Solar Thermal Energy for Sri Lanka

D. B. J. Ranatunga

Head, Department of Solar Energy,
National Engineering Research and Development Centre (NERD)

Energy is not a primary need for us other than in the form of food. Food itself is a significant component of energy consumption. We need energy for transportation, for the construction, operation and the maintenance of vehicles. We need energy for heating and cooling. There are many other needs of energy for the additional comfort of man and also for the machinery needed to replace or supplement human muscle power.

There is no substitute for energy which has to be met either by our accumulated sources or renewable sources. Energy, in most cases, is not an end product and hence one of the simplest and most satisfactory way of economising on energy is through a better utilization of it. That is to achieve the same end results using less energy.

Each of us is constantly burning up food as fuel for the human machine, at the rate of about 120 watts. The energy that is utilized to produce our food is very much greater than this. For vegetable food, the basic energy source is solar. In order to grow food, irrigation, fertilizer, tractor, human effort, etc., are needed which has to be paid for and these too consume energy. Thus the total energy input may be 50 times higher than the amount we burn in our own bodies. There is also a great contrast in energy usage between industrialised and developing countries. In developing countries, it is about 300 watts per head and in the developed world it is 5 kw per head.

Apart from the energy used directly by man, there are indirect uses such as industrial processes in making cement, steel and aluminium, plastic, glass, etc. All require high temperature heat energy. The demand for energy can be classified as low temperature, high temperature and motive power. It can also be divided into domestic, transport and industrial use.

WORLD ENERGY SUPPLY

Before the industrial revolution, the chief source of heat was firewood, while human and animal food were needed partly as a basis for motive power in the form of human or animal muscular effort. Food and firewood both derive their energy basically from solar radiation. The maximum incident amount of solar energy is nearly 1.35 kw per sq. metre on the topmost layer of the atmosphere. Averaged over all latitudes and throughout the day it is a quarter of this value. Over three-quarters of it falls on the oceans where it is directly exploited only through fishing. More important from our point of view is the resulting evaporation which leads to rain.

A major portion of the sun's radiation incident on land falls on areas which are infertile due to extreme climatic conditions. Much of it is reflected back into space by the atmosphere, but some of it is eventually absorbed by the air causing the winds, which to a small extent we can exploit directly but which are vital for us, mainly by bringing the water evaporated from the oceans over land, and so making it fertile.

Wood is another ready source of medium temperature heat, and with moderate rate of use forests are self replenishing. However, wood cannot be used for high temperature applications such as for the manufacture and shaping of iron. For centuries the chief high temperature source was charcoal, then coal and now oil. At the present rate of exploitation, our coal resources are sufficient for about 250 years and oil for only 30 years.

The sun is the direct or indirect source of various renewable energy sources such as solar, hydro, wind, wave energy and ocean thermal gradient. There is a long history of exploitation of wind power until it was replaced by coal. In Sri Lanka, we use one of these sources, namely hydro, for most of our electricity needs.

EARTH AND SOLAR SYSTEM

The earth is a very small portion of our solar system and the sun in turn is an insignificant spark in a galaxy and several such galaxies constitute the Universe. The sun in spite of being 150 million km away, provides us warmth on a daily basis, to raise crops, and to produce coal and oil in the past. It also exerts control over our climate which results in using up scarce fuel for winter heating and cooling in summer. Bad weather also leads to floods and droughts which also drains on our energy resources in removing flood water and providing irrigation. Photosynthetic conversion of solar energy also provides the vegetation that is widely needed for the existence of mankind. It is clearly evident beyond doubt that the energy needs of man cannot be discussed without reference to the sun.

SOLAR ENERGY

A satisfactory standard of living is possible for all of us using this virtually inexhaustible energy resource. The solar radiation incident upon the earth everywhere is 5×10^{24} joules, many orders of magnitude greater than our world energy use per annum which is around 2×10^{20} joules.

Solar energy can be utilized in different ways. There are direct methods where the incoming solar energy is converted into another form such as heat or electricity and indirect methods such as exploitation of kinetic energy of wind and waves and potential energy of rainwater.

Storage poses the most difficult problem in the usage of an energy resource. On the one hand, our society requires energy in a fluctuating fashion on demand, and on the other hand our energy sources must have the most economic patterns of energy production. Solar is most economic in supplying energy in daylight hours. In between the source and the user some storage system must be used. This accounts for a substantial portion of the cost of energy.

At the earth's surface, the intensity of solar energy when the sun is directly overhead on a clear day is about 1 kw per sq. metre. The average daily incident solar energy is about 5 kwh per sq. meter in Sri Lanka. This figure may be around 3 kwh per sq. meter for England, and that too is less evenly distributed over the year. However, one should note that a a substantial portion of our incoming energy is in the form of diffuse radiation which cannot be used in a concentrating type of collector. Therefore, for major use in Sri Lanka we should rely on non concentrating flat plate collectors.

SOLAR THERMAL ENERGY FOR SRI LANKA

There are many devices used in the conversion of Solar Energy into Thermal Energy. These can be broadly categorised as follows :—

1. Non—concentrating Collectors
   (*a*) Low Temperature
   (*b*) Medium Temperature

2. Concentrating Devices
   (*a*) Medium Temperature
   (*b*) High Temperature

Most prominent among the non—concentrator is the flat plate collector. A simple, single glass, black painted, flat plate collector is capable of generating hot water for low temperature application upto about 60°C. The National Engineering Research and Development Centre (NERD) had done extensive studies on this type of collector, selecting the most economical materials available in the local market and the type of of collector best suited for our climatic conditions. The conversion efficiency of solar radiation to heat at 60°C of the collector developed at National Engineering Research and Development Centre is around 60%.

The Medium Temperature flat plate collector requires much more sophisticated manufacturing technology. These normally use double glass and selectively absorbing surfaces. These collectors are mainly used for application such as refrigeration, air-conditioning, pumping and for solar engines. However they do not offer higher efficiencies than ordinary flat plate collectors at low water temperature. At medium temperature applications, their performances are much superior. This type of collector is still beyond our manufacturing capability. Even India has not yet commenced the commercial manufacture of this type of collector.

Concentrator types are essential for high temperature needs. These are more expensive due to the necessity of tracking the sun and also the sophistication involved in the manufacture. The NERD Centre has experimented with several of these concentrators and is at present installing a 30 kw steam generating plant.

Even though we have a relatively high degree of solar radiation compared to the high latitude countries, about 50% of our radiation is in the form of diffuse radiation, which cannot be focused in a concentrator type of collector. This fact makes the concentrator less suitable compared to flat plate collectors unless the end use demands a high temperature, which cannot be achieved with a flat plate collector. There are several other collecting devices such as non-convecting solar ponds which are still in the experimental stage.

Under our conditions, the most promising area of solar thermal application is in our industrial sector. This is in contrast to most of the developed world where the emphasis is on comfort heating due to their extreme weather conditions. As such our R & D efforts should be on a different line to those of the developed world.

A substantial portion of hot water requirements in our industry mainly food processing, dairy and textiles is below 60°C. These hot water requirements can be easily met with solar collectors during sunshine hours and at other times using the conventional fuels. Another important requirement of energy in our industry is steam. In this area too, solar energy can be used in pre-heating boiler feed water. NERD Centre has conducted a few energy surveys in the public sector industries with a view to identifying possible areas for the use of solar energy. The results are extremely encouraging and has a programme of extending this facility to other industries as well. The boiler feed water heating system has the additional advantage of not requiring hot water storage and automatic controls usually needed for such systems. The estimated capital pay back period for such a system is less than 4 years, based on the current price of fuel. Already a leading private sector industry has commenced the installation of flat plate solar collectors for heating boiler feed water. There are indications that many other industries will follow suit.

In the domestic sector, the energy needs such as lighting, cooking and other forms of human muscle replacement, machines cannot be conveniently met with by solar energy. Unlike in high latitude countries, we do not require central heating or hot water. As such the use of solar energy in the domestic sector in Sri Lanka will be minimal.

However in the tourist industry and hotels, there is a growing demand for hot water below 60°C. This can be very conveniently met with the type of collector described earlier. India has made substantial progress in this sector and their experience can be very valuable to us. Here too the NERD Centre could assist the tourist industry in the manufacture and installation of solar collectors with electrical or oil fired boosters. These will take care of rainy weather and night time hot water needs.

In the agricultural sector, solar drying can be of great assistance to the farmer in providing a cheap and more hygienic way of crop drying. Solar pumping and solar refrigeration can also be economical in remote areas where the national electricity grid has not yet been reached. Even the domestic lighting can be met with by solar photo—voltaic cells. However these applications are not as attractive as those in the industrial sector.

ENERGY CONSERVATION

As mentioned earlier, energy is not used as an end product but used in producing other forms of end products. As such, efficient methods of production will result in a substantial saving of energy. To meet this end we have to revise our manufacturing and production techniques and new industries should be evaluated on the basis of their energy efficiency.

Energy conservation starts with some one taking a closer look at the energy flow of the industry. This involves drawing up of a complete energy balance of the industry, the type of energy used, where it has been used, how efficiently it was used, etc. Such a study forwarded to the management indicating the energy accounts in terms of money as well as joules will greatly help in the decision—making process. To take a simple example, a recent survey carried out in a U.K. paper mill showed that the steam whistle of the mill which cost £2 for each blow, blows 4 times a day. When this was pointed out they decided to stop it. Similarly if a trained observer can point out to the management that through a leaking steam joint, the Company is losing so many gallons of fuel per day (1 gallon of fuel is needed to generate 100 lbs of steam) all possible action will be immediately taken to stop the leak.

The NERD Centre has carried out several studies in energy auditing in public sector industry. This facility can be made available to any interested industry either public or private by the NERD Centre.