
SCIENCE NEWS

SOLAR ENERGY: IS IT A VIABLE ALTERNATIVE?

Solar energy is an abundant and renewable energy source. The annual solar energy incident at the ground in India is 20,000 times the present electricity consumption. Hence the present electricity demand can be met by covering just 0.5% of India's area by solar energy devices (with an efficiency of 1%). Thus solar energy has the potential for meeting the current and future demands of electrical energy in India. Agricultural societies which primarily harvest solar energy have had stable existence for more than 10,000 years. Industrialised societies which are dependent heavily on fossil fuels have survived from one energy crisis to another. Why has solar energy not been considered seriously as a viable alternative energy resource in India? The energy planners and managers in India consider solar energy conversion to be not a proven technology. This is, however, not true anymore.

After the oil price increase of 1973, there has been an explosive growth in research and development on solar energy devices. This has yielded rich benefits. In the last 15 years many solar energy devices have been shown to be technically viable and reliable. Most solar energy devices require high capital investment. This is because solar energy is a dilute energy resource (around 5 KWH/m² day). Hence large collection areas are required. Since solar energy is intermittent, some form of energy storage is required. Both these factors increase the capital cost of solar energy devices. There are three methods for conversion of solar energy. They are (i) thermal conversion, (ii) electrical conversion, and (iii) bioconversion. The thermal and electrical conversion entail high capital cost and low running cost. The conversion of solar energy into biomass involves lower capital cost but higher running cost. In this article we will discuss the technical and economic aspects of thermal and electrical conversion.

The conversion of solar radiation to thermal energy is a well-known technique. If the temperatures required are below 100°C, then flat plate collectors or solar ponds can be used. Millions of flat plate collectors are being used all over the world to meet the domestic hot water needs. In India, flat plate collectors have been installed in hotels and dairies. The cost of these collectors (which use copper, glass and aluminium) is around Rs. 3,000/m². They will deliver about Rs. 600 KWH of thermal energy at 60°C. Hence the cost of this thermal energy

will be a less than Rs. 1.0/KWH, which is comparable to the cost of obtaining hot water by electric heating in many parts of India. The demand for flat-plate collectors has not been high for domestic or industrial use. This is because of the high initial capital investment. The government provides some subsidy but the procedures are too cumbersome. There is a need for imaginative financial credit schemes to encourage domestic and industrial consumers to buy flat-plate collectors. There is a need also for strict control on the quality of flat-plate collectors produced by different manufacturers. Many energy planners are reluctant to continue the subsidy for flat-plate collectors. They do not, however, seem to be worried about the indirect subsidy which keeps the cost of electrical energy low and hence discourages the use of solar collectors.

For large scale applications, solar flat plate collectors become cumbersome on account of the large amount of plumbing. Solar ponds are appropriate for such applications. A solar pond is a large body of water used for collection and storage of solar energy. The density of the water at the bottom of a solar pond is kept high by dissolving common salt. Solar radiation is absorbed at the bottom of the pond and heats the bottom-layer of the pond. This layer does not mix with the colder upper layers because of the density stratification. The highest temperature that can be attained in a solar pond is 95°C. In favourable sites the solar ponds can cost as little as Rs. 100/m². Hence they make solar energy utilization economically more viable than flat-plate collectors. A typical solar pond has a total depth 2.5 m, which includes a 1 m storage zone at the bottom. The large amount of solar energy that can be stored in a solar pond makes it a reliable source of solar energy even when solar radiation is intermittent. In Bangalore where the number of clear days is around 180, the temperatures in an experimental solar pond never went below 55°C during the last four years. The major drawback of the solar pond is the need for land area at ground level. Flat plate collectors can be placed on the roof of buildings. Hence solar ponds must be located in places where land use is not intensive. Thus it cannot be used in urban areas or intensively cultivated rural areas. The technical and economic viability of solar ponds for electric power generation has been demonstrated by Israel. Since 1982 a 250,000 m²

solar pond near the Dead Sea has been generating 5 MW of electric power a few hours each day. Solar ponds are ideal for meeting peak power demands because thermal energy is stored in the pond and available for use at short notice. Based on the experience of this project, Israel estimates that electrical energy can be produced using solar ponds at a cost of Rs. 1/KWH. This cost is somewhat higher than the cost of generating electricity using coal or nuclear energy. In India, large scale salt production is confined to the states of Tamil Nadu and Gujarat. These states have arid land not fit for agricultural use. Hence these states would be ideal for location of large solar pond based power stations. The combined area of Tamil Nadu and Gujarat is 10% of India's area. The overall efficiency of solar ponds for power generation is 1%. Hence 5% of the land in these two states will be sufficient to meet the present electric demands of India. The capital cost of solar pond power station is estimated to be around Rs. 30,000/KW (electrical) which is about 50% higher than the capital cost of nuclear power plants.

There are many industries in India which need hot water or steam in the range 100–200°C. For such applications we need solar concentrators. Concentrators can be non-tracking, single-axis tracking and two-axis tracking. The non-tracking concentrators use the principles of non-imaging optics. The maximum achievable concentration with these devices is around 10. Non-imaging concentrators need no daily tracking but an occasional adjustment of the North-South tilt. Non-imaging concentrators in conjunction with vacuum tube receivers can attain 200°C. They represent one of the remarkable achievement of the intensive research and undertaken by University of Chicago and Argonne National Laboratory in U.S.A. This new technology has not been given any serious consideration in India so far. Single-axis parabolic concentrators can be used for steam generation and power production. The LUZ Company of California has demonstrated that this technology is technically and economically viable. There are plans to build a 30 MW (electrical) demonstration power plant in India based on this technology. Two-axis tracking concentrators have been considered for attaining very high concentration. In such designs, a large number of mirrors (called Heliostats) concentrate solar energy in a central receiver called the power tower. Steam is generated in the central receiver and used to run a conventional turbines. Two large power plants have been built based on this concept. A 1 MW (electrical) power plant was built in Italy while a 10 MW

(electrical) power plant was built in California. Both these power plants demonstrated the technical viability of the power tower concept. Their economic viability cannot be judged unless these power plants are produced on a large-scale. The use of techniques of mass production will reduce the cost of these power plants dramatically. These techniques cannot be used unless a large demand is created for such power plants.

Solar drying of agricultural produce and solar cooking has long been considered a potential area of application for solar energy in India. Natural open solar drying is being already used by most farmers. It is difficult to see how solar air heaters can be economically viable for drying of agricultural produce. This is because the drying of agricultural produce has to be done within a short period after harvesting. The use of solar air heaters for drying in industry may be viable because the industrial demands for drying occur all around the year. Solar cooking has very limited scope because it demands a change in cooking habits of people. Solar cooling of buildings should find applications in India but there has been no large-scale demonstration project so far.

If the primary goal is to obtain electrical energy, then solar-thermal conversion route is complicated. In this approach solar energy is first converted to thermal and then to mechanical energy through heat engines and finally to electrical energy. The direct conversion of solar energy to electrical energy is the simpler route. The direct conversion using solar cells was shown to be reliable 30 years ago. The cost of solar cells was around Rs. 4,000/peak watt in the early 70's. On account of intensive research and development work the cost came down to Rs. 100/peak watt in early 80's. If this trend had continued the solar electric conversion method would have become economically very attractive. The market for solar cells in industrialized countries has not expanded rapidly as expected by many experts. This is primarily on account of the decrease of the price of oil in the early 80's. Thus the capital cost of electric power generation by solar cells is about a factor 5 higher than that of nuclear power plants. Hence electric power generation by solar ponds is more economical than the use of solar cells at this juncture. Direct solar electric conversion is still more attractive than solar-thermal-electric conversion because of the simplicity and low maintenance needs of the former.

From the above survey we find that solar energy technologies are available today for large-scale use.

Some of these technologies do not look economically viable now because of the high capital investment. The capital cost of many solar energy technologies will come down substantially if the techniques of mass production are used. This can be done only if there is an assured market for such devices. In industrialised countries the market for solar energy devices has not grown on account of the decreasing cost of oil. Among the major countries of the world, India is the only country which does not have a large reserve of good quality coal. Hence we must depend in the long run on nuclear energy or solar energy. Our energy planners have tended to put their faith more on nuclear energy than on solar energy. This is unfortunate because the fundamental issues regarding nuclear reactor safety and waste disposal have not been discussed widely in public. In whichever country such discussions have been permitted the people have opted not to go for nuclear power generation. We have seen that the capital cost of a solar power plant is about a factor of 2 to 5 times the

capital cost of a nuclear power plant. This difference is not much if you consider that the economies of scale have not yet been utilised in solar power plants. In addition, solar energy research has not been supported as generously as nuclear energy. The government has supported nuclear energy research generously for the past 40 years. The budget for research and development in nuclear energy is almost ten times that provided for solar energy.

If solar energy research, development and demonstration is pursued with same vigour and vision that was shown earlier for the establishment of department of atomic energy and department of space, then solar energy will emerge as the cleanest, the safest and the best energy source for India in the 21st century.

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