



petroleum imports took up more than one quarter of our total import bill. Petroleum imports upto 1973 had always been less than 10% of the country's import bill, but in 1974 and 1975 it took up 20 percent while in 1976 it covered as much as 26 per cent. The fears that we could run out of energy have thus made it imperative to consider the need for a national energy policy.

### The Functions of Energy

Broadly speaking energy is work or effort, and it includes stored energy. The problems about energy that have captured the attention of the whole world and its leaders relate, however, mainly to commercial energy; that is, energy that can be bought and sold.

Energy of this sort, which is often supplemented by non-commercial energy, is used mainly in four distinguishable areas:

- industrial and agricultural uses, which involve mechanical heating and cooling processes, and include ploughing, harvesting and crop drying.
- domestic and commercial uses, which include lighting, heating, cooling and communication.
- transportation, which is the movement of goods and people by many different modes.
- electricity generation, which is not an end-use in itself, but a means of converting energy into a versatile form and of transporting it for use in the above three end-use sectors.

Most of the end-uses of commercial and non-commercial energy are similar throughout the world, except that the need to heat and cool homes, offices, factories, vehicles or food is a necessary function of climate and to some extent an optional function of extravagant living.

When man first came across fire many centuries ago, little did he consider that nearly every aspect of the life of his descendent of the present day would be governed by the control of heat or energy. Whenever we ride in a motor vehicle or turn on a powered machine or appliance we are dependent on energy inside the engine; whenever we turn on an electric light, we are dependent on the energy produced by the current; when we sit down to a meal we are dependent on

TABLE 1  
Sri Lanka Energy Use 1972—1976

	Hydro-power			Petroleum			Total		
	gwh	Gal. equiv.	trillion btu	Thousand tons	m barrel	m gal	trillion btu	gal. equiv.	trillion btu
1972 ..	846	68	11	930	4.1	244	41	312	52
1973 ..	698	56	9	964	7.2	253	43	309	52
1974 ..	997	80	13	766	5.7	201	34	281	47
1975 ..	1,077	86	14	735	5.5	193	32	279	46
1976 ..	1,108	89	14	731	5.5	192	32	281	47

#### Sources

CEB and CPC — Annual Reports

#### Conversion assumptions—

- 1 Kwh = 13,000 btu = 12 gallon crude = 11½ gal. petrol
- 1 ton crude = 7½ barrels = 262½ gal = 43 M btu
- 1 gallon motor gasoline = 146,000 btu
- 1 gallon mixed output = 168,000 btu

TABLE 2  
World Energy Use 1973

	Whole world	USA	Japan	Eire	Sri Lanka
Petroleum .. ..	118,500	32,300	11,200	223	43
Natural gas .. ..	47,800	25,200	200		
Coal .. ..	69,100	13,300	2,200		
Hydro .. ..	13,200	3,000	800		9
Nuclear .. ..	1,900	900	100		
Others .. ..					
<b>Total .. ..</b>	<b>250,500</b>	<b>74,700</b>	<b>14,500</b>	<b>223</b>	<b>52</b>

#### Source

US Dept. of Interior's Bureau of Mines (BOM)  
"International Petroleum Annual 1973" and "Energy Perspective 2".

the heat energy that cooked it; whenever we do anything at all we are dependent on the energy within our body which allows us to move. So vital a role does energy play in the life of man and yet human settlements are consuming more and more energy, particularly when mankind has become aware of the need to call a halt to all wasteful uses of non-renewable energy resources.

### The Sources of Energy

All sources of energy derive from the sun, but are normally defined in the following categories:

#### Commercial

- Petroleum
- Natural gas
- Coal
- Nuclear fission (uranium)
- Hydro-power

#### Non-Commercial

- Trees or firewood
- Muscle (animal and man)
- Gravity
- Wind
- Sun

New sources of commercial power are expected in:

- Oil shale and tar sands.
- Geo-thermal (both land and sea).
- Energy plantations.
- Direct solar applications.
- Wind, tide and wave power.

Very little study or quantification has been done on non-commercial energy; yet it is obvious that in this part of the world animals and indeed men do a lot of work which might have to be done by commercial energy elsewhere. And much heating or drying of crops uses combinations of sun, wind and firewood which in colder climates would need commercial fuels. Furthermore, energy for warmth of man comes straight from the sun in sufficient quantities in countries closer to the equator.

### Energy and the Quality of Life

United Nations' studies commonly compare countries by GNP per capita or similar measures, and also in terms of energy per capita per annum. But this is clearly a misleading comparison for two main reasons. Firstly, as

pointed out earlier, warmer climates do not need commercial energy for warmth, nor for many crop conversion processes. This lack of need for warmth permeates many aspects of life, including even the tending of of working animals. Hence warmer countries need less commercial energy per capita.

Secondly, patterns of life can be energy-profligate or energy-thrifty. It is well known how Americans wantonly use energy, especially for personal transportation, and for home heating and cooling, while another nation of similar climate e.g. West Germany, may use half the energy per capita of North America. This does not of itself mean a lower standard or quality of life for the former.

### Sri Lanka's Energy Consumption

Figures are not available anywhere as to the quantities of firewood consumed for drying and cooking, nor do there seem to be any estimates. Likewise, the amount of commercial energy saved by using man-power and animal power seems to have received scanty thought, let alone quantification.

Commercial energy used internally over the last five years are set out in Table 1, on page 4.

To put this in perspective, the 1973 world picture in trillion ( $10^{12}$ ) btu is shown in Table 2, also on page 4.

### The World Problem

Before analysing the use of commercial energy in Sri Lanka it is worth having a brief look at the world situation, and at what the leaders of most nations are worried about. Sri Lanka, as shown above, takes such a negligible quantity of world oil production that in one way it does not seem relevant how much is used here. But of course, if world oil supplies diminish, the price will go up and even the little used here will cost more than Sri Lanka may be able to afford.

The magnitude of the world's problem is seen in the steady growth of consumption represented by Table 3 comparing 1960 and 1973 in physical terms.

TABLE 3  
World Energy Use Growth

	Unit	1960	1973
Petroleum	billion barrels	7.9	20.7
Natural gas	trillion cu.ft.	16.4	44.4
Coal ...	billion tons	2.4	2.7
Hydro ...	billion kwh	.7	1.3
Nuclear	billion kwh	—	.2

Source "Energy Perspectives 2"

The greatest cause of concern is petroleum, because it is an eminently transportable fuel (by sea, pipeline, rail, road etc.) and suitable for many of the world's presently conceived needs, especially transportation (cars, planes, ships, trains, buses, trucks) and also home heating and industrial heating. World, US and Sri Lanka consumption is shown from 1960 in Table 4 in million barrels.

Most studies expect world consumption to increase from 20 billion barrels (3 billion tons) yearly to about 50 billion barrels (7 billion tons) yearly, not only because the 'profligate' countries like USA and Canada will continue to demand and use more oil, but more importantly because emerging countries like Brazil, India, USSR and China are expected to breakthrough present constraints of use. Even if consumption is held at 20 billion barrels the picture is not rosy because world "proven" reserves of oil have been estimated to stand at 600 billion barrels or 30 years supply at the most.

"Proven" reserves is a flexible term because nobody has gone down in the earth to measure it, and furthermore, oil companies and countries are thought to expand or contract their estimates as part of their bargaining with their own and world governments. Broadly, however, oil optimists expected "discovery" to go roughly hand-in-hand with consumption so that there would always be about 35 years of proven reserves in the ground. However just as raw oil is discovered and its quantity estimated, oil reserves are sometimes re-estimated either upward or downward when oil wells approach primary exhaustion.

Whether big new discoveries are made henceforth or not it is obvious that oil will run out between 20 and 30 years from now. Many studies consider that consumption will hump over into the 1990s. The factor that will prevent complete exhaustion is price. The price of oil will rise steeply as the commodity becomes scarce, and countries which keep their oil in the ground (by a carefully designed pricing policy) will seek their maximum benefits at that later stage. In any event oil prices are estimated to rise faster than general prices irrespective of inflationary rates. Some forecasters expect oil to double (in 1977 dollars) by the year 2000, but others expect it to multiply by eight, which would represent \$100 per barrel in current dollars.

TABLE 4  
World Oil Use 1960—1976

	Whole world	USA	Socialist world	Greece	Sri Lanka
1960	7,929	3,275	1,108		
1961	8,492	3,287	1,184		
1962	8,788	3,417	1,318		
1963	9,777	3,851	1,414	27	4
1964	10,515	3,959	1,522	30	5
1965	11,318	4,126	1,647	31	5
1966	12,166	4,325	1,765	34	6
1967	12,993	4,585	1,927	40	6
1968	14,252	4,902	2,061	41	6
1969	15,588	5,160	2,228	45	7
1970	16,682	5,364	2,374	45	7
1971	17,701	5,555	2,622	54	7
1972	18,745	5,900	2,608	63	7
1973	20,426	6,317	3,173	77	7
1974	19,790	6,078	3,034	77	6
1975	19,317	5,946	3,232	70	6
1976	21,000	6,350			5

#### Sources—

1960—1962 BOM "Energy Perspectives 2"  
1963—1975 BOM "International Petroleum Annual" several eds.  
1976 —BOM News Release 14.3.77.  
Sri Lanka —Ceylon Petroleum Corporation  
BOM figures for Sri Lanka are inconsistent as regards re-exports.

What does the world expect to do about this? President Carter wants to discourage demand by anticipating price increases. He hopes to impose the mildest of mild taxes on oil, but the US Congress seems opposed to even that.

The world is applying research both to new sources of energy and to methods of conserving energy use. But significant breakthroughs are not seeing the light of day. Conventional fission development, breeder nuclear power, fusion nuclear, oil shale, coal gasification, geothermal, wind tide and sun, are all held back by a variety of obstacles including cost, environmental opposition, safety and other hazards and some are thought to be capable of a rather insignificant impact on the problem.

For instance in President Carter's new policy, coal rather than nuclear is the thing of the future. Interestingly enough very few serious studies have been made of expanding hydroelectric power which too has met the opposition of environmentalists. USA alone is exploiting only about 55,000 MW out of some 178,000 MW identified as far back as 1964 when oil was abundantly cheap and looked as if it always would be. This aspect of hydro-power is referred to later on.

Before leaving the world scene it is useful to note that many American writers have accepted that oil has always been underpriced in terms of its scarcity (a favourite theme of the Shah of Iran). Table 5 gives the US sources of energy in 1976, shown in quads.

It will not be easy for Americans to reduce their reliance on foreign oil to meet their transportation requirements over half of which is used to fuel their automobiles.

TABLE 5

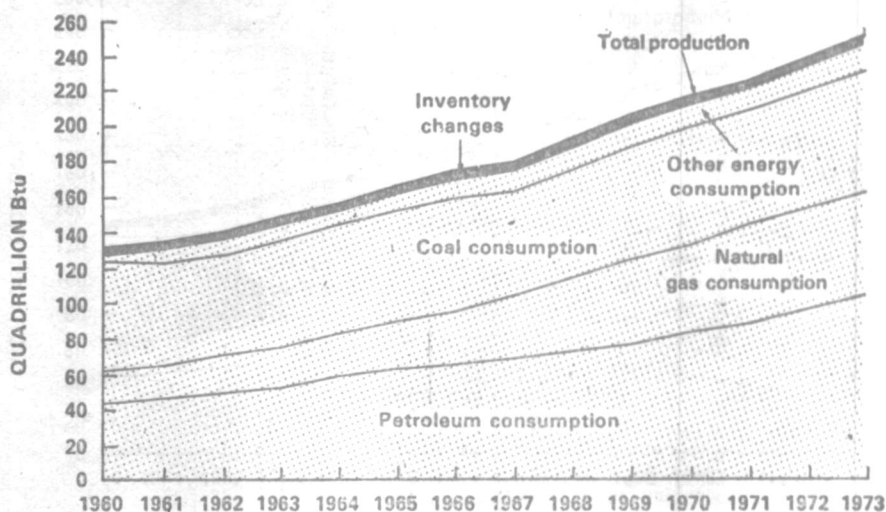
Use of US Energy 1976 (quadrillion btu)

	Direct Use			Total	Electricity	Total
	Residential & Commercial	Industry	Transport			
Oil	7	6	19	32	3	35
Gas	8	8	1	17	3	20
Coal		4		4	10	14
Hydro					3	3
Nuclear					2	2
<b>Total direct</b>	<b>15</b>	<b>18</b>	<b>20</b>	<b>53</b>	<b>21</b>	<b>74</b>
<b>Electricity</b>	<b>12</b>	<b>9</b>		<b>21</b>		
<b>Total</b>	<b>27</b>	<b>27</b>	<b>20</b>	<b>74</b>		

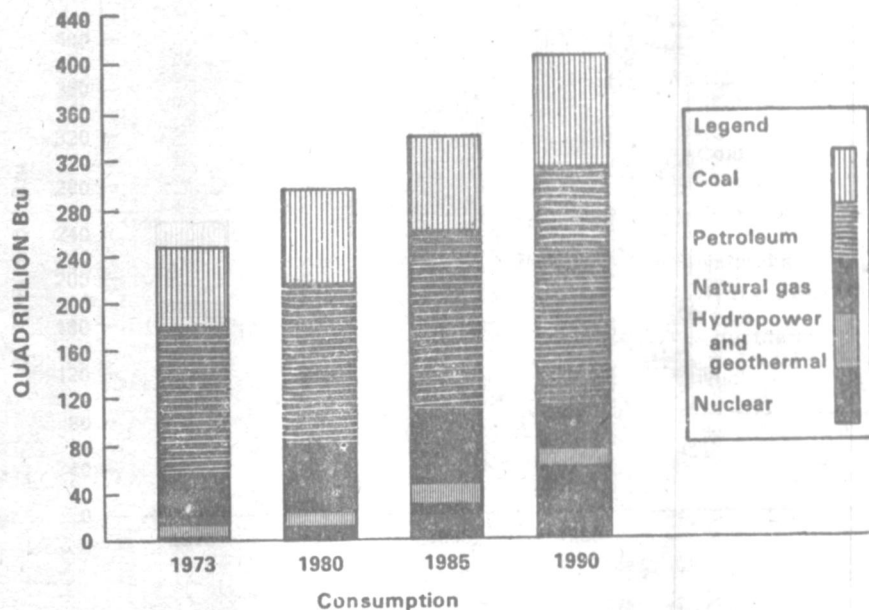
Source—BOM News Release 14.3.77.

## WORLD ENERGY CONSUMPTION

Production and Inventory Changes



## WORLD ENERGY PROJECTIONS 1930-90



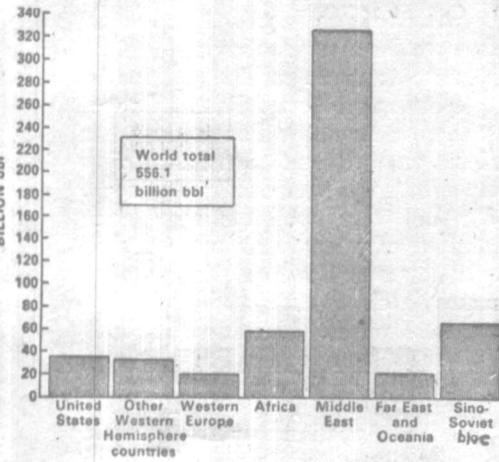
### World Energy Trends

Total world energy consumption is projected to increase from 250.4 quad-

trillion btu in 1973 to 406.1 quadrillion btu in 1990, an annual growth rate of 2.9 per cent. Nuclear energy shows the highest annual growth rate for this period (22.2 per cent), followed by natural gas (2.3 per cent), petroleum (2.1 per cent), hydro power and geothermal (1.7 per cent), and coal (1.6 per cent). From 1960 to 1973 world consumption of energy, measured in quadrillion btu increased at an annual rate of 5.1 per cent. During this period the combined share of petroleum and natural gas increased from 48 per cent in 1960 to 66 per cent in 1973, while coal's share declined from 47 per cent to 28 per cent.

The Diagrams on pages 6 and 7, which are intended to depict the general picture of the world energy situation are from the US Department of the Interior publication "Energy Perspectives 2" and are based on the various quoted against the tables in this document.

World Estimated Crude Oil Reserves January 1, 1975

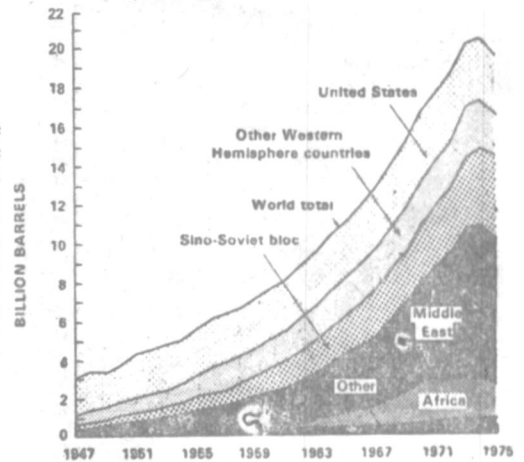


**ENERGY PERSPECTIVES**

**Oil**

During the 1947-75 period, world crude oil production increased at an annual rate of 6.9 per cent and, from 1960-1975, at an annual rate of 6.5 per cent. In 1975 Middle Eastern production constituted 38 per cent and that of the Socialist bloc countries constituted 22 per cent of total world crude oil production. The Middle East, with 59 per cent of the world crude oil resources is in a position to retain its dominance in world crude oil exports for the foreseeable future.

World Crude Oil Production



**Coal**

In 1974, the Sino-Soviet bloc accounted for 59 per cent of the total world coal production, while the USA produced 19 per cent of the total. Coal production growth patterns have varied among regions of the world primarily because of the differences of timing and impact of competition from oil and natural gas. World coal reserves were estimated at 669 billion short-tons in 1974. Coal production was 2.47 billion short-tons that year, significantly less than 1 per cent of total reserves. Of the total world recoverable coal reserves 46 per cent were located in the Socialist bloc and 32 per cent in the USA.

**Natural Gas**

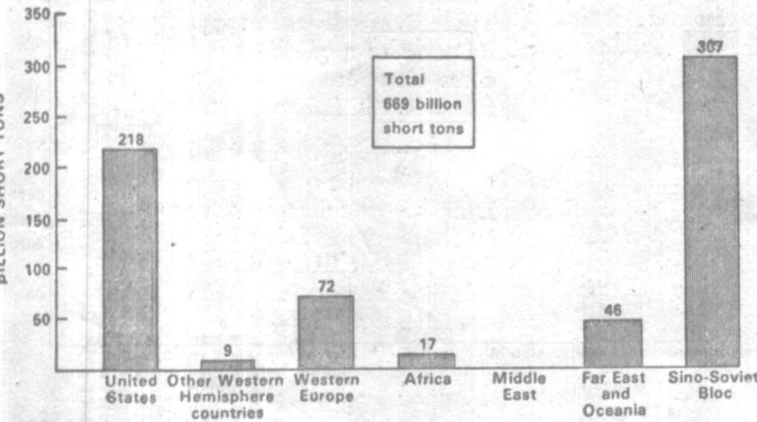
World natural gas production increased at an annual rate of 8.7 per cent during the 1947-1974 period. In 1947, US natural gas production constituted 97 per cent of the total world production and in 1974, 46 per cent of the total; while Western Hemisphere countries accounted for nearly 25 per cent in 1973 and the Sino/Soviet bloc nearly 15 per cent of world estimated reserves of natural gas. 34 per cent was located in the Sino/Soviet bloc nation at the beginning of 1975 mostly in USSR, the Middle East 28 per cent and USA 11 per cent.

13 per cent of the non-socialist world's uranium reserves. In 1975 uranium oxide production was 24,109 short-tons, or approximately 2 per cent of the 1.5 million short-tons reserve of the non-socialist world. Production and reserves of the Sino-Soviet bloc nations were not available.

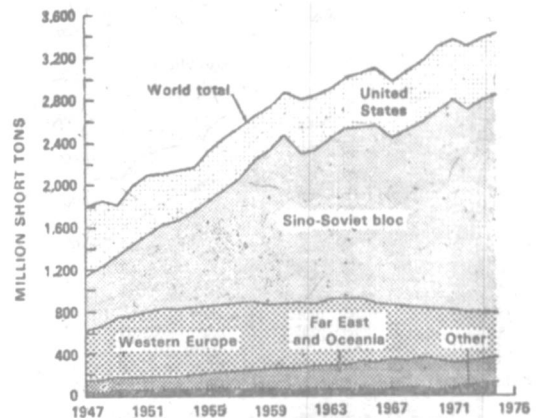
**Hydro Electricity**

The world has developed 13.6 per cent of its total hydro-electric capacity and 13.3 per cent of its ability to produce hydro-electric power. Europe (less the USSR) had had the most intensive development of both its power capacity and production capacity which are in the region of 50 per cent of this region.

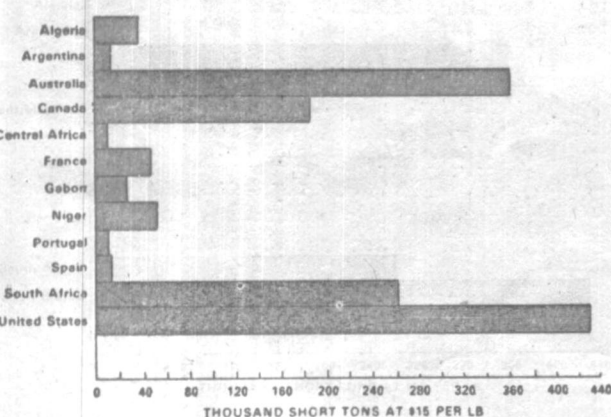
World Recoverable Coal Reserves 1974



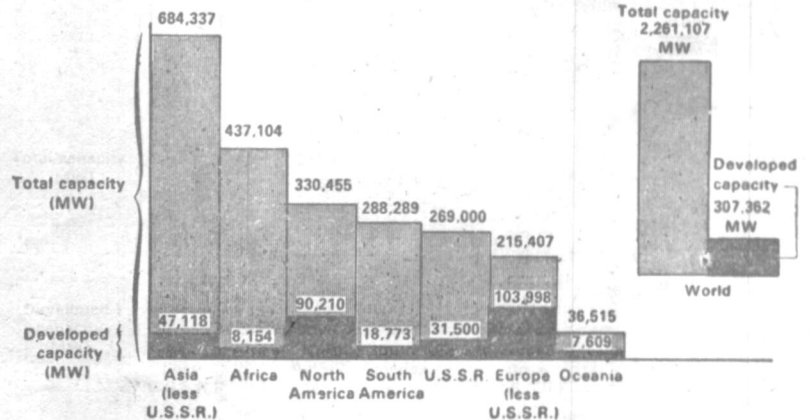
World Coal Production



World Uranium Reserves



World Hydro-electric Power Capacity 1974



## Impact of the World on Sri Lanka

What effect will World problems, and especially American problems have on Sri Lanka? Can we afford to ignore US problems altogether? The answer is plainly no, because the North American addiction to energy-intensive life, which has already spread to Japan and most of Western Europe will not abate itself, and the consequent demand for petroleum will force up its price to a future level (which could be anything upto \$100 per barrel) which this country will not be able to afford except in much smaller quantities than we are already used to.

How dependent are we on oil? Can we substitute hydro-electricity, or wood, or windmills, or direct solar energy for oil? Arthur Clarke had advocated exploiting ocean thermal gradients off the coast near Trincomalee. There is a small but powerful body of opinion advocating a nuclear reactor by the mid 1990s.

A look at the recent history of petroleum products used in Sri Lanka will be illuminating. Table 6 shows the internal sales (i.e. excluding bunkers, aviation fuel and exports) of the Ceylon Petroleum Corporation since it became responsible for all local distribution.

after the 1973 OPEC oil price hikes. Whether the 30 million gallons can be contained, and perhaps further reduced is partly a transportation problem involving transfer of travel from personal to public vehicles, and partly a technological problem involving alternative fuels for motor cars.

It is interesting that in 1976 the two transport fuels, petrol and auto-diesel, took up exactly half the quantity of the petroleum products consumed. Auto-diesel which is used mainly by lorries, buses and trains, has steadily increased from 40 million gallons in 1964 to 66 million gallons in 1976. This is a reflection of increasing economic activity involving the transport of goods and people. If such activity is to continue growing, then oil requirements for the purpose would also increase, unless ways are found to increase efficiency of use (for example by modal transfer from highway to railway or canal) or to electrify part of the transport task. These options are discussed later.

Heavy diesel, which is mostly used for stationary engines, has declined from 22 million gallons in 1964 to just 9 million gallons in 1976. This reflects the transfer of local power systems at Jaffna and other provincial areas to the hydro-fed grid, the re-

between 1964 and 1976. There seems to have been an underlying gradual increase from 22 million gallons in 1964 to 29 million gallons in 1976, with non-recurrent lumps used for Kelanitissa Power Station during drought years, especially in 1973. On the other hand the 1974 price increase may have driven tea drying and other agricultural drying processes back to firewood and convectional winds. This question too is discussed later under Industry and under Electric Generation.

Kerosene used mostly for domestic purposes, was steadily rising from 50 million gallons in 1964 to 76 million gallons in 1973, but plunged by 20% to around 60 million gallons over the period 1974 to 1976. Substitute fuel is mostly firewood. Whether this is good for the country's overall forest cover, and whether electricity, biogas and solar cookers are possible alternatives for cooking in the future, will be discussed under the section on Residential and Commercial Energy.

Sri Lanka's overall oil consumption, made up of petrol, auto diesel, heavy diesel, furnace oil and kerosene, as evident in the table, rose from 176 million gallons in 1964 to a peak of 254 million gallons in 1973. By 1976, however, overall consumption had come down to 192 million gallons following OPEC price increases.

The types of oil used and the purposes for which they are used in Sri Lanka is peculiar to the country's level and type of development. Before passing from oil to electricity it is interesting to consider how oil is used in a highly modernised and developed economy like that of the USA and in Sri Lanka. Table 7 shows the figures for 1976 in fuel type categories. See page 9.

## The Electricity Alternative in Sri Lanka

The chief source of energy supplementing oil in Lanka is hydro-electricity. This position was seen in Table 1. At the point of use, the alternative to oil is electricity, irrespective of whether it is generated from oil or falling water as the primary source.

Much emphasis had however been placed on hydro-electricity in all development programmes since 1948. A substantial portion of a cost of Sri

TABLE 6

Ceylon Petroleum Corporation Annual Internal Sales in Million Gallons

			Petrol	Auto diesel	Heavy diesel	Furnace oil	Kerosene	Total
1964	...	...	42	40	22	22	50	176
1965	...	...	41	43	22	30	51	187
1966	...	...	41	47	22	34	57	201
1967	...	...	41	53	24	40	61	219
1968	...	...	42	56	25	41	65	229
1969	...	...	44	60	24	40	69	237
1970	...	...	44	66	23	30	76	239
1971	...	...	41	65	22	26	75	229
1972	...	...	39	69	18	41	78	245
1973	...	...	38	68	17	55	76	254
1974	...	...	28	63	11	39	60	201
1975	...	...	28	64	9	33	59	193
1976	...	...	30	66	9	29	58	192

Source: *Petroleum Corporation Audit Reports*.

Petrol consumption had declined from a peak of 44 million gallons in 1969 to 28 million gallons in 1975, with a small upward trend to 30 million gallons in 1976. Petrol is used mainly by motor cars, motor cycles, scooters and light goods vehicles. The reduction in use by one third from 1974 is a direct reflection of the local petrol price increases

duction in use of the Colombo diesel-electric generators after full commissioning of Kelanitissa Power Station, and gradual electrification of tea estate factories. Further reduction, which is unlikely, is discussed in the section on Industry.

Furnace oil consumption, as seen in Table 10, shows erratic fluctuations

**TABLE 7**  
Oil Fuels Used in 1976 in USA and Sri Lanka

	USA		Sri Lanka	
	<i>m. gal.</i>	%	<i>m. gal.</i>	%
Gasoline (petrol) ...	89,635	45.5	30	15.6
Distillate (diesel) ...	39,837	20.2	75	39.1
Residual (furnace) ...	34,954	17.7	29	15.1
Kerosene ...	12,211	6.2	58	30.2
Sundry ...	20,521	10.4		
<b>Total ...</b>	<b>197,158</b>	<b>100.</b>	<b>192</b>	<b>100.</b>

Source for USA BOM News Release 14-3-77 (barrels converted to imperial gallons at 35 gals. per barrel).

The figures in Table 7 are converted to sectoral use in Table 8, with the assumption that all Sri Lanka furnace oil and heavy diesel is used for industry.

Lanka's electricity supply programmes has been met by foreign borrowing notably from the World Bank. Foreign financing has been a feature of the country's power programme and one of the reasons why the finance agencies have readily supplied credit to this sector is because electric power has been regarded as a "sound investment". Over the last few decades rural electrification has been one aspect of electric power supply to which much attention has been diverted. The argument was that not merely does rural electrification bring the electricity supply to farming and rural industry but it is also an agent of modernisation. However, there have been several practical difficulties in implementing the country's rural electrification programme according to schedule.

Table 9 sets out the sale of electricity to different sectors from 1964 to 1976.

It is noteworthy that even without breaking down and re-allocating the local government re-sales, industrial consumption has risen from 40% to over 50% of the total. And whereas total consumption has multiplied threefold between 1964 and 1970, identified industrial use has multiplied fourfold.

Upon a very arbitrary estimate that local government re-sales and sundries could be allocated one-third each to the industrial commercial and domestic sectors, Table 10 gives a picture of end-uses of electric energy.

Table 13 also shows the remarkable growth of industrial use of electricity which undoubtedly reflects the growth of industry itself, as well as electrification of tea estate factories earlier run on diesel engines.

While Table 13 indicates how industrial use of electrical energy has grown 3½ times since 1964, it also shows that commercial and residential use has multiplied only 2½ times. However, these multiplying rates depend on the accuracy of the arbitrary allocation of re-sales by local authorities. It is certainly met that the CEB obtains and publishes the breakdown of local government resales into end-user categories. It will be emphasized later that one of the

**TABLE 8**  
Sectoral Use of Oil in USA and Sri Lanka in 1976

	USA		Sri Lanka	
	<i>m. gal.</i>	%	<i>m. gal.</i>	%
Domestic and commercial ...	33,012	16.8	58	30.2
Industrial ...	23,296	11.8	38	19.8
Transportation ...	120,869	61.3	96	50.0
Electric generation ...	19,565	9.9		
Sundry ...	416	.2		
<b>Total ...</b>	<b>197,158</b>	<b>100.</b>	<b>192</b>	<b>100.</b>

Source for US figures BOM News Release 14-3-77 (barrels converted to imperial gallons at 35 gal. per barrel).

**TABLE 9**  
Electricity Sales 1964—1976  
(IN GIGAWATT HOURS: GWH = MILLION KWH)

	RETAIL				Bulk to local Govts.		Total
	Indus-trial	Com-mercial	Dom-estic	Total	local	Sum-dries	
1964 ...	132	58	42	232	75	14	321
1965 ...	141	63	44	248	84	14	346
1966 ...	160	67	45	272	95	40	407
1967 ...	213	72	48	333	111	28	472
1968 ...	251	78	53	382	122	34	538
1969 ...	294	76	57	429	148	8	585
1970 ...	329	87	62	478	164	11	653
1971 ...	373	93	65	531	191		722
1972 ...	410	102	72	584	210		794
1973 ...	466	109	81	656	211		867
1974 ...	478	117	82	677	215		892
1975 ...	520	124	86	730	230		960
1976 ...	514	137	93	744	251		995

Source Department of Government Electrical Undertakings and Ceylon Electricity Board.

TABLE 10

## Electric Sales Allocated to End-Uses

	Industrial Sector	Commercial and Residential			Total
		Com.	Res.	Total	
1964	161	88	72	160	321
1965	173	95	76	171	344
1966	205	112	90	202	407
1967	260	118	94	212	472
1968	303	130	105	235	538
1969	346	130	109	239	585
1970	388	145	126	265	653
1971	436	157	129	286	722
1972	480	172	142	314	794
1973	537	179	151	330	867
1974	549	189	154	343	892
1975	596	201	163	364	960
1976	597	221	177	398	995

difficulties of studying energy in Sri Lanka is the lack of relevant published data and delays in making available any data.

Before passing on to the generation of electricity it is pertinent to look at Table 11 which compares end-use of electricity in USA and Sri Lanka.

Recent figures published by the Bureau of Mines offer the comparison for 1974 shown in Table 12.

While the USA typifies profligacy of energy use, including electric energy use, and is thought by some scholars to have reached near saturation (NO-GROWTH) where electricity use is concerned, USA is not typical in electric energy for transport. In this sphere USA has minimal electrification of railways as against West Germany which hauls 80% of its rail ton-miles by electricity and all of whose principal cities have extensive electric suburban railway, subway and tramway networks.

TABLE 11

## End-use of Electric Energy USA &amp; Sri Lanka 1974

	USA		Sri Lanka	
	gwb.	%	gwb.	%
Household and Commercial	927,602	58.1	314	39.5
Industrial	664,898	41.6	480	60.5
Transportation	4,534	.3		
Total	1,597,034	100.	794	100.

Source for USA Federal Energy Administration (FEA) "Project Independence" November, 74.

TABLE 12

## Electricity End-use, USA and Sri Lanka, 1974

	USA		Sri Lanka	
	gwb.	%	gwb.	%
Household and Commercial	1,080,000	63.5	343	38.5
Industrial	617,000	36.3	549	61.5
Transportation	3,000	.2		
Total	1,700,000	100.	892	100.

Source "US Energy Through the Year 2000" Dupree and Corsentino, Dec. 1975.

## Sources of Electric Energy

Electricity is not so much a type of energy as a means of transporting energy, similar in some ways to pipelines, bowsers, colliers and coal or oil trains. But while oil and natural gas can be used for lighting and heating directly, and for propulsion either through combustion or through the steam cycle, and while coal can likewise give heat through burning, and movement through the steam process, water power is not so versatile.

The old water mills on which the American industrial revolution was launched are no longer considered viable, and have severe technological problems as to scope and scale. Hence the kinetic energy in water drawn from the hills to the sea by gravity is limited for practical exploitation to hydro-power. Is this indeed a limitation?

Since electricity itself is a wonderfully versatile form of energy, being both cheaply transportable and instantly tappable for various uses, including lighting, movement and heating, it negates the so-called limitation of water power. The principal function that electricity cannot perform in a practical manner is propel vehicles along sparsely trafficked routes unless and until there is a technological breakthrough in the field of batteries, and the resources needed to make them in large quantities.

Sri Lanka's electric energy resources have been generated as shown in Table 13.

Two important points emerge from Table 13. Firstly if not for hydro installations, Sri Lanka would have needed an estimated 85 million gallons of oil to generate the 1976 hydro energy supply. This would have been 2½ million barrels costing about \$30 million or (without FEECs) Rs. 240 million which represents about one twentieth of the country's import bill in 1975.

But if, as is to be expected, international oil prices increase rapidly towards the end of the century, the value of 1976 hydro generated electricity may well, in the year 2000 be equal, without taking general inflation into account, to the country's entire 1976 import bill.

TABLE 13  
Sri Lanka Electricity Generation 1964 - 1976

	Thermal Generation			Hydro-power gwb	Total gwb.
	m. gal. oil	kwb. p. gal.	gwb.		
1964	...	...	68	315	383
1965	...	...	64	345	409
1966	...	...	87	390	477
1967	...	...	161	399	560
1968	...	...	160	465	626
1969	...	...	14.5	540	722
1970	...	...	3.0	740	785
1971	...	...	1.8	825	849
1972	...	...	7.4	846	944
1973	...	...	20.5	698	979
1974	...	...	1.1	997	1,011
1975	...	...	.1	1,078	1,079
1976	...	...	1.8	1,109	1,133

Source DGEU and CEB Annual Reports adjusted where necessary to make the data consistent.

If one adds to this, the fact that electricity consumption is expected by the year 2000 to have multiplied several fold, one can see the enormous value to the country of accelerating hydro power development as fast and widespread as possible.

#### Hydro-Power

How much and how fast can hydro-power be developed? The present CEB program for development is set out in Table 14.

This programme is based upon earlier UNDP and other reports identifying certain schemes and sites which were considered as "economically viable" in the 1960s. Most of these reports

identified Sri Lanka's hydro potential at around—

Capacity ... 1,500 MW — 1,600 MW  
Annual energy 6,000 gwh — 8,000 gwh

The latest published report giving credence to this identification as some sort of "limit" is the UNDP (FAO) Mahaweli Ganga Irrigation & Hydro-power Survey Summary Statement issued by the Ministry of Irrigation, Power and Highways on 31st Dec. 1975, but of course actually written in 1968, when oil was \$2 per barrel. This report says blandly on page 2 without mentioning its source:

"The total hydro-power potential of the rivers of Ceylon is estimated at about 6,300 million kwh per year".

TABLE 14  
CEB Programme of Hydro Development  
(the initial 328 MW excludes 50 MW thermal capacity)

	MW Capacity	Annual gwb.	Equiv. in m. gal.
1976 with Ukuwela	328	1,536	123
1979 Bowatenna	40	108	9
1981 Canyon	368	1,644	132
	30	144	12
1983 Samanella	398	1,788	143
	120	588	47
1988 Kotmale	518	2,376	190
	100	440	35
	618	2,816	225

Source Institution of Engineers Report on Railway Electrification, May 1977 plus Kotmale from CEB.

Intriguingly this report on page 49 discusses Mahaweli power (including Polgolla and Bowatenna) and indicates that the following Mahaweli potential "greatly exceeds the prospective demand for power in the whole country for the next twenty years"—

Mahaweli Capacity ... 955 MW  
Annual Energy ... 4,720 gwh

It is true that this Mahaweli quantity and the "total potential" mentioned above is many times the 1976 production. However, several writers have predicted that this "total potential" will be overstepped by demand in 1995, and that other sources such as nuclear will be needed then to meet steadily increasing demand. (See G. B. A. Fernando "The Need for Energy in Society" paper at the Institution of Chartered Accountants Energy Seminar, August 74). Hence it becomes important to understand what is meant by "total potential" and "economically viable".

In Parakramabahu's terminology "every drop of water" precipitated onto land higher than sea level ought to do useful work as gravity induces its downward flow to the ocean. But obviously it was not possible with Parakrama Bahu's or with today's technology to harness the descent of every drop over every inch of "head". Hence, "total potential" is a measure of schemes which has been identified, the cost of which, compared with its likely output, makes it look viable in any given time or context.

The viability limits will cut off construction of hydro projects which would produce energy more costlier than either:

- \* the cost (or the perceived cost) of alternative energy.
- \* the price at which it may be better to do without.

Such viability measurement requires formulae involving the direct cost of constructing projects by technologies of differing degrees of sophistication and appropriateness; the number of years over which society (or bankers) look forward to deriving benefit from the materials and effort invested; and the quantum of energy expected to emanate from it annually.

As long ago as 1974 some writers suggested (J. Diandas "A Basis for a National Energy Policy" paper at

**TABLE 15**  
**Hydro Construction Forecasts**

			Mabes- waran Mar. 1970	CEB forecast 1970	CEB energy balance 1974	Inst. of Engineers 1977
Ukuwella	...	...	1973	1973	1975	1975
Bowatenna	...	...		1975	1977	1979
Canyon	...	...			1978	1981
Samanala	...	...	1976	1977	1980	1983
Kotmale	...	...	1980		1983	

the ICA Energy Seminar, August 74) that in the new context of oil at over \$10 per barrel and the certainty of its continued price increase as reserves deplete, the viable potential of hydro-power in Sri Lanka should be as much as 3,000 MW.

Whether this is an overstatement or understatement cannot be known until a new survey is done in the light of present day conditions and those of the foreseeable future. But it is necessary that such a survey examines the validity of formulae developed elsewhere for measuring viability; and that non-quantifiable environmental and other nationwide impacts be included in the viability studies.

It is equally important that the identified big schemes and other small schemes be set going quickly, and some method found to short-cut the excessive lead times that elapse now between commitment and commissioning.

Samanalawewa was all but designed as long ago as 1960, but still in 1977 work has not yet begun. It is interesting to note (see Table 15) the slippage of hydro development programmes as forecast in different studies.

#### Other Primary Sources for Electric Energy

The other possible sources for the generation of electric energy are:

- \* Coal
- \* Nuclear
- \* Hydrogen
- \* Energy crops
- \* Ocean thermal gradient.
- \* Solar, Geothermal, Wind, Wave, Tide.

Coal as a power station fuel, despite its sulphuric pollution problems, is

coming back into its own in American, European and Indian planning, but is regarded as clearly out of range for Sri Lanka because of its bulk and cost of carriage.

Nuclear power, whether in the form of conventional fission, fast-breeder-fission or fusion, have all been on the world's horizon for some time. But the technological feasibility of fusion, which alone will provide superabundant quantities of energy is expected to remain on the horizon for at least another twenty five years. The breeder too requires far more research before it meets environmental and safety standards as expected by President Carter. And conventional nuclear fission reactors, although approved by Mr. Carter, are slowing down in their acceptance in many parts of the world and could in any case be subject to uranium depletion. Furthermore, all these technologies are not available in small-scale (minimum size today is about 600 MW).

Hydrogen power has been talked about for a long time. Its problem is that energy is needed in the first place to release hydrogen from water. It is an environmentally attractive fuel because its only significant effluent is water. It is also claimed to be cheaply transportable as well as versatile, though it has its dangers too. It would be used for airplanes and other mobile needs when oil is finished.

Trees have for long provided energy. They were replaced by coal, and then oil in the northern hemisphere partly because of the superior "usability" quality of coal and oil, and partly because people cut down their trees faster than they re-afforested. But trees have not yet been used for large scale generation of electricity. There are active studies underway (Dr. Szezo of Intertechnology Corporation in Warrenton, Va.

and Dr. Devanathan in Sri Lanka are exponents). Alternatively some annual crops could be grown for the sole purpose of burning in power plants. One could speculate whether *Japan Jabara* (Water Hyacinth) which is an obviously efficient absorber of solar energy may be a potential source of electricity via steam or via chemical conversion.

The ocean thermal gradient is emphasized by Arthur, Clarke. The significant temperature difference between water at different levels in the ocean just off Trincomalee can be tapped to produce electricity. However the technology is still under preliminary development in a few other places in the world (such as Puerto Rico) where the same phenomenon exists favourably.

Geothermal energy which needs exploiting of the high temperature of rocks and fluids beneath the earth's surface, are expected to play a significant role in favourable locations, and so too tidal power and even wave power. But their likelihood in Sri Lanka is rather remote.

The direct exploitation of solar energy for generating electricity is a remote technology although the use of solar energy for home heating and cooling and for cooking is expected to receive much impetus especially in USA.

Wind power, biogas and other technologies, some new and some revived from earlier days are expected to contribute to local energy needs, though not for electrical generation.

#### Overall Picture of Commercial Energy Use in Lanka

Before passing on to consumption sectors, it is worth collecting together the total picture for a given year. A very round tentative picture was given in a lecture in August 1974 at an Institute of Chartered Accountants seminar as shown in Table 16.

A picture of the last 25 years is given in a recent unpublished paper where commercial energy is converted to electrical (gwh) units. A few of the years are presented in Table 17 with conversion into gallons alongside to make it comparable with Table 16 and with others presented here.

**TABLE 16**  
Sri Lanka Commercial Energy Use in 1973  
(million gallons oil equivalent)

From	Transportation			Indus- try	Domes- tic	Elec. gen.	Total
	person	goods	Total				
Petrol ...	40	5	45				45
Auto diesel ...	25	40	65				65
Heavy diesel ...	5	5	10	5		5	20
Furnace oil ...				30		10	40
Kerosene ...				5	75		80
Total oil ...	70	50	120	40	75	15	250
Electricity ...				65	30	15	80
Total ...	70	50	120	105	105	—	330

Source "A Basis for a National Energy Policy", J. Diandas at the Institute of Chartered Accountants Seminar, August 1974.

**TABLE 17**  
Energy Consumption in Sri Lanka 1950-1975

	Million kwh				Million gals.			
	Oil	Coal	Hydro	Total	Oil	Coal	Hydro	Total
1950 ...	618	549	46	1,213	55	48	4	107
1960 ...	1,605	480	258	2,343	142	42	23	207
1965 ...	1,860	256	310	2,426	164	23	27	214
1970 ...	2,679	47	625	3,351	237	4	55	296
1973 ...	2,890	19	628	3,537	255	2	55	312
1974 ...	2,294	19	880	3,193	202	2	78	282
1975 ...	2,193	19	966	3,178	194	2	85	281

Source "Trends in Energy Consumption in Sri Lanka 1950-1975": Energy Policy Planning Paper 2: Sankar and Fernando: May 1977, unpublished draft.

Conversion: 3 mwh = 1 tonne oil = 265 gals., therefore 1 gal. = 11.32 kwh.

**TABLE 18**  
Commercial Energy in Sri Lanka 1976  
(million gallons equivalent)

	Transport			Indus- try	Dom. & Com.	Elec. gen.	Total
	Person	Goods	Total				
Petrol ...	27	3	30				30
Auto diesel ...	31	29	60	6			66
Heavy diesel ...				9			9
Furnace oil ...	1		1	26		2	29
Kerosene ...				6	52		58
Total oil ...	59	32	91	47	52	2	192
Coal ...		1	1				1
Total fossil ...	59	33	92	47	52	2	193
Hydro ...						89	89
Total input ...			92	47	52	91	282
Electric ...				55		91	146
Total ...			92	102	88	—	282

It is now possible to give a tentative picture of Sri Lanka's energy use in 1976. Table 18 gives a very round view that commercial energy is used approximately one third each in the three end-use sectors:

- \* Transportation
- \* Industry
- \* Domestic and Commercial

However, this leaves out altogether solar, wind and wood. Even if one regards solar and wind drying as being a free and inexhaustible resource, and therefore not to be accounted, wood cannot be so lightly disregarded especially in the light of constant complaints by the Conservator of Forests, by responsible political leaders and by environmental and conservation bodies, all of whom claim that devastation of forests, and even of single urban trees, can lead to irreversible harm to the country's agriculture, temperature, quality of life etc.

How does one bring firewood into this picture? It should undoubtedly include wholesale systematic chopping for tea estate driers and by firewood merchants, as well as innocuous looking jungle thinning by villagers seeking cooking fuel.

A little insight into the significance of firewood may perhaps be gleaned from India. Approximate Indian figures for 1968-69 are shown in Table 20 with the Sri Lanka commercial energy figures placed alongside. See page 14.

One may assume that India's higher commercial energy per capita is a function of its heavy industry; that Lanka's need for rural energy is slightly less for climatic reasons; and that firewood in Lanka must cover the work done in India by cowdung and half of vegetable waste (the balance half being covered by coconut fronds, pruning etc.) A possible Sri Lanka picture could then emerge as shown in Table 19.

**TABLE 19**  
Sri Lanka Total Energy 1969

	gal. per capita	%	m. gals.	m. tonnes
Firewood ...	26	52	372	3.8
Vegetable waste	2	4	24	.4
Non-commercial	28	56	336	4.2
Commercial ...	22	44	264	
Total ...	50	100	600	

**TABLE 20**  
Indian Energy 1968 - 1969 (Population 528 Million)

Source	Units	At		m. tonne coal equiv.	m. gal oil equiv.	gal per capita	%	Sri Lanka 1969 m. gal per cap.
<b>Commercial</b>								
Coal	... m. tonnes	72.9	1.	73	12,045	23	34	4 .3
Oil	... -do-	14.8	1.6	24	3,960	7	11	218 18.2
Hydro	... 1,000 gwh	20.8	.5	10	1,650	3	4	42 3.5
Total	...			107	17,655	33	49	264 22.0
<b>Non Commercial</b>								
Firewood	... m. tonnes	142.	.5	71	11,715	22	33	
Cowdung	... -do-	50.	.5	25	4,125	8	11	
Farm waste	... -do-	37	.4	15	2,475	5	7	
Total	...	229.		111	18,315	35	51	
Grand total	...			218	35,970	68	100	

Source: "The Energy Outlook for India During the Seventies", Labiri and Sinha at the National Seminar on Fuel Efficiency, October 1970. Sri Lanka figures from earlier tables in this study. Conversions: 1 tonne coal equivalent = 165 gal. oil.

It might at first sight give some sense of relief that an estimated 4 million tons of firewood, coconut fronds and prunings are substituting for over a million and a quarter tons of oil, which at \$12 per barrel could cost \$115,000,000 or close to Rs. 1,500 million rupees with FEECs.

Whether in Lanka's climatic and soil condition it would be wise or possible to encourage use of firewood with parallel timber or bracken replenishment programmes is a matter for research, but it should also be remembered that hydro schemes too need trees in their catchments, and any reduction in forest cover above hydro reservoirs would diminish hydro-electric energy as well as bespoil the soil.

### End-Uses of Energy

The three major sectors in Sri Lanka in which commercial energy is used are transportation, industry, and domestic and commercial end-uses. An analysis of the end-uses of energy in the latter two sectors follow. For a detailed analysis of the end-use of energy in transportation see the feature article by J. Diandas appearing on pages 28 to 32.

### End-use: Industry

Once again, there is a paucity of reliable data. Estimated industrial end-use, excluding firewood, is recapitulated in table 21 from the overall summary for 1976 in table 18:

**TABLE 21**  
Industrial Use of Energy in Sri Lanka 1976 (million gallons)

<b>Oil</b>			
Furnace oil	... ..	26	
Heavy diesel	... ..	9	
Auto diesel	... ..	6	
Kerosene	... ..	6	47
<b>Electricity</b>			
Direct	... (514 gwh)	47	
Local Govt. re-sale	(83 gwh)	8	
Total	... ..	55	102

Source: Table 18 above

With the same assumptions as made in table 18 and table 9 (for local government electricity re-sales) the historical position is laid out in table 22:

**TABLE 22** Industrial Energy in Sri Lanka 1964-1976

	Electricity				Oil m. gals.							
	g w h			m. gal. equiv.	FO	HD	AD	KE	Total	Total		
	direct	local	total									
1964	...	...	132	29	161	15		4	5			
1965	...	...	141	32	173	16		4	5			
1966	...	...	160	45	205	19		5	6			
1967	...	...	213	47	260	24		5	6			
1968	...	...	251	52	303	28		6	7			
1969	...	...	294	52	346	32	38	18	6	7	69	101
1970	...	...	329	59	388	36	26	20	7	8	61	97
1971	...	...	373	63	436	40	24	22	7	8	61	101
1972	...	...	410	70	480	44	33	17	7	8	65	109
1973	...	...	466	71	537	49	33	16	7	8	64	113
1974	...	...	478	71	549	50	36	11	6	8	61	111
1975	...	...	520	76	596	55	32	9	6	8	55	110
1976	...	...	514	83	597	55	27	8	7	8	50	105

Source: Prior tables. Assumptions: One third local government electricity to industry; one tenth of auto diesel and kerosene to industry.

The picture given in table 22 from 1969 (from which year full estimated figures are available) is one of steady electrification rather than steady growth of industry. However firewood is left out, and the decline in furnace oil from 1974 may be due to a reversion to firewood by some tea factories and dessicated coconut millers. 1972/1973 is the peak for oil but not for electricity.

One State Corporation's energy consumption from 1970 is set out in table 23.

**TABLE 23**  
Tyre Corporation Energy 1970-1976 (million gallons)

	Electricity		Furnace	
	gwh.	m. gal. equiv.	m. gal. oil	Total
1970	...	7.0	.6	1.4
1971	...	9.1	.8	1.6
1972	...	9.8	.9	1.6
1973	...	11.4	1.0	1.9
1974	...	11.5	1.1	1.8
1975	...	11.1	1.0	1.8
1976	...	11.7	1.1	2.0

Source: Tyre Corporation. Assumption: 10.85 KwB at point of sale = 1 gal.

It is interesting that this corporation alone accounts for 2% of total electricity sales to industry and 3% of furnace oil. If the Industries Ministry, or any researcher, were to be able to collect the energy consumptions of the 20 largest factories, it might amount to half the industrial energy use, and provide a useful picture not only of growth, but also of recent fuel changes from oil to electricity and to wood.

Without such data no evaluation is possible. It is hence pertinent at this stage to deplore the lateness and lack of data published by important institutions. It is interesting that the Institute of Chartered Accountants issued on 6-1-75 a "Directive Accounting Standard on Quantities" which says inter alia:—

"It is desirable that wherever possible all statements of account should include relevant and useful quantities, and where apt, per unit averages. This applies to all statements, from internal information accounts to published accounts, consideration being given to the usefulness of the statement to the users for whom it is prepared or who are likely to use it..... The Institute desires that its members, using their own judgement as to what is possible, apt and compatible, make every endeavour to comply with this standard, and to this end, seek to persuade their clients or employers to adopt it."

The CPC, CEB, CTB, CGR and Tyre Corporation, although late in differing degrees, do publish some significant quantitative data about their activities, but even these do not indicate the quantities of energy they use in their own productive processes.

#### End-use: Commercial and Domestic

By its very diffused nature, consisting of numerous scattered consumers, the commercial and domestic energy end-use sector, does not publish useful data. The figures shown in earlier tables (which exclude wood) for 1976 are recapitulated in table 24:

TABLE 24

#### Domestic & Commercial End-use of Energy in Sri Lanka 1976 (million gallons)

Oil:	<i>m. gal.</i>	
Kerosene ...	...	52
Electricity:		
* Commercial ...	137	84
* Domestic ...	93	84
* Total ...	230	168
Total ...	36	88

The historical picture, also from prior tables, is given in table 25:

TABLE 25  
Commercial and Domestic Energy End-use in Sri Lanka 1964-1976

Year	g w h			million gallons				
	electricity			electricity			kero- sene	total
	com.	dom.	total	com.	dom.	total		
1964 ...	88	72	160	8	7	15	45	60
1965 ...	95	76	171	9	7	16	46	62
1966 ...	112	90	202	10	8	18	51	69
1967 ...	118	94	212	11	9	20	55	75
1968 ...	130	105	235	12	10	22	58	80
1969 ...	130	109	239	12	10	22	62	84
1970 ...	145	120	265	13	11	24	68	92
1971 ...	157	129	286	14	12	26	67	93
1972 ...	172	142	314	16	13	29	70	99
1973 ...	179	151	330	16	14	30	68	98
1974 ...	189	154	343	17	14	31	52	83
1975 ...	201	163	364	19	15	34	51	85
1976 ...	221	177	398	20	16	36	50	86

Source prior tables.

Assumptions Local government re-sales of electricity are 1/3 each to industry, commercial and domestic; 9/10 of kerosene is domestic use.

Conversion 10.85 kwh at point of use = 1 gallon

It has to be repeated again that table 25 does not include firewood. With this qualification, and the qualification that the figures incorporate a lot of estimation, two clear trends stand out.

The first clear trend is that electric energy can be absorbed by the domestic sector just as fast as it can be made available by dint of the successive commissioning of hydro generating plants, and their related transmission lines, and the supply of connections to suburbs, villages and at the end of the line, houses. This in turn predicated the growth of the wiring and appliance industry. And if natural rubber rather than oil-based polymers is used for insulation, there can be nothing but benefit to the country and its people by expanding domestic and commercial use of electric energy even tenfold over the next twenty years. This advantage will obtain notwithstanding that domestic use of electricity is very peaky, adding to the need for generating capacity as well as energy.

The second clear trend in table 25 is the 20% drop in use of kerosene after the price jump in January 1974. Though at first sight this seems to relieve the country's oil import burden to a discernible degree, a corresponding use of firewood, and the concomitant cutting of forest cover

(including trees of every description) may be more costly in its long-run and perhaps irreversible effects. Is it a coincidence that loud cries are heard in these last two or three years about timber cutting in Nuwara Eliya and elsewhere? Is this a reflection of increased environmental awareness alone, or of the first visible effects of cumulative actions of a decade or two, or of an actual increase in felling over the three years since 1974?

This is a matter to be investigated because the price of oil, including kerosene, will go up again and again over the next two decades at a higher rate than other prices, and if each price rise entails fall-off in kerosene use together with increased deforestation for firewood, there can be disastrous consequences for the country UNLESS the problem is understood in advance and a campaign of growing firewood (energy) trees is launched and maintained at an appropriate rate.

This may be especially important because substitutability between electricity, kerosene and firewood is not absolute or automatic. Electricity does anywhere for lighting, and is very handy for heating water if appliances are cheaply available, but is not generally thought to be as easily adaptable to village or suburban cooking as kerosene is.

## SUMMARY CONCLUSIONS

This survey has set out primarily to lay down basic facts as they have been and as they are, and to a lesser extent, how they will or may be in the future, with the idea that only on the basis of a reasonable layout of facts can any policy be conceived, or even the necessity for a policy be perceived.

The layout of facts is without doubt inadequate primarily because data of any sort is hard to get, and up-to-date data even harder. However, one can draw some broad conclusions about what ought to be done in Sri Lanka.

Briefly the obvious steps that could be taken are:

1. Formulate an energy policy.
2. Inhibit the use of petroleum energy.
3. Electrify all that can be electrified.
4. Accelerate hydro-electric development.
5. Promote energy plantations and farms.
6. Postpone nuclear commitments for a decade or two.
7. Reshape the formulae for deciding on energy investments.

The necessity for an energy policy can be predicated upon three safely predictable factors:

1. The supply of oil will diminish and its price will increase.
2. Wood availability will diminish unless it is controlled.
3. Demand for commercial energy will go on increasing.

That this country has neither an energy policy as such, an energy ministry, an energy department, or an energy university chair, is a reflection of the fact that there was, all these years, no crisis and therefore no apparently compelling reason to formulate comprehensive or conjoined national policy. Till now, the generation and sale of electricity and the import refining and selling of oil have always been under two different ministries. 'Electricity' has been placed either with engineering and construction activities or alongside Irrigation, which reflects how it is made rather than its function in society. Likewise oil was with Trade and later with Industry, again a reflection of how oil was obtained rather than what its function is. And the question of firewood has not been a subject at all.

Hence, there is a need to establish at least a separate department which will assemble facts and forecasts, both national and international, keep a watchful eye on world developments, and formulate alternative policies. Perhaps the energy desk recently established in the Ministry of Planning with foreign assistance is a possible nucleus of a functional ministry or department of energy.

There could be several possible ingredients for a national energy policy.

Since the worldwide energy crisis was petroleum-triggered, the inhibition of petroleum use should be an obvious component of Sri Lanka's energy policy. Such inhibition can have two parts:

- \* firstly suppressing the use of energy altogether by suppressing the activity that uses it, or making that activity more energy-thrifty;
- \* secondly substituting other energy sources for petroleum in the same activities.

Suppressing or depressing activity that uses energy could apply only to motoring which is estimated to have used 27 million gallons of petrol in 1976 and will, judging by recent motor car imports, resume its tendency to increase. Assuming that half of motoring could be adjudged a luxury, or frivolous, or a needless waste, either because the journey itself is not very necessary or the journey could be more thriftily accomplished by bus or train without loss of nationally essential speed or comfort, then 12 or 13 million gallons of oil could be inhibited from use. Such inhibition can be by regulation or by price.

Regulation could mean banning the entry of private vehicles into city centres (with consequent advantages to mobility on foot and in bus and to the environment) or banning parking on public and private land etc. Such steps would form a part of the standard restraint practice in many countries today.

Inhibition by price would be merely anticipating world oil price increases by imposing taxes on petrol of the type now proposed by President Carter, but much harsher in degree as befits our less affluent state of being. It has been estimated that an eightfold increase in petrol price

would be needed to bring about a saving of up to one tenth of our oil imports.

Increasing the efficiency of oil use can range over the whole spectrum of end-uses. Lorries can improve their energy-thrift by maintenance engineering and by better utilisation of load capability. This might mean monopolising common carrier road haulage, and protecting common carriers from intrusion by individual and institution (such as plantation) owned lorries. Kerosene usage could be improved by better designed cookers, better home maintenance, and better education about how to get the most out of fuel, but here too price increases tend to exact their own disciplines in efficient end-usage.

Substituting other energy sources for petroleum lies in maximizing the use and replenishment of non-commercial energy, exploiting the so-called exotic sources of energy (solar, wind, biogas etc.) and electrification. The UNEP triple energy village scheme near Hambantota is an experiment to be watched carefully, because it claims to use renewable resources with the declared objective of improving the quality of village life without drawing on high technology energy intake from the national economy. However, this type of energy will not in reality substitute for present use of oil, but diminish the need to increase oil use.

One viewpoint is that real substitution of present use could come about only by systematized wood-fuel exploitation for heating, and electrification of mechanical functions in both mobile and static machines. The possible oil saving out of present use may be (in million gallons):

Electrification ...	20
Wood burning ...	20

Electricity can be used as a substitute for oil in:

Transport
Industry
Home lighting

So long as energy comes from hydro and not thermal generation the saving is almost absolute. Even if it comes from thermal generation, there is a degree of saving because central conversion of oil to electricity is more efficient than localised, especially mobile, conversion to mechanical movement.

The fourth obvious step in the component of a national energy policy, is to accelerate hydro development. This involves determination coupled with completely new approaches to:

- Surveying potential sites.
- Measuring viability.
- Useful size and scale.
- Decision-making procedures.
- Appropriate construction technology.
- Letting contracts.

The objectives of the new approaches would be to commission all the presently identified sites up to 1,600 MW before the turn of the century, as well as numerous 3 MW to 5 MW schemes (to use President Carter's scale of thinking), and to be ready with a large number of cascade systems on the smaller rivers and tributaries. Certainly in these matters, the objective of all planning should be the betterment of this country's future generations rather than satisfying stale criteria stipulated by international lending institutions.

The fifth obvious step as part of an energy policy is to promote the use of solar energy via the photo-synthetic process. Trees and plants absorb solar energy and are ready for optimum combustion in time-spans ranging from 6 months (energy crops) to 15 years (eucalyptus trees). This is much faster than the fossilisation resulting in coal and oil. The systematic planting of crops and trees for the declared objective of obtaining energy is as yet novel, but could, if properly planned, yield many by-products. In the case of tree plantations in the upper mountainous areas, the trees will fulfil water storage, soil enrichment and anti-erosion functions during their lifetime and supply energy by burning or oil extraction on felling. Even in low-country areas the continuous planting of trees will enrich the total village or urban environment during the living cycle of each tree, and may provide food as well, before succumbing to the firewood man's axe and giving room for a new sapling to grow.

The sixth step to be taken as part of an energy policy is to postpone any nuclear commitment, for a decade or two. The nuclear energy spectrum basically falls into three categories:

- Conventional fission reactors.
- Fast breeder (plutonium) reactors.
- Fusion.

Starting with fusion, this is not likely to reach experimental power generation for at least another 10 to 20 years; we thus need not be concerned with it, except to watch carefully how research is going on elsewhere.

The fast breeder reactor was thought to be capable of relieving the world from the consequences of uranium resource depletion. This relief arises because the breeder breeds more fuel than it uses. However, there are several problems of safety and technology yet to be solved, and in addition the breeder is capable of supplying plutonium for non-peaceful uses. This is the reason why President Carter says (The National Energy Plan, April 77, page 102):

"Many countries are developing breeder technologies. These technologies could be made commercial by the end of the century. However, the proliferation risk from a plutonium economy and the availability of energy alternatives make it advisable to defer further development of the plutonium breeder technology."

This leaves conventional fission reactors for our possible use. Their protagonists in this country argue that hydro potential is limited, (a contention that is contested above); that the limit will constrain power development in the 1990s; and that a start is needed now if a nuclear reactor is to be installed by 1995 or so. This gives a lead time of 18 years of study, technology training, site selection, contract letting, construction, teething etc. Leaving aside the argument that hydro power is not in fact so limited, the main objections to conventional fission reactors could be:

1. pending breeder technology, the world's uranium resources are also limited; this will be reflected in uranium prices as time goes on;
2. the technology is not only complex but sequentially elongated so that we cannot avoid dependence on foreign help at many points on the chain from uranium mining through enrichment, grading, emplacement, fission, and waste disposal;
3. all nuclear reactors are subject to international inspection;
4. the fear of sabotage, with an entirely different scale of consequences from sabotage of hydro schemes;
5. the fear of accidents with similar disaster-prone consequences. (This is real notwithstanding the proved and documented excellence of nuclear safety performance to date);

6. the problem of waste disposal which has not yet been permanently solved for the 100 odd nuclear power plants in operation around the world;
7. the minimum unit of nuclear power generation is now said to be 600 MW which is and will be too large to instal in our grid system and
8. the cost, including advance costs, is getting higher and higher every day.

One strongly held view is that in all the circumstances it would be unnecessary and unwise to make an irreversible decision before around 1995 about nuclear power. By then world research is likely to have answered many of the problems either for or against the various nuclear alternatives, and may even have opened the door to practical use of thorium instead of uranium as a breeder fuel. Meanwhile however, it would also be unwise to ignore the long-term future in which one or other form of nuclear may play an important world role. Hence we ought to have a small spectrum of scientifically informed nuclear watchers who would keep abreast of trends, provided only that they do not become a lobby in their own cause or in the cause of bigger interests overseas.

The seventh component of a national energy policy (set out at the beginning of this section) is less obvious than the others but perhaps the most important with an added aspect of applicability to all policy making. This component is to reshape the formulae for deciding on energy investments. This amounts to reshaping our attitude towards the future. It is an axiom that man is the one animal with a proved conscious interest in not only *tomorrow, next year and his own old age*, but also in at least *one or two generations to come*. All monuments are evidence of this human capability. Sri Lanka has no lack of monuments designed to last longer than the lifetime of the decision-makers who commissioned them. Such monuments include those of purely aesthetic and cultural value and those of immense economic value. The latter include tanks and irrigation canals.

Yet in "modern" project evaluation techniques, the future, beyond a twenty or thirty year lifespan, is made to look like nought. This is perhaps valid for private sector undertakings where investors seek their "pay-back" within foreseeable time-spans as a condition of investment, and want the pay-back in money or money's worth.

The theory of pay-back is responsible for the concepts of discounted cash flow, discount rates, first year

rate of return, internal rate of return, etc. and even the wider looking social cost benefit studies. These theories postulate that public funds, being short, should be invested only where there is a promising return on or within the horizon.

In terms of these theories there are engineers who postulate that hydro-

electric energy (from yet-to-be commissioned schemes) will cost say 16 cents per kwh of which 12 cents or so is said to be foreign cost. But they neglect to tell us that these costs are on the footing of counting only firm energy over perhaps 30 to 40 years of use. When examined closer these calculations show that all secondary energy during the limited time-span,

and all energy after it is over, will be almost free.

The same formulae make heavy infrastructure like railways, and railway electrification (and indeed highways) look expensive and low-yielding because they discount future benefits. In the case of highways this is overcome by imputing (in the feasibility studies) values to personal time-saved by future users, and by complete neglect of after-completion accounting of any sort.

One result of feasibility studies is that if a country or its leaders want a monument badly enough they finance it out of current revenue and nobody knows whether or not it will or does achieve an internal rate of return. Schools, Hospitals, Assembly Halls Statues, Parks and many other monuments are financed and built under this philosophy. We must assume that past public works like Tissa Wewa and Yoda Ela were similarly financed.

The question arises then, whether future investment in energy production, or investments in other fields intended to conserve imported energy, should not be evaluated in similar terms with a view of the future which favours long-term over short-term benefits rather than the other way round.

Such an outlook would certainly make it possible—to proceed incrementally with hydro-electric schemes and railway or street transport electrification using revenue funds little by little; to use foreign loans only at the point when foreign machinery has to be installed in lumps; and to free the whole process from the strait-jacket of international project lending rules.

One might finally go back to the beginning of this study and ask why so much emphasis is given at the start to the energy outlook in the United States of America. The answer is, of course, that that mammoth producer and consumer of energy is so poised in the whole world energy market that we have to lose by almost every action taken there. Even the recent Alaska pipeline explosion, which will delay American use of Alaska oil and force US to buy 20% more oil from the world than it expected to this coming winter, will have its effect on the December 1977 OPEC oil ministers' conference, the outcome of which will certainly be felt here.

## Jimmy Carter's Energy Plan

*Extracts from "The National Energy Plan" issued by the White House on April 29, 1977*

### The Future

We can rediscover the ingenuity and the efficiency which have made our nation prosper, rather than deepening our dependence on insecure imports and increasingly expensive conventional energy supplies. We can rediscover small-scale, more creative ways of satisfying our needs. If we are successful, we can protect jobs, the environment, and the basic American standard of living, not only for ourselves but also for our children and grandchildren.

The year 2000 is a short period away in terms of the time required to develop new sources of energy.

The United States should be prepared to import foreign oil for a number of years because it is an available source of supply that does not deplete domestic resources.

To eliminate imports would be to sacrifice an economic benefit of major proportions. Imports also reduce the depletion of America's own critical oil reserves. Moreover, by substituting for domestic production and by obviating the need for immediate massive development of all energy sources simultaneously, imports help maintain the quality of the environment.

### Rest of the World

All nations, including the oil exporters, will someday have to meet their energy needs from resources other than oil and gas. Hence, all nations are part of the coming energy transition, even though they will be affected very differently.

### Past Profligacy

Today, the entire stock of capital goods, from poorly insulated buildings to heavy and powerful automobiles—is tailored to plentiful and cheap energy. Almost all economic and technological developments were promised on cheap energy. The United States consumes more than 30 per cent of the World's energy. Because the United States is the country most wasteful of energy, and because it has been increasing its demand for world oil, the United States has not been able to provide leadership to restrain the growth of world demand.

### Resource Limits

If it could be assumed that world demand for oil would grow at an annual rate of only 3 per cent, and if it were possible (which it is not) that production would keep pace with that rate of growth, the world's presently estimated recoverable oil resources would be exhausted before 2020. At a conjectural growth rate of 5 per cent, those resources would be exhausted by 2010.

Alaskan oil will boost U.S. production for a few years.

Ultimately, there are physical and economic limits on world oil resources. The approach to these limits will be hastened by increasing demand in other countries. During the 1980s the oil-exporting countries will approach their capacity limitation.

The world now consumes over 20 billion barrels of oil per year. To maintain even that rate of consumption and keep reserves intact, the world would have to discover another Kuwait or Iran roughly every 3 years, or another Texas or Alaska roughly every 6 months. Although some large discoveries will be made, the likelihood of a continuous flow of large discoveries will be small. Indeed, recent experience suggests that, from the perspective of world oil consumption, future discoveries will be small or moderate in size, will occur in frontier areas, and will yield oil only at very high cost. Obviously, continued high rates of growth of oil consumption simply cannot be sustained.

### Price Increases

The plan would prepare the United States for the time when the world faces a limitation on oil production capacity and consequent skyrocketing oil prices.

Reliance on oil imports beyond the short-term would also make the U.S. economy even more vulnerable to sudden large oil price increases.

Price could increase dramatically as a result of tremendous pressure on world oil supply.

It is also time to face up to the realities of the price of foreign oil.

If oil importing countries have failed to restrain their demand by the time world oil production levels off, prices are likely to skyrocket and critical shortages are likely to develop.