fuel in biomass boilers as it

is already consuming within the sugar factories for power generation. It has an energy potential of  $2.05 \times 10^9$  MJ per year. That is equivalent to 0.9 millions of tons of steam production. However, this is just to show that available capacity of steam production from the annual bagasse in Sri Lanka.



**Fig. 3:** Bagasse from Sugar cane industry

### Dendro Plantation (*Gliricidia sepium*)

Dendro plantation has become a famous sustainable biomass source in the form of short rotation coppice for biomass power generation (Fig. 4). It has attracted interest as an energy source for power generation due to several reasons. *Gliricidia sepium* for example, is a medium-sized leguminous

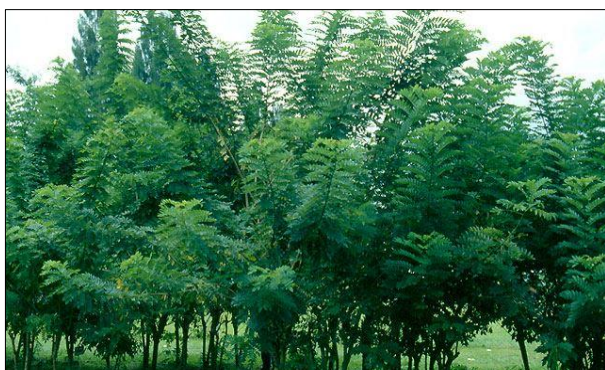
tree, with short term growing time with potential to become a low-cost indigenous energy supply. It is declared by the government of Sri Lanka as the 4th national plantation crop (following tea, rubber and, coconut) [15]. Table 2 indicates that a number of Dendro plantation with a different kind of land availability in Sri Lanka.

**Table 2:** Possibilities of the Dendro Plantation

Growing method	Number of trees per Hectare	Biomass production (tons /Ha/year) (Average 5kg per tree)
Bare land use only for Dendro	10000	50
Intercropping in Coconut lands	2250	11
Vine support for pepper	1500	8
Live fences in home garden	1000	5

### Advantages of Dendro Plantation

- The leaves of *Gliricidia sepium* are useful as animal fodder, mulch for other crops and a good material for the manufacture of compost.
- Minimum annual yield of 20 tons of wood at 20% moisture level per hectare could be expected in the dry zone in Sri Lanka.
- As a short rotating cropping species, it needs around 6 months.
- Based on the recent experiments carried out at the Coconut Research Institute has revealed that the incorporation of 35 kg green *Gliricidia* leaves to a coconut plantation has the equivalent effect of applying 800 grams of Urea fertilizer.
- High growth rate and high coppicing ability.
- Doesn't require replanting for around 20 years period.
- Free of any pest or diseases.
- Can grow in most areas in the Sri Lanka.
- Soil enrichment and avoiding soil erosion.



**Fig 4:** Dendro plantation



**Fig 5:** Dried Dendro wood

The calorific value of the dry Dendro (Fig. 5) is calculated as 20.5 MJ/kg [16].

Based on the information, it can be calculated that 1 million MJ power can be generated per year per hectare. That can be used to generate 450 Tons of steam per year. According to the above-mentioned statistics, it is generating around 16000 MT of steam per day in biomass boilers in Sri Lanka. Therefore, annual steam production from bio mass boilers is 5.8 million MT in Sri Lanka. To overcome the annual steam demand, it is required to plant Dendro in 13000 ha every year.

### Conclusion

Agricultural crop residuals often have a disposal problem associated with farming. Therefore, waste to energy conversion process such as replacing biomass requirement in biomass boilers in Sri Lanka can gain a higher interest and market potential. There are around 400 biomass boilers within the range from 1 ton to 20-ton steam/ hours capacity. Most of the industries are running 12 hours to 24 hours and 300 days to 365 days. Therefore, here in this calculation, it is taken as 4 ton /hour steam capacity, 10 hours operating time for 365 days as average bio mass boiler steam generation. According to the calculation, it is required around 16000 metric tons of steam per day and 5.8 million tons annually from the biomass boilers along.

Most of the biomass boilers are taking rubber wood for the biomass source. However, it is heading for several environmental and economic problems. To overcome that rice straw, rice husk, and Dendro wood is suggested and has proven the capability of replacement. The most suitable plantation is Dendro as it has several side benefits. To overcome annual steam demand from bio mass boilers, it is required to maintain around 13000 hectares of Dendro plantation annually. If it is possible to maintain, that will help on minimization of deforestation, minimization of soil erosion, implementing soil nutrition. At the same time, Dendro can produce at less cost and it can even produce as an intercropping in pepper, coconut industries. Further research has to perform in order to analyze the economic benefits of Dendro plantation as well as suitable areas for plantation.

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