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AN EVALUATION OF THE TRENDS IN THE ENERGY SECTOR AND POTENTIAL FOR DEVELOPING RENEWABLE ENERGY

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This paper is one of the 18 papers, published under a special series of publications by the Sri Lanka Economic Association (SLEA) with financial assistance from the United States Agency for International Development (USAID). The objective of these publications is to provide economic literature on current and topical themes on the economy of Sri Lanka to a broad audience that is interested in economic issues, but has little or no background in theoretical economics, while maintaining high analytical standards. Hence, the papers have been written in simple language avoiding the use of sophisticated technical terms, mathematical equations and models etc. which are normally found in economic literature.

ABBREVIATIONS

AVGAS	aviation gas
AVTUR	aviation turbine fuel
C.E.B.	Ceylon Electricity Board
C.P.C.	Ceylon Petroleum Corporation
CW&GC	Colombo Water and Gas Company
EIRR	internal rate of economic return
FIRR	internal rate of financial return
GWh	giga watt - hour = 1,000,000 kWh
ha	hectare
kV	kilo volt
kVA	kilo volt - ampere
kW	kilo watt
kWh	kilo watt - hour = one unit of electricity
LECO	Lanka Electricity Company
L.P.G.	liquid petroleum gas
LRMC	long run marginal cost
MT	metric tonne
MTOE	million tonne of oil equivalent
MW	mega watt
MWh	mega watt - hour = 1000kWh
NERD	National Engineering Research & Development Centre
OTEC	ocean thermal energy conversion
R&D	research and development
SLCTB	Sri Lanka Central Transport Board
SLEMA	Sri Lanka Energy Managers' Association
TOE	tonne of oil equivalent
Ton	2,240 pounds
Tonne	metric ton = 1,000 kg

AN EVALUATION OF THE TRENDS IN THE ENERGY SECTOR AND POTENTIAL FOR DEVELOPING RENEWABLE ENERGY

1. INTRODUCTION

Sri Lanka has no known oil, coal or natural gas resources. The main sources which provide for the energy consumption in Sri Lanka are biomass (69%), oil (20%) and hydro-electricity (11%). The known domestic (indigenous) resources in respect of the above types consist of biomass and hydro-electricity. The entire requisites of oil (in the form of crude oil and oil products) are imported.

Biomass (inclusive of fuel-wood) is generally classified as a "non-commercial" type of energy source. Thus the only significant "commercial" domestic energy resource presently used is hydro-electricity.

The other major "commercial" energy source (necessary for transport, industry etc.) is oil, which is entirely imported. The petroleum import bill accounts for some Rs. 13 billion per year, nearly 10% of total imports or 12% of country's export earnings. The percentage may vary widely depending on oil prices; the quantities of oil import requirements are gradually increasing over the years. As there has been no firm commitment during the last 4 years for further renewable resource utilization such as hydro, or for a coal power project,

oil usage in thermal electrical power generation is also bound to increase rapidly during the decade of the 1990s.

The main "non-commercial" energy source, which is biomass (inclusive of fuelwood), should be viewed in the context of diminishing forest reserves. Forests which covered 70% of the land area in 1900 have come down to 44% in 1960 and 24% in 1989.

Although concerns outlined above are present, adequate energies in increasing extents are required to support the growth of the economy of the country. Long gestation periods required (5 to 10 years) for the completion of major energy projects, warrant decision making well in advance, though facing uncertainties in respect of demand growth and many other future parameters.

Oil resources in the world are fast being depleted: natural gas and coal too are being gradually exhausted, though at a relatively slower rate. All major energy consumptions have underlying environmental implications to the world and/or to the country. Sustainable development consistent with good environment needs more planning efforts and attention.

The above context mokes it important to examine the present and future rôle of oil, coal and renewable sources of energy for Sri Lanka. It is also important to assess the extent to which conservation and efficiency improvement can be of help.

2. PRESENT ENERGY DEMAND AND RELATED FACTORS

2.1 Supplies used to meet the demand

The gross supply from principal energy source types to meet the demand in recent years is observed from the following table 1 and figure 1.

Table 1

Gross supply from principal energy source types (1990)

	'000 TOE	% share
Fuelwood and other biomass Resources	4.690	68.8
Oil (inclusive of L.P. Gas)	1.367	20.0
Hydro-electricity	0.756	11.1
Others incl. Coal & Coal Products	Approx.	0.1
Total	6.813	100.00

Source: Sri Lanka Energy Balance and Energy Data - 1990. Alternative Energy Development Branch, Ceylon Electricity Board, 1991.

In the compilation of the above table and in figure 1, the direct use of solar energy in applications such as drying of paddy and other grains, drying of fish, extraction of salt from sea water, etc. has not been taken into account, in keeping with usual presentation. Also wind energy use in sailboats and similar applications is not accounted for.

Further if fuel-wood and other biomass supplies are not taken into account and only "commercial"

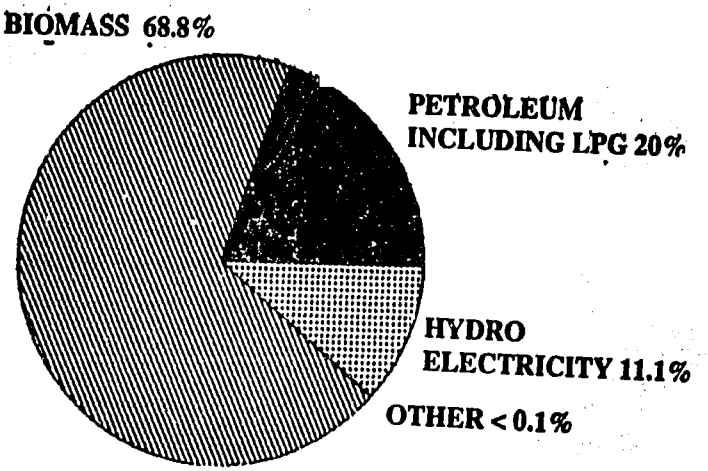


Figure 1. Sri Lanka Gross Energy Supply from Principal Primary Source Types - 1990

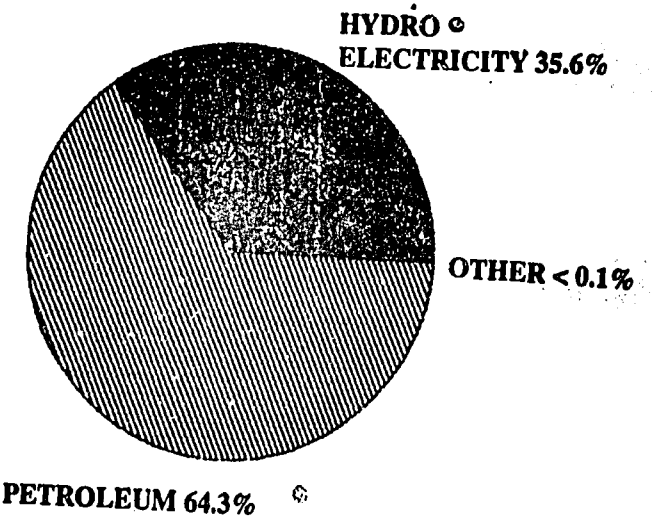


Figure 2. Sri Lanka Gross Commercial Energy Supply from Principal Primary Source Types - 1990

energy supplies are counted, then the share of oil products would assume approximately 64.3% and that of hydro-electricity approximately 35.6% (figure 2).

2.2 Recent use of Electricity

Electricity use in Sri Lanka has, in general, shown an increasing trend, the rate of growth being much higher than for biomass and for oil. During the relatively low economic growth period of 1971 to 1977, use of electricity showed an average annual growth rate of 6.2%. (In this period electricity prices were held constant while oil prices were allowed to rise). During the high economic growth period of 1977-1983, electricity use rose by some 9.5% per annum on the average though electricity prices were revised upwards substantially. During the unsettled period of the country from 1983 to 1989, the average growth rate of electricity came down to 5%. In general, the ratio of electricity growth to G.D.P. growth in recent times (in the 1980s) was of the order of 1:1.5. This ratio is at the high end; in countries such as Japan which use very energy efficient techniques the ratio is closer to 1:1. Perhaps the relatively high growth of household consumption in Sri Lanka is also responsible for this adverse ratio.

The large scale electrification programs introduced after 1977 increased the electricity using population from 9% in 1977 to nearly 33% by 1992. The number of villages which were electrified before 1977 were in the region of 1000; this was raised to over 9000 by 1992. Though the electricity consumption in both industrial and domestic sectors

rose in absolute terms, the fact that the domestic share of electricity consumption rose from 9.5% in 1976 to 17.3% by 1989, while the industrial share dropped from 51.8% in 1976 to 36.1% by 1989 is note-worthy. It should also be of concern, because the lower blocks of electricity sold for domestic purposes have been at a cross-subsidy, at the expense of industrial and other consumers. Continuance of such a cross-subsidy is likely to become difficult in the future, and may be detrimental to industrial growth. It also has a retarding effect on household electricity conservation.

In the year 1988, the total electricity generated was 2799 million units at a peak demand of 594 MW. Of this hydro-electricity accounted for 2597 million units (92.8%) and thermally generated electricity was 202 million units (7.2%). Total sales by the CEB was 2371 million units; which is 84.7% of the electricity generated. Thus, the CEB system losses were about 15.3%. By 1992, the annual generation exceeded 3500 million units, with a peak demand over 700 MW. However, part of the generation went to meet the increased losses, which became more than 20%. If losses in other distribution systems (of licensees such as Municipal Councils, U.C.s etc. and LECO) are included, the total loss is estimated at over 25% of generation. Loss reduction at the suppliers' end is possible; this subject will be addressed later in this paper under the sub-heading "Energy Conservation at the Suppliers' end".

2.3 Recent Use of Oil Products

Sri Lanka has a single oil refinery, owned by the Ceylon Petroleum Corporation and is situated at Sapugaskanda. Crude oil is imported and processed (refined) at this refinery. Most of the product demands of the country are met through processing at the refinery; when certain product quantities fall short of the demand due to output ratios of different refined products (e.g. as in the case of kerosene oil, L. P. Gas), such balance requirements are imported in refined form itself. Certain products which emerge from the process and are in excess of the requirements of the country (e. g. naptha, fuel oil) are exported. The total demand for oil products pertaining to the past has normally been estimated by considering the imported quantity of crude oil and refined products, exported refined products and process as well as other losses.

Petroleum Product Consumption Pattern

The local consumption of petroleum products during the year 1991 is given at table 2.

2.4 Recent use of Fuelwood and other types of Biomass for Energy

As stated earlier, Biomass accounts for nearly 69% of the primary energy consumed in Sri Lanka, when "commercial" as well as "non-commercial" forms of energy are taken into account. The biggest share of the biomass (inclusive of fuelwood) usage is in the domestic sector (82%); industrial sector uses about 14%. Most of the balance 4% goes into the commercial sector.

Table 2

Petroleum Product Consumption Pattern

Product Type	'000 TOE	Percentage (%)
Naptha	0.0	0.0
L. P. Gas	39.7	3.23
Gasoline (Petrol)	181.3	14.74
Kerosene	179.7	14.62
Auto - Diesel	507.0	41.24
Heavy - Diesel	38.4	3.12
Fuel Oil	142.5	11.6
Bitumen	40.0	3.25
AVTUR & AV Gas (Local)	76.5	6.22
Residual Oil	24.4	1.98
Total	1,229.5	100.0

Source: "Sri Lanka Energy Balance, Energy Unit, Ceylon Electricity Board for year 1991.

Nearly 93% of the population of Sri Lanka (which stood at 17.3 million in 1992) depend on fuelwood and other forms of biomass for their daily cooking of meals. This is the **least-cost** fuel for most, though **not the most convenient**. Since spending habits and living patterns of the low-income families are driven by the least-cost solution, this over-all pattern will remain during the 1990s, notwithstanding the fact that a small percentage of the population is likely to move towards the use of more convenient energy types (electricity, L. P. Gas etc.) for their household cooking needs. The Forestry Master Plan[1] for Sri Lanka of 1986 estimated that even in the year 2000, some 92% of the population of Sri Lanka would use biomass for cooking purposes.

The industrial use of fuelwood in Sri Lanka assumed an upward trend after the oil crisis of 1974. During the latter nineteen seventies and during the nineteen eighties, many small and medium industries changed from the use of furnace oil to wood-fuel for heating purposes. Such industries include tea factories, brick and tile manufacturing etc,. Even when the world crude oil prices dropped from the region of US$ 30 per barrel to less than US$ 15 per barrel in 1986, the tendency did not reverse because the local Rupee prices of refined oils that were sold were not reduced by an appreciable amount. (There was a slight reduction by 13% to 21% in the prices of different industrial fuel oils only, followed again by a gradual escalation. By 1990, the sale prices in Rupee terms of all oil products were above the 1985 prices).

The Forestry Master Plan of Sri Lanka (1986) estimated the total biomass demand for the period 1984-85 as 9.17 million tons per annum, and for the period 1986-90 as 9.675 million tons per annum. These estimates agree closely with that of Mick Howes[2] who quotes a demand of 9.37 million tonnes per annum in 1990.

2.5 Aggregate Sector-wise Energy consumption

Energy from hydro-electricity, bio-mass and oil have all been converted to a common unit (tonnes of oil equivalent-TOE) and added for this purpose.

The aggregate energy consumption, depending on whether bio-mass is taken into account or not, is as given in column A or column B respectively in the table 3 given below:

Table 3

Sector-wise Energy Consumption (1991)

	A. Biomass taken into account		B. Commercial Energy consumption. Biomass not taken into account	
	'000 TOE	% share	'000 TOE	% share
Household	3603.8	62.56	435.8	23.9
Transport	767.1	13.32	767.1	42.0
Industry	1067.6	18.53	410.0	22.5
Commercial	282.1	4.90	171.3	9.4
Agriculture	40.0	0.69	40.0	2.2
Total	5760.6	100.0	1824.2	100.0

Source: Sri Lanka Energy Balance 1991. Alternative Energy Unit, Ceylon Electricity Board.

Practically all the energy requirements of transportation are met from oil (auto-diesel and petrol). Most of the kerosene usage is for domestic purposes (mainly for lighting). Electricity and oil are both used for various industrial, commercial and domestic purposes. Fuelwood and other Biomass forms are used mainly to meet domestic and industrial needs.

3. PRESENT AND POTENTIAL ENERGY SUPPLIES

3.1 Oil/Gas

Although seismic surveys carried out in different parts of Sri Lanka indicated possibilities of oil and/or gas, drillings carried out have not shown positive results. In order to establish the presence or absence

of oil or gas, the drillings carried out so far are not at all adequate.

Drillings were carried out in some off-shore areas also during the nineteen seventies; these too did not lead to the discovery of any oil or gas. However, a relevant factor is that India discovered oil in the Cauvery Basin, within about 15 miles from the maritime border of Sri Lanka. There is a possibility for the existence of oil sources within the Sri Lanka territory and adequate investigations should be carried out to establish the availability of oil or otherwise. It appears that the particular locations within the Sri Lanka maritime border (close to where India discovered oil) have been allocated to an Indian Agency for further drilling and investigation purposes. There has hardly been any progress since this allocation in 1987. Sri Lanka should more actively pursue the related studies, with the assistance of Indian or other competent agencies.

Other identified prospective sites for oil are also still to be investigated. It is desirable to continue the investigation of these sites during the nineteen nineties. In the absence of such studies, the potential oil/gas resources cannot be estimated; one can only repeat the form "there are no known resources of oil, gas or coal in Sri Lanka"!

3.2. Peat

Another source of energy which is of a lower quality (and has a lower energy content per kilogram than oil or coal) is peat, which is available in Sri Lanka and has been quantitatively identified to some extent. The available peat at Muthurajawela

is as follows. At Muthurajawela, the area where more than 1 meter deep deposits are found is about 240 hectares. The amount of useful peat at Muthurajawela is estimated at 3.14 million cubic meters or 285,000 tonnes of dry matter. Of this volume, 94% is in layers thicker than 2 meters and 52% is in layers more than 3 meters thick[3].

The total quantity of usable peat in accumulations deeper than 1.5 meters is 258,000 tonnes. (This quantity is inadequate to operate a medium sized (100 MW) power plant even for 2 years. Thus the identified peat resources cannot be thought of as a substantial energy source for utilization in power stations.)

Another limiting factor regarding the Muthurajawela peat is its high sulphur content, which is around 5%. This figure is high compared to those peats in other parts of the world; typical sulphur content of peat in Finland is 0.2%. The high sulphur content has to be borne in mind in any application because of environmental pollution properties. Thus, use for domestic cooking appears to be unsuitable.

Fluidized bed technology with limestone injection to neutralize the sulphur (in moderate sized industrial boilers) appears to be a possible application for the peat.

It has also been found that small quantities of peat are available in several other parts of the country. But adequate investigations have so far not been carried out to identify the extent of extractable peat. It is appropriate to carry out at least reconnaissance

level investigations on the peat availability, to enable assessment of the quantities. Such investigations on peat resources are considered appropriate, particulary in the absence of any indication of coal resources.

3.3 Fuel Wood/Biomass

Biomass inclusive of fuelwood and agro-waste from forest and non-forest sectors are now providing the largest share of energy in Sri Lanka, though it is "non-commercial" in classification. However, one should not, and cannot prevent fuelwood from gradually becoming a "commercial source" of energy in the context of Sri Lanka.

The Forestry Master plan for Sri Lanka[1] (1986) estimated the availability (supply) of fuelwood and the demand on it in the following manner.

Table 4

Projected Fuelwood Supply Demand Balance

Period	Availability	Demand	Excess of supply over demand
	1000 Tons/annum	1000 Tons/annum	1000 Tons/annum
1986-1990	11375	9675	1700
1991-1995	11629	10359	1270
1996-2000	10959	10950	9

Source: Forestry Master Plan for Sri Lanka[1], 1986

From the Forestry Master Plan for Sri Lanka it is observed that the supply demand balance for the whole country will remain positive till the year

2000 (though regional deficits may occur). Of particular importance is the fact that the Forestry Master Plan proposed forest and fuelwood management programs which will enable an availability of about 10% higher fuelwood than the demand, extending to year 2020.

More recently (1990), Mick Howes[2] took an account of fuelwood and other biomass fuel. Most rural homes can use agro-waste and other biomass as a fuel for cooking purposes. Mick Howes arrived at the estimate of present annual potential biomass supply (as distinct from fuelwood supply) to be 16.5 million tonnes. It would be seen that this biomass supply is considerably higher than the present and (un-manipulated) medium-term demand.

It would be seen that the present use and future potential of biomass as the main energy supply resource for Sri Lanka cannot be over-emphasized. The important aspects are how this source could be developed, and how and where it can be best made use of. These aspects will be discussed later.

3.4 Hydro-Electricity Supplies

Hydro-Electric projects already in operation have a combined long-term capacity to generate about 3,900 GWh per year under average hydrological conditions. The total installed capacity is approximately 1100 MW in major hydro stations. An additional capacity of 20 MW is available in three small hydro plants, which have to be operated in a manner consistent with the water release requirements for irrigation.

A fair number of potential hydro-electric power station sites remain to be developed. The economic competitiveness of these developments depend largely on the cost of generation by alternative thermal means (oil or coal). If the alternative thermal generation is with low-speed high efficiency diesel plants, the remaining hydro-electric potential may be summarized as follows:-

Table 5

Potential for Further Economic Hydro-electricity Development

Oil price level US$/bbl)	Total additional economic potential	Total No. of sites
20	340 MW, 1430 GWh/annum	10
30	624 MW, 2639 GWh/annum	16
40	782 MW, 3300 GWh/annum	22

Source: Master Plan Study for the Electricity Supply of Sri Lanka, 1989

If US$ 40 per bbl is considered to be the upper limit of oil prices, 782 MW and 3,300 GWh/annum may be taken as the remaining economic potential in the country by way of large and medium-scale hydro-electric development. A further 200-300 GWh per annum may be available in small hydro-plant sites.

The capacity in MW given above has been on the basis of a fairly high plant factor (48%). However, to

meet the future needs of peaking capacity (with base load thermal plants which appear necessary after the year 2000), the hydro-plant may need to be designed for a plant factor of 35% or so. Based on such a design, the potential capacity for further development in the future corresponds to about 1,000 MW at an energy output of about 3,300 GWh per annum, which is somewhat less than the development which has been carried out up to now.

The total hydro-electric potential that is yet to be developed on an economically competitive basis (even if oil prices rise to US$ 40 per barrel) quoted above is 3300 GWh per annum, which is equivalent to 792 thousand TOE. This would be in the order of 10% of the total energy requirements by the year 2000, which is estimated at 8110 thousand TOE.

A firm commitment on the next large hydro-power station has not been made so far. In Sri Lanka, it usually takes a minimum of 6 years or so to complete a medium-sized hydro-power station after a firm "go-ahead", because of the time required to find finance, construction, commissioning, etc.. Thus one cannot expect additional major hydro-power until about the year 2000, purely based on physical considerations and logistics. Thus for the decade of the 1990s, hydro-electricity supplies available are likely to remain near the present level. However, if hydro-power (which is a renewable source of low environmental damage) development is vigorously pursued, medium-sized power stations can be commissioned by about year 2000.

3.5 Classification of Energy sources to Renewable/ Non-Renewable and to Local/Foreign

The following table gives a classification of the major energy sources presently utilized.

Table 6

Classification of Energy sources to Renewable / Non-Renewable and to Local / Foreign

Source Resource	Oil	Coal	Hydro-Electricity	Biomass including Fuel-wood
Renewable/ Non-Renewable	Non-Renewable	Non-Renewable	Renewable	Renewable
Local (indigenous)/ Foreign	Foreign	Foreign	Local	Local
Approximate percentage of present total energy usage	20%	<0.1%	11%	69%

It is interesting to note that Hydro-electricity and bio-mass are both local and renewable. Bio-mass presently supplies the largest share of energy and has a considerable potential for future expansion.

4. TRENDS IN THE ENERGY DEMAND

4.1 Factors Influencing Future Energy Demand

A large number of factors will influence the future demand on energy. The living habits of the people, their ability to afford various appliances, world oil prices, local energy prices, steadiness of the country, wars and civil disturbances, G.D.P. and G.N.P. growth rate are amongst these. Further, the weightages of sectoral components responsible for G.D.P. growth also matter. There are no firm projections of G.D.P. itself over a 10 year period. In this context, demand projections over a 10 year span are only a guide at best.

The basic large scale primary types of energy sources are fuelwood, oil and hydro-electricity for the Sri Lanka scene. Coal may enter the scene based on decisions that are to be taken particularly in the electrical power sector; it is unlikely that large scale coal will enter the scene before year 2000.

It is possible for certain types of user needs to be met from a variety of types of energy by source (e.g. cooking can be done using fuelwood, L.P. Gas, kerosene, electricity, agrowaste etc.) Therefore, it is difficult to project the demand for any individual type of energy as the users could shift from one type to another. In fact, they could be made to shift by application of suitable policy tools. Such shifting may be desirable, depending on economic considerations, supply deficits, foreign exchange conservation etc.. This subject will be addressed later in this paper.

4.2 DEMAND ON NON-TRADITIONAL ENERGY SOURCES

Non-traditional sources of energy discussed in the Sri Lanka context from time to time are as follows:-

1. Solar photo-voltaic for electricity
2. Solar thermal for heating
3. Wind Energy (for water pumping and electrical power generation)
4. Saw-dust and wood-waste
5. Paddy husk
6. Coir-dust
7. Mini-Hydro and Micro-hydro electric generators
8. Municipal and other waste
9. Ocean Wave Energy
10. Ocean Thermal Energy Conversion (OTEC)
11. Tidal Energy

Of the above, due to technical, economic or other reasons, the likely technologies for Sri Lanka for the decade of the 90s are the first nine.

The likely demand for any of the above during the next decade will depend on the price, availability and convenience of use. The basics in relation to energy supplies from the above identified non-traditional sources are as follows.

4.2.1 Solar Photo-voltaic (electricity)

Solar photo-voltaic electricity use in Sri Lanka during the next 10 years, as foreseen now, is

based on Solar-Cells with an associated system of batteries, invertors fluorescent lamps etc., The most expensive component in such a solar electric supply is the array of solar photo-voltaic cells, which is a product made by large-scale manufacturers who have access to and are capable in high technology, Solar-cells presently cost in the region of about US $ 4 to $ 5 per peak watt (F.O.B. buying price), although predictions a decade ago indicated that the cost should by now be in the region of one U.S. dollar per peak watt. Though this prediction was not fully realized, one should not be discouraged because prices dropped from about US $ 12 per peak watt in the seventies to the present US $ 4 to $ 5 per peak watt during the eighties. There could be further gradual drops in the nineties, when large scale mass production of solar-cells takes place.

The practical use of Solar Cells expected in Sri Lanka during the nineties is based on using this device to charge a battery (during sunlight hours), which would in turn supply electricity for two or three small (1-foot, 5W fluorescent lamps, radios etc. The cost of practical solar electricity systems to support such small demands of a house hold is in the region of Rs. 7,000 to Rs. 20,000.

At a cost of US $ 4 to $ 5 per peak watt of solar cell, the cost of solar cells, battery etc. to supply a small black & white Television receiving set would be in the range of Rs. 10,000 to Rs. 20,000, which is far more than the cost of the TV set itself. But there will be some such applications in locations away from the electricity grid. The use of Solar cells for heating purposes (or even an electric iron for

ironing of clothing) is generally prohibitive in view of the high capital cost of Solar-cells.

The price of Rs. 10,000 for a solar-cell system per household for minimal (16W) internal lighting appears high, in a way. However, looking at this from a different perspective, in a way, it is not too high, when one considers the capital cost that goes into the expansion of the electricity grid & distribution system, particularly in the case of rural domestic consumers who live in a spread out geography. Even the rehabilitation of electricity in run-down areas costs in the region of Rs. 10,000 per consumer. Cost of providing electricity per consumer in new locations by expanding the grid electricity distribution is of the order of Rs. 30.000. Of course this is for a much stronger supply than from solar cells; grid connected supplies will allow heating as well as motors, and can support a small industry even in a house.

Solar electricity can be used even in a remote area or a house far away from the electricity distribution lines, and can be trouble free if properly maintained. In Sri Lanka, the battery which has been used to receive the charge from solar cells is of the lead-acid type. Such batteries will need to be replaced every 5 years or so at a cost of about Rs. 2000. The biggest obstacle to the use of solar cells arises from the relatively high capital cost of solar cells themselves to derive a sizable quantity (units) of electricity per day.

Considering all the above factors, it is estimated that solar electricity supplies could be in the region of

0.5 million kWh units by the year 2000, which would still be less than 0.01% of the total electricity demand.

4.2.2 Solar Heating

Solar Heating of water is possible by mounting solar collector/heat exchanger panels in a suitable manner on roof top or other location. Capital cost of reliable solar water heaters are in the region of Rs. 35,000 (for small domestic use). The hot-water using population of Sri Lanka (for bathing and washing) is very small. They generally prefer electric geysers. Thus the use of solar heating for domestic purposes is not likely to grow rapidly in the Sri Lanka context. A small extent of use in industry (for preheating etc.) may take place; the likely extent is quite small in the context of total energy requirements, and it is not attempted to estimate the same here.

4.2.3 Wind Energy

Wind Energy is being used to a very small extent, so far mainly for water pumping. Mechanical energy derived from rotating blades is directly used to drive piston type or other water pumps. Because the mechanisms can be kept simple, depending on technology transfer and promotion efforts as well as the price of diesel oil, a certain extent of wind energy supply expansion for water pumping applications is likely to occur during the 1990s. The potential for such wind energy units for water pumping is estimated at 5000 (small machines of 1/8 H.P. each)

during the next 10 years. The total energy from 5,000 such wind mills would be in the order of 001% of national energy consumption.

Wind energy for electricity is nearing competitive levels, partly due to the rise in the cost of conventional fuels. Generally, the optimum machine size for this purpose is accepted as being a fraction of a Mega-watt, eg. 300 kW. When a large power or energy is desired, the practice of constructing "wind farms" which have hundreds of small wind driven generators, is emerging in certain countries. In Sri Lanka, an experimental 5 kW wind generator was installed at Pattiyapola in the Hambantota District more than 10 years ago. No moderate scale plants have been installed. The investigation of wind energy potential at several sites was carried out by the Ceylon Electricity Board, with the assistance of the Netherlands government.

The results of this investigation showed that wind generated electricity would be more expensive at the moment, compared to traditionally generated electricity. Quoted benefit/cost ratios are of the order of 0.5. However, wind generation is "environment friendly" and is from a renewable energy resource. The CEB is approaching the Global Environment Fund for assistance because of this. If such attempts are successful, it is possible that Sri Lanka may install a few moderate sized wind-energy generating plants during the nineties. However it is unlikely that the energy supplies from such wind farms would exceed a million kWh units per annum by the year

2000. The energy would still be less than 0.02% of the total electricity supply.

4.2.4 Saw-dust

Saw-dust arises from sawing of timber and is readily available at small, medium and large scale timber mills. At one time, saw-dust was a nuisance to timber millers, but with cost of other fuels rising, fairly simple saw-dust burning stoves were made for use in homes. In fact in and around Colombo timber mills now sell a bag of saw-dust at about Rs. 5 to Rs. 10. Thus, most of the saw-dust can be expected to add to energy supplies by the year 2000. Its potential is generally included under forest industry residues.

4.2.5 Paddy-husk

Paddy husk too, which was hardly used in the sixties, came into use for domestic cooking and other purposes as a fuel during the seventies. Par-boiling of paddy is now widely carried out using paddy husk. By the year 2000, about 50% of the paddy husk is expected to be used as fuel. Its potential is generally included under agro-waste.

4.2.6 Coir-dust

Using of coir dust for energy production by burning is much more difficult than using saw-dust or paddy husk. This is due to the presence of moisture in the coir dust which is very difficult to expel. Extraction requires considerable energy in the form of heat or pressure movement. A limited degree of success has been achieved. Further Research

and Development is needed prior to making coir-dust into a wide-spread fuel source; however it should not be forgotten that there are perhaps better uses for coir-dust such as spreading in pineapple or similar plots to retain moisture. There may also be an export market. Hence, coir-dust is not counted as a significant energy source during the nineties.

4.2.7 Mini-hydro Plants (Inclusive of Micro-hydro)

Potential mini-hydro power plants can be divided into two categories for our purposes here. They are:-

(a) mini-hydro Power plants which were operated earlier, but were discarded 25 to 35 years back with the advent of grid-electricity.

(b) potential new mini-hydro plants.

In general, it is financially and economically viable to rehabilitate most of those in category (a). Those in category (b) need much more capital investment, and only a few are viable in the medium term.

Considering both categories the commissioning potential by the end of the nineties has been estimated at a power of 5 MW and an energy supply of 14 million kWh units per year. This is less than 0.3% of the total annual requirement of electricity, or .03% of the total aggregate energy requirement.

4.2.8 Municipal Waste and Similar Waste Material

Deriving of energy from Municipal waste and similar waste materials, when coupled with the necessity for disposal of such waste, may be attractive.

It is possible to think in terms of a small power-plant of about 5 MW capacity for the Colombo Municipality. The potential would depend on the viability, possible benefits being electricity, waste disposal as well as fertilizer output, but its contribution to the overall energy supply is not likely to be appreciable.

4.2.9 Ocean Wave Energy

Sri Lanka is an island surrounded by the sea and subjected to two monsoon periods during a year. Thus, the ocean surrounding Sri Lanka is rich in wave energy but the intensity of energy is diffused over a wide area. Further, the extent of power will (vary) depend from day to day. Due to these and other practical reasons, it is difficult to foresee large-scale exploitation of ocean wave energy in the near future. However, users in convenient locations along the sea-coast may harness small extents of ocean wave energy in the future. At the moment there is no commercial ocean wave energy generation in Sri Lanka.

4.3 Aggregate of Non-traditional Sources

Considering the above analysis, the total energy output from non-traditional sources by year 2000 is unlikely to exceed .02 million tonnes of oil equivalent, which is only about 0.2% of the energy requirements of the country.

4.4 Demand on Electricity

The projected electricity sales demand is given at table 7.

Table 7

Projected Electricity Sales Demand

Year	Electricity Sales Million kWh Units
1993	3085
1995	3589
2000	5370
2005	8018

Source: Ceylon Electricity Board, 1993.

While Table 7 gives projected demand on sales, the resulting demand on generating plant is higher, depending on Transmission, Distribution and other losses. Table 8 below gives the projected demand on generation, as well as a probable subdivision to hydro-electricity and thermally generated electricity.

The demand on electricity is on composite (hydro and thermal) electricity. The subdivision into Hydro and Thermal generation depends on the plant commissioning program and rainfall that will be received in future years. In years of average or more than average rainfall, the hydro generation would be higher than indicated; the projected thermal generation (which is used to bridge the deficit between electricity demand and hydro generation capability) can be in error by many fold. Likewise,

when drought years are encountered, hydro generation would be lower and thermal generation higher.

Table 8

Projected Energy Demand on Generating Plants

Year	Overall Demand	Probable Sub division of Demand if major additional hydro plants are not installed		Approximate Oil (or coal) needed to meet thermal generation
	Million kWh Units	Hydro Million kWh Units	Thermal Million kWh Units	'000 TOE
1991	3377	3116	260	62
1993	3804	3200	604	145
1995	4371	3400	971	233
2000	6370	3800	2570	616
2005	9323	3800	5523	1324

Table 8 implies, that to cater for the thermal generation, continuous additions of thermal plant will be required from 1995 onwards. Also, oil or coal requirements will rise very rapidly as indicated in the last column. (10 fold from 1991 to 2000, over 1.3 million tonnes of oil equivalent by year 2005!).

To reduce these large-scale imports and also the adverse environmental impacts, a combined effort of energy conservation and renewable plant commission-

ing is desirable. These aspects are discussed later under the heading "Increasing the role of Renewable Energy."

4.5 Demand on Oil

The projected demand on oil product sales and primary oil consumption is given in table 9. Column 2 gives the sum of demand on final energy of all types of oil products (L.P.G., Gasoline, Kerosene, Diesel, Fuel oil and AVTUR etc.), summed after conversion to TOE. Column 3 gives the projected demand on primary oil consumption, which includes losses, including the petroleum refinery consumption, as well as non-energy oil products. The 1989 figures are actual.

Table 9.

Projected Local Demand on Oil

Year	Demand on oil (final energy) 1000 TOE	Primary oil consumption 1000 TOE
1989	1105	1230
1995	1341	1496
2000	1641	2126

Source: Ceylon Petroleum Corporation.

4.3 Demand on biomass

The projected demand on biomass inclusive of fuelwood is given in Table 10.

Table 10.

Projected Demand on Biomass

Year	Demand on biomass (Final Energy) 1000 TOE	Demand on biomass (Primary Energy) 1000 TOE
1989	4611	4642
1995	5067	5154
2000	5483	5610

Source: Compiled by Author based on L.C.A. de S. Wijesingha[11] and Mick Howes[2]

About 83% of the biomass is used for household cooking purposes. Only about 17% is used to meet industrial and other needs. It is, therefore, necessary to emphasize that the projected total demands could be drastically modified by further R & D on fuelwood efficient cooking stoves, and their popularization. Because the units given above are in TOE (Tonnes of Oil Equivalent), the biomass demand in actual tonnes is about 2.22 times the TOE shown; i.e. for 1989 it would be about 10 million tonnes.

The biomass sources used for energy can be categorized for convenience into two groups. The first can be termed "exportable fuelwood" and consists of rubber, coconut and forest. The second group consists of biomass which normally has to be

used close to the sources and consists of fuelwood and fuel from home gardens, sparsely used crop land, cinnamon, tea shade trees, coconut, palmyrah etc.. According to Mick Howes[3] the exportable fuelwood is about half the total biomass annually becoming available.

4.7 Projected aggregate Demand on Primary Energy.

The projected aggregate demand on energy supplies (primary energy) is given in table 11 and in figure 3.

Table 11.

Projected Aggregate Primary Energy Demand

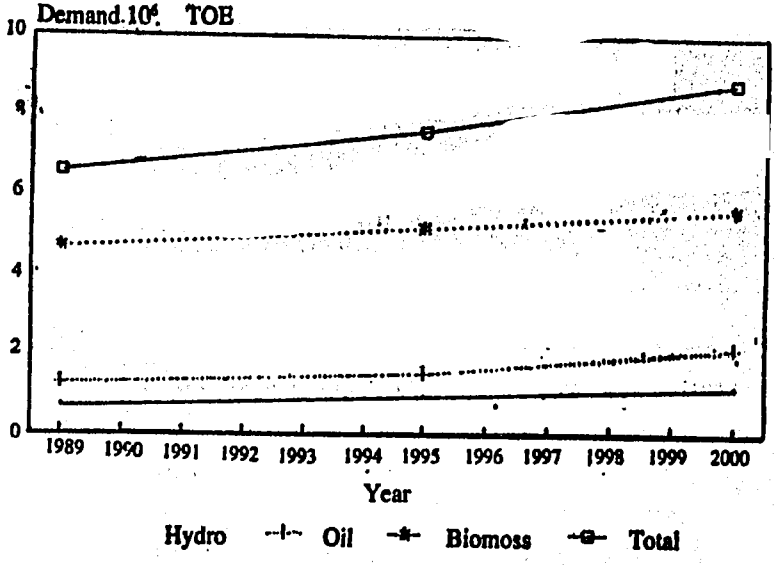
Year	Demand in 1000 TOE			
	Biomass	Oil	Hydro	Total
1989	4642.3	1220.4	672.4	6545
1995	5154.0	1496.1	944.5	7595
2000	5510.4	2126.7	1148.1	8885

Source: Compiled by Author

A word of caution is necessary regarding the interpretation of table 11 and figure 3. The actual disaggregate demands can change depending on interchange of source type by users. Also depending on actual rainfall during a particular year, the

Figure 3.

Projected Annual Primary Energy Demand.



availability of hydro-power and the necessity for thermal generation (using oil) will vary substantially. Optimum reservoir operation and catchment management will also change the extent of thermal generation needed (and thus the demand on oil.)

4.8 Switching from Non-Renewable Energy Sources to Renewable Resources

If some uses of oil (e.g. in transport, electricity generation, industrial heating) can be switched to utilize renewable sources such as biomass supplies (which are available and can be developed further), the requirement of oil (and coal if coal powered electricity is decided upon) can be reduced. This aspect will be dealt with later.

5. IMPROVING THE ECONOMY OF MEETING ENERGY DEMAND. CONSERVATION

5.1 Supply and Demand Sides.

One usually thinks of meeting the rising demand for energy by increasing the supplies. However, it is usually possible to effect economies on the consumption (demand side management), as well as to increase efficiency on the suppliers' side, so that the required increase of the supplies is kept to a minimum.

5.2 Aspects and Significance of Energy Conservation

By the term "Energy Conservation" more efficient use and reduction of waste is implied.

Energy conservation does not mean the discouraging of energy use; adequate quantities of energy should be used when necessary in an efficient manner.

Conservation of energy is desirable from several points of view. Firstly, fossil fuel sources of energy are being depleted and hence conservation helps to prolong their availability. Secondly, inefficient energy consumption is usually associated with environmental degradation; e.g. belching motor vehicles which are not properly tuned. This implies costs associated with environmental degradation (e.g. health costs) can be reduced through conservation. Further, conservation or efficient use of energy is usually financially and economically rewarding, which properties are generally considered by the user or the supplier.

5.3 Energy Conservation at the Supplier's End. Some Examples

It is not the intention here to delve deeply into micro-aspects of energy conservation by suppliers or utilities; such details are best worked out by specialized units of the suppliers themselves. (It is usually worth while to develop the required capability within the utility to monitor conservation aspects pertaining to operation as well as to planned development). Only certain salient features are mentioned here.

On the macro-scale, the suppliers handle the largest amounts of power and energy. Thus, even a small percentage improvement of efficiency at the supplier's end has a large quantitative result. For example, the losses occurring in the transmission and distribution of the Ceylon Electricity Board were

in the order of 20% in early 1980s. A World Bank supported loss reduction project was launched to bring down the losses, which were reduced to approximately 15% by 1988. However, by 1992 the losses in the Ceylon Electricity Board system itself increased to nearly 20%. A saving of 8% of total annual generation (approximately 3800 million units), which is quite feasible through loss reduction, amounts to approximately 304 million units. This amount is equivalent to the generation by a moderate sized power station of 80 MW capacity at an annual plant factor of 43%. (The Sapugaskanda Diesel plant is of 80 MW capacity and has so far been called upon to run at an annual plant factor less than 43%). If the construction of a power station can be avoided or postponed by conservation efforts of this nature, the financial savings arising from capital needs are also quite large. The environmental benefits will also be substantial as burning of oil or other fossil fuel will be reduced. Such loss reductions can be accomplished by proper operation, management and technical installation.

In respect of crude oil processing to obtain products, the Ceylon Petroleum Corporation which owns the only oil refinery in Sri Lanka is best suited for and has been undertaking conservation and efficiency improvement work. An aspect needing continuous effort is the minimization of "evaporation" losses of crude and refined oils. Losses during shipment of crude oil also need attention; more accurate quantity measurements at loading and unloading points appear desirable.

Small parcels of Liquid Petroleum Gas (approximately 1000 MT each) have to be regularly imported due to the demand marginally exceeding the

refinery output. In view of the limited storage facilities available, coordinating between refinery output and imports is often found difficult and increased flaring of gas at the CPC refinery is sometimes resorted to. The economic feasibility of increasing storage capacity should be studied; if the economic feasibility is established, the storage capacity should be increased.

Another aspect which needs study is the handling of imported L.P. Gas. The present mode of transfer from ships to storage tanks is through road transport. Considerable evaporation and other losses can occur during this process; alternative transfer methods need study. The Colombo Water & Gas Co. (CW & GC) as well as the Ceylon Petroleum Corporation could study these, taking into account the growth potential during the 1990s.

5.4 Energy Conservation at the Users' End

5.4.1 Industrial Sector Users

Industrial energy cosumers can be classified into two groups. The first group comprises the energy intensive industries in which energy costs represent a large share of total production costs (between 15 and 50 per cent). These include steel, cement, paper and certain chemicals. The energy consumption of these industries account for about 50% of the commercial energy consumed in the industrial sector.

Recent pre-feasibility studies have shown that energy cost per unit output in these industries could be significantly reduced through a variety of measures,

ranging from better house-keeping, energy management and improved monitoring/control systems to capital requiring methods in retrofitting existing equipment and using more energy efficient processes.

One way of estimating the maximum energy saving potential is by comparing current energy performance of industries with the best known international performance in similar industries. As shown in table 12 the maximum saving potential rates vary from 38% in the cement industry to 100% in the paper industry (where all fuels could be from wood wastes and black liquor etc.) Theoretically it appears that 53% of total commercial energy used in major industry could be saved if all plants were modified to meet the best international performance.[13]

The maximum energy saving potential given in Table 12 is theoretical, as it is quite unrealistic to assume that all existing plants in Sri Lanka could be modified to the same configuration as the best performing plants in the world. A more realistic exercise is to rely on detailed estimates made in other developing countries with energy performances similar to those in Sri Lanka. By applying such saving factors, it is seen that a more realistic figure of 22% to 28% of the commercial energy used in major industries could be saved. Such savings are illustrated in table 13.

The motive power required to turn or move the machinery in industry generally comes through electric motors. All types and makes of motors, some of which are efficient and some quite inefficient, are available in the market. It would be desirable to

Table 12

Comparison of Sri Lanka Energy Performance With the Best International Performance

Industry	Product	SCEC in Sri Lanka TOE/ton	Best International SCEC TOE/ton	Maximum Saving Potential %
CEMENT	Portland	0.167	0.103 (Japan)	38
CERAMIC	Tiles, Sanitary-ware	0.771	0.250 (Japan)	68
*PAPER	Paper	0.669/0.79	0.000 (Finland)	100
TYRE	Tyre	0.831	0.450 (France)	46
STEEL	Miscella-neous	0.204	0.145 (Sweden)	29
Glass	Bottles etc.	0.142		

*Figures based on Valachchena/Embilipitiya in 1987

SCEC – Specific Energy Consumption

Source: Proceedings of Sri Lanka Energy Managers' Association, Annual Sessions, 1990.

insist that the label on the motor should indicate the efficiency at suitable shaft powers. It would, however, be not desirable to insist on minimum efficiencies; the user should have the freedom to select a relatively efficient or inefficient motor, depending on how often it would be called upon to work, and other appropriate criteria.

There are some traditional light-industries in Sri Lanka which consume fuelwood as the principal

Table 13

Theoretical and Practical Energy Saving Poten tial in Industries of Sri Lanka

(Basis: 1985 production and commercial energy consumption)

Industry	Energy consumption		Theoretical Maximum saving		Practically Possible Saving
	TOE	%	TOE	%	TOE
CEMENT	62400	38	23914	20 to 25	12480 to 15600
CERAMICS	22393	68	15135	30 to 40	6718 to 8957
PAPER	20572	100	20572	20 to 25	4114 to 5143
TYRE	6008	46	2756	30 to 40	1802 to 2403
STEEL	7151	29	2076	25 to 30	1788 to 2145
GLASS	1706	—	—	—	—
TOTAL	120229		64453		26902 to 34248

Source: Proceedings of Sri Lanka Energy Managers' Association, Annual Sessions, 1990.

source of energy. The fuelwood consumption of these industries in 1985 was estimated at 1.1 million tons which is about 1/8 of the household consumption. The major industries using fuelwood and the percentage consumption of each are given in table 14.

Table 14.

Percentage Consumption of Fuelwood by Major Industrial Consumers

Tea Industry	— 33%
Small Hotels	— 15%
Brick and Tile Kilns	— 13%
Desiccated coconut and oil mills	— 11%
Tobacco curing	— 10%
Bakeries	— 08%
Rubber Manufacturing	— 06%
Others	— 04%

Source: SLEMA Journal, Vol 2, No 3, June 1989.

The average specific rates of fuelwood consumption in several industries are given in table 15.

Table 15.

Specific Rates of Fuelwood Consumed in industries

Product	Unit	Fuelwood consumed (kg)
Tiles	1000 nos	2670
Bricks	1000 nos	500
Coconut oil	1900 kg	300
Desiccated coconut	1000 kg	1500
Tobacco	0.4 ha	7000
Rubber	1000 kg	1000
Tea	1000 kg	3300*

Source: L.C.A. de S. Wijesinghe[11]

* Note by Author: This fuelwood consumption figure for tea can vary widely and can be as low as 1000 for low-country tea.

Energy conversion technologies used in most of the above industries are very inefficient. Detailed energy audits carried out in the plantation sector show that simply by replacing the inefficient air heaters used in most tea factories and in some cases by introducing improved drying technologies through gasifiers or fluidised-bed drying, the consumption of fuelwood in tea industry could be reduced by 50%. This is significant because, of all the industries consuming fuelwood, tea industry uses the most.

5.4.2 Commercial Sector Users

Commercial consumers of energy include banks, hotels, hostels, boutques, shops and similar establishments. Practically all of these establishments generally use electricity for purposes of lighting and air conditioning where installed. Most large urban or suburban hotels use L.P. gas for cooking purposes and oil fired boilers to provide hot water. Some smaller suburban or rural hotels use fuelwood for cooking purposes.

Energy conservation principles and methodology described under the industrial sector apply in general to commercial establishments also. However they generally have daily consumption patterns which differ from those of industries. Through various methods[13] there are commercial establishments such as hotels which now conserve more than 25% of their earlier energy consumption, without adversely affecting guest services and comfort. Such methods should be propagated to other users also.

5.4.3 Transport Sector Users

Sri Lanka uses more than 1.2 million MT of crude oil annually. The crude oil is refined and thereafter used as petrol, diesel etc. for various purposes. More than 50% of the entire oil consumption goes into the transport sector. Because of this large share, any successful programme in the management and conservation of energy in the transport sector will bring direct and sizeable benefits to the economy.

The transport sector is large and diversified with thousands of consumers or points of usage. Measures directed towards energy conservation in transport need a relatively large effort to implement and the savings are difficult to monitor. Furthermore, other related issues such as road conditions, passenger convenience and costs of vehicles/maintenance are all important considerations in the planning and management of energy use in transport. The policies and measures that could be adopted to achieve a higher energy efficiency in transport are numerous. These range from "good housekeeping" measures such as regular tuning of vehicle engines to major projects such as railway electrification and energy efficient road construction and maintenance.

Transport of passengers as well as goods can be done with better efficiency. Use of larger buses in urban and suburban areas is one such measure which can bring in conservation of fuel[5]. In the goods transportation area, more transport by train as opposed to lorries can bring in fuel savings. It

has been estimated that up to a maximum of 38 million litres of diesel oil per year can be saved in the passenger transport area[13]. These are the maximum estimated savings and, in practice, the amounts which can be saved may be about 50% of the above estimates.

5.4.4 Domestic (House-hold) Sector Users

Table 16 gives a break-up of the total domestic energy consumption in 1989.

Table 16.

Source-wise Break-up of Total Domestic (House-hold) Energy Consumption (1989)

Type of Energy Source	Energy Consumption (Thousand MT)	Thousand (TOE)	% of Energy Consumption
Fuelwood & other forms of Biomass	8555.00 MT	3827.25	93.8
Kerosene	140.19 MT	147.20	3.6
Electricity	918.40 kWh	78.98	1.9
L.P. Gas	24.34 MT	25.81	0.6
Charcoal	.49 MT	0.32	

Source: Sri Lanka Energy Balance 1989, C.E.B.

Biomass: It would be noted that fuelwood and other forms of biomass have contributed to supplying the major share of total domestic (household) energy demand.

The domestic sector has utilized 8.555 million MT of fuelwood and other forms of biomass, which is approximately 86% of the 1988 national biomass consumption. It is estimated that out of a total of around 3.19 million house-holds, about 91% depend entirely on fuelwood and other biomass to meet their cooking needs.

Most of the households in Sri Lanka still employ the traditional hearth consisting of three stones or the semi-enclosed hearth for cooking. It has been estimated that the efficiency of these stoves is around 5 to 9%. Under the circumstances, improved types of fuelwood stoves are of great importance, since they enable significant biomass savings.

Recent field evaluations suggest that improved stoves, where used, provide an average efficiency improvement of 25% thereby reducing the per house-hold consumption rate from the present 2.3 tons/annum to about 1.8 tons/annum. Some individual house-holds save as much as 35%.

Undoubtedly biomass has to remain, at least for another 20 years, as the major energy source for domestic cooking. An accelerated program of improving the usage efficiency of fuelwood as a cooking fuel, through a more intensified program of dissemination of the improved types of stoves, therefore, appears to be one of the best strategies in the national effort towards fuelwood conservation. As a double-stove costs only about Rs. 60/- such a program can be launched without direct subsidy, with marginal expenditure for propaganda and awareness programs.

Kerosene: Domestic consumers have used approximately 140,000 MT of kerosene in 1989, representing 87.3% of the total national consumption. Most of this is used for lighting of homes.

As electricity is used by only about 33% of the total number of house-hold units, kerosene provides lighting for the other 67% of house-hold units which use a wide range of lamps from bottle lamps to pressure operated mantle lamps. The bottle lamp most commonly used in rural homes is an inefficient device which is also dangerous. A nationally organized effort to design and popularize a cheap but efficient kerosene oil lamp to replace the bottle lamp, could to some extent yield a reasonable saving in the use of kerosene and enhance safety.

L.P. Gas: L.P. gas is fast becoming popular as a domestic cooking fuel in urban and suburban areas due to its convenience. Efficiency in its use can be improved by proper maintenance arrangements of gas stoves, which can be undertaken easily by the private sector. The training of maintenance & servicing mechanics could initially be by the state sector such as by the Colombo Water & Gas Co. (C. W. &. G. C). Consumers should be sensitized by pointing to them the financial savings from which they will benefit. It is estimated that about 10% saving of gas consumption could be achieved through proper maintenance of gas cookers.

Electricity: Efforts to achieve conservation of electricity in the domestic sector could be aimed at

—reduction of wasteful use (through good-house-keeping etc.)

-use of more energy efficient devices.

e.g. fluorescent lighting, compact fluorescent bulbs etc. in place of ordinary incandescent bulbs)

—effective means of discouraging use of heavy domestic appliances (e.g. electric cookers, washing machines) during the hours of evening peak demand.

—encouraging an alternative to electrical cooking.

These measures can bring about a saving of at least 60 MW at peak demand time and 60 million kWh units of electricity per year.

5.4.5 Energy Conservation through Appropriate Buildings.

If buildings are appropriately designed and constructed, energy conservation throughout the life of such buildings can be expected. Thus the long term energy savings can be substantial; there are likely to be corresponding financial savings to the owner or user of such buildings.

The electricity requirement for the lighting of buildings can be reduced by a proper design which will enable maximum use of natural sun light. Lighting load can also be reduced by the use of efficient lighting fittings with suitable reflectors, using fluorescent lamps, high efficiency compact fluorescent bulbs etc.. Air conditioning loads can be reduced or eliminated by use of proper ventilation, heat-insulation etc..

It is not intended here to go into details of energy efficient building designs. It is emphasized that public awareness of these matters be encouraged. It is also useful to conduct specially designed courses on energy conservation for engineers and architects responsible for building design and construction.

5.5 Possible Overall Savings through Energy Conservation

The following summarizes possible quantitative effects of energy conservation on the primary energy demand by type of energy sources.

Biomass: Though household fuelwood consumption can be reduced by about 30% with already proven technology of inexpensive and relatively efficient cooking stoves, a conservative 20% saving is assumed here. In industry too, a very modest 20% figure is assumed, though up to 50% savings are reported possible in large scale industries such as the tea industry. These yield a possible annual saving of 1.93 million tonnes of biomass or equivalently 0.87 MTOE approximately, which can be achieved through systematic effort on conservation.

Oil: Petroleum oil savings in industry of approximately 26,900 tonnes per annum can be achieved. Saving of oil in transport at a moderate 10% gives an approximate saving of 29,100 tonnes per annum. Thus a total annual saving of 56,000 (approximately 0.06 MTOE) is assumed achievable by the year 1995 and continued thereafter.

Electricity: savings at the suppliers' end and consumers' end are estimated at 119 million units per annum by year 1995 and 201 million units per annum by year 2000.

Aggregate Energy Savings

The above conservation measures, if implemented, would result in a saving of approximately 110,000 tonnes of oil per annum by the year 2000. The total savings, when savings of hydro-electricity and of fuelwood are also included, has been estimated[13] to be over a million tonnes of oil equivalent per annum.

6. INCREASING THE RÔLE OF RENEWABLE ENERGY

6.1 Major possibilities for Sri Lanka

From the foregoing analysis it will be clear that in the context of Sri Lanka the only major possibilities for increase in renewable energy supplies during the next 10 years arise from:

1. Hydro-electric power
2. Fuel-wood and other biomass resources

The extent of hydro-electric power expansion is also limited as most of the attractive hydro-electric power stations are already developed; what remains to be developed is less than 50% of the total economically feasible hydro-power potential. Although at present hydro-electric development is able to cater for the supply of nearly 90% of the **electricity** demand, the share of hydro-electricity in the **total** energy supply sector is only in the region of 11%. Even if all the remaining economic hydro - electric potential is developed in the next 10 years, due to increasing demand the total share of hydro-electric generation would meet less than 15% of the total

energy requirements of the country. (With the generation expansion plans that are currently envisaged, the share of hydro-electric generation is not likely to exceed 11% at any time.) As the demand for energy increases further, the percentage share of hydro-electricity is bound to decrease steadily.

For the utilization of biomass (inclusive of fuel-wood), there is much more scope. Fuel-wood and other types of biomass have been utilized for more and more applications progressively in the recent past. For example, when the oil prices increased sharply in the 1970s and in the 1980s, many tea factories switched to the use of fuel-wood (from oil usage earlier) for purposes of drying tea leaves. Most tile factories which used diesel oil for firing of kilns, changed over to the use of fuel-wood. There are more and more uses where fuel-wood could replace oil and other non-renewable resources provided adequate steps are taken including research and development at laboratory and field levels. Such replacements fall into the general frame-work of changing from the present energy usage pattern towards nationally beneficial directions. This aspect is briefly discussed below.

6.2 Changes from the present energy usage pattern towards nationally beneficial directions

As mentioned earlier, the major primary energy sources used in Sri Lanka are hydro-electricity, oil and fuel-wood. Their proportions are approximately 11%, 20% and 69%. By giving suitable incentives and using other policy tools, the usage pattern itself can be modified (which will be reflected as a shift in the above percentages) in addition to conservation through efficiency improvement.

6.3 Interdependence of demand for different Types of Energy

Demand on energy is created by end users. In many applications the end user can utilize different forms or supplies of energy to satisfy his requirement. For example, domestic lighting can be through electricity or kerosene oil or petrol. Among those which are utilized widely for cooking are electricity, kerosene oil, firewood and Liquid Petroleum Gas (L.P.G). Thus the demand on electricity will depend on the extent to which people will change from kerosene oil lighting to electrical lighting. In a ten year time span, it is even more dependent on the possible change from firewood cooking to electrical cooking, because of the much larger extent of energy needed per household for cooking than for lighting. Similarly, the demand on oil, firewood and other forms of energy are also inter-dependent; in many applications one form of energy can be substituted for another.

6.4 "Quality" of Energy

For simple heating needs such as in cooking, it is possible to obtain the required heat energy by burning kerosene oil, firewood, paddy husk, saw-dust, agro-waste, peat, coal, L.P. Gas, or electricity using inexpensive and simple appliances. But for turning a grinding machine the choices available are much less; usually an electric motor or an oil driven engine has to be used. To work a radio or a TV, operate an amplifier or a telephone exchange, there is no choice; electricity is essential. Thus it is seen that certain types of energy are more "versatile" than

others from the point of view of the user. It is therefore possible to think of the more versatile types (or sources) of energy as being of a higher "quality" because they lend themselves to a multiplicity of end uses relatively easily. A possible classification according to this concept of quality is given in table 17.

Table 17.

A Classification according to Quality of Energy

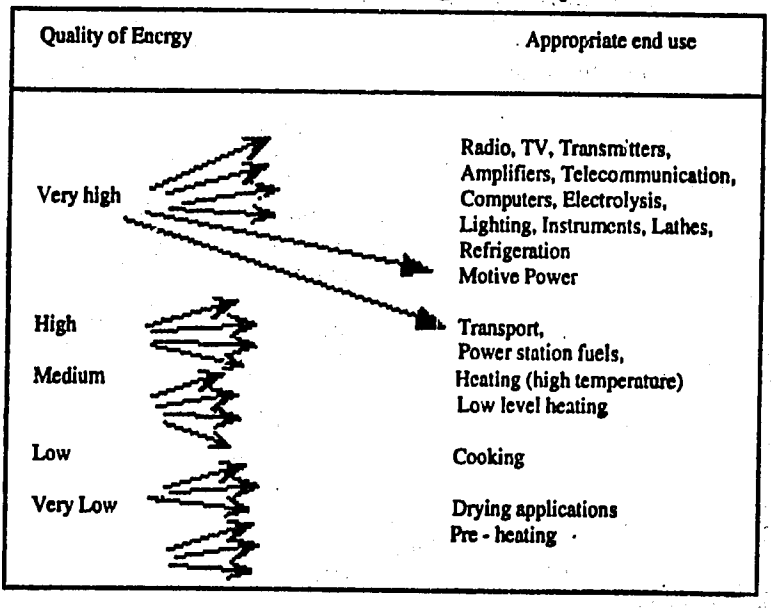
Energy Quality Class	Type or Source or Carrier
Very High (VH)	Electricity
High (H)	Diesolene Furnace oil Bunker oil Coal
Medium (M) &	Peat Firewood
Low (L)	Wood Wast addy-husk aw-dust Agro-waste
Very Low (VL)	Wind Tidal Ocean Thermal Energy (OTEC) Wave

Source: Perera K.K.Y.W., "General Management of Energy", Proceedings, Section C, Sri Lanka Association for the Advancement of Science, December 1981.

It can be shown that in the context of Sri Lanka, "matching of energy quality to end-use needs" implies the use of higher quality sources to the applications where their use is most desirable.[13] Lower quality energy sources which have limited applications, are to be used wherever they can be used. Figure 4 below illustrates this concept.

Figure 4.

Matching End-use according to "Quality " of Energy. An approximate guide only



Fortunately, in the context of Sri Lanka, matching of energy type to end-use requirements according to energy resource availability also dictates the same change of directions in energy type utilization.

The only national resource of energy at the high quality end having a substantial potential is hydro-electric energy. The total potential of economic large and small hydro-power is estimated at around 7600 million Units per year which would indicate an installed capacity of about 2100 MW at 40% plant factor. The hydro-power plants that are presently (1993) commissioned total up to a power rating of approximately 1100 MW and have a total potential energy yield of approximately 3900 million units per year in the long term. The potential hydro-energy which can be further developed being of the same order as presently harnessed, and with a demand doubling period less than 10 years, it is not too long that one can go with hydro-electricity, even if one finds a method of meeting the burden of high capital cost and associated high electricity cost.

From the above, it is seen that development of hydro-electricity cannot absorb much additional electrical demand arising from heating or other similar needs. Most of such requirements will necessarily have to be met with thermal electricity generated from petroleum oils or coal. It is, therefore, more reasonable to use oil, coal or L.P. Gas directly for heating applications rather than electricity. This is because when oil or coal is used to generate electricity through the conventional boiler - turbine - generator set-up, only about **one third** of the energy ultimately gets converted to electricity. (The balance **two thirds** go to warm up the environment.) Thus one needs about three times the fuel to get the same useful heat through oil - electricity - heat route. It is even more preferable to use renewable biomass (firewood, agro-

waste, wood-waste or paddy husk) for heating applications where possible. The electricity potential, if relieved from heating applications as far as possible, could be put to better use in applications where it is most needed; electronics, communications, radio, TV, motive power in industry & transport, lighting etc..

When looking at the future, in another 10 to 15 years time the electricity demand would reach a value exceeding the present and the future potential for hydro-electric development of the country. This too points to the using of the "Very High" quality type of electrical energy for end uses where its availability would be essential. The maximum possible use should then be made of biomass. wind, solar etc., in instances where such sources will be adequate to satisfy the end use needs. In the intermediate period from now till another 10 to 15 years too, it is not possible to make hydro-electricity abundantly available at cheap prices, because of the long lead-times and heavy investments needed for hydro-power construction. Thus to match by resource availability for hydro-electricity, we must divert all low quality users away from electricity.

The large scale medium/low quality energy Sri Lanka now possesses is from biomass. This source presently supplies over 70% of the total energy consumed in the country and consists of about 10 million tonnes per year of biomass, inclusive of forest and nonforest resources. The annual supply potential is quoted to be much higher[2] (approximately 16 million tonnes); with adequate attention to reforestation, aforestation and biomass management

in general it should be easily possible to maintain a surplus level of supply. Resource matching could be approximated, if attention is given to the methodology of the following paragraphs.

Of the total 9.5 to 10 million tonnes per year of biomass consumed, about 8.5 million tonnes are used by the household sector for cooking purposes. Most cooking is still done by a simple hearth, of very low efficiency. Low cost improved hearths which save about 30% of the normal extent are being introduced progressively. Further improvements (through R & D) and wide-spread use of such devices (through popularization by various methods) should enable the reduction of biomass consumption by 35% or so. Some of the firewood component of biomass thus saved could be channeled to meet the many needs of the industry for medium/low quality energy, thus arresting or reducing the growth in demand for oil and electricity. In addition trees can be grown for use as fuelwood and for other general purposes.

Presently transport needs in Sri Lanka are almost entirely met from oil sources. Thus to meet the demand of increased transport requirements, additional oil supplies will be needed, unless hydro-electricity and biomass are progressively used in the transport sector too. Railway electrification and introduction of electric trolley buses in Colombo are desirable from this point of view as well as from better transport efficiency and environment considerations. The industrial heating energy requirements will have to be progressively met with medium/low quality energy resources such as fuel-wood paddy husk, wood-waste, etc.

Because of Sri Lanka's specific endowments such as the availability of marginal land (more than 1 million Acres) suitable for growing some type of trees or forest (which can be used as a fuel source) availability of unemployed or semi-employed persons distributed throughout most parts of the country who can be utilized for growing of trees, and because of the availability of sunshine and rainfall, growing of trees as an energy source as well as for other general purposes should be encouraged.

As there are no indigenous resources of coal or oil or natural gas yet discovered in Sri Lanka, an attempt should be made to contain consumption of these at low-levels, (particularly in the context of a weakening Rupee) without impeding industrial and economic growth. Moreover, coal and oil are depleting resources; their consumption is associated with environmentally harmful effects. The above would be steps in this direction.

Specific cases of promoting the use of wood-fuel into two new application areas, those of transport and of power generation, are given below.

6.5 Possibility of Using Wood as a Fuel for Transport

Some interesting Research & Development work has been carried out during the nineteen eighties in Sri Lanka and abroad on wood-fuel gasifiers. R & D carried out in Sri Lanka is more relevant; the work of the NERD Centre has reached an advanced stage. In this technique, controlled burning of fuelwood in an enclosed chamber produces combustible gases.

Such gases can be used for practically all heating requirements, ranging from drying applications to melting of metal in foundry work.

Research and Development for fuel-wood gasifiers to run Diesel or petrol driven types of engines has been more challenging. Clean gases are a necessity for such engines, and load variations also throw demanding design conditions. Design for use in vehicular engine applications is even more exacting in view of the requirements for frequent starting, stopping acceleration and deceleration. Such gasifiers are also subjected to vibration, road shocks etc. The vehicular environment also calls for light weight small space designs which recognize the need to refuel during long trips.

The National Engineering Research and Development Centre has operated for several years, a few vehicles fitted with gasifiers of their own design. The claims made by the NERD Centre indicate satisfactory operation and lower fuelwood cost in comparison to diesel or petrol. It is desirable that one or two long distance commercial vehicles (lorries and buses) be tried out on a daily basis to prove the claims and test the reliability. If these are successful, the first promising routes could be in the flat country such as Colombo-Matara, Colombo Jaffna etc. With reasonable further R & D effort, there is a possibility that about 10% of the annual transport needs of oil could be reduced by the use of fuelwood during the nineties. Such an achievement would be significant in the context that more than 55% of the total oil consumption is by the transport sector.

6.6 Use of Wood-fuel for Electricity Generation. Dendro-thermal concept.

Use of wood-fuel for electricity generation in conventional boiler - turbine - alternator line up is proven technology. However, the fuelwood requirement for a given quantity of energy (kWh) is 2 to 2.5 times that of coal by weight. Further, transport of bulky fuel wood over long distances is expensive (and also requires energy!). Only a limited extent of annual fuelwood yield can be obtained by growing a forest within a restricted area around a wood-fueled (dendro-thermal) power station. Thus large dendro-thermal power stations, requiring fuelwood transportation over long distances, are likely to be uneconomical. Smaller power stations connected to the local electricity grid are economical, based on estimates made. It is thus desirable that research & development as well as proving trials on a pilot plant be undertaken. If these trials become successful, a large number of dendro thermal plants can be constructed geographically spread over the country, by the end of this decade. This would help the environment (net zero Carbon Dioxide release because trees absorb Carbon during the growing process, which is released during burning for energy), increase employment (in the growing of forest and in forest industry) and reduce the foreign exchange drain. It is worth noting that conventional coal burning adds considerable quantities of Carbon Dioxide to the atmosphere, contributing to global warming. Further burning of coal adds Sulphur to the atmosphere in the form of Oxides, responsible for acid rain, leading to deforestation. Wood-fueled

power stations are virtually free of above pollutants and rely on renewable resources. These facts were pointed out by Perera[13] in March 1992.

A project proposal on "Trees - Growing fuel-wood for Energy" was prepared by an expert panel[1] appointed in 1992. Its recommendations for promoting the wood-fueled (dendro-thermal) power stations and growing of trees by the public and private sectors, submitted through an inter-ministerial group and the Ministry of Power and Energy, were approved by the Government in 1993. Active follow up is now required, to enable large-scale renewable wood-fuel based generation with the experience of initial proving trials.

6.7 Growing of fuelwood and Availability of Land

One should not bear a misconception that additional utilization of fuel-wood and other biomass will have a detrimental effect on the already diminishing forest reserve of Sri Lanka.

One must consider the facts pointed out in the Forestry Master Plan for Srilanka[1] as well as by Mick Howes[2], that there is a surplus annual yield of fuel-wood and biomass in the country even till after the year 2000 (though there are regional deficits), even without resorting to forestation plans recommended in the Forestry Master Plan. It has been pointed out by land specialists that there are more than a million acres of marginal land which can be utilized for further growing of various types of trees. In any case, further utilization of fuel-wood and biomass for electric power generation or for transport should

definitely be coupled with the growing of adequate trees organised for this and other purposes. Biomass so produced can be harvested and used to meet additional energy needs as well as timber requirements etc.

6.8 Relative Contribution Possibilities of Renewable Resources

From the foregoing, it is clear that the largest renewable energy resource that Sri Lanka has, and which can be further developed is bio-mass (inclusive of fuel-wood.) Hydro-power, including mini-hydro, would be the next in order. The nine items given at section 4.2 earlier under non-traditional sources (including wind generation, solar-cells etc.) could also be used to give a much lower but nevertheless important contribution.

7. CONCLUSIONS

The three main energy consumptions in Sri Lanka are from sources such as biomass (inclusive of fuel-wood), oil and hydro-electricity, which account for approximately 69%, 20% and 11% respectively of the total energy consumed. While biomass is a domestic (indigenous) resource, hydro-electricity has a large foreign cost component due to imported capital equipment and works. They are both renewable resources. The potential of hydro-electricity now remaining for development is less than what has been developed already. The entire requirements of crude oil and oil products are imported. Moreover, they are depleting energy resources, the use of which is environmentally unattractive. Thus, in the Sri Lanka

context, hydro-electricity expansion (which has only a limited potential) and more importantly biomass development (inclusive of fuel-wood) are the promising indigenous and renewable resources of energy.

To sustain economic and social growth, increased energy utilization will be required. In an eight year span, the annual electricity sales are projected to nearly double (increase by 100%). The annual oil requirements are estimated to rise by about 33% in eight years' time. The annual biomass requirements in another eight years are projected to increase by 10%. These "untampered" demands on energy sources can be modified to advantage through several mechanisms, two of which are dominantly important.

Conservation

The first and generally recognized method is energy "conservation", both at user and supplier ends. Such conservation should be without detriment to the economy and without adversely affecting production and productivity. It encompasses more efficient and effective **use** as well as **supply** of energy. Examples are the use of more efficient fuelwood stoves, use of fluorescent lamps or compact fluorescent bulbs (in place of incandescent bulbs), better tuning of vehicles to save fuel and lowering of transmission losses in the supply of electricity.

Demand Switching or Change

The second but equally important (though not readily recognized) method is through **demand switching** or **shifting,** particularly from one **source type** to **another**, e.g. from oil to fuelwood. Demand shifting by time of the day (e.g peak demand time to

off-peak time for electricity), will also reduce overall average demand due to loss reduction. This will not only curtail the day to day energy production cost; the loss reduction is accompanied by flattening the demand and lowering its peak, thus contributing to reduced capital investment needs.

In fact the demand on oil could be reduced by some 360,000 tonnes per annum (worth over Rs. 2,000 million per annum) by the year 2000 (from what it would otherwise be), through the application of **conservation** and **demand shifting** (switching) methods. Although the major shift would be towards the use of biomass, the biomass consumption itself can be maintained at nearly the present level, through the adoption of conservation efforts. These aspects in quantified form are illustrated in table 17.

Table 17

Combined Effect of Conservation and Induced Shifting of Energy Usage Pattern on Projected Primary Energy Demand

Projected	Annual Demand in Million Tonnes of Oil Equivalent				
	1989	1995		2000	
		without (conservation +change)	with (conservation +change)	without (conservation +change)	with (conservation +change)
Biomass	4.35	4.66	3.97	4.93	4.31
Oil	1.23	1.50	1.26	2.13	1.77
Hydro-electricity	.67	.93	.90	1.05	1.05
Total	6.25	7.09	6.13	8.11	7.13

Source: Perera, K. K. Y. W.[18]

From the table, it will be seen that the annual demand on petroleum oil has been reduced by approximately 240,000 tonnes in year 1995 and 360,000 tonnes in year 2000 (with respect to the "raw" demand). Simultaneously, the biomass demand (which absorbs the effects of most change-overs from oil) has been kept below the 1989 level (through conservation). It should, however, be emphasized that this is only one of the possible scenarios, and its achievement will depend on efforts towards **conservation**, inducement for certain "**shifting**" of demand (oil to fuelwood, etc.) and adequate **Research & Development** backing. Growing of trees for fuelwood (and other general purposes) should also be encouraged so that a much larger extent of energy could be tapped from biomass in the twenty first century.

In order to be able to sustain continued increases on the use of biomass for energy (resulting from shifting petroleum oil usage) beyond the year 2000, a proper forest management program (inclusive of aforestation) is necessary. The program outlined in the Forestry Master Plan[1] of 1986, or a modified form may be suitable. Such a program will increase the supply of wood in general (timber for construction, furniture etc.) and will have an enhanced fuelwood component also. In view of the time required for forest to grow, it is emphasized that such a program should be vigorously followed from now onwards, which will also result in the biomass availability to improve further by the year 2000. Such efforts would enhance the environment and also increase potential employment at district levels in a distributed manner. The FIRR (over 20%) and EIRR (over 30%) quoted in the Forestry Master Plan[1] are supportive of such action.

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