SOCIAL COST OF ENERGY USE

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Energy is an essential item of our civilization in spite of the fact that no energy source is completely free of risks and no energy source is completely trouble free. Different energy sources are associated with different types and levels of risk and in all cases the risk can be reduced by many various mechanisms which all cost money and increase the unit price of energy. Increasing the price of energy also introduces risks to society. The problems associated with energy are mainly, environmental pollution under normal working conditions and accidents. Environmental pollution can lead to health problems, fatalities, obliteration of scenic beauty, and damage to environment and property. Accidents can lead to injury, fatalities and serious effects on the environment.

In addition, the burning of fossil fuels contribute to the green house effect. This aspect of energy supplies is dealt with in the sections contributed by Mrs. Kamini Vitharana and Dr. Arjuna Zoysa.

However these problems have not suppressed the growth of the demand for energy as the adverse effects of not having adequate supplies of energy are even worse. Economic retardation resulting in unemployment, poverty, shortage of medical facilities, shortage of education facilities, malnutrition, inability to provide old age benefits, lower standards of living, short life span and increase of child deaths are the main adverse effects of energy shortages.

Table 1
Use of Engery (Kilocalories) by Man at Different Ages

	Primitive man	Hunter	Primitive Farmer	Developed Farmer	Industrial man	Techno-Logical man
Food	1,500	6,000	4,000	6,000	6,000	9,000
Domestic and Service		2,000	4,000	11,000	34,000	64,000
Transport			4,000	3,000	12,000	64,000
Industry				6,000	25,000	90,000
Total	**1,500**	**8,000**	**12,000**	**26,000**	**77,000**	**2,30,000**

Each step in the evolution of human society had been marked by an improvement in man's conditions of life as a result of his growing command of the energy sources.

Fig 1. & Table 1 show how man at different stages of civilization having different standards of living and different levels of technological capability has used energy. Table I gives an indication of the quality of life these people had access to.

The primitive man, a million years ago, to whom the only available source of energy was his own mussle power, had access to only 1500 kilo calories of energy per day. This entire amount of energy he had to use for finding his food. He had no energy available for other activities of life.

Hundred thousand years ago, the hunter who was more civilized had access to 8000 kilo calories of energy per day. By this time man had discovered fire. Instead of eating raw flesh he cooked it and ate. Instead of staying the night always in the dark he used fire to get light when necessary. Instead of suffering when cold, he used fire to warm his body when cold. Instead of suffering from fear of wild animals even when sleeping and resting, he used fire to eleminate risks from wild animals. The hunter used 6000 kilo calories of energy per day for finding and preparing his food and 2000 kilo calories for other house hold work such as lighting, heating and keeping away wild animals.

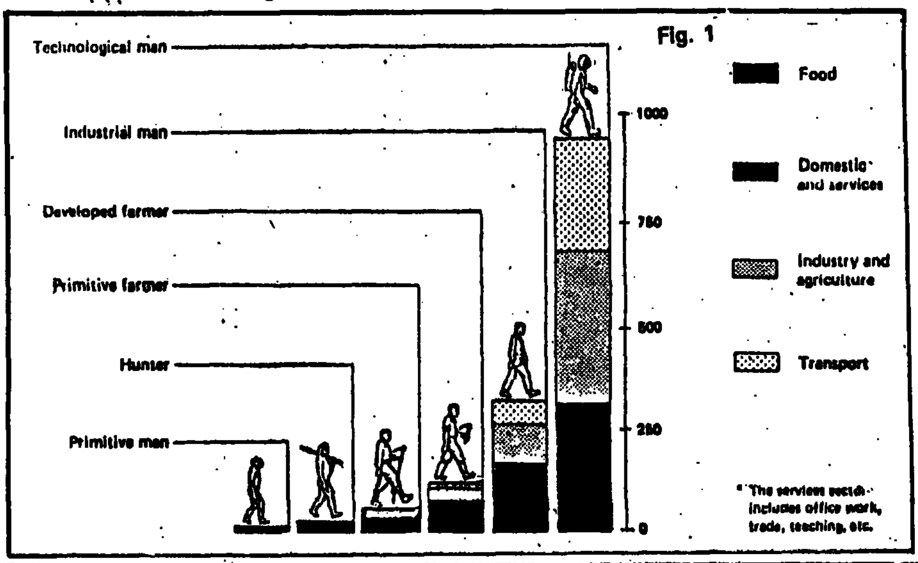


Fig. 1

As man became more and more civilized he discovered new sources of energy and new ways of using them to improve the quality of his life.

The 15th century medieval farmer used 12,000 kilo calories of energy per day. At this stage man knew the art of getting work out of animals such as cattle. He had water wheels, wind mills and a little coal available to him. Out of the 12,000 kilo calories he used 4000 for producing and preparing food, 4000 for domestic activities and services and 4000 for transport.

The more modern farmer of the later period who knew to use coal and simple machines used 26,000 kilo calories of energy per day. Of this he used 6000 kilo calories for producing and preparing food, 11,000 for domestic activities and services, 3000 for transport and 6000 for industry.

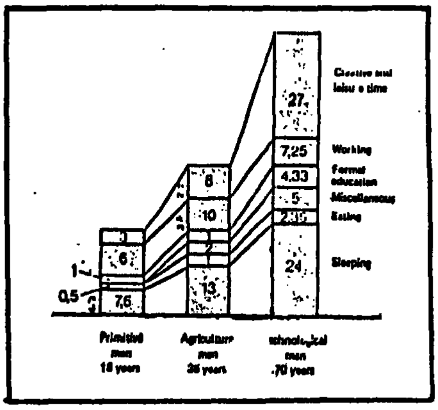
The man of the industrial age who had steam, internal combustion and turbine engines at his disposal and also had mastered the art of generating and using electricity had access to more modern sources of energy such as oil, coal, gas, hydroelectric-power etc. He used 77,000 kilo calories of energy per day. Of this he used 6000 for production and preparation of food, 34,000 for domestic work and services, 12,000 for transport and 25,000 for industry.

Today's most modern technological man of the space age uses 2,30,000 kilo calories of energy per day. of this he uses 9000 for producing and preparing his food, 64,000 for domestic work and services, 64,000 for transport and 90,000 for industry.

Energy is used in two different ways in our daily domestic activities. They are energy that we consume daily for activities such as lighting, heating, transport etc. and energy which has been used to make the objects we use daily. Table 2 shows the energy used for various devices we use daily. Table 3 shows the energy used to make various items of daily use.

Here we have to note that increased use of energy for domestic activities and services make our lives more comfortable and often more productive. For example use of modern devices for cooking and washing clothes will save a lot of time which can be devoted to creative and intellectual activity and leisure.

Figure 2
NUMBER OF YEARS SPENT IN LIFE ACTIVITIES



Increased use of energy in industry reflects the production of our daily needs in adequate quantities and making them accessible to a larger proportion of the people. Increased use of energy for tansport reflects increased contact among people at far away places, increased exchange of knowledge & information, and increased levels of trade & commerce.

Fig 2 shows how the primitive man, the medieval man and the technological man could organize their activities through the use of the energy available to them. The primitive man had an average life span of 18 years, where as the life spans of the medieval and technological men are 35 years and 70 years respectively. The primitive man had to spent 42% of his life span for sleeping where as the medieval man and the technological man had to spend only 37% and 24% of their lfie spans respectively for sleeping. The primitive man and the medieval man had to spend 33% and 28% of their life spans respectively working, where as the technological man has to work only 10% of his life span. The primitive and the medieval men could devote only 1 year of their life spans for education where as the technological man can devote 4.33 years for this purpose. For creative and leisure activities the primitive, medieval and technological men could devote 3 years, 8 years and 27 years of their life spans respectively.

Intellectual activity, scientific discovery, technological achievement as well as creativity and progress in art, culture, literature and poetry depend on the availablity of adequate time for creative work and leisure which in turn depends on the availability of adequate energy at affordable prices. Commerce, trade, exchange of information and knowledge transfer of technology relationships and exchanges among defferent clultures depend on the availability of energy for transport at affordable prices.

Child labour (of children, sometimes as young as 6 years of age) under dirty and trying conditions, hundreds of feet underground if it was in a mine for over 12 hours a day for a pittence was common when men had to spend a large fraction of their life spans working. Thanks to the availability of more energy this curse is no more heard in today's society.

Table 2
Use of Energy in the Home

	Yearly average in Kwh
Electric water-heater (200 litres)	1850
Electric stove with oven	1300
Dishwasher (with electric water-heater)	900
Lighting a flat or a small house	700
Refrigerator (200 litres)	440
Washing machine (with electric water-heater)	430
Colour TV	93
Radio	20

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Human society has now generally recongnized the essential need for adequate quantities of energy to maintain our civilization and our living standards. The dependence of standards of living on energy consumption is so clear that there are definite relationships between the GDP and the per capita energy consumption of a country. The per capita energy consumption can even be used as a rough measure of standards of living. People in the advanced societies in the west consume very large quantities of energy compared to their breathren in the third world. Of the world's energy production 76% is consumed by the affluent 27% of the world's population leaving the balance 24% to the 73% of the population in the third world. The overall energy development strategy in a country must be geared to achieve the highest benefit and the lowest risk to society.

Unavailability of adequate energy supplies increases the risk sharply at low energy consumption rates. Higher the price of energy, higher will be the overall risk component due to the 2nd factor. Production of energy has its own attendent risks due to pollution, accidents, green house effect etc. Hence use of unnecessarily high amounts of energy or wastage of energy unnecessarily increase the risk with no additional benefit.

The reslultant of all these factors will show a minimum risk region and the optimum benefit to society will be in this region. Can we further reduce this minimum risk level? If we succeed we will have a better quality of life. We may choose a type of energy or a energy mix, the use of which will give us a lower risk level. However if this choosing is at the expense of keeping prices as low as possible, the risk factor due to inaccessibility will increase and the over all risk may even increase. Similarly if we reduce the risk associated with a given type of power source by introducing new devices, the resulting increase in price may increase the risk due to the inaccessibility factor

Where does Sri Lanka stand on these risk curves? Probably well to the left of the minimum region, where the overall risk is much above the minimum risk region.

There are also other lesser contributions to energy risk considerations, sometimes from least commonly known factors. For example energy conservation measures introduced in cold countries after the petroleum price hikes during the last decade and a half included tighter sealing of doors, windows against loss of heat which resulted in reduced ventilation. Reduced ventilation caused higher radon levels inside houses thereby increasing the incidence of lung cancer.

Table 3

Energy Cost of Common Goods

How much energy is needed	Oil equivalent
to produce 1 kilogram of sugar	400 grams
to get a kilo of fresh fish from the sea to the table	1.2 kilos
to produce 1 kilogram of paper	500 grams
to produce 1 kilogram of synthetic cloth	5 kilos
to build a 100-square meter house	200 kilos
to prepare a year's meals for four person	200 kilos
to make a sink	10 kilos
to make a 1000 kg car	1.3 tons
to run such a car 12000 km a year	1.3 tons

In the same way factors which are relatively lower in risk get exaggerated very often due to lack of familiarity and factors which are higher in risk get under estimated due to familiarity.

Under estimating the risks associated with what is familiar and over estimating the risks associated with what is not familiar is a common human error which is often repeatedly made. However if we are to estimate the overall resultant risks involved in different energy scenarios we must accept a scientific way of quantifying the risks associated with different energy systems so that comparison is possible.

Such quantitative evaluation of the risks associated with energy systems is now carried out by a technique known as Probabilistic Safety Assessment (PSA) which is a technique developed as a logical extension of the old engineering discipline of reliability analysis. PSA has evolved as the method of evaluating risks associated with power systems in the 1970's. Significant developments in the field of information technology notably in the computing power of personal computers, have made it possible to evolve the PSA technology to the present level of sophistication, completeness and reliability.

PSA includes a systematic analysis of each item of each aspect of a power system by modeling the response of these to all possible events by the fault free method and finally evaluating the probabilities of each eventuality.

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