ENERGY SECURITY FOR TEA INDUSTRY IN SRI LANKA:

A REVIEW OF PRESENT STATUS & OPPORTUNITIES FOR SELF SUFFICIENCY

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ABSTRACT

Continued stability and growth of the tea industry is paramount to the Sri Lankan economy. However, the tea industry is faced with many challenges of which the cost of energy and security of supplies is becoming a grave concern for all tea producers. Two main forms of energy used in tea factories are electrical and thermal. While electricity needs have been subsidized by the Ceylon Electricity Board (CEB) over many years, this situation may change due to financial constraints faced by the CEB and thus the rising cost of electricity may become a major problem for the tea industry.

Decades ago thermal energy needs were met by imported liquid fuels. With relative Dollar price of oil increasing in comparison to FOB price of tea, where for example, quantity of tea to buy a barrel of oil has increased from 10 kg to 19 kg over the last decade, use of fuel oils in meeting thermal energy needs in tea processing is now completely replaced by Firewood. Though cheaper, there is very little sustainable management of firewood in tea industry where most factories rely on purchases from whatever available source. This mostly involves ad hoc felling of trees in jungles and other homesteads. This situation cannot continue in the future.

The tea industry however holds key advantages of access to lands, labour and expertise in large scale plantations to convert this risk to an opportunity and to become a net energy exporter going beyond just self sufficiency for its own needs. Thus it can regain its position as a major contributor to the export earnings not only by the export of tea alone but by the reduction of the import of fossil fuels. This paper reviews the energy demand and supply situation at present, immediate and long term problems of reliability and sustainability of supplies and environmental issues, strategies to enhance the energy security of the tea industry and recommendations to implement these much needed strategies.

INTRODUCTION

The importance of the tea industry in the Sri Lankan economy requires no elaboration. In addition to the growing contribution the tea industry has made to the GDP and for generation of export income, considering the special significance of "Ceylon Tea" as the most recognized icon of the Sri Lankan identity in the world scene, the continued stability and growth of the tea industry, is paramount. However, the tea industry is faced with many challenges which threaten its ability to maintain and enhance this role. Amongst these the security of supply of the energy resources, at an affordable cost, is becoming a grave concern for all tea producers.

The process of manufacture of tea requires two forms of energy, i.e. electrical and thermal energy. The electricity is required for driving machineries and lighting and thermal energy needs are for withering and drying operations. Average electrical energy demand in tea factories varies in the range of 0.63-0.75 kWh/kg made tea while that of thermal energy is in the range of 1.5-1.7 kg of firewood per kg of made tea (Ref 1 & Ref 2). In the estate sector, there is also a great energy demand for domestic cooking and lighting of resident plantation workers.

Nearly all 695 tea factories in operation in Sri Lanka are grid connected. Sri Lanka in general enjoys a stable and reliable electricity supply from the National Grid. The tea industry consumes only about 2.5 % of the electricity generated. Although, the electricity supply from the national grid is a reliable source, there may be issues of cost of electricity in the coming years with the rising fossil fuel prices and the tea industry may have to look for alternatives for electricity in the future. Nevertheless, presently, the greater issues are with the availability of fuelwood for tea processing and hence, proper evaluation of demand, availability, supply and efficiency of use of fuel wood in tea factories is the need of hour.

Fuelwood demand for tea processing and domestic use in estates

In the past, even after the first and second oil shocks in 1973 and 1978, the price of oil in Sri Lanka market was low enough not to be a significant contributor to the cost of production of tea. However, over the past decade or two the price of oil has continued on an upward trend and coupled with the depreciation of the rupee against the US dollar, the cost of oil has become significant and many factories have modified their equipment for the use of fuel wood for this purpose. With the introduction of hot water generators most operation and maintenance issues associated with firewood fired furnaces have been removed, which allowed even the most discerning quality producers to shift from high cost oil firing to much lower cost firewood firing without compromising on quality of the process. Therefore, nearly 90% of the factories uses fuel wood and only exceptions are few factories using low cost materials such as saw dust and paddy husk and also costlier furnace fuel. When national tea production in 2012 (326 million kg) is considered, the thermal energy need of the tea factories could have been about 6608 $x10^3$ GJ/year (Ref 1). Assuming a specific fuel wood consumption of 1.5 kg of fuel wood per kg of made tea, the estimated consumption of fuel wood by the tea industry is about 489,000 tons per year (approximately 1.7 million m^3) and that for domestic use in the corporate sector estates is approximately 1.3 million m^3**.** Of the total fuelwood demand for processing, about 60% (293,000 tons per year) is accounted for by bought leaf factories.

PRESENT SOURCES OF SUPPLY

With the conversion of the energy supply to fuel wood in many factories the primary source of supply targeted was the rubber wood. With a program of replanting of rubber as well as the conversion of rubber plantations to other crops when the margins of profit from natural rubber were at a very low level, this was an abundant and cost effective source. Further, rubber wood was then not considered as a source of timber and hence, trees were commonly sold for generating energy. As a result, it was an abundant and a cost effective source of energy. However, the situation has now changed and presently, the value of rubber wood as timber is markedly high. Several other circumstances too have changed the rubber wood supply scenario adversely, in the past few years. These include reduction of rubber extent being uprooted for replanting due to high prices of natural rubber, use of rubber wood as a source of valuable timber for making furniture, floor boards and MDF boards, fuel switching by other industries from fossil fuel to fuelwood due to high cost of the former, government regulations restricting felling of fuelwood tree planted by estates and selling of fuelwood trees as timber for higher prices.

To be self sufficient in supply of wood fuels, tea estates were expected to devote a certain extent of lands for growing of fuel wood. In high yielding estates in Kenya the norm is 30%, whereas the recommendation of the Tea Research Institute of Sri Lanka was 10-15% of the tea extent as fuel wood. Very low productive/abandoned tea fields, scrub lands and ravines of tea plantations can be effectively used for planting fuel wood to meet this requirement. Some plantation companies commenced establishment of wood lots since 1980s. The total extent of the wood lots planted by the industry is reported to be about 19000 ha It is to be noted that the species selected for the wood lots were mainly *Eucalyptus spp, Acacia spp and Albizzia spp* which require a minimum of 10 years to grow up to the required girth for fuel wood. In addition, it is reported that some plantations have cultivated small extent of short rotation coppicing (SRC) trees such as *Calliandra* and *Gliricidia* as fuel wood lots in the recent past.

The estates also do have an additional source of fuel wood by way of the shade trees grown at specified spacing. Of the two types of shade trees viz: High and Medium Shade, the medium shade of short rotation coppicing tress such as *Gliricidia Sepium* and *Caliandra calothrysus* are viable sources of fuel wood, being pruned periodically to maintain the optimum levels of shade. However, till recently there was not much interest by the factories to use these coppices as fuel wood. It is important to note that all biomass or fuel wood irrespective of the species has a calorific value of about 4500 kCal/kg measured on dry ash free basis. Nevertheless, establishment and management of shade trees in tea lands are also not up the recommended levels that deprive estate of harnessing their full benefits as a source of fuel wood for their factories. As a result, 80% of the fuelwood demand of tea factories is being supplied by outside contractors (suppliers of fuelwood).

Rubber Wood Supplies

In spite of the demands by other sectors a significant amount of fuel wood supplied to the tea factories is still rubber wood. However, the quality of supplies has deteriorated with the short supply and factories being forced to accept roots and other sections, which they would have rejected in the past. The price levels have also risen to the level of Rs 1250-2200 per Cu Yard from levels of Rs 500 per Cu yard prevailing prior to year 2000. The market is now entirely supplier driven with the suppliers laying down the conditions to the factories desperate to obtain their requirements practically on a hand to mouth basis. Once converted to cost per ton with a moisture content of about 50% at point of receipt, the cost at present would be in excess of Rs 6.50 per kg. However, some corporate sector plantations with rubber cultivations have the privilege of using rubber firewood at a cheaper cost covering part of their requirements.

Mixed Fire Wood

The factories also receive increasing quantities of other species of fuel wood euphemistically called mixed fuel wood of approved species. In case of some bought leaf factories their constitute the majority of supplies exceeding 80% (Ref 3)

The supply of mixed firewood has to be viewed with concern as there is a grave danger of un-controlled felling of jungle wood with absolutely no regeneration. Hence, this source is not reliable and it is a fast diminishing supply. Further, environmental concerns can also surface sooner than later thus restricting the supply of mixed firewood in the near future. The tea industry also has to take cognizance of such facts and should not be seen as being a party to environmental degradation in the country. At present mixed fuel wood fetches a slightly lower price than rubber wood and is in the range of Rs. 1000-1500 per Cu yard.

Firewood from Wood Lots and shade trees

Although, some estate based factories have a potential to obtain firewood from their wood lots, it is currently hindered by the regulatory problems. A very small percentage (<3%) of SRC wood species mainly Gliricidia, is delivered to bought leaf factories, by the regular fuel wood suppliers. Additionally, pruning of the shade trees are also being used by estate based tea factories. However it is learnt that the establishment and management of shade trees are much below the recommended levels.

STRATEGIES FOR REDUCING FUELWOOD DEMAND AND SUSTAINING SUPPLY

In order to ensure thermal energy security of the tea industry, it is important to reduce fuel wood demand and ensure sustainable supply at a reasonable cost. In order to achieve these goals, following strategies can be recommended.

1. Demand Side Management
    a. Improvement of Operating Practices
    b. Efficiency improvement of factory machineries
2. Diversification of suppliers and species
3. Self generation of fuelwood

Demand Side Management

It has been noted that the consumption of fuel wood in the tea factories has been sub optimal due to both poor operating practices as well as the low efficiency of the combustion and heat transfer equipment. Without embarking on a major change to replace the main heat transfer equipment which would require heavy capital expenditure, strategies have to be developed to promote and facilitate proper operational practices, which by themselves could contribute to substantial savings. In this context, some areas in need of greater attention are as follows.

1. Use of fuelwood with a high moisture content for firing
2. Use of large logs leading to lower combustion efficiency and excessive loss of energy as waste
3. Potential for recovery of waste heat from the stack, for drying of fuel wood

It is an axiom of the combustion technology that the fuel should be fed at the smallest possible size and with lowest possible moisture content to ensure high combustion efficiency. Therefore a radical departure from the current practices of feeding large logs with a higher moisture content (>20%) is necessary. Feeding small sized or chipped fuel wood pre-dried to acceptable moisture content (<20%) will result in immediate savings in the fuelwood consumption. In this regard, reducing the size of traditional fuel wood logs to a typical size of 25 mm- 50 mm in diameter may be considered impractical and costly. However, the additional cost of labour and energy used in this operation would be more than compensated by the increased efficiency of combustion. An estimated 50% savings of the specific fuelwood consumption can be achieved by reducing the size of fuelwood logs and moisture content to acceptable levels (Ref 1,2)

Diversification of suppliers and species

Green leaf suppliers as energy suppliers

It is eminently feasible to create a culture of the green leaf suppliers graduating to be suppliers of both the raw material and the energy for the bought leaf factories. The small holders being the backbone of the supply chain for these factories currently cultivate more than 118,000 ha of tea lands. They have the potential to generate more than 531,000 tons of fuel wood per year by planting Gliricidia as medium shade trees at an initial density of about 900 trees per ha giving an average fuelwood yield of about 5 kg per tree per year. This is far in excess of the all the fuel wood requirements of the bought leaf factories estimated to be about 293,000 tons per year.

Since this practice is not prevalent at the moment a concerted awareness campaign will be required to generate the necessary enthusiasm amongst the small holders, highlighting both the additional monetary gain by the sale of the fuel wood to an assured market with the bought leaf factories as well as the value of the foliage as fertilizer. Since the bought leaf factories will be the greatest beneficiaries of such a change they would need to evolve the necessary strategies to entice the small holders. The potential revenue of Rs 600 million annually that could flow into the hands of the small holders, only by the sale of the wood (@ Rs 2,000.00 per ton) could be highlighted in this exercise.

Short Rotation Coppicing (SRC) species as fuelwood

The tea industry has traditionally used rubber wood supplied in log form as the main supply mode. While all factories have invested in wood splitters, the feed to the furnace is in the form of relatively large chunks of wood mostly with high moisture content. Both these practices lead to inefficiencies of combustion. In order to achieving increased combustion efficiencies, without the over head for reducing the size of logs traditionally used, the SRC species of wood can be targeted, which are generally harvested when the branches are 25-50 mm in diameter, which lend themselves to meeting the preferred requirement of smaller size of fuel wood more readily. Such small size fuelwood is a prerequisite for automated feeding systems. Further, efficiency of use of such fuelwood (0.85 kg/kg of made tea) is much more attractive than the traditional fuelwood (1.5 kg/kg of made tea). The commonest SRC species that could be considered for fuelwood are *Gliricidia sepium* and C*aliandra calothyrsus.* These species are known to be well adapted to the soil and climatic conditions in tea growing regions. Moreover, they are familiar to tea growers and are available in substantial quantities as shade trees and fencing and wind barriers. These species are also having the environmental advantage of being nitrogen fixing and/or generation of nitrogen rich foliage and more importantly being tolerant for continued coppicing at short time intervals. This quality makes them a truly renewable resource of fuelwood.

Self Generation of fuelwood

The foregoing analysis amply demonstrates the feasibility of generating fuelwood more than the requirement of the tea industry by the estates and the small holders themselves through diversification of fuelwood species without fully depending on rubber and mixed firewood. Any surplus can generate an additional income to both the plantation companies and the small holders, given that the demand for fuel wood is growing in the other sectors as well. This would be a boon to the country at large providing a means of limiting the import of fossil fuels and expanding the power generation from renewable resources.

Availability of land for fuelwood plantations.

As per the available records, there are substantial extents of lands within corporate sector plantations, which can be utilized for generation of fuelwood that ensures reliability of the supply. Survey conducted by the Tea Research Institute has shown that there are 14,287 ha of uncultivated lands in the corporate sector tea estates of which 7789 ha are at low elevations (Samansiri et al, 2011). In addition, there is about 12,569 ha of forest/scrub lands. It is also a well known fact that large extents of marginal tea lands with an uneconomical productivity exist in the sector. It may be prudent to progressively convert such lands to fuelwood lots. The estimated extent of such marginal lands yielding less than 1000kg/ha/yr is more than 19000 ha.

Economic viability of fuelwood cultivation

Detailed financial analysis (Shyamali, 2013) given below (Table 1a-c) indicates that the establishment fuelwood plantations is an economically viable venture giving attractive returns. Moreover, such plantations are of great environmental importance by way of fixing carbon dioxide and controlling soil erosion in poorly managed tea lands.

Table 1Economics of energy plantations

a). Gliricidia Plantations per Acre

Criteria	@15% discount rate		@20% discount rate	
	Wood value	Wood+leaves	Wood value	Wood+leaves
B/C	1.38	1.66	1.14	1.38
NPV Rs.	108735	191239	Rs. 34039	Rs.91373
IRR	24%	30%	24%	29%
Payback Period	6 yrs	5 yrs	6 yrs	5 yrs

(Shyamali, HW, 2013. Tea Research Institute of Sri Lanka)

b). Albizia plantations

Criteria	@15% discount rate	@20% discount rate
B/C	2.53	1.19
NPV (Rs.)	462156	51589
IRR (%)	21	21
Payback period	12 yrs	12 yrs

(Shyamali, HW, 2013. Tea Research Institute of Sri Lanka)

c). Eucalyptus plantations

Criteria	@15% discount rate	@20% discount rate
B/C	4.32	2.06
NPV (Rs.)	1024118	299068
IRR (%)	26	26
Payback period	12	12

(Shyamali, HW, 2013. Tea Research Institute of Sri Lanka)

Potential of net energy export

While the primary focus is on achieving self sufficiency of fuelwood to meet the thermal energy needs of the tea industry, the potential for generation of a significant surplus of fuel wood from within the tea sector has been demonstrated in the evaluations done above.

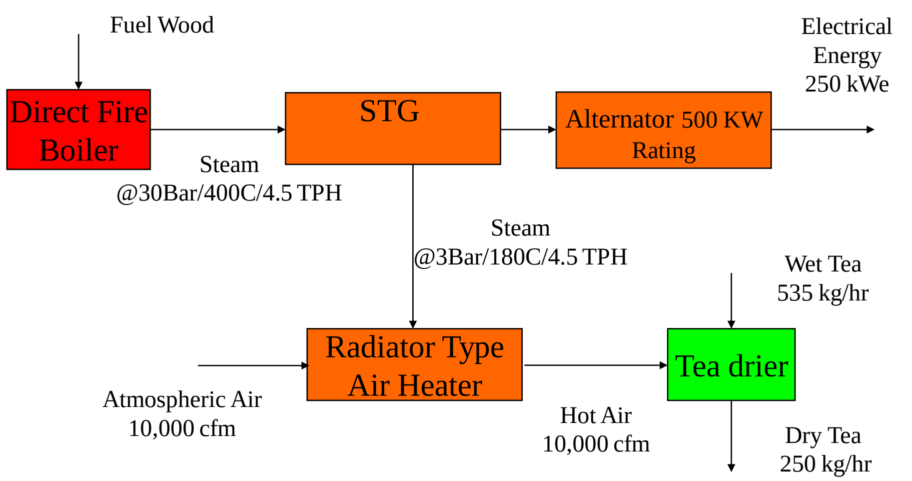
Thus it is possible to examine the more ambitious prospects of generation of electrical energy as well within the tea sector. This need not be limited to the internal needs and the variability of the demand over the 24 hour period can be explored to permit the export of excess power to the national grid atleast during part of the day, this generating an extra income.

The distinct possibility of the consumer tariff even for industries escalating in the future such that the cost of self generation may become more economical in the coming years is a reality. The most attractive feed in tariff for biomass based power generation is a further incentive to explore this potential.

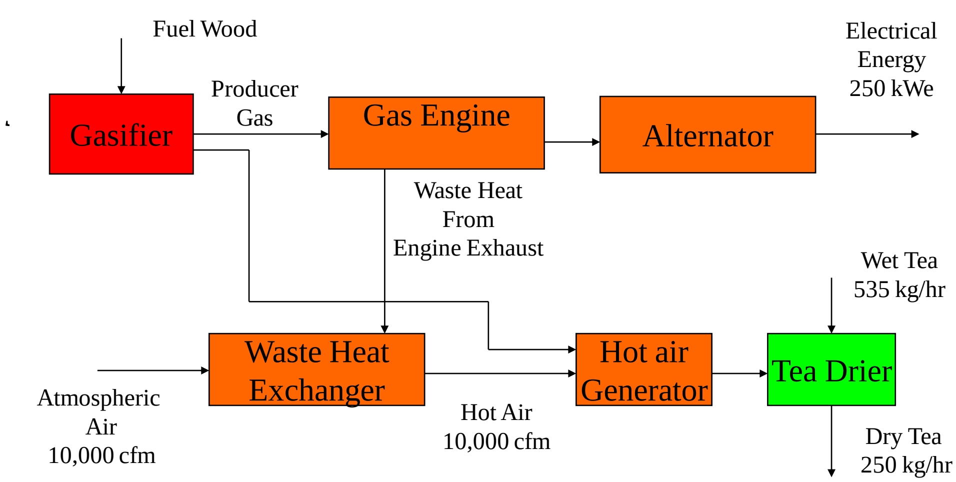
To garner the best advantage any power generation system should be designed on the combined het and power model since the process of manufacture of tea requires both these modes of energy. The relative demands were described earlier and the variability of the hours and levels of demand of the two forms of energy can be leveraged to optimize the system, coupled with the means of export of the excess power to the national grid.

While the capacity of the individual systems and the final model selected will vary form factory to factory, primarily governed by the availability of fuelwood, the following schematic diagrams illustrate the different possibilities.

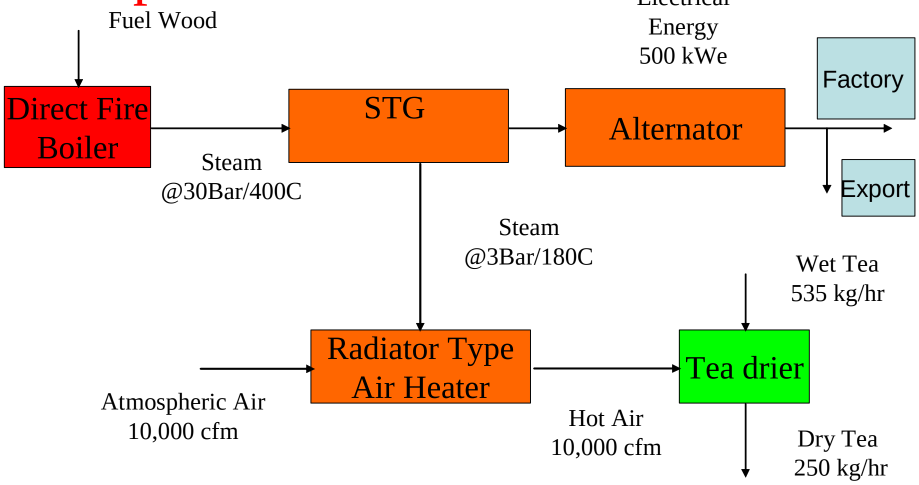
Option I – Primarily Self Generation



- Option II



- Option III Self Generation & Export to Grid



While the systems above would require considerable initial capital expenditure , with the total control over the supply and cost of the primary input of fuel wood, a life cycle cost analysis would prove the financial viability.

The Additional fertility benefits of leaves

It is well known that the recommendation for growing SRC species such as Gliricida and Caliandra in the tea plantations has been done to achieve a dual advantage. One is as the means of providing the required shade and its controllability. The other is in recognition of the fertility value of the leaves and small twigs left on the field after loping of the branches.

However, in recent times successful experiments have bene conducted in the tea sector of deriving even greater benefits of fertilizer value of the Gliricidia leaves. This process constitutes of manufacture of a liquid fertilizer of which the main ingredient is the leaves and small twigs of Gliricidia.

The ingredients for manufacture of 100 litres of liquid fertilizer consists of

- **Water 100 litres**
- **Raw cow dung 10 kg**
- **Green Gliricida leaves 25 kg**

- **Lantana Camara leaves (gandhapana)   5 kg**
- **Moringa Oleisera leaves (murunga)   500 gm**
- **Hand full of top soil**

Under the present circumstances when the cost of imported fertilizer is on the increase and the burden on the state coffers to maintain the current levels of subsidies, the above option may prove to be a great boon , particularly for the small holder tea growers. Moreover this would prove to be grate incentive to promote the growing of Gliricidis which will solve the problem of energy self sufficiency.

RECOMMENDATIONS AND BARRIERS TO OVERCOME

From the foregoing it is evident that the self generation of total fuel wood requirements is feasible within the industry itself with substantial surplus. In addition such an approach would create additional sources of income for both the estates and the small holders. The most important spin off benefit would be the prevention of the environmental degradation caused by the unchecked extraction of so called Mixed Wood from non renewable sources.

However, since it appears that such potential is not appreciated either by the estates or by the small holders, several measures would need to be taken to create the necessary awareness as well as to overcome potential barriers.

The following measures are therefore, recommended to ensure energy security of the tea sector in Sri Lanka.

1. Promote the adoption of fuelwood saving technologies discussed above to reduce the consumption of fuelwood.
2. Create suitable avenues of concessionary credit for the plantation companies to embark on an urgent and time targeted program for the establishment of fuel wood plantations.
3. Evolve a program with the bought leaf factories to encourage the small holders to grow fuel wood at least as the shade trees in tea smallholdings.
4. Obtain the commitment of the relevant state agencies under to facilitate the planting of SRC species and regulate the sale in lines similar to that of bought leaf.
5. Relax or remove the undesirable regulations on harvesting and transport of cultivated firewood lots and provide guidelines for the proper methods of periodic harvesting of the various species to maintain the growth and renewability.

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