Current Status of the Energy Situation in Sri Lanka

By

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1. Introduction

Energy is a vital input to our day-to-day life in the households, industry and commercial sectors. Knowledge of how much of energy is input to the economy and the quantities of different forms of energy used in various activities is always useful for planning the future energy system in a country. The energy demand of Sri Lanka is supplied by combination of following types of sources

- Indigenous primary sources of energy
- Imported primary sources of energy
- Imported secondary sources of energy

The indigenous primary sources such as biomass and hydro contribute major part of the energy supply. Imported primary sources are crude oil and small quantities of coal. Refined petroleum products are the imported secondary energy sources.

Energy supply in Sri Lanka is handled by several state agencies and private institutions. It is necessary to bring the different forms of energy supplied by different institutions, used for various economic activities, to a common basis for comparison. And it is important for policy makers and other interested parties to have a historical collection of such data for future planning and decision making.

This document gives a description of the Energy sector in Sri Lanka, the key players and the institutional structure. The energy inputs and outputs of each supply-side institution are explained.

2. The Energy Supply - Past and Present

The main indigenous primary energy sources of Sri Lanka are biomass and hydro electricity. These two sources of energy constituted more than 56% of the primary energy supply in 2004. The next promising primary energy source would be wind energy. Although the potential has been identified in a preliminary study the exact amount which can be absorbed technically and economically is not yet established.

Although economically extractable fossil fuels reserves are not identified so far, the Government of Sri Lanka is committed to go ahead in the identification the resource with the help of foreign experts. It is believed that substantial resource of crude oil is available in the seas in the territorial waters of Sri Lanka. Crude oil is the main primary energy source imported. Large quantities of Diesel are LPG are imported to cater the increasing demand which cannot be supplied by the local refinery.

2.1 Electricity Supply

Electricity supply sector at present in Sri Lanka is mainly driven by two primary energy sources; petroleum based thermal power and hydro electricity. Since most of the economical hydro potential in the county has been already harnessed, Sri Lanka will have to depend on petroleum based power generation during the next decade, until the next economical primary source, coal is introduced to Sri Lanka power sector.

Sri Lanka has total identified major hydro power potential of 2006 MW out of which 1207 MW is harnessed as at present. One 150 MW Upper Kotmale hydro power project is under construction and scheduled to commission in 2011. 300 MW privately owned Combined Cycle Power Plant operating on furnace oil at Kerawalapitiya is under construction. Full operation of that power plant is expected in 2009. According to studies the mini hydro potential is identified as 200 MW out of which 110 MW has already been developed.

Sri Lanka's 7 to 8% annual load growth that exceeds generation expansion, its heavy reliance on hydro power, with fluctuating capacity depending on drought conditions, and its limited additional hydro development potential combined with pressure to decrease electricity tariffs has motivated CEB and the government to pursue additional and more cost-effective generation technologies. This includes fuel-oil and diesel-fired thermal power generation expansion in the near term and large coal-fired thermal generation expansion in the next decade. The construction of the 300 MW Norochcholai Coal Power Plant located in the west coast of Sri Lanka is underway with the financing from Chinese Government.

The different modes of grid connected electricity generation in Sri Lanka, are listed below.

(i) CEB major hydro

(ii) CEB non-conventional: presently only wind power

(iii) CEB thermal: presently oil fired (Diesel, furnace oil and residual oil)

(iv) Independent Power Producers (IPPs): presently oil-fired thermal (Diesel & furnace oil)

(v) Small Power Producers (SPPs): presently small hydro and CHP, embedded in the distribution network

Electricity generation from various sources since 1970 is shown in the table 1 below.

Table 1- Power Generation in the National Grid

In GWh

	1970	1975	1980	1985	1990	1995	2000	2001	2002	2003	2004	2005
CEB Hydro	740.3	1077.6	1480.1	2394.6	3144.7	4514.0	3153.8	3044.9	2588.6	3190.0	2755	3173
CEB Wind							3.4	3.5	3.6	3.4	2.7	2.4
CEB Thermal	45.4	1.3	188.8	69.4	5.0	269.1	2205.3	1895.5	1952.6	2193.2	2507	2162
IPP Thermal							863.6	1057.8	1243.3	1732.4	2064	3152
SPP Hydro							43.1	64.7	103.5	120.3	206	280
Hired Thermal							443.4	471.1	939.2	394.4	509	0
Gross Generation to CEB Grid	**785.7**	**1078.9**	**1668.9**	**2464.0**	**3149.7**	**4783.1**	**6712.7**	**6537.5**	**6831.3**	**6831.3**	**8043**	**8769**

Source – Energy Data, SEA, 2005

The Government has taken a policy decision in 1996 to invite private investors to invest on power generation in the country and as a result, the first private power plant was commissioned in 1997.

In early 1992, the Ceylon Electricity Board (CEB) has announced inviting the connection of existing privately owned micro hydro plants (MHP) to the national electricity grid with an offer to purchase electricity from such plants at the rate of Rs. 2.60 per kWh. As a result the first MHP was connected to the grid in 1996 followed by several plants located in the central hill county.

It is shown in the table above that hired thermal plants running on auto diesel were introduced in the year 2000. This was first introduced in 1996 by the Government to fill the gap of energy deficit caused by the drought conditions.

CEB has introduced wind power into their generation mix as a 3 MW pilot project in 1999 with the assistance of the World Bank & Global Environmental Facility under the Energy Services Delivery Project. The intension of the pilot project is to expand the wind capacity in the generation mix with the experience of the pilot project. In line with the objective of the pilot project CEB in 2002 called proposals a 20 MW wind project under for BOO (Built Own & Operate) basis. Although considerable number of investors showed their interest at the beginning, only one bid was received at the time of bid closing. The reason for this poor bidding was mainly due to non availability of wind experience partners to make the joint venture for bidding purposes. CEB has not started any development on wind power or called proposals for wind power after 2002. As a result no wind power has been added to the system.

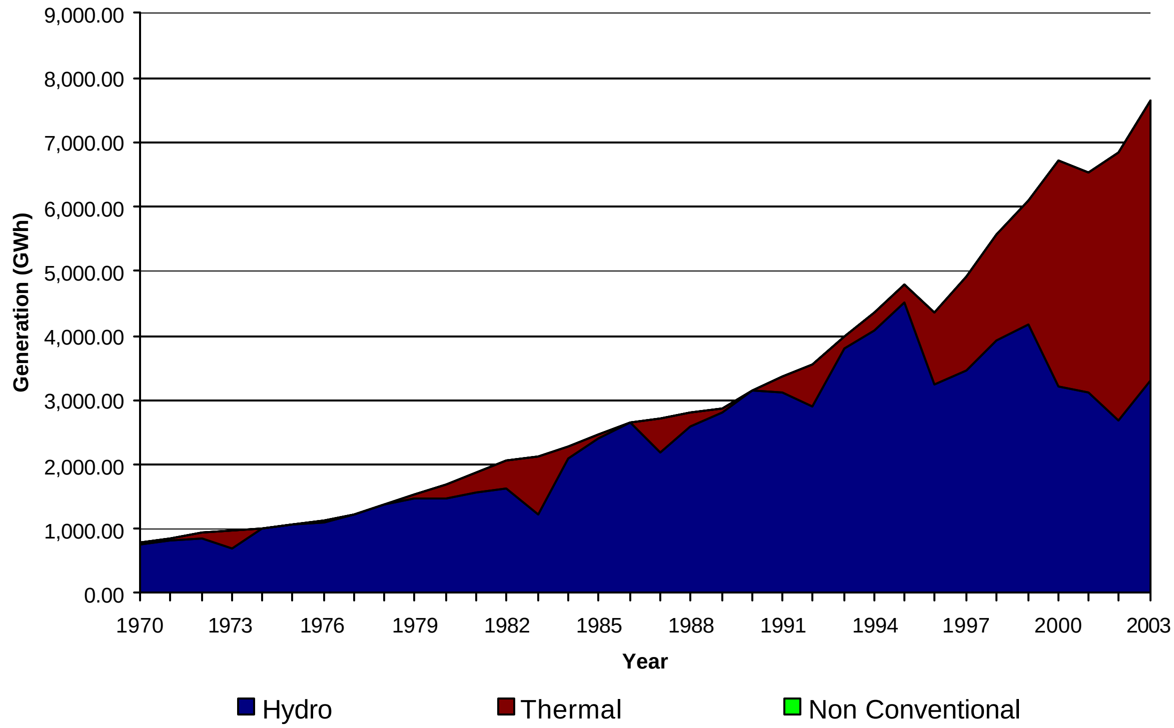


Figure 1- Hydro Thermal Share of Electrical Energy in the National Grid

The above figure shows the energy mix by thermal and hydro. It clearly shows that the percentage energy contribution by hydro is declining from 94% in 1970 to 32% in 2004. Thermal generation share has been increasing rapidly since 1996. This is mainly due to the limitation in the development of hydro resources further. Since then CEB has been facing financial crisis due to large share of expensive thermal generation.

Future Electricity Supply Options

CEB is solely responsible for the planning of the future generation mix in order to provide reliable, quality electricity to the entire nation at affordable prices. The latest CEB Generation Plan shows following capacity addition by plant type.

Table 2 Planned Electricity Supply Options of the Future

Type of Plant	2007-2011 MW	2012-2016 MW	2017-2021 MW	Total capacity addition MW
Hydro	150			150

Combined Cycles	300			300
Coal	570	2100	2400	5070
Gas Turbines	525			525
Total	**1545**	**2100**	**2400**	**6045**

Source – Long Term Generation Expansion Plan 2005, CEB

In 2021 the major share of the new capacity (84%) will be from coal-based power plants. Hence coal based power plants will play an important role in the future electricity sector. The present capacity of 2228 MW will be increased to 7630 MW by the 2021. According to the plan the thermal plants will supply 86% of the electricity demand.

Upper Kotmale Hydro Project (150 MW), Kerawalapitiya Combined cycle power plant (300 MW) and the Norochcholai Coal Power Plant (300 MW) have been considered as firmly committed plant for the plan. CEB Generation expansion plan recommends to implement 300 MW coal plant at Norochcholai immediately with necessary steps to expand up to 900 MW and to initiate Hambantota and Tricomalee coal power plants developments immediately. Although the construction of Notochcholai first phase (300 MW) is underway the other two proposed coal plants are still in pre-feasibility stage.

During the initial stages Norachcholai coal power project came under heavy opposition from the environmentalist and the people in the area. Large number of people in this area are depending on the fishing industry. This area has also a successful agriculture industry with various vegetables, such as cabbage, red onions and sweet potatoes. The villages fear is that once the coal plant is in operation the residue of ash from the burnt coal will be deposited in the environment and destroy the agriculture. CEB believes that the most of the environmental hazards will be mitigated with proper design and operation of the plant. However it is believed that the benefits of such a plant far out weighs the environmental problems (if any) it could cause.

As it is clearly seen hydro projects such as Gin Ganga (49MW), Broadlands (35 MW), Uma Oya (150 MW) and Moragolla (27 MW) have not been included in the plan horizon. The specific capital cost of all these plants are in the range of 2600 to 3200 US$/kW whereas the specific energy cost varies from 7.9 to 10.72 USCts/kWh. The planning criteria is that no consideration is given for hydro plants less than 15 MW capacity and specific cost greater than 15 USCts/kWh.

The plan has considered 8.4% capacity increase every year on embedded renewable energy which resulted the postponement of some thermal power plants.

2.2 Electricity generation by off-grid

The first off grid village hydro scheme was commissioned in 1992. Since then the village hydro schemes became very popular specially in Southern and Sabaragamuwa provinces.
These village hydro schemes were built, owned and operated by rural communities through electric co-operative societies that are set up for the purpose. As a result, the application of village hydro schemes were established to provide power to rural households, which are very far

from grid electricity. During the early years of development, the average electricity from village hydro is about 100 W per household and maintained a fixed tariff of Rs. 100 per month per household. The present records indicate that over 5000 houses are connected to village hydro schemes with the total capacity of 1.4 MW.

Several other non-conventional primary sources have been used for electricity generation in Sri Lanka. Solar photovoltaic systems have been increasingly used from early 1980s. At present about 60,000 solar photovoltaic household systems were installed due to the innovative financing schemes such as ESD and RERED project with private sector involvement.

2.3 Petroleum supply

Present Supply

Imported petroleum, which currently account for 43% of primary energy supply will continue to play a major role in our energy future. The total value of imports of petroleum products and crude oil in 2005 is US$ 1.45 billion. This is a 35% increase compared to 2004 imports. The value of petroleum related imports contribute 16% of the total national imports to Sri Lanka in 2005.

The Ceylon Petroleum Corporation (CPC), a state-owned organisation, and Indian Oil Company (IOC) were responsible for all aspects of petroleum supply in Sri Lanka during year 2004, except that of LPG, which is now handled by Shell Gas (Lanka) Pvt. Ltd. and Lanka Auto Gas Pvt. Ltd., and Marine bunkering. After liberalization of bunkering market in 2001, a number of private operators entered the market under license issued by Ministry of Power and energy.

As a result of increased thermal electricity generation, the demand for diesel oil and fuel oil has increased substantially in the resent past adding to the existing imbalance in the demand pattern and refinery production. The imports and refinery production for 2005 are shown in the following table.

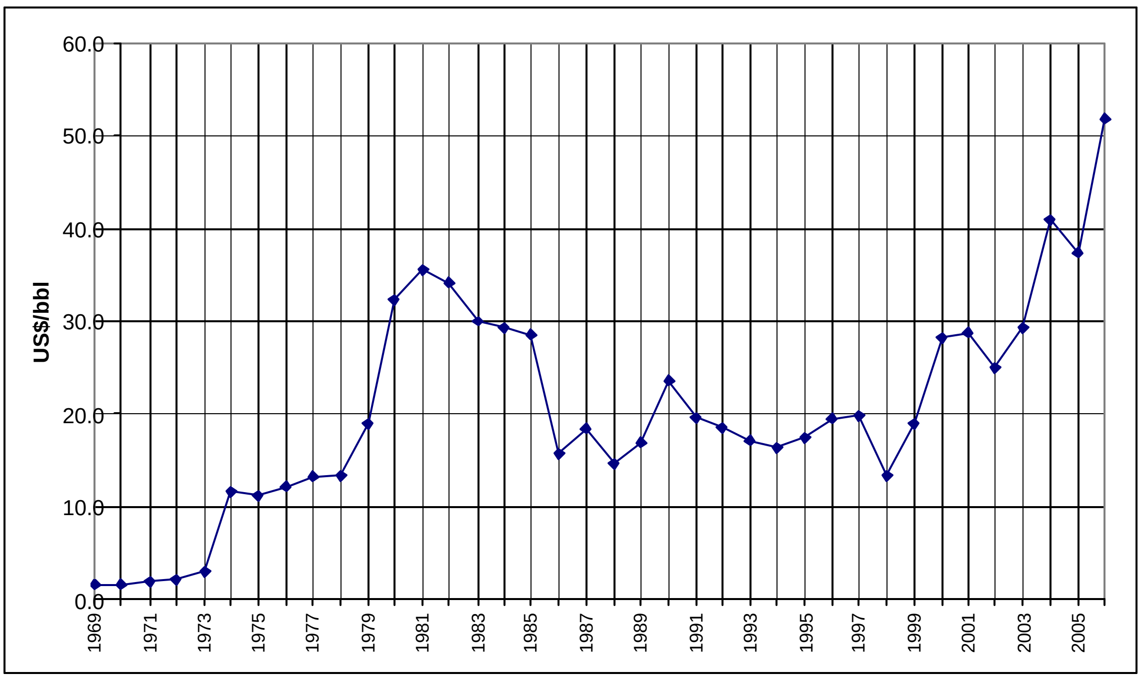
	in Thousand MT	
	Imports	**Refinery Production**
Crude oil	2200	0
LPG	148	15
Petrol	149	202
Avtur (Aviation fuel)	200	126
Kerosene	57	143
Auto Diesel	1348	677
Furnace Oil		786

Source- Statistical Digest, Ceylon Petroleum Corporation, 2005

Petroleum Refinery Operations

The bulk of the country's petroleum product requirements are imported as crude oil, which is then processed at the 2.3 million MT per year (52,000 bbl/stream day) CPC refinery at Sapugaskanda. The crude slate comprises mainly of Middle East crudes and Malaysian crude. While CPC has purchased part of the crude oil requirement in the open market at times, during the last two years CPC acquired crude oil through state-to-state deals with the Government oil companies of Iran, Saudi Arabia, United Arab Emirates and Malaysia.

The refinery maximum throughput is less than the total requirement for petroleum products. Besides, its production slate differs significantly from the mix of product demand. Operating at maximum design capacity to meet the demand for middle distillates, kerosene Jet A-1 and diesel, has still resulted in a deficit of these products with a need for supplementary imports while at the same time producing a surplus of naphtha which is now utilised for165 MW CEB owned combined cycle power plant. The figure 2 shows the C&F prices movements of the crude oil imported by CPC for refining purposes. It is that the crude oil is in the increasing trend from the reason past.



Source- Energy Data, SEA,2005

Figure 2 – Historical crude oil import prices (C&F)

Future Prospects of discovering Oil

CPC carried out some petroleum exploration activities in 1970s without any success. At that time, seven wildcat wells were drilled both on shore and off shore, and all were found to be dry. Renewed interest has now shown in exploration activities, as the import cost of oil becoming a major burden on the economy. There are two sedimentary basins, which may bare oil and gas, off coast of Sri Lanka. Cauvery basin located between northwest coast of Sri Lanka and Gulf of Mannar basin situated between western coast of Sri Lanka and India. India has been successful in exploration activities on their side of Cauvery Basin and has discovered both oil and gas. Presently India is producing 3 millions of barrels per day of oil and about 180 million cubic feet of natural gas per day in this area.

Recently carried out seismic and magnetic gravity surveys confirm the presence of reservoir rocks of good quality and oil bearing structures. However the type of oil whether light or heavy oil is not confirmend yet. It is more likely that Gulf of Mannar, which is much deeper, would yield gas deposits rather than oil. The Government of Sri Lanka is committed to go ahead in the identification the resource with the help of foreign experts.

The Ministry of Petroleum Resources is planning to finalise bids in the near future to coduct oil exploration in the Mannar Coastal basin. Two out of six identified basins have been earmark for India & China. The others will be developed by a propspective investors with 50-50 production sharing arrangement. It will take three years for the first bucket of oil to be extracted from the time one wins the tender.

2.4 Biomass

Forest products and agricultural residues are of central importance to Sri Lanka's overall primary energy supply. Energy statistics of 2004 shows that biomass use accounts for about 48% of the total primary energy supply. Nearly 90% of the biomass supply is from fuel wood. Biomass fuels are consumed mostly households, but also in tea, rubber and brick & tile industry to a grate extent. Biomass energy consumption has been increasing by 3% annually. Sawdust, a potential fuel, is still wasted in Sri Lanka. Coir dust is exported to European countries in briquette form as a soil conditioner and therefore no longer freely available as a potential fuel.

Fuelwood

The table below shows the sectoral consumption of fuelwood over the past 30 years. This gives revised estimates, using more recent surveys about household fuelwood use and industries. The reason for flattening the household demand for fuelwood after 1990s is mainly due to the increase in usage of LPG for cooking with the privatisation of LPG distribution in 1995. .

Table 3- Sectoral Consumption of Fuel Wood (thousand MT)

Year	**1975**	**1980**	**1985**	**1990**	**1995**	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**
Industries	1407	1292	1423	1512	1800	1870	1878	2979	2570	3043	3116	3293
Household, Commercial & Others	6690	7260	7740	8110	8290	8310	8240	8350	8390	8035	8156	8157
Total	**8097**	**8552**	**9163**	**9622**	**10090**	**10180**	**10118**	**11329**	**10960**	**11078**	**11272**	**11440**

Source- Energy Data, SEA,2005

Fuelwood is not a commercial fuel therefore the historical price data are not readily available.

Baggase

Bagasse is the waste form of sugar cane, which is used in sugar factories for combined heat and power generation. The table below shows the historic trends in the usage of bagasse.

Table 4 – Usage of bagasse (thousand MT)

	1977	**1980**	**1985**	**1990**	**1995**	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**
Bagasse	59.2	113.1	95.3	377.4	301.7	238.6	253.8	264.8	188.4	128.9	212	235

Source- Energy Data, SEA,2005

Biogas

The first community based biogas (Indian type) generator was established at the Rural Energy Centre (REC) at Pattiyapola in 1978. This REC is a community project with its maintenance and operation being the responsibility of the entire village. The daily cow dung requirement for the biogas generator is about 2400 kgs. The biogas produced by the generator was used to operate 37.5 kW engine generator. The major obstacle was the regular supply of cow dung and the villages reluctance to work with cow dung.

Contribution by the biogas energy to the total energy scene is insignificance. There had been many governmental and non-governmental organizations that had been involved in biogas promotion and implementation in Sri Lanka . However the results from the national survey conducted by Energy Forum indicated that the country had not benefited significantly from these activities.

The effort involved in the collection of raw material such as cow dung is most common factor for failure of most of the community based biogas plants and single owned biogas generators in Sri Lanka. However the industry based biogas plants specially integrated with farms and municipal waste disposal systems are fairy successful. Biogas system's value as an environmental management technique is key factor in utilizing the technique across sectors such as urban environment, industrial waste treatment and livestock management facilities.

In 1996 ITSL has carried out a sample survey to find out the present status of biogas technology. The study reviled with unconfirmed data that the total number of biogas units constructed through out the country is around 5000. The above sample survey results indicate that the function rate is as low as 28.5%

Biofuel

The Sri Lankan transport sector is totally dominated by petroleum fuels, and biofuels (ethanol and biodiesel) are not at all used presently. However, Sri Lanka does have a small ethanol production integrated with sugar production industry which is exclusively used for alcoholic beverage industry. Therefore, it can be observed that Sri Lanka possesses the technology and experience to produce a limited amount of alcohol (ethanol). As per the current status of capacities of two major sugar factories namely Sevanagala and Pelwatta, with assumption of conversion of 50% of the ethanol to industrial ethanol, it could produce 21,500 litres annually. The publication titled "Promotion of Biofuels for Sustainable Development in South and South-East Asia" by SLEMA reveals that, in order to have a 10% blend with gasoline, an additional 12,000 ha of sugar cane cultivation is required.

However at present there is no capacity to produce biodiesel in an industrial scale in Sri Lanka. The above report further reveals that in order to replace 10% of the current diesel consumption, an area of 225,000 ha will be required to grow Jatropha. This is about 1/3 of the combination of wetland, barren land and other open land.

Currently dedicated crops for biofuels are not grown in Sri Lanka. Sugarcane is grown with the priority on sugar production. The vegetable oil industry too focuses on edible and non-edible vegetable oil market. Therefore a clash of priorities may occur with respect to supply of raw materials for biofuels. Dedicated biofuel plantation will have to compete with agricultural land required for food production. The use of non-arable lands for growth of biofuel crops have to be explored. Above all common problems faced with energy plantation will be a major issue. Hence these constrains related to raw material supply would definitely be an issue to be addressed.

Currently the cost of production of biofuels is around three times that of petroleum products. Therefore producers should be provided with the necessary incentives and know how to attract. Other overriding concerns would be assurance of a continuous supply, quality and warranty issues.

Biomass Power Generation and Issues

It is generally considered that sparsely used croplands and land under shifting cultivation could be used for fuelwood plantations. It is believed that 400 hectares of land could provide the necessary fuelwood requirement for 1 MW plant.

The Bio Energy Association of Sri Lanka (BEASL) was formed by a group of professionals with the intension of promoting the use of biomass resource for power generation thus reducing the increase dependence on imported fossil fuel. BEASL revealed by their publication titled "Regaining Sri Lanka with Bio Energy, 2003" that the total extent of degraded marginal land suitable for energy plantation in Sri Lanka is 1.6 million hectares. Hence total national potential for Dendro power considering 400 ha for 1 MW, estimated to be 4000 MW with annual generation of 24,000 GWh. This is nearly 4 times the total hydro potential in Sri Lanka. Therefore BEASL claims that the Dendro potential in our country is adequate to meet our electrical energy demand for many decades.

BEASL also clams that every MW of Dendro power could provide employment to 150 farmer families providing employment for 300 workers for 150 days of the year. With the total potential of 4000 MW it could employ 600,000 families throughout the year with total workforce of 1,200,000.

A study done by the Center for the Energy Studies of the University of Moratuwa recommends the purchase of electrical energy produced by Dendro should be on the basis of avoided cost. The avoided cost in this case has both capacity and energy components unlike in the case of small hydro plants where there is no capacity component. Therefore it recommends that the tariff for Dendro plants can enhanced by approximately Rs. 1.40 per kWh to reflect the capacity benefit to the utility.

Issues Pertaining to Dendro Power

LTL Energy (Pvt) Ltd has built a 1 MW pilot Dendro power plant at Walapane in Nuwaraeliya District using the conventional steam turbine system. Ceylon Tobacco Company manages the fuelwood supply chain. This supply chain comprises of 30 fuelwood suppliers each supplying 40 Tones of dried Gliricidia a month. Each fuelwood supplier purchases Gliricidia sticks from 22 small farmers on wet basis. These wet sticks are chopped to a suitable size and dried before supplying them to the power plant. The plant was commissioned in November 2004.

Initially the agreed tariff was the standard power purchase tariff common for all renewables below 10 MW capacity. However few months after commissioning the technical and fuel supply issues immerged and caused the plant to cease operation due to financial losses. The operator then requested the Government intervention to increase tariff by Rs. 1.50 per kWh above the SPPA tariff for which the Government positively responded. The energy production figures of the dendro plant shows downward trend even after the introduction of the concessionary tariff.

There are several issues pertaining to the application of biomass energy technology for power generation. Some of the key issues presented in the article “Prospects, Trade-offs and Challengers of Using Woody Biomass for Power Generation and Thermal Applications in Sri Lanka” by R.M.Amaraseka are;

- Lack of awareness and recognition of the potential and multiple benefits by public and relevant authorities
- Competition from fossil fuels
- Uncertainty of sustainable supplies and negative impacts
- Time consuming process of energy plantation
- Lack of financing for large scale projects
- Lack of understanding of operational problems in the large scale biomass power generation
- Lack of studies on socio economic and environmental impacts of large scale fuelwood plantation

This article further suggest that the biomass power generation should not endanger the energy security of using biomass for cooking by the urban and rural poor.

2.5 Wind

Systematic studies concerning the development of wind power resources in Sri Lanka were commenced in late 1977 with technical assistance from the government of Netherlands. The project was executed by the Water resources Board (WRB) aiming towards the development of water pumping wind mills for small scale farmer in the dry zone. Besides hardware development activities, the project also carried out some preliminary studies concerning the assessment of wind energy resources in Sri Lanka. In 1987 Sri Lanka has started a project aimed at the assessment of wind and solar energy resources in the Central Highlands and Southern Lowlands. From 1988 to 1992, CEB conducted a wind resource assessment study in the southern lowlands that included nine 20- metrological towers. The project is apart of the Netherlands Ministry of Development Cooperation for assistance to Sri Lanka in the field of energy. The project has been implemented by the Ceylon Electricity Board (CEB), in view of the potential contribution to the electricity generation in the country. The study concentrated on the southern lowlands of the island. This area is well exposed to both the southwest monsoon and the northeast monsoon. Wind resource data was collected and analyzed at various monitoring sites for several years.

Based on the outcome of the study CEB made a proposal to the World Bank for funding the pilot wind power project for which World Bank positively responded and funded the 3 MW pilot wind power project in Hambantota. CEB has initiated a prefeasibility study and a feasibility study for a pilot project in the years 1995 and 1996 respectively with the financial assistance from the World Bank and GEF.

This pilot project was expected to demonstrate the commercial viability and long-run economic potential of wind power in Sri Lanka, and to catalyze future private sector windfarm development. The Central Environmental Authority (CEA) approval for this project was granted after significant delays (primarily due to protests concerning wild life issues related to birds and elephants). However, since implementation, there have been no environmental incidents of any significance. From an environmental perspective, the wind farm appears to have achieved its objective of demonstrating that it is a benign technology.

There have been several proposals to develop wind plants by Private Sector in the Southern part of Sri Lanka. CEB also has undertaken with the financial assistance from UNDP to set up a network of wind measuring station in the western coastal area and some parts of the central hills. The western coast is a promising area for future wind development where the land is freely available with less environmental problems. The main objective of that UNDP study is to establish a wind map for that area to support the wind development in the country.

The regions covered in that study are believed to be only a fraction of the likely national wind power potential. Therefore CEB has taken initiative to estimate the total wind potential and its distribution in the country. In response to a request by the CEB trough the government of Sri Lanka, the United States Agency for International Development (USAID) has assisted Sri

Lanka' to develop a meso-scale wind map for the island using advanced techniques developed in the US during the last two decades. Overall responsibility for the project is vested with the National Renewable Energy Laboratory (NREL) based in Denver, Colorado.

NREL estimates that there are nearly 5000 km^2 of windy areas with good-to-excellent wind resource potential in Sri Lanka. About 4100 km^2 of the total windy area is land and about 700 km^2 is lagoon. The windy land represents about than 6% of the total land area (65,600 km^2) of Sri Lanka. Using a conservative assumption of 5 MW per km^2, this windy land could support almost 20,000 MW of potential installed capacity. If the windy lagoons are included, the total wind potential increases to approximately 24,000 MW. **Additional studies are required to accurately assess the wind electric potential**, considering factors such as the existing transmission grid and accessibility. The complete study report and the wind energy resource atlas of Sri Lanka is now available for potential developers. Therefore all the effort should be focused to develop and absorb this enormous indigenous potential without any arguments. All the technical and non technical barriers should be properly identified and country specific solutions should be introduced.

Table 5 shows the proportion of windy land in each province with good-to-excellent resource and moderate-to-excellent resource.

Table 5 Sri Lanka – Wind Electric Potential

Good-to-Excellent Wind Resource at 50 m

Wind Resource Utility Scale	Wind Class	Wind Power at 50 m W/m^2	Wind Speed at 50 m m/s*	Land Area km^2	Lagoon Area km^2	Total Area km^2	Percent Windy Land	Total Capacity Installed MW
Good	4	400 - 500	7.0 – 7.5	2,341	664	3,005	3.6	15,000
Excellent	5	500 - 600	7.5 – 8.0	788	41	829	1.2	4,150
Excellent	6	600 - 800	8.0 – 8.8	517	0	517	0.8	2,600
Excellent	7	> 800	> 8.8	501	0	501	0.8	2,500
Total				4,147	705	4,852	6.4	24,250

Moderate-to-Excellent Wind Resource at 50 m

Wind Resource Utility Scale	Wind Class	Wind Power at 50 m W/m^2	Wind Speed at 50 m m/s*	Land Area km^2	Lagoon Area km^2	Total Area km^2	Percent Windy Land	Total Capacity Installed MW
Moderate	3	300 - 400	6.4 – 7.0	6,119	196	6,315	9.5	31,600
Good	4	400 - 500	7.0 – 7.5	2,341	664	3,005	3.6	15,000
Excellent	5	500 - 600	7.5 – 8.0	788	41	829	1.2	4,150
Excellent	6	600 - 800	8.0 – 8.8	517	0	517	0.8	2,600
Excellent	7	> 800	> 8.8	501	0	501	0.8	2,500
Total				10,266	901	11,167	15.9	55,850

Assumptions
Installed capacity per km² = 5 MW
Total land area of Sri Lanka = 65,610 km²
Percent windy land calculation does not include windy lagoon area.
Source- NREL, 2003

Table 6 Wind Electric Potential (on land only) by Province

Province	Good-to-Excellent Potential MW	Moderate-to-Excellent Potential MW
Central	7,550	11,750
Eastern	150	1,350
North Central	300	4,100
North Western	1,100	2,050
Northern	4,950	13,450
Sabaragamuwa	2,200	4,100
Southern	650	2,900
Uva	3,850	11,650
Western	0	0

Several local companies have shown interest to participate in developing wind power in particularly in western coastal area. CEB has already issued 4 LOIs to 4 local companies in this regard. The Government has agreed to provide part funding for the establishment of 132/33 kV grid substation in the vicinity of potential wind site near Kalpitiya as an encouragement. So far none of the projects took off the grounds due to delay in acquiring finances.

2.5.1 Issues of wind Power Development

Technical Issues

There are several technical issues that result in challenges, if not barriers, to the development of wind energy in Sri Lanka. These technical issues are further categorized and discussed below.

Electrical Infrastructure

In most areas of the country, the transmission lines have adequate capacity to accommodate additional power from moderate sized generation projects including wind. The exception is in northern Sri Lanka where much of the electrical infrastructure has been damaged. Unfortunately, the overall system stability and the substation capacity preclude the addition of any substantial amounts of capacity in many areas. On the west coast and in the southern region most substations could accommodate only about 20 MW of additional capacity. Substation capacity in the central hills can accommodate somewhat larger amounts of additional capacity, perhaps up as much as 30MW. CEB's previous estimate was that the system is limited to an additional wind capacity of 7% of peak load, or approximately 100 MW.

Transportation Systems

Colombo has a modern, medium-size container port that is adequate for receiving large utility-scale wind equipment. There are several smaller ports along the west and south coasts where equipment could be shipped by barge. In some cases this is likely to be more logistically feasible than transporting equipment by truck for long distances.

The Road Development Authority in Sri Lanka is likely to have specific weight and dimensions limitations for the major roads. Roads into the central regions are less developed than coastal roads and have many sharp bends and low capacity culverts. Therefore, these road conditions will preclude the use of wind turbines larger than approximately 600 kW in the central region. The turbine blades are the greatest challenge due to length and the required turning radius. Large construction cranes are wide and quite heavy and in some cases can be the most challenging equipment to transport when constructing a utility-scale wind project.

Construction Logistics

Although Sir Lanka has some experience with large infrastructure projects, mobile construction cranes required for installing utility-scale wind equipment will be leased and barged over most likely from the south coast of India. This appears to be a reasonable solution at least for the west coast of Sri Lanka. One of the private local wind developer researched the cost and availability of using an Indian crane and determined that it was economically feasible.

While Sri Lanka has limited experience with utility-scale wind development, there is an adequate labor pool and experience with large infrastructure projects. Additional expertise may be available from India, which currently has more than 6,000 MW of installed wind capacity.

Providing CEB with additional analysis tools and an increased understanding of developers' needs for the successful financing and construction of a wind project will also promote future wind power development. Expanding the number of in-country organizations that understand the issues critical to project development and how they impact site selection will facilitate further development of wind energy in Sri Lanka.

2.6 Solar Photovoltaic

Solar Photovoltaic (PV) was introduced to Sri Lank by CEB in 1981 by selling small 10 W household PV systems. About 700 such systems were sold from the CEB head office in spite the of the hardship faced by the people having to travel to Colombo to buy them. These systems are designed to fulfil rural energy needs (lighting) in the absence of grid electricity. The success of these schemes, in terms of rural acceptance to the rural community, could be attributed to its ability to provide safe and quality lighting needs compared to kerosene. The increase use of solar PV could be attributed to;

- Early promotional activities of CEB leading to the commercialisation of solar PV
- Creating awareness
- Maintenance free system
- Innovative financial scheme such as ESD & RERED projects

The household electrification through grid has now reached nearly 80%. Through the abovementioned innovative financing schemes the total number of solar PV systems installed in Sri Lanka has now reached 60,000. This amounts to 6.4% of the un-electrified households. With the recent increase of Kerosene substantially would create a rapid increase in the demand for solar PV with proper promotional campaign.

There is also a great future for solar PV in urban areas if a proper scheme is introduced similar to other countries. Concept of zero energy houses are popular in Japan and some western countries where the electricity production through rooftop solar PV is fed to the national grid during the day time and the electricity is consumed from the grid during the night time. This could, to some extend reduce the national peak electricity demand and also reduce the distribution losses. Both could assist financial gains to the country by saving expensive energy generation. Heavy subsidy is required to promote this in mass scale. However local research and development of an indigenous industry would ensure that Sri Lanka will not have to depend on importation of technology and hardware as the market for solar PV increases.

Solar Energy Potential

Sri Lanka lies within the equatorial belt, a region where substantial solar energy resources exist throughout much of the year in adequate quantities for many applications, including solar water heating, solar electricity, and desalination Solar photovoltaic technology is currently cost-effective for meeting remote electrical loads and for providing a distributed source of electricity without the requirement of adding extensive grid infrastructure or putting a burden on the existing grid. Nevertheless, a good, quantitative knowledge of the distribution and extent of solar resources in Sri Lanka is essential in order to make appropriate decisions on the application of solar technologies, to properly size the systems being designed to meet loads, and therefore to attract further investment in these technologies.

The extent of solar resources in Sri Lanka has been estimated in the past based on a study of the daily total direct sunshine hours recorded at a number of weather and agricultural stations throughout the country The results of this study shows that the distribution of annual solar resources varies from 15-20 MJ/m2/day (4.2 to 5.6 kWh/m2/day) across the country, with the lowest values occurring in the hill country in the south-central region.

A systematic assessment of the solar resources has been developed by NREL, USA in 2002 for Sri Lanka using a methodology that converts cloud cover information, derived either from surface observations or satellite imagery, into solar resource estimates. The results for Sri Lanka are consistent with earlier studies using sunshine recorders. The study shows that, because of its tropical setting, ample resources exist throughout the year for virtually all locations in Sri Lanka for photovoltaic, such as solar home systems and remote power applications. Because of the general high level of cloudiness and humidity, the resources for concentrating solar power are generally less than adequate, except for certain times of the year.

The shows that the highest resources are in the northern and southern regions, and the lowest resources are in the interior hill country. The seasonal variations in solar resources in Sri Lanka are considerably greater, and the effects of the changing directions in wind flow and storm patterns between the southwest and the northeast monsoons is quite sharp. However, the highest resources occur during the hot dry period from March and April when the transition between the northeast and the southwest monsoon occurs.

2.7 Mini Hydro

2.7.1 Potential

The governmental policy directions for power sector envisages that the hydro power generation potential of the country will be developed to its full potential as it is the major indigenous resource for power generation as at present. Under this policy, all large-scale hydro power generation facilities are to be remain under government control for the foreseeable future. Private sector financing will be utilized for power generation from small hydro power plants.

Several assessments of small hydro power potential have been done by various agencies. According to the most recent study done by ITDG shows that the exploitable small hydro potential in Sri Lanka is as nearly 100 MW. This does not include the potential sites with head range below 30 m and taking into these factors it could be safely assumed that the total exploitable small hydro potential in Sri Lanka might be in the range of 170 MW – 180MW. However some believe the potential could be more towards 300 MW.

2.7.2 Present Status

In early 1992, the Ceylon Electricity Board (CEB) has announced inviting the connection of privately owned MHP plants to the national electricity grid with an offer to purchase electricity from such plants at the rate of Rs. 2.60 per kWh. In addition CEB offered to provide assistance in the execution of feasibility studies for projects up to 500 kW at no cost.

Electricity generation through the grid-connected and off-grid hydro plants were popularized under the World Bank and Global Environmental Facility (GEF) assisted Energy Services Delivery (ESD) project, implemented by the Government of Sri Lanka during 1997-2002. On the success of the ESD project the follow-on Renewable Energy for Rural Economic Development (RERED) project was formulated in 2003 and expected to complete in 2007. Grid-connected projects are commercial initiatives carried out by private sector developers. A total of 15 mini hydro subprojects with an installed capacity of 31 MW were financed under the ESD Project. The RERED Project extends term loans through Participating Credit Institutions to commercially viable subprojects using renewable energy technologies. It targets a capacity addition of 85 MW through grid-connected renewable energy projects mainly MHP, each typically under 10MW in capacity. The summary of the present status of grid connected mini hydro develop0ment is given in the table 7 below.

Table 7. A summary of the Projects implemented under the Standardized PPA up to end 2006

Status	Number of Projects	Capacity MW	Annual Energy GWh
In operation	56	106.9	346
Under construction	38	91.5	
LOI issued	69	108.6	

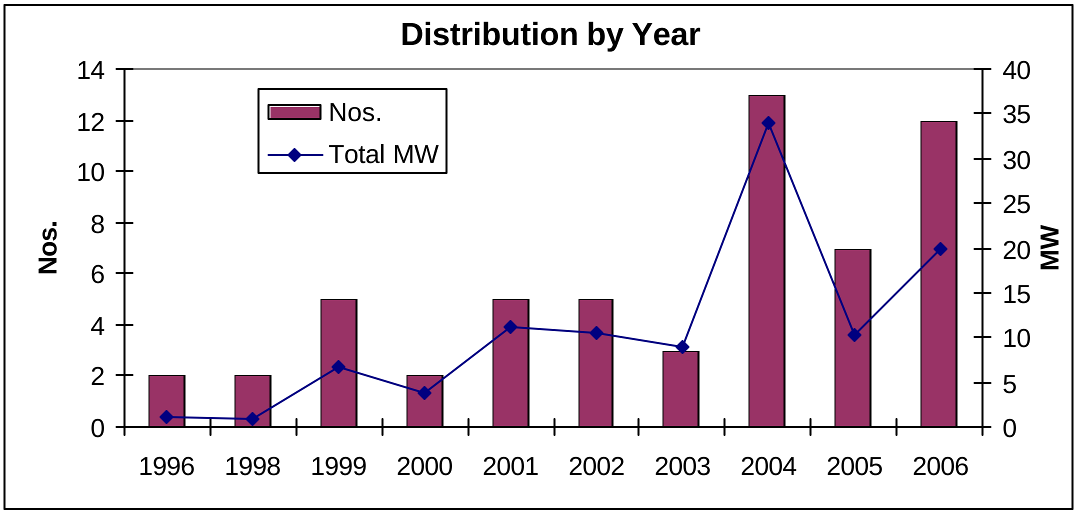
Source: CEB

At present Ceylon Electricity Board enters into a Standardized Small Power Purchase Agreement (SPPA) with the developer for 15 year term. This Standardized Small Power Purchase Agreement has the following main features:

- All energy produced by the Facility will be purchased by CEB
- The power plant is not subject to dispatch
- Applicable for renewable projects below 10 MW installed capacity
- The Power Purchase tariff is based on the Avoided Costs of CEB, and is announced each year
- The floor tariff over the term is 90% of the initial year Tariff. If during the term of this Agreement, the Tariff forecast for any year becomes less than 90% of the Tariff on the date of the execution of the Agreement, the Tariff applicable for that year will be equal to the Tariff applicable for the previous year.
- The cost of transmission interconnection has to be borne by the Developer

Although the SPPA is a bankable document, the grid-connected developers do have concerns related to long-term stability of the power purchase tariffs, due its almost full dependence on oil prices. On the other hand, the maximum price that CEB can offer is its avoided cost, seasonally differentiated. Recently, the mini hydro developers with other renewable developers and the GOSL/CEB have come to an agreement to have a different tariff methodology for renewable energy projects below 10 MW capacity. The proposed tariff structure is technology based with approximate cost components for each system. The Energy Conservation Fund (ECF) will take a leading role in the implementation of the new mechanism. The Cabinet approval has already been obtained and it is now at the stage of implementation.

Number of plants commissioned and their capacities in respective years since 1996 are given in the chart below.

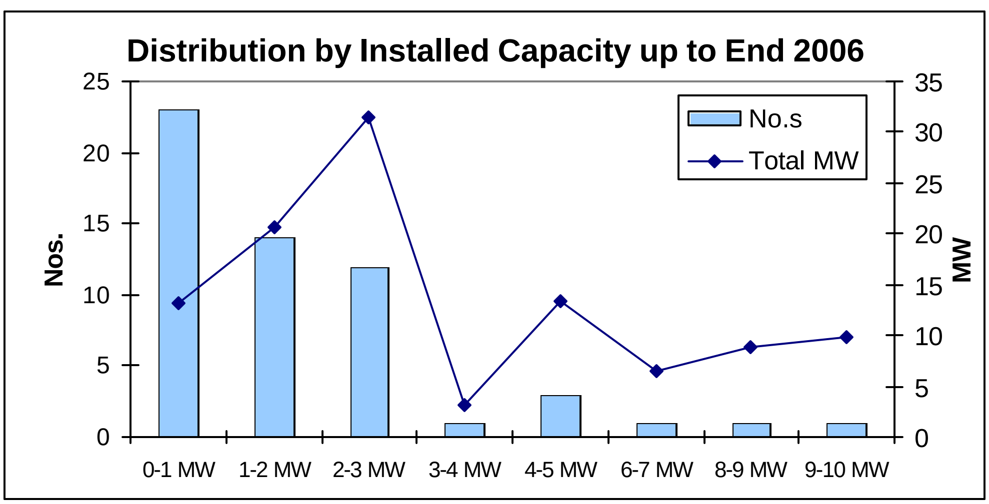


Source: CEB

Figure 3. Number of MHP plants Commissioned with their Capacity

At the end of 2006 the total capacity addition of MHP to the national grid is 106.9 MW from 56 plants. Among the grid connected plants few are providing excess power to CEB grid and the others are solely for purpose of selling electricity to CEB grid. The most number of plants totaling 13 numbers comprising of 34 MW capacity were commissioned in 2004. The total number of Letter of Intents (LOIs) issued by the CEB so far is around 250 and out of them 100 developers have signed power purchase agreements with the CEB. Altogether 45 companies are involved with these 56 operational plants.

The chart below shows the distribution by the installed capacity of MHPs at the end of 2006. It is clear that most of the plants (23 numbers) are within 1 MW range.



Source: CEB

Figure 4. Distribution of MHP Installed Capacity at the End 2006

Tariff

Avoided cost of energy represents the maximum value of generation avoided by CEB as a result of any purchase or produced of energy from sources in the CEB system. Ideally, this value should be the value of one unit of energy (kWh) displaced at the margin by a unit of energy produced or purchased by CEB from such sources. According to this rather broad definition, the avoided cost of a unit of electricity comprises fuel and variable O&M costs of generation displaced at the margin by a unit purchased/produced at a given instant. This is generally the cost of most expensive unit being generated a that instant, since it is implied that different generators are dispatched in their merit order of costs, subject to availability.

For purchases of energy from the developer, the maximum price the CEB is willing to pay for energy is its avoided cost. The avoided generation cost is calculated separately for dry and wet seasons of the year. "Dry Season" each year is defined as the period commencing on the 1st February and ending on the 30th April. The balance period (i.e. 1st January to 31st January and 1st May to 31st December) is defined as the "Wet Season".

The tariffs applicable for each year are tabulated below.

Table 8. SPPA Tariff Since 1997

	Tariff	
Year	Dry Season (February - April) Rs/kWh	Wet Season (balance months) Rs/kWh
1997	3.38	2.89
1998	3.51	3.14
1999	3.22	2.74
2000	3.11	2.76
2001	4.20	4.00
2002	5.13	4.91
2002*	5.90	5.65
2003	6.06	5.85
2004	5.70	4.95
2005	6.05	5.30
2006	6.73	5.82
2007	7.64	6.94

Source: CEB

The total energy sold to CEB by the MHP developers in 2006 is 346 GWh whereas the total payment by CEB comes to Rs. 2,066 million bringing the average unit price slightly below 6 Rs./kWh.

Possible Issues

MHP development will have any challenges to face in the future. Since the high and medium head MHP are limited the potential sites in the future will be mostly small head sites across major rivers and streams. Irrigation and environmental issues would make the site selection more difficult. Possible inundation of habitat lands and risk of flooding are the main concerns. Increasing equipment costs and rupee depreciation would also challenge the project viability. Deforestation in upper catchment areas would result the lower run off which will invariably leads to lower turnover from existing MHPs.

Other issues are the land ownership issues and grid connection issues. Land ownership issues create delays in implementation of projects. Grid connection issues in relation capacity limitations in substations is the also cause delay in implementation. Government has initiated a program to augment the selected grid substations to absorb MHP power. However the program has not taken off the ground due to delay in securing financing.

With the formation of Sustainable Energy Authority (SEA) under the Ministry of Power & Energy seems is a significant movement by the government towards addressing the above mentioned issues favourably. As shown in the table 7, 69 LOIs have been issued for 108.6 MW of capacity. According to CEB the progress of these projects are not up to the expectation owing to the issues mentioned above. The primary objectives of the SEA is to expedite the implementing such projects.

3 Energy Sector Organizations

3.1 Ministry of Power and Energy

The Ministry of Power and Energy is the main body responsible for the management of the Energy Sector as a whole. The Ministry consists of several Divisions to discharge its functions in Planning, and in the Management of sub-sectoral state institutions. From time to time, the subject of Energy has been combined with others such as Irrigation and Lands, in the establishment of the Ministry. The Ministry of Power & Energy is the key organization instrumental in the formulation of policy.

The following four state-owned Energy Institutions presently operate under the supervision of the Ministry of Power and Energy.

Ceylon Electricity Board (CEB)

Established in 1969, CEB is empowered to generate, transmit and distribute electricity in the country. CEB presently generates about 60% of electrical energy supplied through the national grid, while the balance is generated by private power plants. The entire 220 kV and 132 kV national grid is owned and operated by CEB. Medium voltage transmission at 33 kV too, is CEB owned. CEB directly serves 89% of electricity customers in the country. The CEB’s program of developing new generating facilities has been lagging far behind the schedule, causing severe constraints on capacity, this coupled to the very poor rainfall in the hydro catchment areas led to island wide rotating power cuts in 2002. With the operation of expensive power plants to makeup for the delays in major power plant projects, coupled with a stagnant retail tariff, CEB is presently in deep financial crisis. Rural electrification projects of CEB have accelerated over the past decade, with the household electrification rate increasing from 29% in 1990 to 78.1% in year 2006.

Lanka Electricity Company (Pvt) Ltd (LECO)

LECO was established in 1983 to distribute electricity in areas, which were previously served by Local Authorities (Municipal Councils etc.). LECO receives electricity from CEB at 11 kV and distributes in LECO franchise areas. LECO serves about 11% of the customers in the country. LECO's franchise area steadily increased from 1983 to 1990, and the Company implemented a major rehabilitation program in the newly acquired distribution networks, that reduced the losses from 33% in 1990 to 5.3% in year 2003.

Ceylon Petroleum Corporation (CPC)

Established in 1961, CPC is the authorized institution for the import, refining and distribution of petroleum products in the country. CPC owns and operates the only refinery in Sri Lanka, with a daily throughput of 50,000 barrels. The demand for petroleum products have significantly increased. In 2004 the CPC has provided 10% of the total requirement of LPG and 1/3 of the auto diesel demand. The balance requirement is imported by CPC as well as newly player in the petroleum sector Lanka IOC.

Energy Conservation Fund (ECF)

ECF was established in 1984 with a mandate to promote energy efficiency in the country. The responsibilities of the ECF are facilitation and promotion of energy conservation & management, promotion of development & use of renewable energy and development of policies, mechanisms & strategies for energy sector. ECF after realising the short coming of the present institutional and regulatory framework and anticipating a liberal energy market in the future, the ECF initiated the establishment of Sustainable Energy Authority (SEA). The SEA Act has already been approved by the parliament.

Public Utilities Commission Sri Lanka(PUCSL)

PUCSL was established by the Act of Parliament No 35 of 2002 as a multi-sector regulator to regulate certain physical infrastructure industries in the country. It came to operation in mid 2003 with the appointment of the key members and staff. Initially the PUCSL is entrusted the duties with regard to regulate Electricity and Water Services Industries. Later in 2006 Petroleum was also added. The objectives of the PUCSL are to carryout following;

- Protecting the interest of the consumers

- Promoting energy efficiency in both capital investment and operations in the utility industries
- Promoting efficient allocation of resources within them
- Benchmarking of utilities against international standards
- Promoting safety and service quality
- Ensuring that the price controlled entries act efficiently

3.2 Other Energy Sector Institutions in the Business of Energy Supply.

Administrative Unit of RERED Project

Renewable Energy for Rural Economic Development (RERED) Project is funded by World Bank and Global Environmental Facility (GEF) and its objective is to promote renewable energy resource for the economic development of rural communities. The Administrative Unit is the authorised body to implement RERED project in Sri Lanka coordinating government authorities and many private companies.

Shell Gas Lanka (Pvt) Ltd.

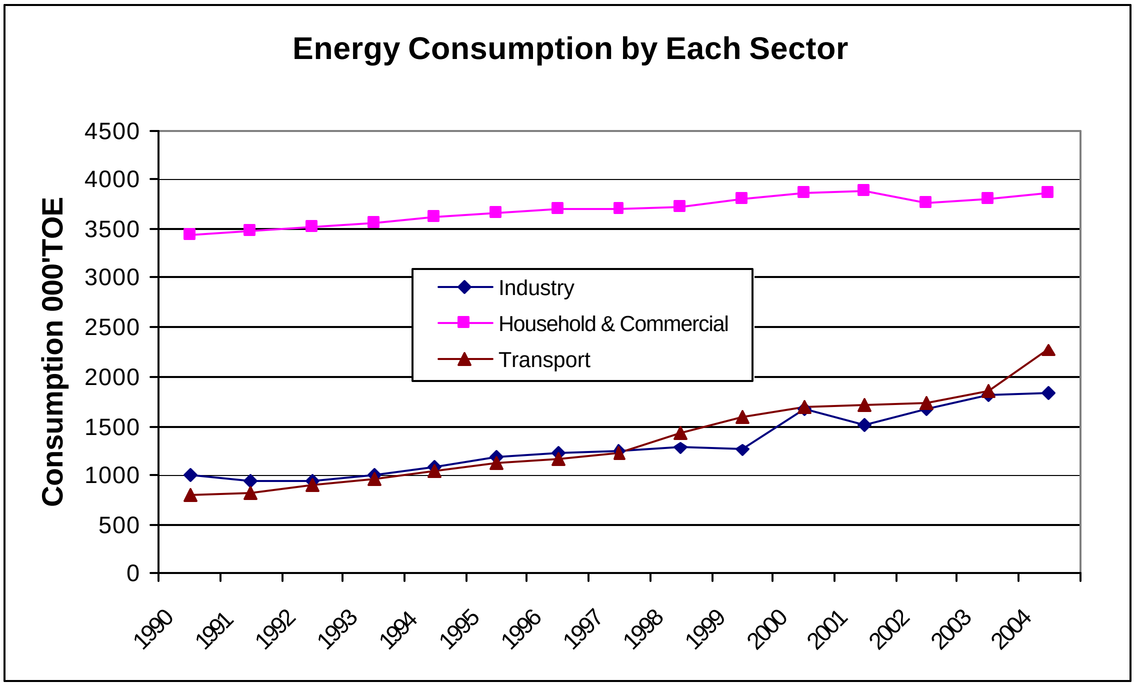
Liquefied Petroleum Gas (LPG) industry was privatised in 1995, when Shell Gas purchased a stake in the previously Government-owned Gas Company, under a five-year concession. Over 1995-2000, Shell Gas imported LPG, purchased the LPG available in the CPC refinery, and marketed the product. The monopoly status ended in late 2000. The Company markets LPG to all segments of the market, in all Provinces on the Country.

Laufgas

Initially, the Lanka Autogas Company established filling stations and other services to cater to the increasing market for LPG used in motor vehicles. Since the end of the monopoly offered to Shell Gas, the Company entered the LPG retail market, at start marketing the output of the CPC refinery and the LPG imports to the domestic LPG users mainly in the Western Province. The Company now imports LPG and has expanded their operations to other provinces.

4. Energy Consumption

Increasing consumer energy consumption has been historically linked to economic growth and population growth. Several important policy changes in the late 1970s had a significant influence on the energy consumption level and pattern in Sri Lanka. With the liberalization of the economy in 1977, the demand for energy has increased substantially, particularly in the industrial and transport sectors. Total energy consumption in Sri Lanka increased on the average by 3.4% per annum during 1990-2004. Sectoral energy consumption pattern is shown in figure 7 below. Electricity consumption grew relatively faster in the household sector than in the industrial and commercial sectors.



Source- Energy Data, SEA, 2005

Figure 5. Sectoral Energy Consumption Pattern

Practically all the energy requirements for transportation are met from oil (Auto-diesel and Petrol). Both electricity and oil are used for various industrial, commercial and domestic purposes. Most of the Kerosene usage is for domestic purposes mainly for lighting. Fuelwood and other biomass forms are used mainly to meet domestic and industrial needs.

Table 9 shows the Total Energy Consumption and GDP in constant 1982 prices. The energy intensity in TJ/US $ Million is shown in figure 8. It is clearly seen that there is a declining trend in energy intensity over the years and it is still continuing. This trend can be attributed to many factors of which the following are considered to be significant. a) The rising cost of energy b) Major shift to services sector in the economy c) Major structural change in the industrial sector from high energy consuming to more labour intensive industries (such as garment industry) d) greater awareness through state sponsored and non governmental activities in energy conservation.

Table 9. Energy Intensity Treads

	1975	1980	1985	1990	1995	2000	2004
Energy Demand in million GJ	150.71	169.75	196.19	219.70	249.74	303.09	333.88
GDP 1982 million Rs.	65,219	85,146	109,570	129,256	167,953	214,422	245,175

GDP 1982 million US$.	3059	3994	5139	6063	7877	10,057	11,499
Energy intensity of GDP (Energy demand TJ/constant 1982 million US$)	49.27	42.50	38.17	36.23	31.7	30.14	29.03

Source: Energy balance of Sri Lanka, 1975-2004, ECF and Central Bank Reports

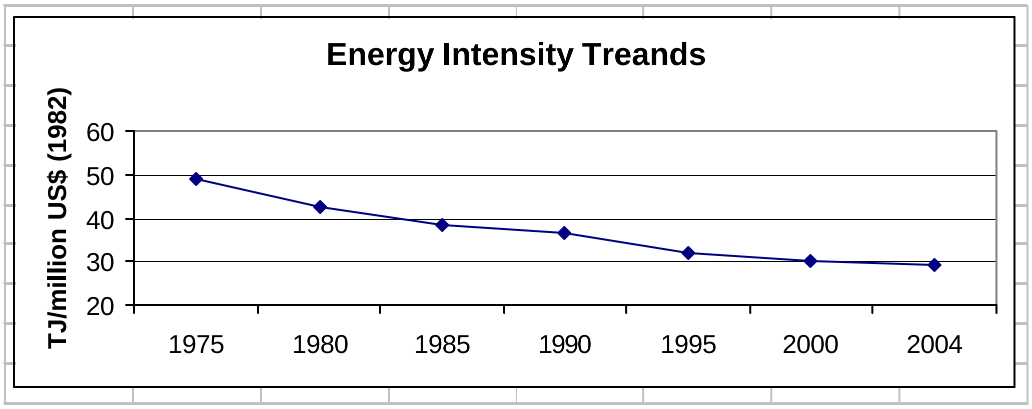


Figure 6. Past Energy Intensity Trends

4.1 Electricity Consumption

Electricity consumption in the country has been growing at rates above 10% per annum in the early eighties. These high growth rates were the result of rapid economic growth and rural electrification experienced in those years. Contribution to total energy demand from electricity has increased from 3.9% in 1990 to 7.3% in 2004. Percentage of households that have access to electricity has increased from 10% in 1977 to about 30% in 1990 (76.7% in 2005). Electricity consumption and the number consumers for 2001 & 2002 in each province is given in the table 10 below.

Table 10 Provincial Level Electricity Consumption

PROVINCE	UNITS IN GWh			NO: OF CONSUMER ACCOUNTS		
	2001	2002	% INCREASE	2001	2002	% INCREASE
COLOMBO CITY	722.975	780.023	7.89%	118,161	122,717	3.86%
NORTH WESTERN	480.617	494.643	2.92%	335,171	351,965	5.01%
NORTH CENTRAL	141.051	173.997	23.36%	140,163	148,749	6.13%
NORTHERN	58.475	60.763	3.91%	61,610	66,621	8.13%
Total - Region 1	**1403.118**	**1509.426**	**7.58%**	**655,105**	**690,052**	**5.33%**
WESTERN - NORTH	1080.827	1139.769	5.45%	355,210	370,181	4.21%
CENTRAL	360.748	374.887	3.92%	336,181	354,981	5.59%

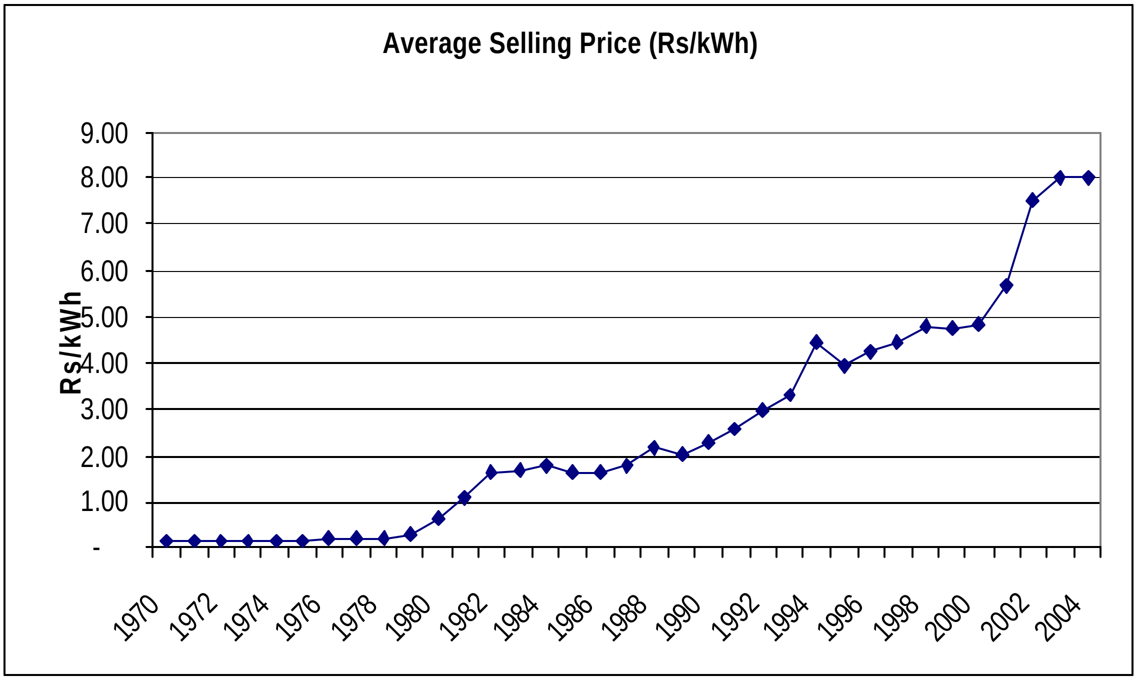
EASTERN	167.745	181.463	8.18%	168,496	179,886	6.76%
Total - Region 2	**1609.320**	**1696.119**	**5.39%**	**859,887**	**905,048**	**5.25%**
WESTERN - SOUTH 2	662.811	715.580	7.96%	208,988	219,823	5.18%
UVA	218.796	214.183	-2.11%	206,377	217,906	5.59%
SABARAGAMUWA	296.420	304.244	2.64%	246,828	261,047	5.76%
Total - Region 3	**1178.027**	**1234.007**	**4.75%**	**662,193**	**698,776**	**5.52%**
WESTERN - SOUTH 1	579.743	592.872	2.26%	149,203	156,560	4.93%
SOUTHERN	466.217	469.831	0.78%	358,752	377,277	5.16%
Total - Region 4	**1045.960**	**1062.703**	**1.60%**	**507,955**	**533,837**	**5.10%**
GRAND TOTAL	**5,236.426**	**5,502.254**	**5.08%**	**2,685,141**	**2,827,714**	**5.31%**

Source – CEB Statistics

In 2005 the gross electricity demand (sold) was 7255 GWh and 8.8% increase compared to the previous year. The demand comprises of industrial, household and commercial sectors. Unlike in developed countries, electricity is not utilised so far for transport and agricultural sectors in Sri Lanka. 40% of the total electricity in 2005 was consumed by domestic sector whereas 37% and 21% consumed by the industrial and commercial sector respectively.

Among 3 million domestic electricity consumers in 2005, the average monthly electricity consumption for a household is 67 kWh with average selling price of 5.64 Rs./kWh. The average selling price for industrial and commercial sectors are 8.36 and 11.88 Rs./kWh respectively. The overall average selling price in 2005 is 7.71 Rs./kWh. Therefore it is evident the heavy cross subsidy flows from industrial and commercial sectors towards domestic sector.

The figure 7 below shows the historical average selling price trend since 1970.



Source – CEB Statistics

Figure 7 – Historical Average Selling Price of Electricity

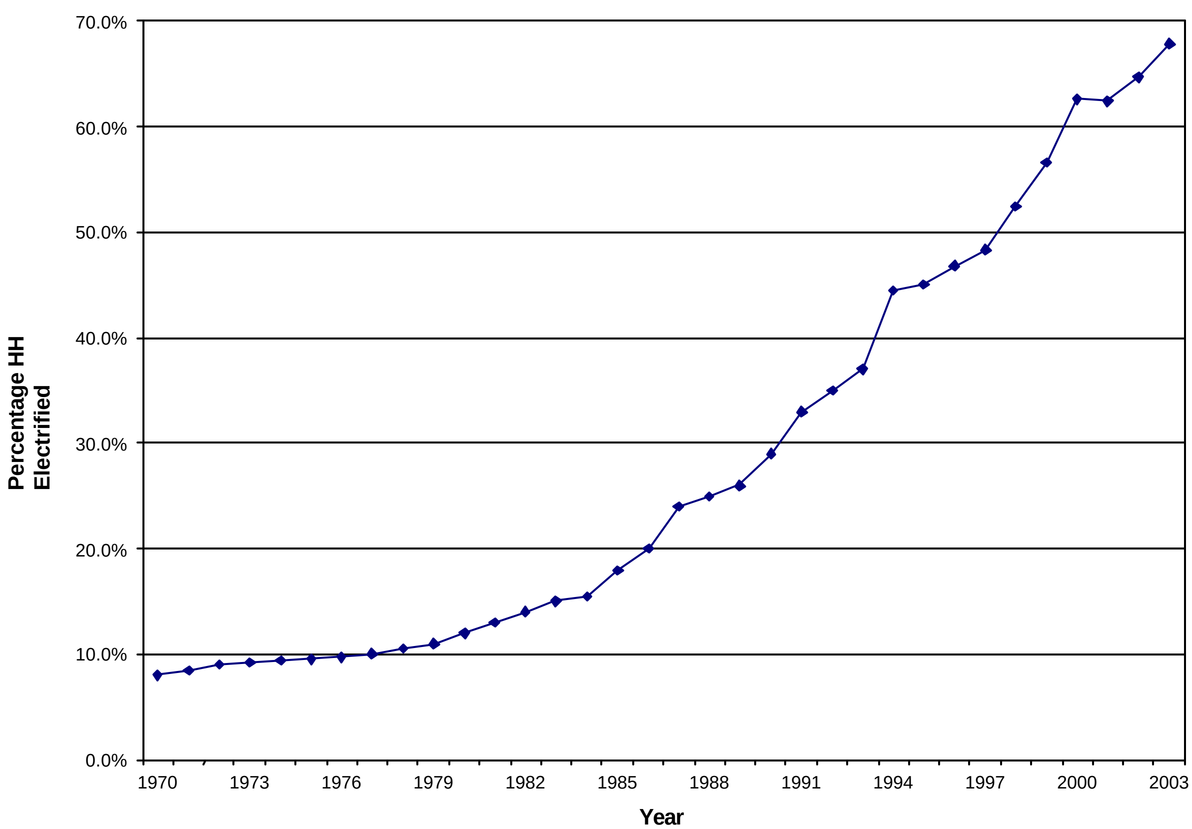
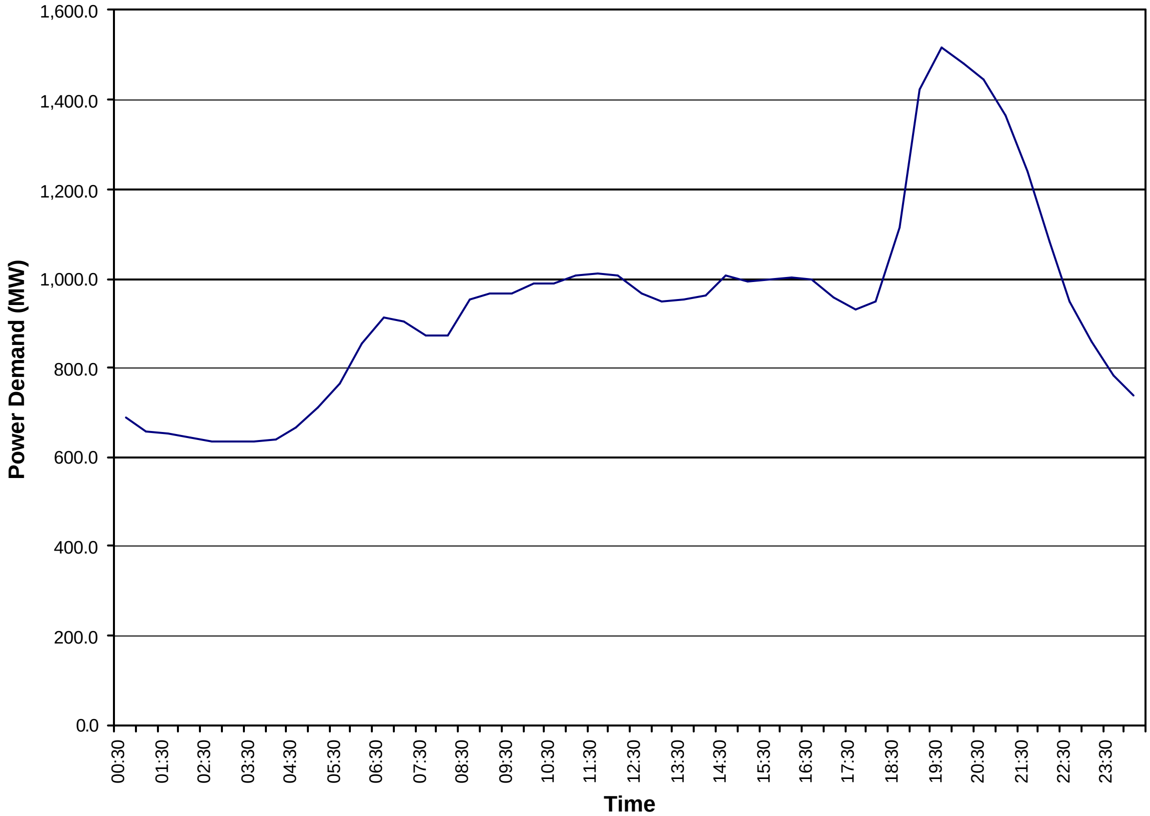


Figure 8 - Household Electrification by the Grid



Source – CEB Statistics

Figure 9- Typical System Demand Profile (on December 13 , 2003)

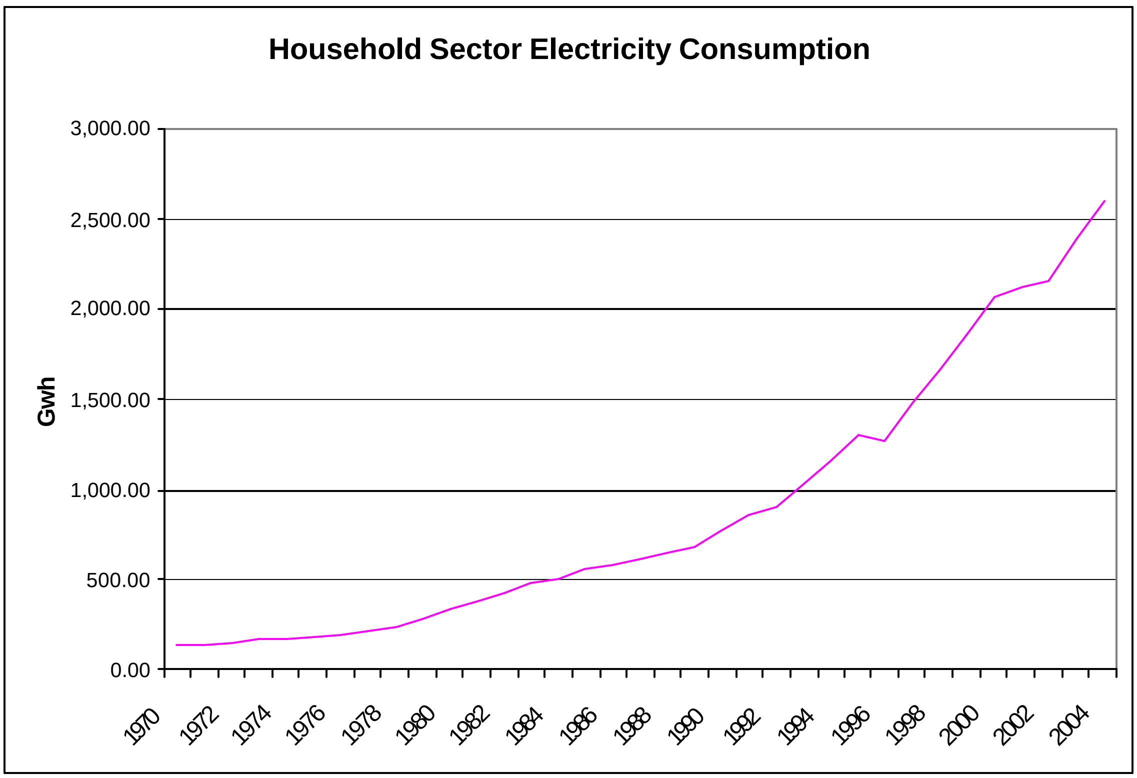
(The highest evening peak of the year occurred on this day)

The maximum night peak on 25th May 2005 for 2005 and 15th May 2006 for 2006 found to be 1748 MW and 1892 MW respectively and this is an increase of 144 MW in 2006 over 2005. On average, the peak demand increase is around 150 MW each year. In other wards, the electricity system capacity should be increase at least by 150 MW each year. CEB has been promoting energy efficient lights (CFLs) to reduce the peak demand. This could reduce or delay the investment required for additional peak generation. Further the lower the system peak the lesser the system operating cost during the peak time since the peak demand is met with expensive thermal generation such as gas turbines.

4.1.1 Household Sector Electricity Consumption

Electricity consumption (sales) contribution of the household sector has grown from 22% to 38% of the overall electricity sales from 1970 to 2004. The annual average electricity consumption growth rate in the household sector is around 9.1%. Electricity is consumed by the household sector in both rural and urban mainly for lighting and for appliances such as TV and radio. However in majority of urban households the electricity is utilised for refrigerators, heaters, fans, cookers and irons. It is evident that few numbers of rural households are also posses some of the appliances mentioned above. As shown in the figure 9 above peak demand of electricity is mainly contributed by the usage of lighting and television. Air-conditioners and water heaters are also utilised in small quantities in urban households. Contribution of each type of appliances or lighting on overall electricity consumption of the country cannot be estimated mainly due to lack of data.

Household sector electricity consumption trend is shown in figure 10.



Source – CEB Statistics

Figure 10 Electricity Consumption of the Household Sector

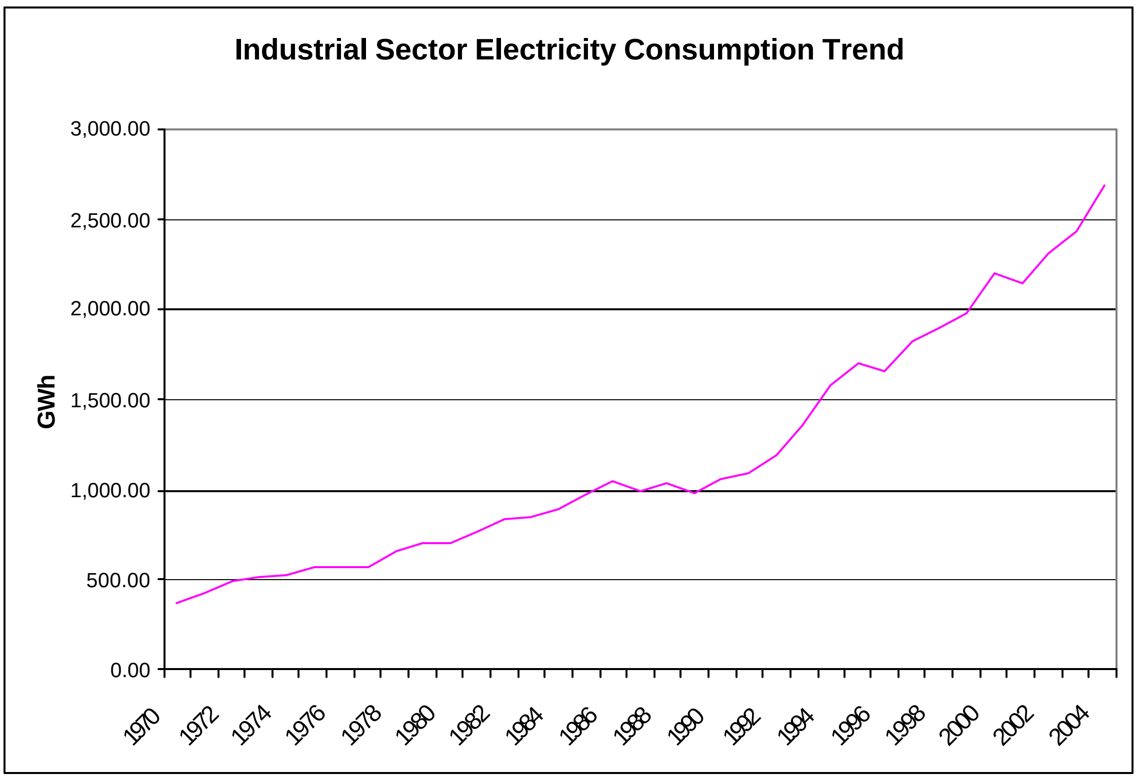
The present domestic electricity tariff is given below. The tariff structure is designed to discourage the consumers to consume more than 90 units per month by introducing a unit charge above the average selling price of the CEB.

First 30 units	Rs. 3.00 per unit
31-60 units	Rs. 4.70 per unit
61-90 units	Rs. 5.10 per unit
91-180 units	Rs. 12.10 per unit

Above 180 units	Rs. 17.30 per unit

4.1.2 Industrial Sector Electricity Consumption

Industrial sector comprises of nine major manufacturing sub sectors. Among them the major electricity consuming sub sectors are Textile & Leather Products and Food & Beverage industry. Electricity consumption contribution of the industrial sector has reduced from 60% to 40% of the overall electricity sales from 1970 to 2004. The annual average electricity consumption growth rate in the industrial sector is around 6.1% with a distribution of higher and negative growth rates in some years. The electricity consumption in the industrial sector is mainly contributed by motive power and lighting. Based on the energy audits carried out for industries revealed that 85% of the electrical energy is consumed by motors. Overall electricity consumption trend of the industrial sector is given in the figure 11.

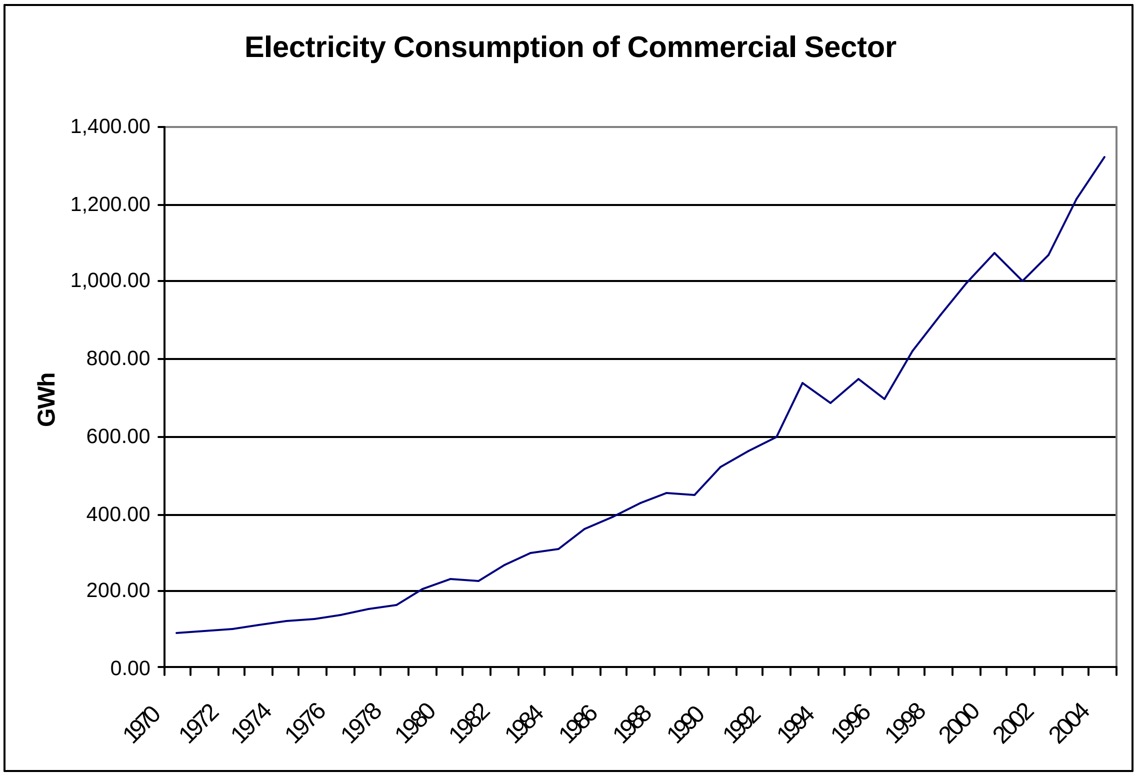


Source – CEB Statistics

Figure 11 Electricity Consumption of the Industrial Sector

4.1.3 Commercial Sector Electricity Consumption

Commercial sector is disaggregated in two sub-sectors namely Hotels and Office/Shops/other institutions for the purpose of energy consumption estimates. The energy consumption in this sector comprises of electricity, fuel oil and LPG. Electricity is mainly utilised for lighting and air conditioners. Breakdown of the consumption of electricity for each sub category is not available however some estimates are available based of various study reports. Electricity consumption pattern of commercial sector is given in figure 12 below.



Source – CEB Statistics

Figure 12 Electricity Consumption of the Commercial Sector

4.2 Petroleum Consumption

Petroleum products are mainly consumed by transport, industrial, commercial and power generation sectors. Household and agricultural including fisheries sectors consume lesser quantities in comparison to others. Following table shows the consumption trend of each fuel type over the past 32 years.

Table 11 Petroleum Product consumption trend in thousand MT

Product	**1970**	**1975**	**1980**	**1985**	**1990**	**1995**	**1998**	**1999**	**2000**	**2001**	**2002**
LPG	0.035	0.6	6.7	13.4	34.9	76.5	117.3	139.9	146.0	141.0	157.5
Naphtha				7.5	0.0					14.1	56.1
Gasoline	148.4	95.1	107.7	121.6	181.1	189.7	204.4	213.1	224.4	249.5	286.1
Kerosene	272.5	209.8	188.3	153.7	167.2	222.3	235.9	243.4	229.1	227.8	228.8
Diesel	342.4	282.8	461.7	525.6	548.1	896.3	1225.6	1416.8	1730.4	1674.0	1775.2
Furnace Oil	208.8	143.6	193.8	142.8	157.8	241.1	556.0	557.6	736.7	748.8	757.6
Total Demand	**972.1**	**731.8**	**958.2**	**964.5**	**1089.2**	**1625.9**	**2339.2**	**2570.7**	**3066.6**	**3055.2**	**3261.3**
Fuel Used For Electricity Generation											
Furnace Oil	1.0	0.5	45.1	11.8	1.3	34.6	263.0	284.0	525.2	511.6	523.9
Diesel	10.7	0.0	13.3	5.3	1.3	49.7	109.4	194.3	447.6	369.2	451.1

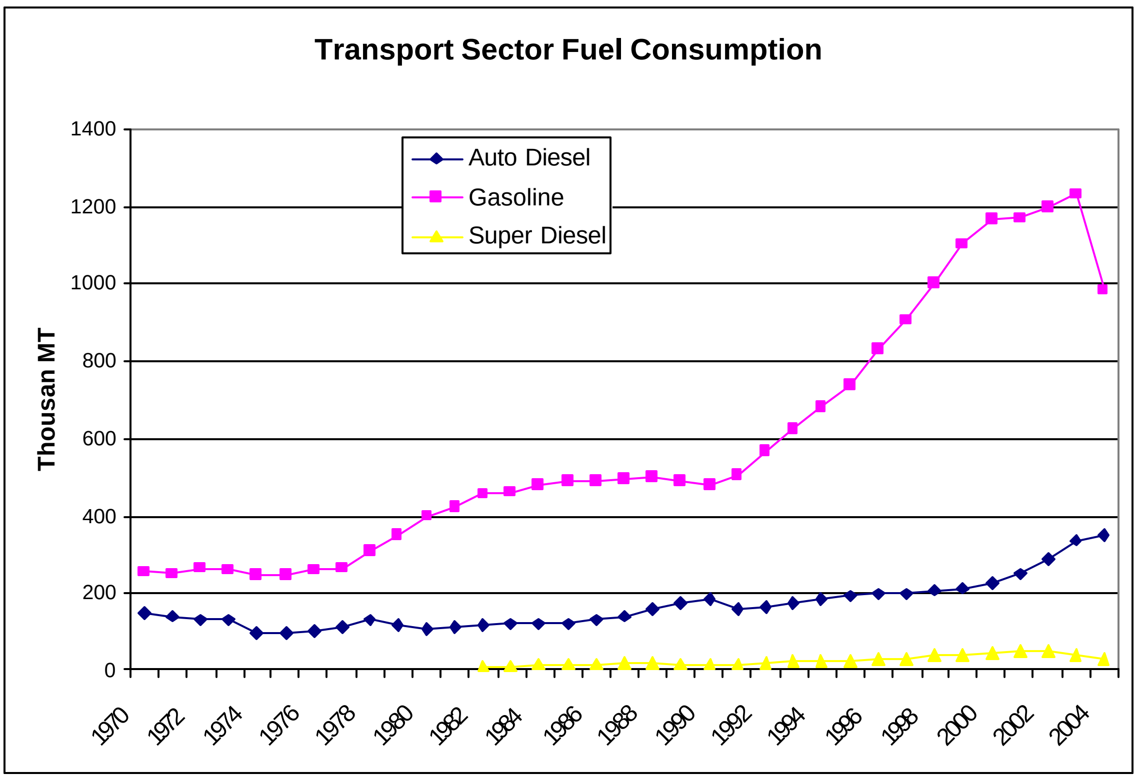
Naphtha										11.7	54.6
Sub Total	11.7	0.5	58.4	17.1	2.5	84.3	372.4	478.3	972.9	892.6	1029.6
% Of Total Demand	**1.2**	**0.1**	**6.1**	**1.8**	**0.2**	**5.2**	**15.9**	**18.6**	**31.7**	**29.2**	**31.6**

Source – CPC Statistics

It is significant that the overall fuel consumption has contributed immensely in the recent past for the significant increase in the petroleum consumption

4.2.1 Transport Sector Petroleum Consumption

Transport is the biggest consumer of petroleum products. Transport comprises of road and rail transport. The data published by authorities do not show the breakdown of consumption of these two categories. The biggest consumed fuel type is auto diesel for heavy vehicles and light vehicles. The consumption trend of each fuel type is shown in the figure 13 below.



Source – Energy Data, ECF 2004

Figure 13 Transport Sector Fuel Consumption Trend

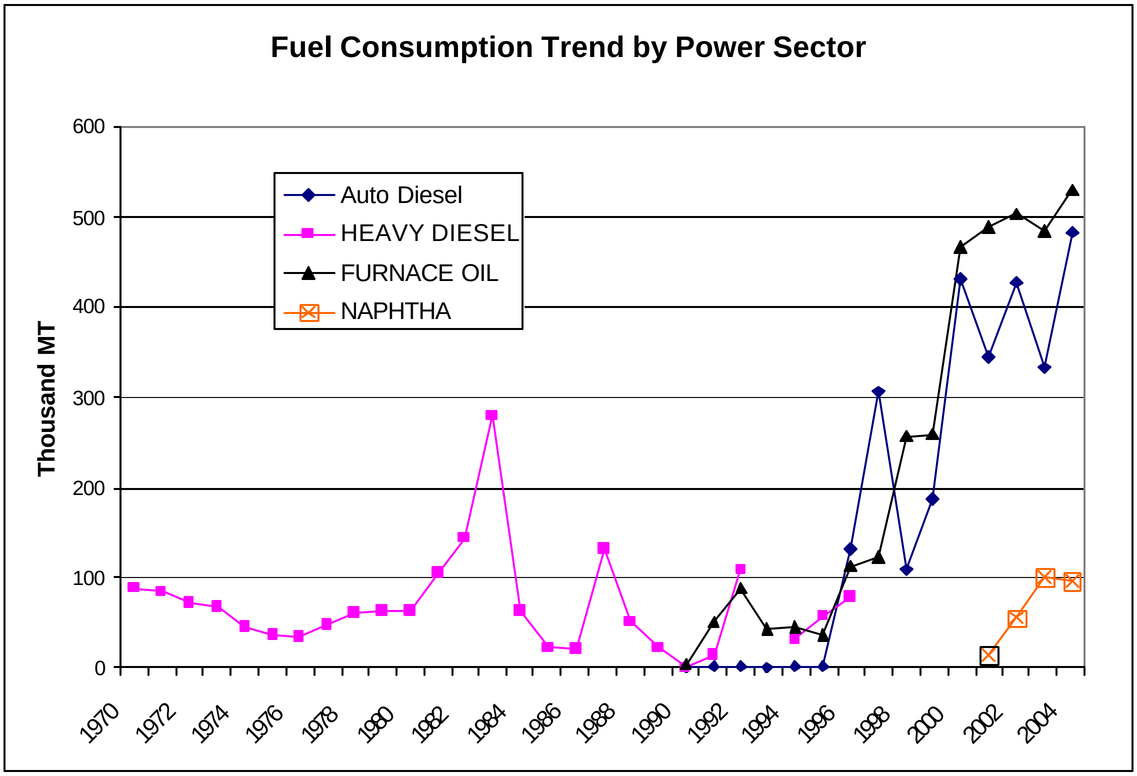
Following table indicates the transport sector indices. It is clear from the figures that the rail transport is most energy efficient transport system for both passenger and goods.

Rail passenger	0.006 kg of diesel per passenger km
Rail goods	0.018 kg of diesel per ton km
Passenger buses	0.0033 kg of diesel per passenger km

Passenger cars	0.036 kg of petrol per passenger km
Lorries	0.042 kg of diesel tom km

Transport Sector Statistics, 1990

4.2.2 Power Generation Petroleum Consumption



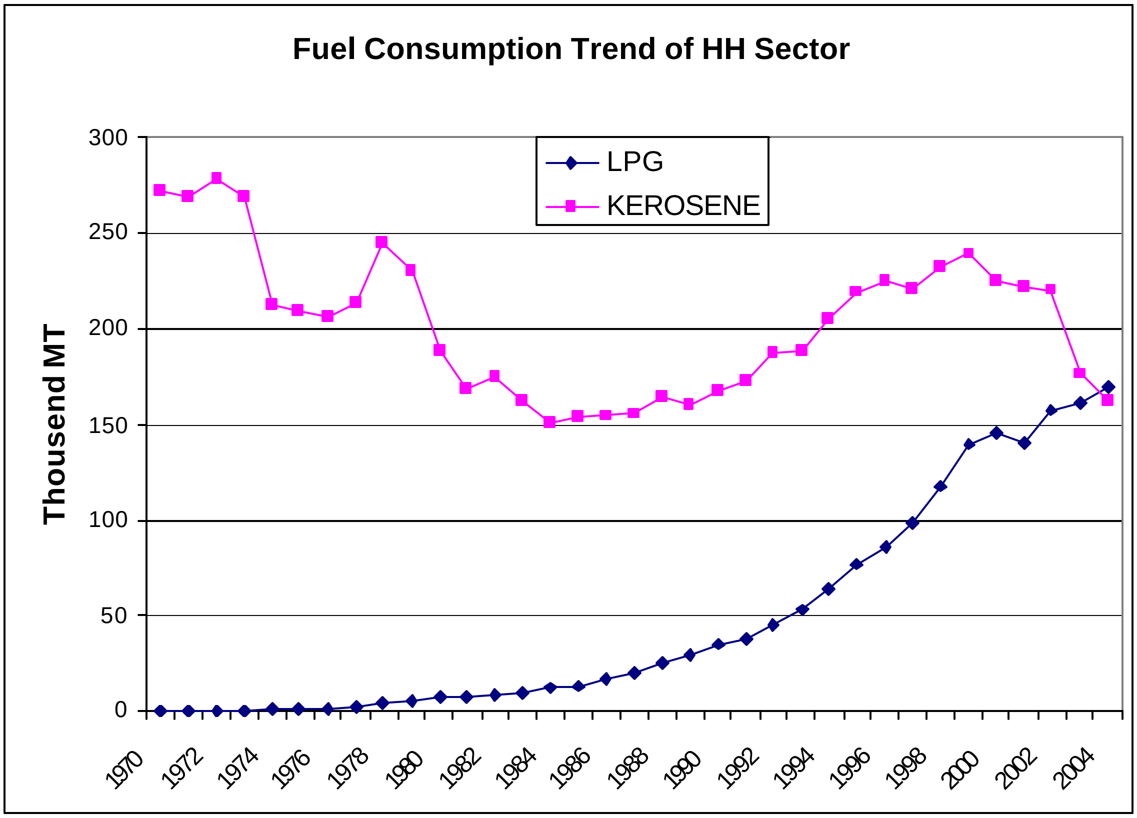
Source – CEB Statistics

Figure 14- Fuel Used for Electricity Generation

Power sector has become the second largest fuel consumer in the country. As shown in the figure 14, there is rapid growth in consumption of fuel oil and diesel since 1996. As mentioned earlier in the report this is mainly due to addition plants to the system. This trend will continue until the addition of 300 MW Kerawalapitiya combined cycle power plant in 2008. Thereafter the curve will be flattened with the additional coal plants as planned. Naphtha which is product of the refinery is utilized only at Kelanitissa combined cycle plant.

4.2.3 Household Sector Petroleum consumption

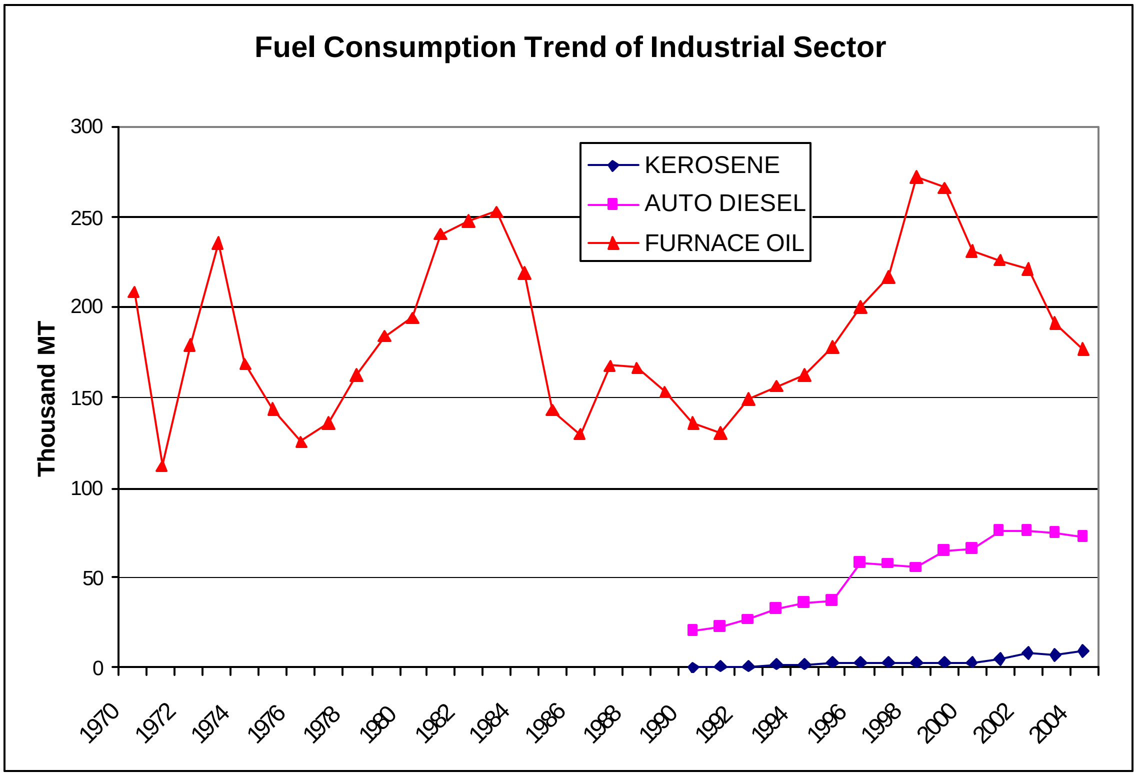
Household sector is the main consumer of kerosene for the purpose of lighting in unelectrified households. Kerosene usage for coking purpose cannot be estimated due to lack of data. It is clear in the figure 15 that there is sharp drop in the kerosene consumption in late nineties which possibly contributed by the increased household electrification. LPG consumption over the past decade has shown rapid growth due to switching over from fuelwood in household cooking to LPG. Analysis of past consumption data reveals that consumption of LPG increased annually by 2% and 5% during 1985–1990 and 1990-1994 respectively.



Source – Energy Data, ECF 2004
Figure 15 Household sector fuel consumption trend.

4.2.4 Industrial Sector Petroleum Consumption

The main fuel consumption in the industrial sector is furnace oil which utilised specially in large industries for heating and steam production purposes. As shown in the figure 16 there is no steady growth of the consumption of fuel oil in the industrial sector. However there is upward trend in the consumption of auto diesel from early nineties owing to increased self generation.

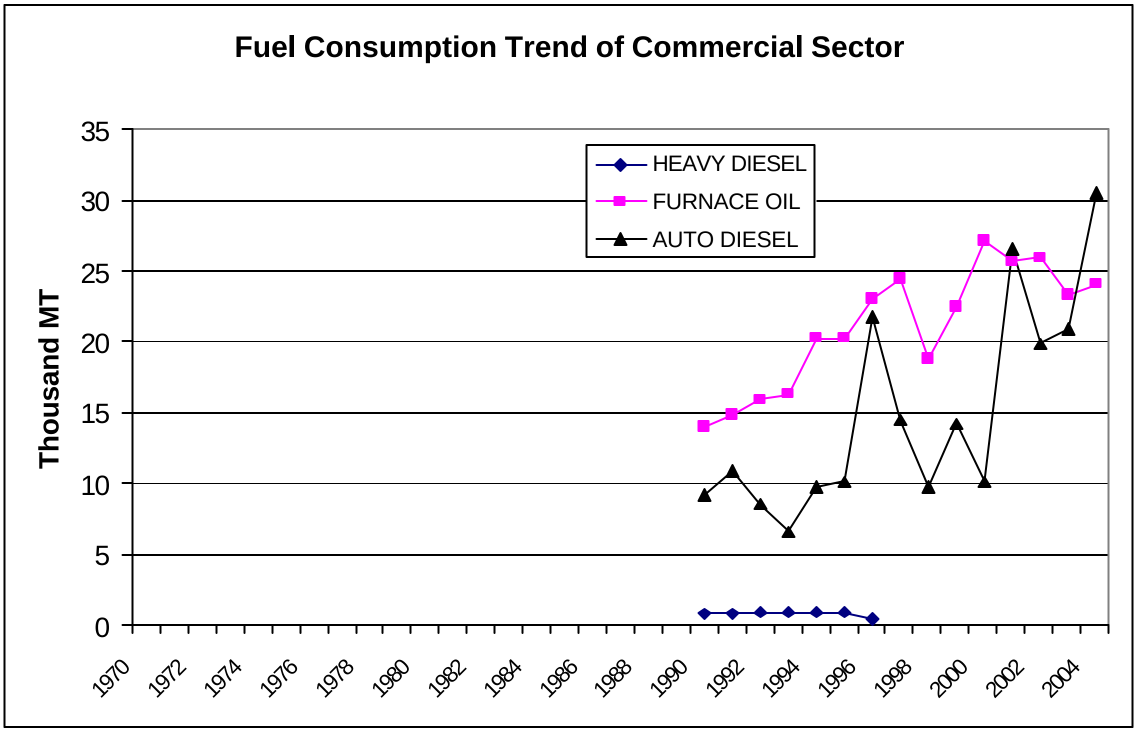


Source – Energy Data, ECF 2004

Figure 16- Fuel Used in Industries

4.2.5 Commercial Sector Petroleum Consumption

The figure 17 below shows the fuel consumption pattern of the commercial sector. The consumption prior to 1990 is not shown probably because the consumption until 1990 was categorised under a different sector. Overall it is seen that there is an increasing trend in fuel oil and diesel.



Source – Energy Data, ECF 2004

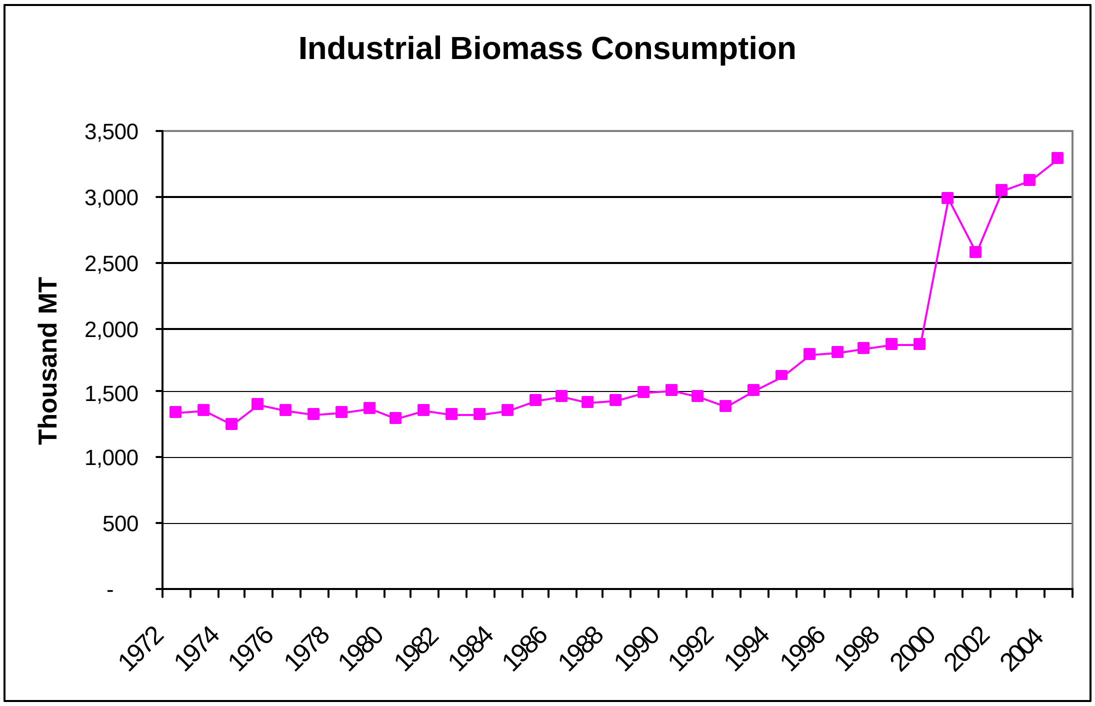
Figure 17- Fuel Used in the Commercial Sector

4.3 Biomass Consumption

Biomass in mainly utilised in the household and industrial sectors. Biomass comprises of fuelwood and bagasse.

4.3.1 Industrial Sector Biomass Consumption

Tile and brick industry is the major consumer of fuelwood. Tea rubber industry is the second largest consumer of fuewood. The overall biomass consumption including the baggase in the industrial sector is shown the figure 18.

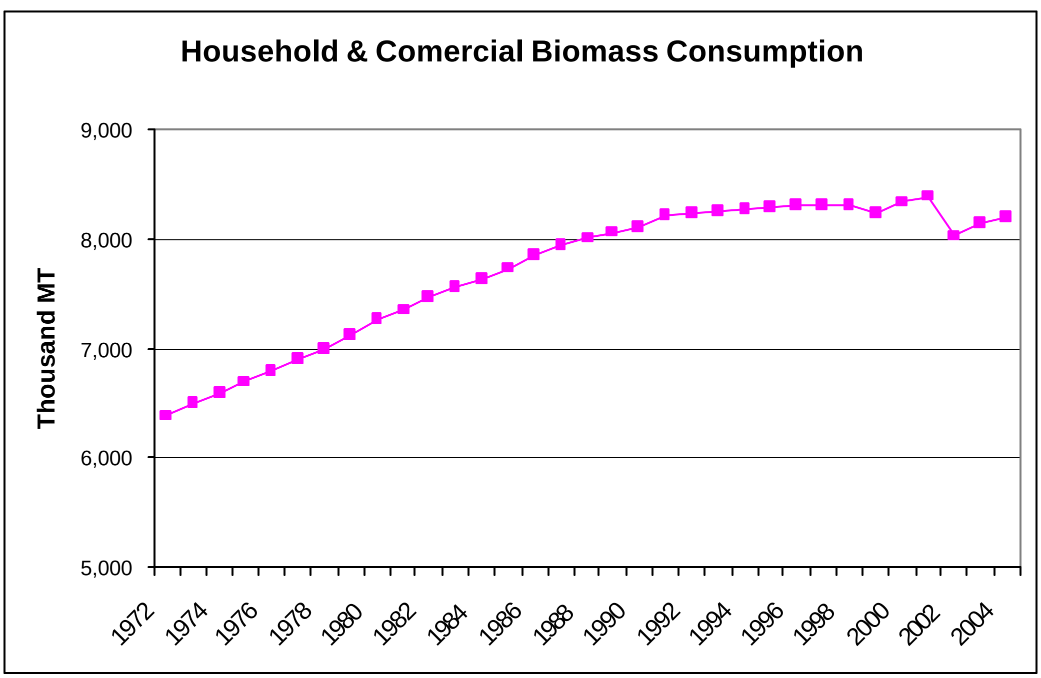


Source – Energy Data, ECF 2004

Figure 18 Biomass consumption of the Industrial Sector

4.3.2 HH & Commercial Sectors Biomass Consumption

Fuelwood is mainly used in household and commercial sectors for cooking purposes. It is evident from the figure 19 below that the fuewood consumption pattern has changed after 1990 owing to the rapid growth of LPG.



Source – Energy Data, ECF 2004
Figure 19 Biomass consumption of the household and commercial sector.

5. Future Consumption Trend

Ideally, a sectoral long term energy forecast should consider the projected development of particular sector, predicted growth of the national economy and the complex links with the development in the other sectors. The sectoral energy forecast presented below is based on a study "Environmentally Sustainable and Energy Efficient Alternate Energy Strategy" carried out in 1995 with the available energy statistics upto 1990. That study is aiming to assess the possible saving potential in all energy demand sectors and the total projection period was 30 years from the base year 1990. The original study has three scenarios namely, Business as Usual (BAU), Energy Efficiency (EFF) and Environmentally Constrained (ENV) scenarios. This chapter only presents the summery analysis of only BAU scenario. The base year actual data of the energy demand was initially disaggregated into five sectors, namely Household, Industry, Transportation, Commercial and Agriculture. In the demand forecast for all the scenarios, the growth in GDP, manufacturing sector value added and population growth are considered as the key parameters affecting the energy consumption in various sectors. Energy forecast is presented for the years 2000, 2010 and 2020. This chapter gives the general pattern of the long term energy demand of energy sectors and the absolute figures may not represent the correct picture in the present context.

The forecast of sectoral energy consumption of all sectors is summarized in table 12. Only the existing proven technologies, which are generally accepted as cost effective, are considered, in order to make the projection more realistic rather than making it a conceptual one.

Table 12 Projected energy consumption of all sectors (Million GJ)

	1990	2000	2010	2020
Household	146.3	158.7	162.4	142.0
Industry	33.5	37.7	58.2	95.9
Transport	33.6	64.9	70.7	105.4
Agriculture	2.5	5.4	6.7	7.5
Commercial	3.8	6.9	11.1	36.1
Total	219.7	273.7	309.1	387.0

Source – EASES Study

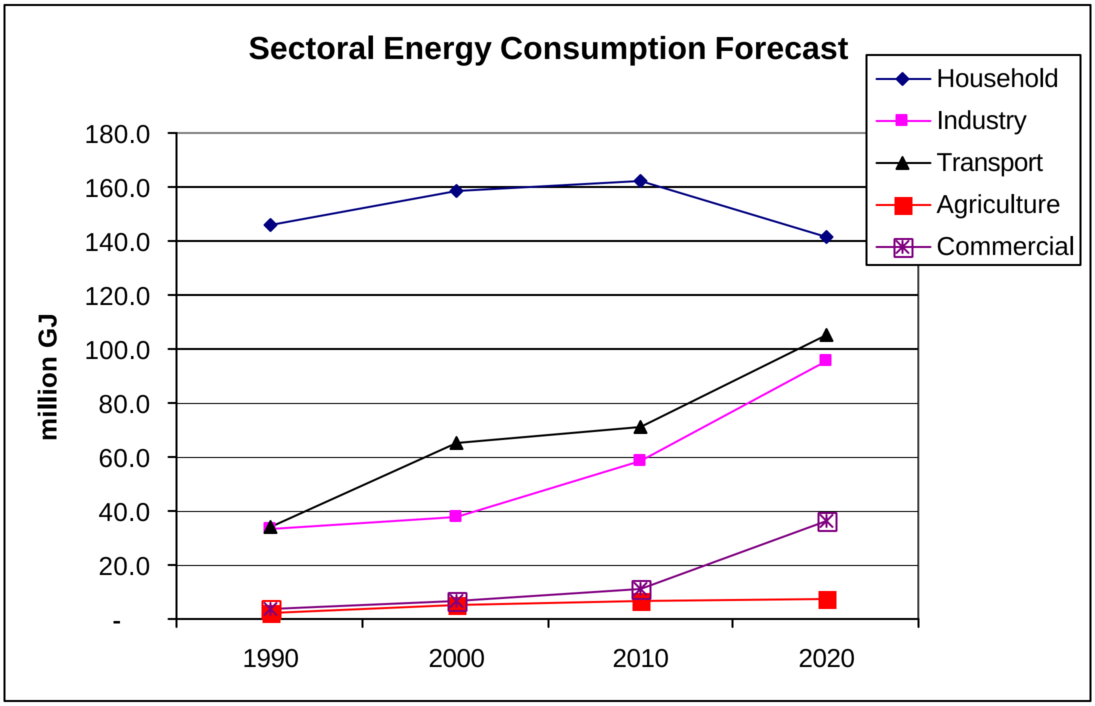
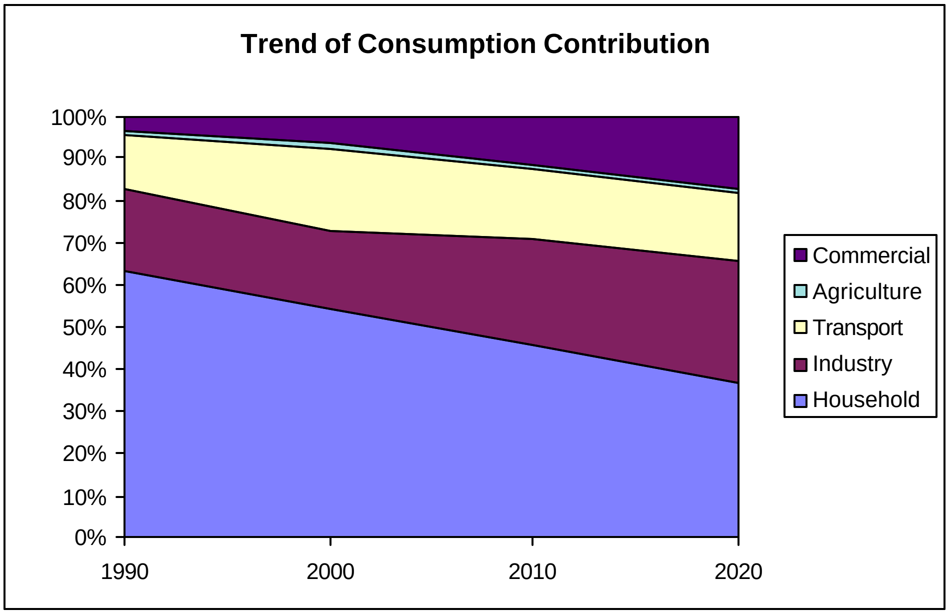


Figure 20 Energy Demand Forecast

According to the projections as shown in Table 12, energy consumption of the household sector will drop from 146.3 to 142 million GJ during the period 1990-2020. The share of household sector in the total final energy demand will drop from 66.6% in 1990 to 36.7% by year 2020.

The energy usage for cooking in both rural and urban sectors decrease with time. This is mainly due to the switching over from the traditional stoves to more efficient cooking devices such as improved stoves and LPG cookers.



Source – EASES Study

Figure 21 Projected percentage contributions to the total energy consumption

According to the projections, energy consumption of the industrial sector shows a very rapid growth. Energy consumption of industrial sector in 2020 (95.9 million GJ) shows a three fold increase from that in 1990 (33.5 million GJ). The share of industrial sector for the total final energy demand will also increase from 15.2% in 1990 to 24.8% by year 2020.

Projections made show that the energy demand of transport sector will increase by 213% from 33.64 to 105.44 million GJ during the period 1990-2020. The share of the transport sector in the total final energy demand will increase from 15.3% in 1990 to 27.2% by year 2020.

Energy demand in the agricultural sector shows a modest growth from 2.48 million GJ in 1990 to 7.53 million GJ in 2020. The share of agricultural sector in the total final energy demand will not change much and the agricultural activities will not have any significant impact on the overall energy demand.

Projection shows the energy consumption of the commercial sector has the highest growth. Energy consumption of commercial sector in 2020 (36.12 million GJ) will be more than 9.5 times of that in 1990 (3.80 million GJ). This rapid increase in the energy consumption in the commercial sector is due to the high growth in the usage of LPG and electricity. The share of commercial sector in the total energy consumption will also increase significantly from 1.7% in 1990 to 9.3% by year 2020.

Table 13 Projected energy consumption from all sectors by fuel type (Million GJ)

	1990	2000	2010	2020
Electricity	5.35	14.22	33.23	68.29
LPG	1.49	5.86	13.27	21.57
Petrol	8.42	12.54	13.41	18.83
Kerosene	7.34	12.56	11.30	8.79
Diesel	23.23	54.82	60.23	89.54
Residual/Fuel oil	7.49	9.64	14.23	20.92
Other fuels	4.44			
Firewood	156.91	153.97	146.44	129.70
Bagasse	6.00	10.46	17.57	25.94
Total	**219.70**	**273.69**	**309.12**	**386.97**

Source – EASES Study

6. Conclusion

It is seen that the Petroleum and Electricity supply sectors will be the dominating energy suppliers in the future. In the electricity sector the National Energy Policy envisages that total households with access to electricity to be 80% by 2010 80%. It also envisages 6% of the households to be electrified by off-grid systems by the year 2010. The greater dependence on imported forms of energy, though undesirable cannot be avoided due to constraints on natural resources of Sri Lanka. However with a proper implementation plan the available resources such as biomass, wind and hydro could be developed. The constraints to each and every energy source should be carefully analysed and action should be taken to overcome these constraints. It is evident that this could be achieved only by the activation of proper regulatory authorities through policy formulation. Sustainable Energy Authority (SEA) is one such agency who could take a leading role in this endeavour.

The present electricity generation expansion plan does not taking into account the medium scale hydro projects, wind power projects and other renewable energy projects. It is therefore required considering the application of suitable methodology for generation expansion plan which will take into account all indigenous resources.

At present there are very little or no data available at the end user level energy usage. This will hinder proper analysis on demand side management activities. Therefore it is advisable to implement proper mechanism to collect end user level energy consumption data in all demand sectors. This could be implemented through SEA under the Ministry of Power & Energy and a suitable organisation under the Ministry of Transport.

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