Some Recent Technological Advancements in the Efficient Use of Biomass as an Energy Source in Sri Lanka

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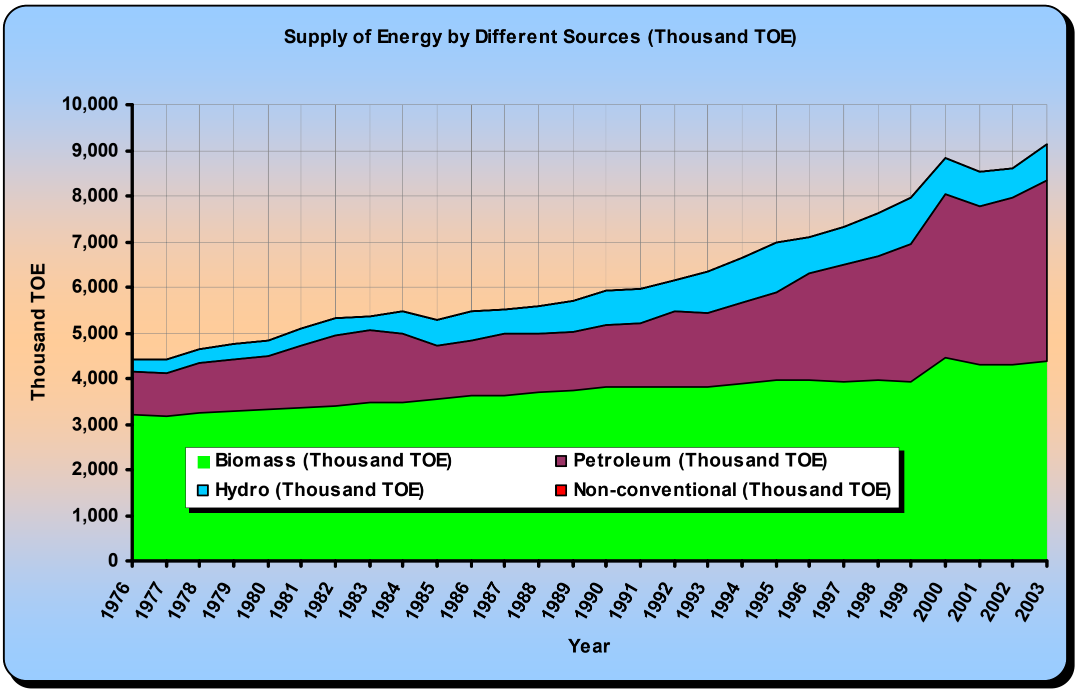
1.0 Introduction

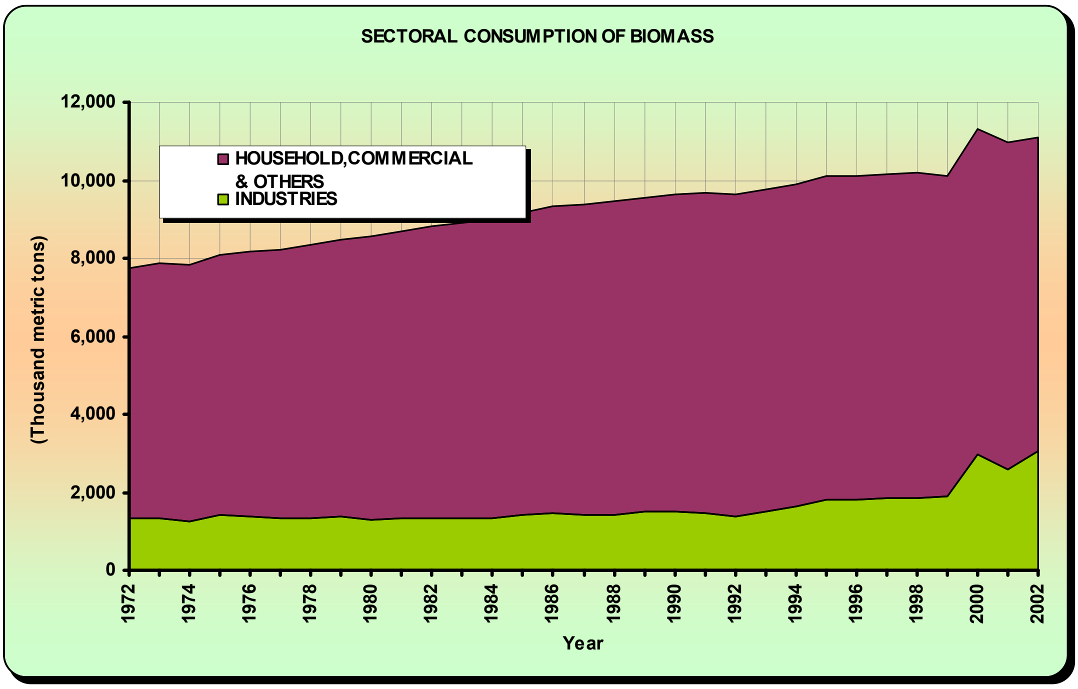
Sri Lanka remains a major user of biomass for meeting it energy needs (Fig. 1). Biomass has been the only indigenous, yet stable, primary energy source that ensured supplying a major portion of Sri Lanka's energy requirements for centuries. Even in the present day, biomass dominates the energy supply with 50 % share. Though biomass has been an important source of primary energy, it has not been produced formally for the purpose of using as an energy source. For instance, biomass has always been a by product of other activities such as agro based industry – replanting, pruning, etc., manufacturing industry – off cuts in timber industry, waste from wood working industry, construction industry, etc and as waste generated from plantation sector - fallen trees & branches, natural waste from trees, leftovers from plantation produce, etc. Unlike with fossil fuels based energy, biomass has never been developed as a formal and sustainable provider of energy. Moreover, despite its continuous dominance in supplying the country's energy needs, biomass was not, until recently, recognized as a potential future energy source that could be exploited in a sustainable manner to meet our value added future energy requirements and, thereby, reduce the over dependency on imported fossil fuels.



Source: ECF (2003) –unpublished data

Fig. 1 – Energy Supply by Source

Dominance of fossil fuels as the most important primary energy resource in the world, despite non-equitable distribution, has resulted in energy research focusing on the exploitation and utilization of fossil fuels for meeting Man's energy needs. As a result no much attention was paid to develop technologies to exploit and utilize other potential primary sources including biomass for energy. Even in countries where there is an abundant supply of biomass for energy, and biomass has been leading the energy supply in the country (as in Sri Lanka), the advent of oil (cheap then) had a detrimental effect on the research and development of biomass energy technologies. Another factor that contributed towards lack of focus on R&D on biomass energy technologies was that the biomass was available very cheap then, and sometimes even free. Hence, there was no demand for improved technologies. This is amply demonstrated by the fact that many present day biomass energy technologies used in the industrial and domestic sectors are highly inefficient and environmentally unfriendly. For example, in Sri Lanka biggest consumer of biomass for energy is the domestic sector for cooking, and Tea and Brick & Tile Industries are major consumers of biomass in the industrial sector (Fig. 2). However, the technologies

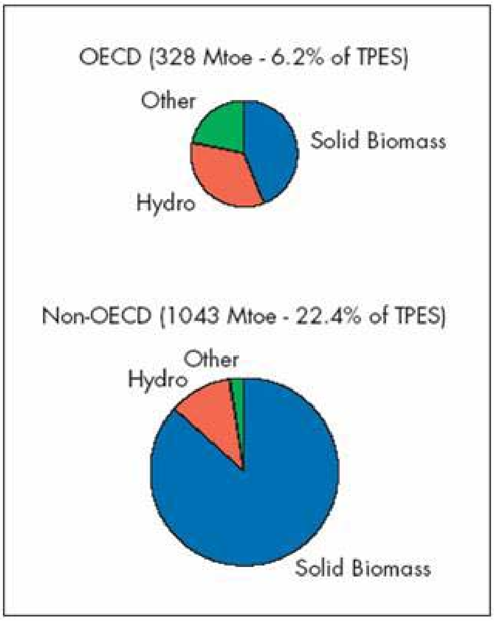


Source: ECF (2002) – unpublished data

Fig. 2 – Biomass Energy Consumption by Sector

used in these sector for converting biomass into useful energy are very old and inefficient and have not undergone substantial improvement for decades, especially in the industrial sector.

The situation, however, began to change since the oil crisis in 1970's and was instrumental in drawing world wide attention on developing other sources of energy and improving energy efficiency. And the environmental consideration, in 1980's, boosted the new energy development, especially the renewable energy, because onsumption of fossil fuels has been the biggest culprit for degrading the environment. It is important to note that biomass dominate the world share of primary energy supply from renewable sources (Fig. 3). There has been growing commitment world wide for R&D in exploiting renewable energy technologies since the oil crisis. This is demonstrated by the substantial increase in R&D expenditure



	World	OECD	Non-OECD
Primary Solid Biomass	76.4%	44.0%	86.6%
Hydro	16.5%	34.4%	10.8%
Geothermal	3.2%	9.0%	1.4%
Municipal Wastes	1.3%	5.5%	< 0.05%
Industrial Wastes	0.8%	2.4%	0.3%
Liquid Biomass	0.8%	1.1%	0.7%
Biogas	0.5%	1.8%	0.1%
Solar Thermal	0.3%	1.0%	0.1%
Wind	0.2%	0.8%	< 0.05%
Tide, Wave and Ocean	< 0.05%	< 0.05%	< 0.05%
Solar Photovoltaic	< 0.05%	< 0.05%	< 0.05%

Source: IEA Statistics.

Fig. 3 – Total Primary Energy Supply from Renewable Sources in the World - 2000

world wide on renewable energy (Fig. 4). It is evident from Fig. 4 that biomass energy development has attracted the second largest R&D expenditure among renewables world wide.

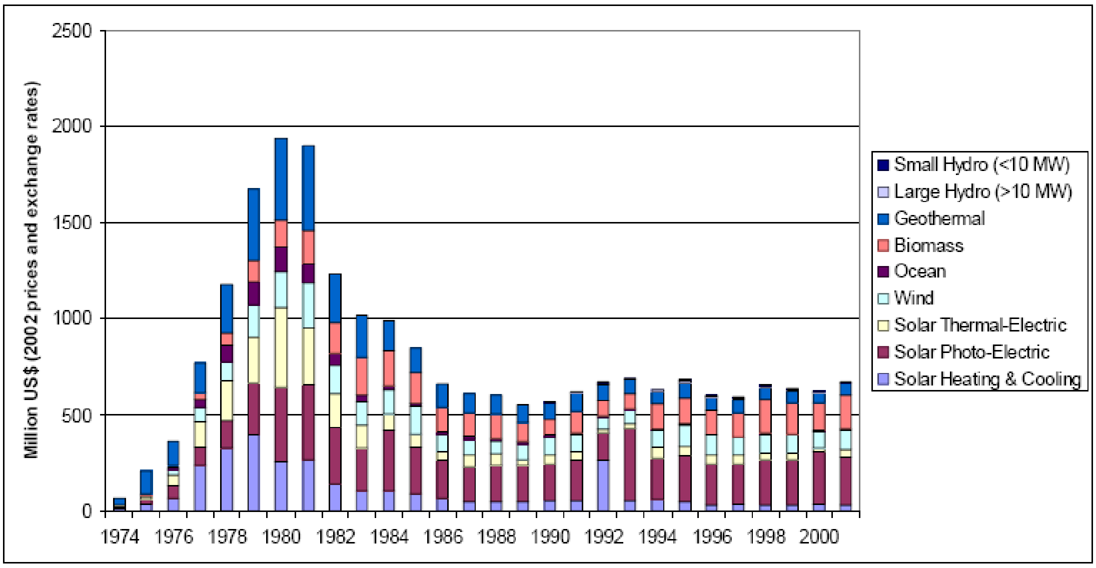


Fig. 4 - Government Renewable Energy RD&D Budgets for IEA Countries, 1974-2002

This paper looks at some of the more recent initiatives undrtaken to improve performance of biomass energy technologies in Sri Lanka and their complementary effects on promoting Dendro power.

2.0 Major biomass for energy consuming processes and technologies

Biomass has been the main source of fuel in the traditional Sri Lankan kitchen for cooking. In addition, a large number of traditional industries in Sri Lanka depend on biomass to meet their energy requirements. These SMEs play an important role in the rural as well as national economy. The main industries which use biomass as the main energy source in the country are Tea – drying of Tea, Brick & Tile manufacture, Rubber – smoking/drying of sheet rubber and crape rubber, Tobacco curing, Paddy par-boiling, Lime kilns, etc. Table 1 shows the consumption by sector/industry in recent years.

Table 1 - Fuel wood consumption by sector – Thousand tonne*

Sector/Industry	2002		2003	
	tonne	%	tonne	%
Agro industry				
Tea	620	5.6	610	5.4
Rubber	91	**0.8**	92	**0.8**
Coconut	82	**0.7**	120	**1.1**
Manufacturing				
Brick	890	**8.1**	950	**8.4**
Tile	630	**5.7**	630	**5.6**
Lime	260	**2.4**	280	**2.5**
Commercial				
Bakeries, hotels & eating houses	470	**4.3**	430	**3.8**

Household Cooking	8000	72.4	8200	72.5
Total	11043		11312	

* - estimates only

Source: Sri Lanka Energy Balance – 2003, ECF – unpublished data

3.0 Recent R&D initiatives in improving biomass energy technologies

3.1 Development of efficient cook stoves in Sri Lanka

Being the largest consumer of fuel wood, cook stoves have been the focus of R&D by many. In addition to large amount of fuel wood consumed for cooking, the environmental impacts, especially on health, associated with inefficient combustion of fuel wood has been a major driving force towards research on improved cook stoves. The traditional 3-stone hearth, which is of widespread use in Sri Lanka, not only is highly inefficient but also associated with emissions detrimental to the health. Continuous improvement to domestic cook stoves resulted in achieving better efficiencies and reduced emissions (Figs. 5, 6&7).

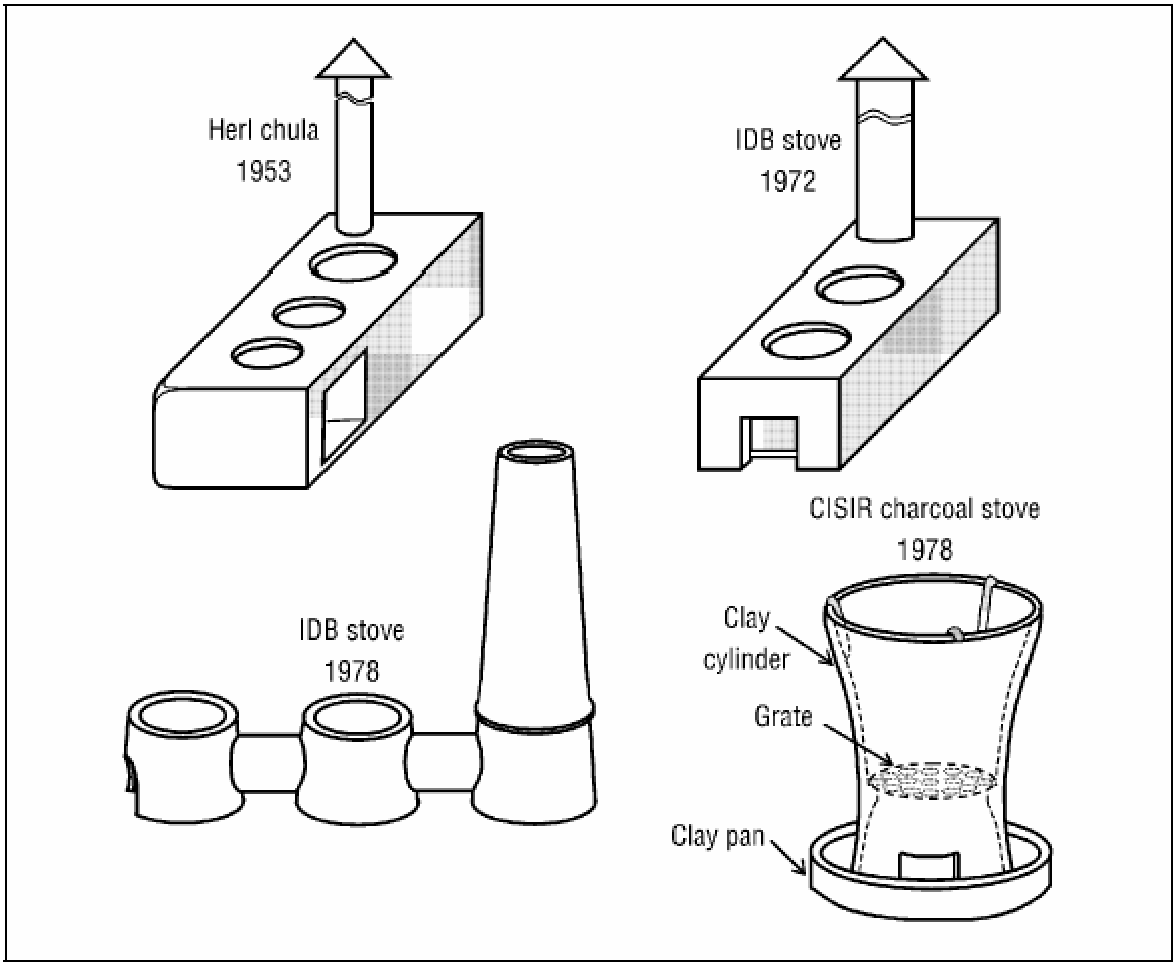


Fig. 5 - Improved cook stoves disseminated in Sri Lanka during 1950-1978

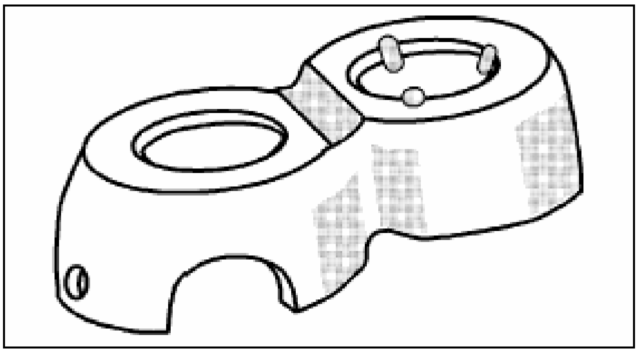


Fig. 6 - Sarvodaya tow-pot pottery –liner stove with a mud insulation (1982)

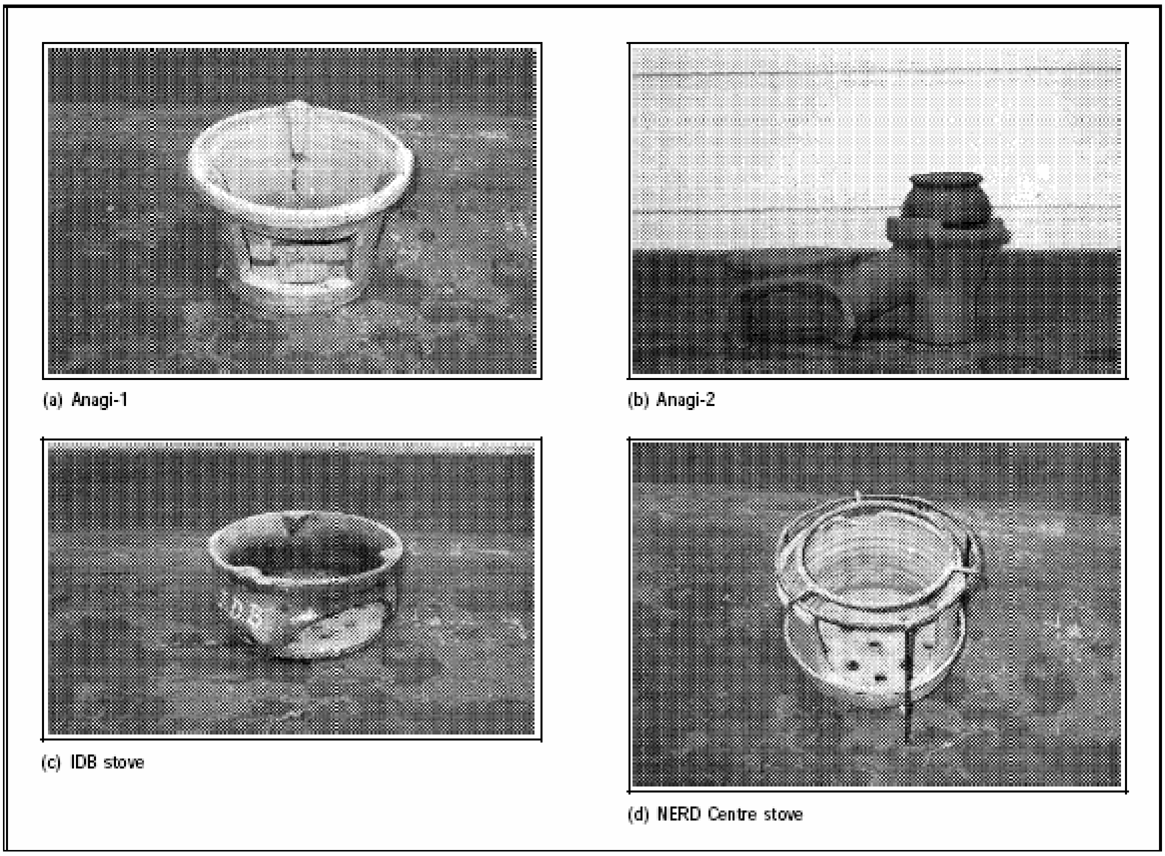


Fig. 7 - Improved Cook Stoves developed during 1983-1987

3.2 Development of a Wood Gas stove

This is the most recent development of a cook stove in Sri Lanka. Here the dried wood, in small pieces, is placed in an upright metal cylindrical chamber and fired from top. The chamber is perforated and combustion air is provided from bottom, sides as well as from top (Fig. 8). The chamber is surrounded by a clay cylinder made of insulating material. There is a metal outer cylinder and an air gap is maintained between the clay cylinder and the inner cylinder. During the operation the combustion air that is provided near the burner at the top is passed through this air gap and get heated up from waste heat.

Forced draft

Natural draft

Fig. 8 – NERDC Wood Gas Stove (2002)

The wood gas stove is operated by filling the inner chamber (combustion chamber) with dried wood pieces and then firing from top. Small amount of kerosene may be used for initializing the flame. As the layers below the flame are heated up, the wood tends to initially emit volatiles and secondly subject to gasification. This process provides combustible gases, which flows upwards and burned at the top when contacted with additional warm air supplied by the system. The burning of fuel wood in the chamber advances downwards unlike in most cook stoves where burning advances upwards from bottom. The burning of fuel wood, therefore, is taken place under controlled conditions. As a result the combustion efficiency improves and results in reducing heat losses and wastage leading to improving the overall efficiency. The system has achieved consistent overall efficiencies up to 35% when compared with less than 8% in traditional 3-stone cook stove. Along with efficiency improvement substantial reduction in harmful emissions also achieved. The wood gas stove is available in two designs – one with forced draft and the other with natural draft (Fig. 8).

3.2.1 Performance of wood stoves

Table 2 shows the performance of the wood gas stove and Table 3 shows the emissions associated with it.

Table 2 – Performance of Typical Improved Cook Stoves (ICS)

Type of Stove	Efficiency (%)	Fuel Type
Three-stone stove (TCS)	8.0	Fuel wood, agri-residues
Single and two-pot mud stove (TCS)	13.0	Fuel wood sticks, agri-residues
Anagi stove – 1 & 2 (ICS)	18.0	Fuel wood sticks
Ceylon charcoal stove (ICS)	30.0	Charcoal
Sarvodaya two-pot stove (ICS)	22.0	Fuelwood Sticks
CISIR single-pot stove (ICS)	24.0	Fuelwood sticks
IDB stove (ICS)	20.0	Fuelwood sticks
NERD stove)ICS)	27.0	Fuelwood sticks
NERD wood gas stove (ICS)	**35.0**	**Fuelwood pieces**

Source: Perera, KKCK. et el (2002) & Bandara (2002)

Table 3 – Emissions of various wood stoves

Device	Emission factor (g/kg of air-dried fuelwood					
	CO_2	CO	CH_4	TSP	SO_x	NO_x
Three-stone stove (TCS)[1]	1151.35	46.64	7.60	7.60	0.44	1.29
Semi- enclosed stove (TCS)[1]	1104.91	74.84	8.69	8.80	0.44	1.25
ICS (e.g. Anagi-2)[1] Average	1056.66	103.64	9.77	10.00	0.44	1.20
NERDC wood gas stove (ICS)[2]		500-600ppm			7-30 ppm	

1. From Perera, KKCK et el (2002)
2. Bandara (2002)

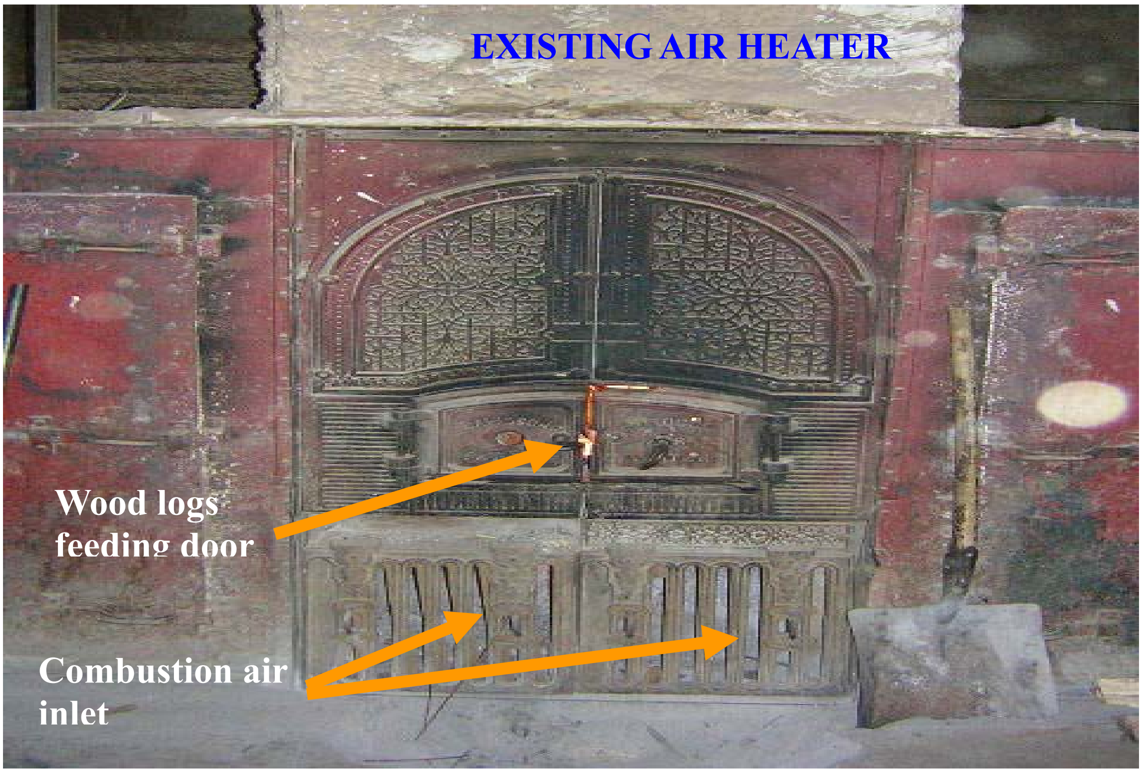
3.3 Development of an improved biomass combustion system for Tea Industry

Tea industry is one of the main consumers of fuel wood and the average consumption is about 610,000 tonne per (table 1). Therefore, the focus is on improving the efficiency of fuel wood combustion technologies in the Tea industry.

This industry, 150 yr old, still uses traditional hot air generators without any substantial technological improvement. With traditional technology, it consumes approximately 2.4 kg of fuel wood to produce 1 kg of made tea and at present day prices the cost of fuel wood is Rs. 9.50 per kg of made tea. An energy audit carried out on this air heater has revealed the following performance of the system.

Type of fuel wood used	- logs
Average moisture content in fuel wood	> 43%
Current overall operating efficiency	~ 40%
Excess combustion air	> 100%
Variation of hot air temperature produced	> ± 20°C
Air heater capacity	~ 450 kW

Fig. 9 shows this air heater and Fig. 10 shows its internal arrangement.



Source: NERDC

Fig. 9 – Traditional Cerricco Air Heater

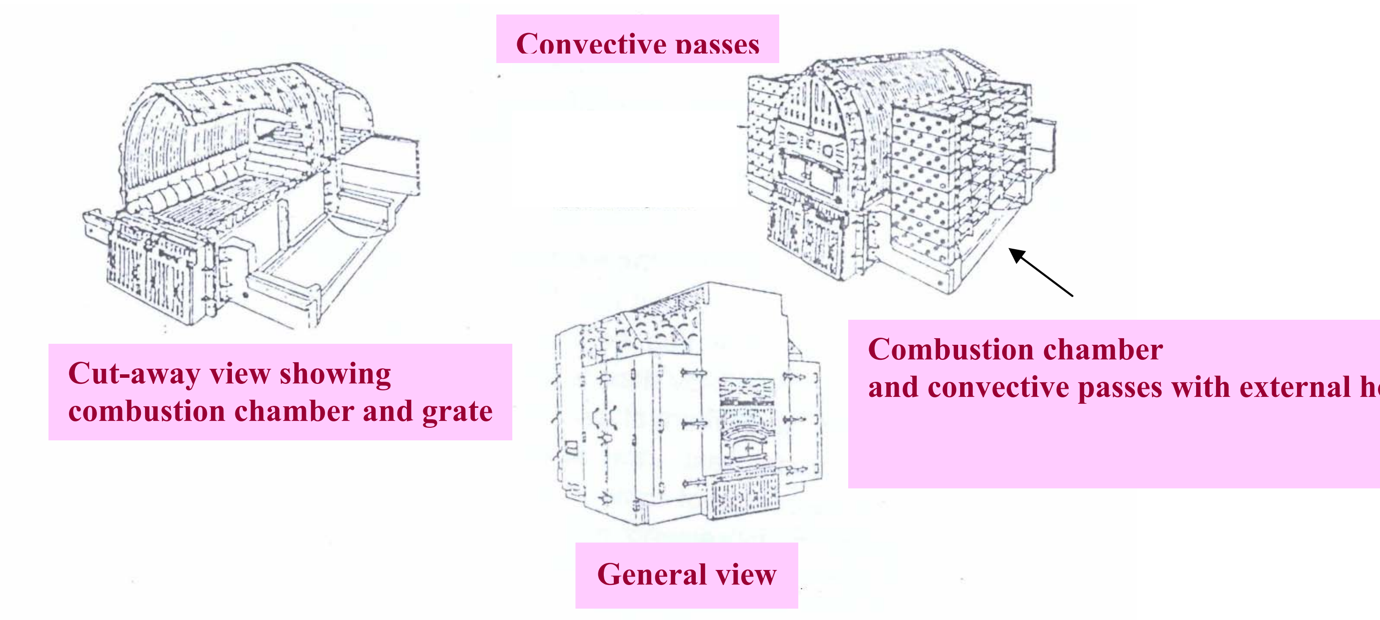


Fig. 10 – Arrangement of Cerricco tubular air heater

Tea industry consumes biomass for generating hot air (at ~ 110°C) to be used in final drying of Tea. In addition, part of this heat is also used for the withering process. Except in a few factories the same air heater is used for providing heat energy for both the processes.

According to the the outcome of the energy audit, the following issues have been the focus for R&D for improving the combustion efficiency.

Identified Problem	Improvement needed	Proposed method
• High moisture in fuel wood	Minimize moisture in fuel wood	Change to chipped wood/ wood pieces
• High excess air	Reduce excess air levels	Control feeding of wood chips/pieces according to hot air temp.
• High fluctuations in hot air temp.	Maintain hot air temp. within close limits	

3.3.1 Modified combustion system to be retrofitted

Proposed system consists of a screw feeder for feeding the wood chips/pieces on to a specially designed fire grate, which facilitate the spreading of wood chips for easy burning. Hot air temperature is sensed and is used to control the speed of the screw feeder motor through a variable speed drive. Fuel wood chips/pieces are fed into the screw feeder through a hopper. Fig. 11 shows the system as retrofitted to an existing hot air furnace.

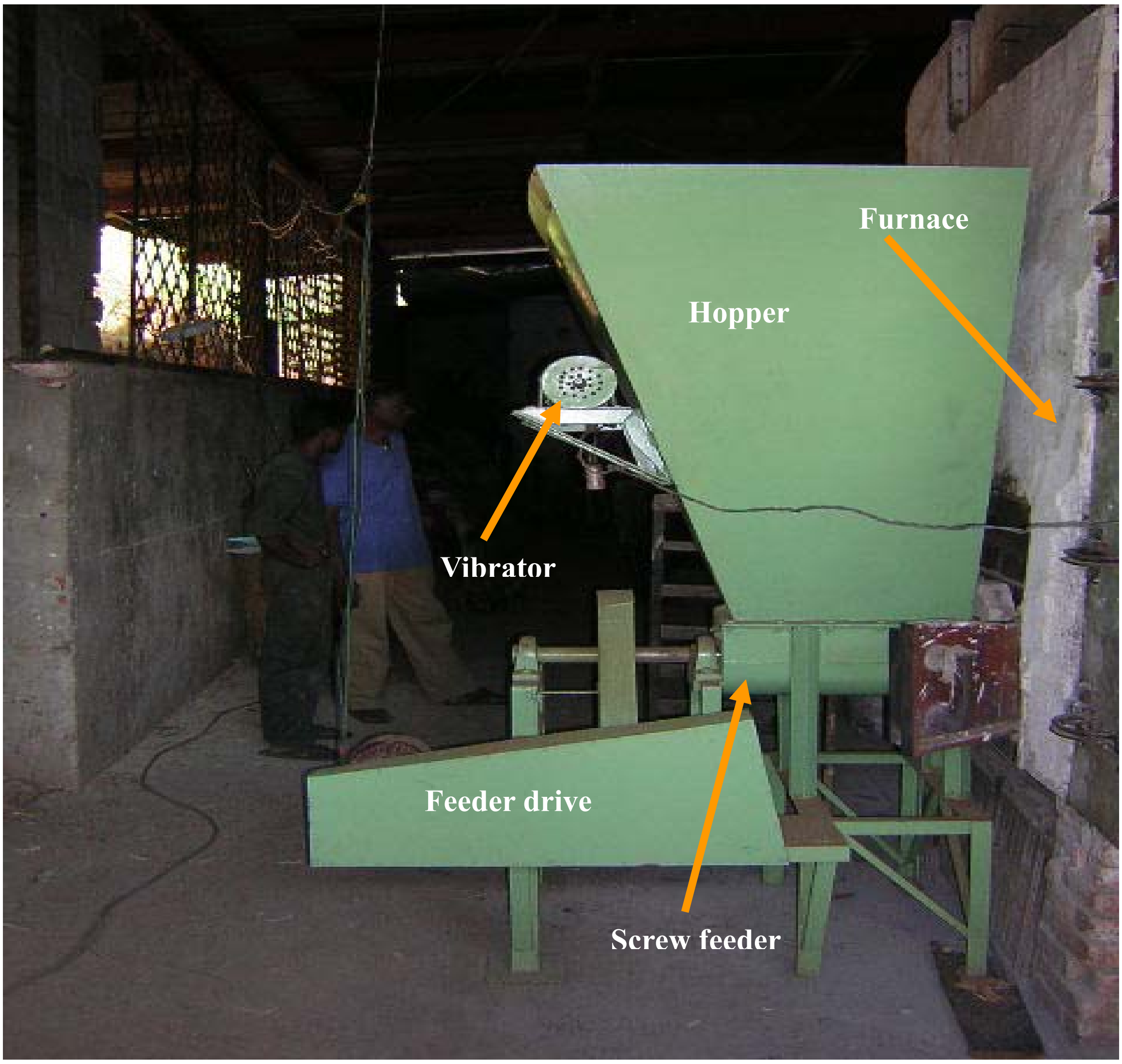


Fig. 11 Improved System retrofitted to the existing furnace

3.3.1.1 Performance of the improved combustion system

Following are the major results of the field trials conducted using the improved combustion system.

- Fuel wood moisture reduced from > 43% to < 20%
- Hot air temperature fluctuations reduced from ± 20% to ± 3%
- Furnace heating up time reduced from ~ 4hr to ~ 2hr
- Fuel wood consumption reduced by ~ 45%
- Overall efficiency increased from ~ 40% to ~ 75%

Fig. 12 shows the types of wood chips and pieces used in the pilot runs. Fig. 13 shows the comparison of hot air temperature with different type and preparation of fuel wood.

Fig. 12 – Wood pieces used

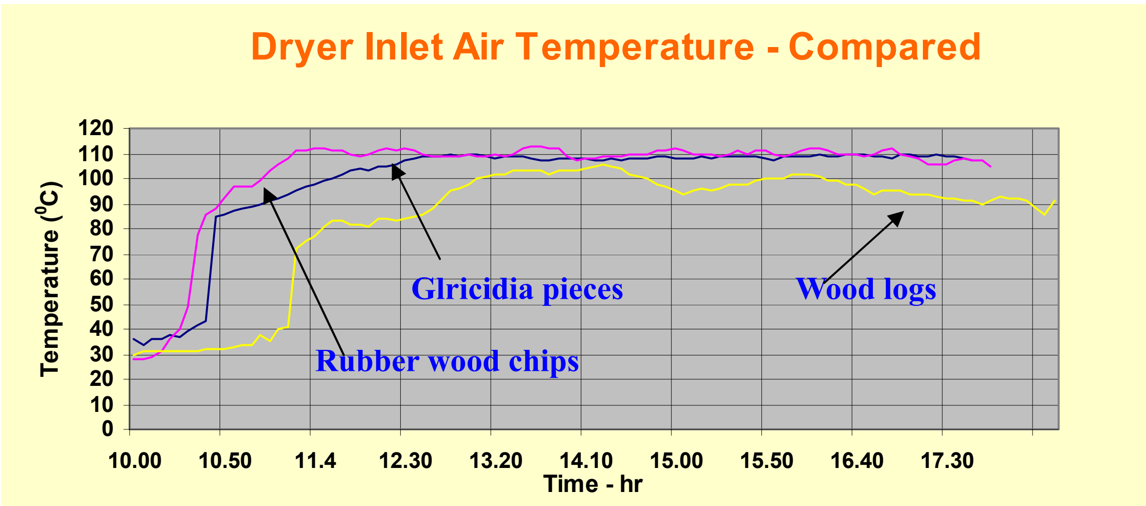


Fig. 13 - Hot air temperature with different types and preparations of wood

Table 3 compares the specific fuel wood consumption and associated specific fuel cost in respect of different types and preparation of fuel wood.

Table 3 – Specific fuel wood consumption and costs with different types

Fuel wood type	Specific fuel wood consumption - kg /kg MT	Specific energy cost – Rs./kgMT	Percent fuel wood savings - %
Wood logs (Present system)	2.42	9.46	Existing system
Wood chips (Improved system)	1.28	5.52	47%
Gliricedia pieces (Improved system)	1.30	3.25	47%

The estimated economic benefits accruable through the improved system are as follows.

Energy cost reduction

With wood logs - specific fuel wood cost	= Rs. 9.46/kg MT
With wood chips – specific fuel wood cost	= Rs. 5.52/kgMT
Reduction in fuel cost	= Rs. 3.94 kgMT

There are about 600 tea factories in the country and the number of hot air furnaces available in these factories is about 1250.

Present annual fuel wood consumption in Tea industry	~ 610,000 tonne
Predicted fuel wood consumption with improved system	~ 323,300 tonne
Potential savings	~ 286,700 tonne
Equivalent annual fuel cost savings	~ Rs. 1,118 M

4.0 Conclusion

Domestic sector and the tea industry are major consumers of fuel wood in Sri Lanka. As seen from the above findings domestic cook stoves have been developed locally on continuous basis and as a result the cook stove efficiency has been increased from mere 8% 30 years ago for three stone hearth to present 35% for modern cook stove. Now, the technology of the most recent developemnt, the Wood Gas Stove, has been transferred to a few entrepreneurs and is being marketed by them. Unconfirmed information shows that nearly 30,000 units have been already sold out. This improved cook stove has the potential to market over three million in Sri Lanka. This will contribute positively to improve the domestic health, especially of women. In addition it can largely mitigate the adverse impact on the country's economy due to escalating fuel prices, especuially LPG and kerosene.

The improved combution system is a new technolgy that came into the industry in more than 100 years. According to results of field trials it's a boost to the technology starving traditional tea industry. It has the potential for bringing down ther cost of production of made tea by nearly Rs. 4 per kg. In addition, this will have a greater impact on promoting sustainable utilization fuel wood as an energy source as this technology will promtote the cause of dendro. There is potential for saving more than 286,000 kg of fuel wood costing over Rs. 1.1 billion annually.

References

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Abstract
Sri Lanka still remains a major user of biomass for meeting it energy needs. Domestic and industrial sectors are the major consumers of biomass for energy. Owing to the continuous escalation of prices of and over dependency on fossil fuels, there was an urgent need to search for potential and reliable indigenous sources of energy. Biomass has been identified as one of them owing to some comparative advantages associated with it. Dendo power has been gaining interest and is being promoted at an accelerated phase to meet the future challenges of energy supply needs.

Along with this there is a need for new technologies, which are both efficient and convenient to the user, in order to support Dendro power. The National Engineering Research & Development Centre (NERDC) of Sri Lanka has been carrying out extensive research on developing biomass energy technologies, and has successfully developed new and efficient domestic cook stoves, small scale bakery ovens for SMEs, efficient industrial biomass combustors, etc. . Many of these technologies have achieved substantial increase in efficiency and end user friendliness, and many of them have been commercialized already and others are being commercialized.

This paper looks at the development of the above biomass technologies with the achievements thereof and their contribution towards cause of Dendro power in Sri Lanka.