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Solar Energy Utilisation for India— Potential, Limitations and Challenges

by

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Demand for energy is rising exponentially all over the world. Total world reserves of coal are estimated at 2.5×10^{12} tonnes. At the level of demand anticipated towards the end of this century this should not last 150 years. Reserves of oil are even less and these will not suffice even for fifty years at that rate. Atomic energy seems to be the next alternative. Since the first achievement of a fission chain reaction by Fermi and his colleagues in 1942, the development of nuclear reactors has proceeded steadily. In India nuclear power began to flow from Tarapur Atomic Power Station at 8.15 PM on April 1, 1969. Its capacity is 420 MWs. Three more atomic power stations are at different stages of construction. Rajasthan Power Station at Rana Pratap Sagar with a capacity of 430 MWs was next to be commissioned. It is now operating at a power level of about 150 MWs. Third one is being built at Kalpakkam near Madras and will have a capacity of 470 MWs. Fourth such station is coming up at Narora in West U.P. It will have two reactors of 235 MW each and will deliver 440 m.w. electricity to the northern power grid when completed.

Thus total nuclear capacity in India by 31st March 1979 is expected to be 1285 MW against a total of 33080 MW from all sources (Hydro, thermal and nuclear). This works out to only 3.8%. In U.K. nuclear power plants shall be providing 20% of the power needs by 1980. Judging from the state of technolgy in our country this achievement is not mean. But it indicates the possibilities and limitations for nuclear power.

This brings us to renewable energy sources. Amongst them solar power has the greatest potential. It can be used for lifting and distribution of water for irrigation, distilling salt water, heating and boiling of water, heating and cooling of buildings, drying grain, vegetables and fruits, producing steam for technological purposes and obtaining ice. It can even be used to fire furnaces. In France, Trombe and his fellows built with amazingly modest funds the largest solar furnace in the world. Advantages of such a furnace are obvious. Once the device is built fuel which is pure, is free. Its operation is simple and it is safe and reliable to use.

But solar energy is intermittent. This creates the need for a storing device. Heat energy can be stored as sensible heat in the form of hot water or rock or as heat of fusion in waxes or salt hydrates. As an example 15 cubic metres of stone aggregate or 3 cubic metres of sodium sulphate decahydrate (Glauber salt) are required to store one million heat units. This heat can be used for heating water or air to be circulated to raise the temperature of environment to a comfortable level.

Potential

India lies between 8°-4' and 37°-6' North latitudes. A fairly complete general picture of solar rediation regime is available from data obtained from 24 radiation stations spread throughout the country.

Sun's rays in this region are nearly vertical. Energy received per square meter is more as compared to many other regions. There is one rainy season of about four months duration and rains are infrequent in the rest of the year. Over 3200 hours of bright sunshine are received in a year at Jodhpur and 2900 hours at Delhi. Indirect radiation over the whole of country is much higher than in Europe and West Africa. Thus we are better placed in this resource as compared to many other countries.

Solar heating system for buildings is effective and practical. It has been proved by installations in India and abroad. It has been claimed[1] that 75 to 85% of the annual heating requirements of a well built residence requiring about 100 million Btu per year can be met by solar system in cold, sunny climate.

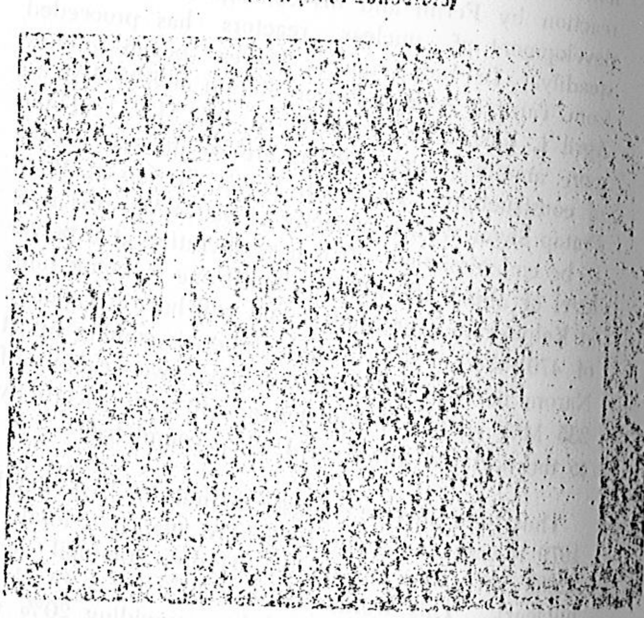
Solar heaters can use liquids or air as heat transport medium. In India most of the installations use water as this liquid. Although not as widely utilised as liquid types, a few solar air heating systems have been experimentally used over the past three decades in foreign countries. During 1975 nearly 100 residential and commercial solar air heating systems have been sold by one energy in USA[1]. In its simplest form, a solar air collector closely resembles the liquid heating type. Uniform sized pebbles (2 to 3 cm dia) are used for storage of heat. Since the air system is permanently dry no significant corrosion occurs. There is no possibility of freezing, though it is zero in plains of India. Boiling cannot occur. Some long term experience with an air system shows that maintenance is not a significant expense and that the equipment can be expected to have a life comparable to that of the building itself.

Supply of hot water for domestic use or hospitals is another area in which solar energy can make a contribution. It is estimated that one million solar water heaters are in operation in Australia, Japan and Israel. Technology for making these flat plate heaters is well advanced. Central Building Research Institute has developed flat plate domestic water heaters as shown in photographs, and four manufactures* are producing these heaters. Advertisement and demonstration of these in fairs and exhibitions will go a long way in promoting their use.

Limitations

Cheapest device for utilisation of solar energy is flat plate water heater. Even here the capital cost of an installed domestic solar water heater is Rs. 2000/- for 140 litres capacity. This is more than double the cost of an electric heater of similar capacity. One who is rich enough to afford a water heater goes for electric or coal fired device. Mr. Dixon[1] says in *Popular Science* of August, 197–, "The manufacture of collectors is largely a matter of cost of materials, not labour. The installatio

Domestic solar water heater with built-in storage (flat plate collectors)



Domestic solar water heater with separate storage tank (flat plate collectors)

*(a) M/s MSC Engg Co. Roorkee. (b) M/s Fertiplant Engg Co. (P) Ltd Jeomoncy, ... Road, Ghnore, Bombay.
(c) M/s B. S. and Services (P) Limited, 62-37 Laxmi Insurance Building, Sir P.M. Road, Bombay-40000
(d) M/s Anup Engg (P) Limited, Anil Starch Premises, Anil Road, Ahmedabad-2.

of course, is labour intensive. But we do not expect that the materials used in solar collectors are going to be less expensive. Nor do we expect the cost of installation to decrease. Rather, all these costs are likely to increase along with normal inflation". Thus these devices shall not be competitive till the cost of electricity increases two or three times.

More serious limitations confront us when we come to solar heat engines and generators. Following table gives a broad outline:—

Approx. efficiency of solar energy conversion to mechanical or electrical work by various devices.

Heat Engines with flat plate collectors'	3-5 %
Heat Engine with concentratic collectors'	15-25%
Thermionic generators with concentrators'	20-30%
Thermo-electric generators with concentrators	3-5 %
Photo electric generators	3-10%

It is clear from the table that for high conversion efficiency concentrating mirrors must be employed. These mirrors must then be steered also to follow apparent motion of the sun. Cost of these mirrors and steering adds upto 75% of the cost of the equipment. Cost of the mirror system is about Rs. 2000 per m² of collector area for diameters of a few meters. For bigger dia. the cost increases sharply.

As against this the cost of flat plate collectors is less than a tenth of concentrating collectors. The capital cost of a heat engine/flat plate collector system is about the lowest among the five devices given in the above table. Even this is not likely to be less than Rs. 1000/- per kw of capacity, when produced on mass scale.

Challenges

Research workers throughout the world are working to find out solutions to the various problems in this field. One such problem is that the selective coating should have absorption coefficient equal to one in the spectral range corresponding to solar energy and emissive coefficient equal to zero for wave lengths greater than 2.5". There is nothing to prevent a single material satisfying these conditions. However, such a material is not yet known.

Efficiencies given in the table above are low. But solar energy being free we can afford to instal these devices, provided the cost per unit of energy produced is low as compared to the cheapest alternative source or there is some other governing factor. In Indian context this factor is our dependence on imports for mineral soil. Hence there is a good case for setting up experimental generating stations with capacities from one to ten kilowatts. On the basis of experience gained bigger stations can be planned and set up.

Another promising field is of solar driers. These are being used for quicker and more efficient drying of grain, fruits and vegetables etc. Central Mechanical Engineering Research Institute, Durgapur, is working on the design and development of continuous solar Grain Dryer. National Industrial Development Corporation, New Delhi, has installed and perfected the design of a Pilot Plant Solar Energy grain dryer of 500 kg/day capacity. On the basis of this study the above Corporation has installed a commercial model of 10 tonnes/day capacity at the Central State Farm Lodhowal (Ludhiana) in April 1977. There is need for Central and State Governments encouraging such activities as it is difficult to get private investment in such fields.

In the end it can be said that solar energy can be harnessed by appropriate effort. World's biggest solar power plant is being manufactured in France. It is to be installed at Dire, a town on the banks of the Niger River in Mali, a land locked country in North Western part of Africa. Its capacity will be 80 kilowatts. For Indian conditions we need smaller plants, specially in far off places in Himalayas where cost of transmission of electric energy is prohibitive. Skill to manufacture these plants is already there. Similarly solar cookers and heaters can be taken up for improvements, commercial production and wide use in our country.

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