As a regulatory commission, we have no role in this debate. While benchmarking costs, we have taken all these factors into considerations and have been quite liberal. Our position is that whatever be the technology let it be demonstrated. The idea is that by end of 2013, if you have a 1000 megawatt capacity, it should have a market. Anybody can come and setup modules and that is how the industry will develop and costs will come down.

Q. When do you think the solar specific REC's (renewable energy certificates) are going to come through and with what expected outcome?

REC is a general scheme. A potential one unit of green energy has two components. One is the conventional electricity component, and that can be purchased by the distributor agencies at average cost of procurement last year. For every 1MW hour of RE, a certificate is generated which will be tradable, and each state regulatory commission will be prescribed renewable purchase obligations.

Today, the cost of solar energy is four times the cost of any other RE source. So, it will be unjust to bracket solar with other RE sources. REC purchase obligations for solar energy will help popularize the development of solar power generation in this country.

Q. How strongly do you feel the need to bring uniformity in RE tariff determination across the SERCs based on the CERC norms?

Our tariff guidelines are meant to guide SERCs. The latter are expected to revise their tariff rates, but definitely not overnight. They are expected to do so over few years. The legal opinion on this too is very clear. Guidelines are almost mandatory. If they want to differ, they have to record their reasons for the same.

Q. Would you kindly like to pass on any special message to the readers of The Solar Quarterly in your distinguished capacity of being an energy economist as well?

We are moving towards grid parity. Solar is available in abundance in India. In the long run, solar should be our major source of energy. However, the journey has just started. The need is to lower the power crisis so that we can achieve grid parity. If, in the coming years, we can get solar energy at affordable prices, it will help in this regard as the cost of conventional electricity is going up.

Problem with solar power is that it is not available 24 hours. However, solar thermal can play a major role in this regard. This will also help quell certain criticisms regarding solar power that we face today.

We are moving towards grid parity. Solar is available in abundance in India. In the long run, solar should be our major source of energy. The need is to lower the power crisis so that we can achieve grid parity. If we can get solar energy at affordable prices, it will help in this regard as the cost of conventional electricity is going up.

FROM THE ARCHIVES

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SOLAR PHOTOVOLTAICS an Indian perspective

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Summary—Solar photovoltaic energy sources have been assessed to be of immense importance for the future supply of energy in India, particularly in the agricultural sector. The present economics are very unfavourable for the large-scale rural application of solar energy sources in India. However, a number of low power 'industrial' requirements can be met with the photovoltaic systems available at present. The energy replacement in all such cases is rather small. In an attempt to make solar photovoltaic systems economically attractive to rural users in India, the traditional sectoral approach of the development and manufacture of technology and the sale of specific photovoltaic systems may not yield the desired results. An integrated approach, involving the distribution of energy throughout the year between various season-dependent loads, is called for. This inherently difficult approach can only be attempted if a thorough assessment of the needs and traditional customs of the users has first been made. A purely commercial approach is not likely to yield results, although it must be recognized that commercial motivations are primarily responsible for the large-scale utilization of innovations and development in technology. This situation has been realized in India, and a long-term programme of research, technological development, manufacture, deployment, demonstration, field trials and study of locally produced photovoltaic systems, particularly for rural application, has therefore been initiated. It is also felt that, because the supply of energy is a crucial strategic area, it is necessary for India to be self-reliant in the field of solar photovoltaics, which is at present in its infancy. In this endeavour, international cooperation, both with industrialized countries and with other developing countries, is necessary.

1. Introduction

With a population of 683 million, living in an area of about 3.28 million km^2, India has one of the lowest energy consumptions per capita in the world; the equivalent of about 315 kg of coal per annum. Approximately 40% of this energy comes from non-commercial sources such as firewood, animal dung, agricultural wastes etc. [1]. The electrical energy consumption per capita is only about 172 kW h compared with a world average of 1700 kW h [2] . This is despite the fact that the installed generating capacity has risen from 2300 MW in 1950 to the present 31 000 MW. More than half of the 576000 Indian villages do not have access to electricity even today; about 80% of the country's population lives in these villages. The recent energy crisis has predictably resulted in a search for economically viable renewable energy sources suitable for large-scale utilization. The technological maturity achieved has naturally guided the Indian planners seriously to consider solar photovoltaic energy sources, among others, as viable future alternatives.

Over the past few years there has been an acceleration in the technological development of solar photovoltaics, specifically in the industrialized countries. In the past, such development has invariably been followed by wide publicity and rosy predictions for the future, particularly for the developing countries. Much of this early crystal gazing has lately been replaced by cautious optimism.

None the less, this optimism and the development of technology in India over the past few years have generated much interest amongst the Indian public. Predictably, they are looking forwards to the time when solar photovoltaic energy will be within the reach of the common man.

Until 1975, activity in the field of solar photovoltaics in India was concentrated only on research into solar cells in a few national laboratories. Developmental activity was directed only towards laboratory-scale solar cell fabrication, mainly for the space programme. In late 1975, the Indian Government initiated a national programme of research, development and demonstration of solar photovoltaic energy sources. The area of interest was gradually expanded from solar cells alone to solar photovoltaics and from purely scientific research to technological and engineering activities. An integrated approach was evolved for research, development, manufacture, deployment, demonstration, education and training, with the active participation of a public sector electronics company and various national research laboratories and academic institutions. Whereas scientific research on solar cells and materials was fully supported in the academic institutions, the product development activity was given priority in the public sector company. The evolution of this integrated plan was gradual and was influenced by various factors such as the energy crisis, public awareness, the technological progress achieved in the photovoltaic scene in India, large-scale government funding in the industrialized countries and the overt publicity by the world photovoltaics lobby.

A 5 year National Solar Photovoltaic Energy Demonstration (NASPED) project was initiated in October 1980, with the following specific objectives: the development of cost-effective photovoltaic technology; manufacture at the pilot level of at least 1 MW year-1 by 1985; effective system design, engineering and integration; system deployment and demonstration; the collection and analysis of field data; the education and training of man-power. The total allocated budget is approximately equivalent to U.S. $15 million.

In January 1981, the Indian Government announced the formation of a Commission for Additional Sources of Energy (CASE) with significant budget provision and administrative powers. The indications are that a large portion of CASE's budget of U.S. $60 million will be allocated for solar photovoltaics during the sixth 5 year national plan (1980 - 1985). In contrast, the Indian Government's expenditure on solar photovoltaics during the previous 5 years was less than U.S. $4 million. All these are very significant positive steps in India. It is generally assessed that solar photovoltaic energy sources will contribute a significant share of India's future energy needs. How distant that future is will naturally depend on various factors, including economics.

In the present paper some of these factors are analysed vis-a-vis the role of solar photovoltaics in India.

2. Relevance in India

Solar photovoltaic energy sources produce d.c. electricity directly from solar energy; their maintenance requirements are minimal; they are absolutely non-polluting and are not likely to produce adverse environmental effects; they are modular in nature. Unlike all other sources of generated electricity, the cost per unit of electrical energy generated does not depend drastically on the capacity of the photovoltaic energy unit installed. Therefore, small stand-alone units are just as viable economically as large and centralized units, at least at the present level of technology. The possibility that the user himself is responsible for the supply of his own electrical energy requirements, with little dependence on external agencies for fuel or maintenance, is very high. All these advantages make solar photovoltaic energy sources eminently suitable for use in areas which are not connected to the electric grid and which are not likely to be connected to it in the near future. Viewed from this perspective, solar photovoltaic energy sources appear to be highly relevant to India.

Solar photovoltaic energy sources can be deployed either as centralized or as distributed systems. In Table 1 the possible deployment schemes of solar photovoltaic energy sources are listed. At present, the centralized schemes have little importance in the context of India. Of the three schemes of distributed sources, the community-based and the user-owned stand-alone systems are of importance to India. The concept of user-owned stand-alone systems connected to a utility grid is of little relevance to India, primarily because distribution grids are unavailable in most places. The utility grid is an excellent storage medium for photovoltaic energy. In its absence, electrochemical storage batteries must be used, where necessary, thus increasing the complexity and cost of the system and the maintenance required. For industrial applications in remote locations where technical assistance can be made available, the use of storage batteries may not introduce problems.

Table 1 Possible deployment schemes for solar photovoltaic energy sources

Nature	Scheme	Power level (MW)	Status
Centralized	Solar power satellites	5000	Fantasy
	Land-based central power stations	100	Future
Distributed	Community integrated and owned[a] (Usage: residential loads, potable water, cottage industries, community services, perhaps also irrigation)	$(10–100) \times 10^{-3}$	Technically feasible; few attempts so far
	Utility (grid) connected stand-alonea user owned (Usage: residential loads)	5×10^{-3}	On the horizon
	User-owned stand-alone a (Usage: irrigation, lighting, industrial applications such as communications, remote area electronics etc.)	1×10^{-3}	Technically a reality; economically uncertain

[a] Relevant to India's present needs.

However, for individual applications in rural areas, where photovoltaics is likely to have its largest impact, the use of electrochemical storage batteries is not to be recommended if the system is to be kept free from unnecessary complexity and the maintenance requirements are to remain low. Therefore, it is of primary importance to realize that, at present, solar photovoltaic application in the Indian rural sector should be attempted, as far as possible, without the use of electrochemical storage and with minimum technical complexity. For community use, however, such storage cannot possibly be avoided. The major use of solar photovoltaics without battery storage is in agriculture.

India, basically, has an agrarian economy; about 50% of contributions to the national income come from agriculture [3] . However, the agricultural sector consumes only about 11% of the total amount of energy consumed commercially in the country [2]. In order to sustain and expand this agrarian economy, it is necessary to have a more effective input of energy to this sector and to all other sectors which support and sustain agriculture. A major input of energy is required in the form of motive power for irrigation, threshing, harvesting, transportation etc. A number of publications [3 - 8] have dealt with the relevance and economics of solar photovoltaic energy sources for lift irrigation in developing countries. At present about 11% of the total (commercial and non-commercial) energy input in Indian agriculture is used for Irrigation; this figure is likely to double by the turn of the century [2,3]. According to a U.S. commercial study [9], the world demand for solar photovoltaic energy sources for irrigation pumping alone is likely to be about 74% of the total demand for photovoltaic energy of approximately 32000 MW, provided that the projected cost goals are achieved. Although these figures may be questioned, there does not appear to be any doubt that the major impact of photovoltaic energy sources will be in the area of lift irrigation in developing countries. Recent studies by international organizations have supported this assessment [6].

Although it has been recognized in India that the major impact of solar photovoltaic sources will be in lift irrigation, there are a large number of other potential areas of application where photovoltaics can make an effective contribution. These include diverse areas such as rural lighting, offshore oil platforms, rural communication systems, weather monitoring systems and community-based audiovisual aids such as radio and television receivers, which require an uninterrupted supply of electricity in remote and distant locations.

3. Economics, technology and approach

The major factor against the large-scale rural application of solar photovoltaics in India is the price. Whereas U.S. Government agencies have claimed the "technology readiness" of U.S. $2.80 Wp -1, no commercial photovoltaic module is available at present below U.S. $10 Wp-1. (In August 1981 a large U.S. photovoltaics manufacturing company quoted photovoltaic modules at U.S. $10 Wp-1 for a purchase volume of more than 1 MWp. A study of eight U.S. photovoltaics manufacturers in June 1981, carried out by the Jet Propulsion Laboratory, Pasadena, CA, indicated that photovoltaic module prices are rising.) Candid conversations with major commercial manufacturers indicate that there is little chance of the commercial price being reduced significantly before 1984. The delivered price of photovoltaic modules would be substantially higher in India because of transportation costs, insurance, levied duties and taxes. A number of economic analyses [5 - 8] have indicated that the delivered price of photovoltaic modules must be less than U.S. $4 Wp-1 for photovoltaic water-pumping systems for lift irrigation to be competitive with the present diesel-driven water pump sets. Without such a price reduction, the impact of solar photovoltaic energy sources in India, and the projected energy replacement, will remain rather weak. There are, however, a number of low power industrial applications of solar photovoltaics in unattended remote areas which appear to be cost effective even at the present price level. Such applications help to sustain interest and activity in the development of technology.

In the present unfavourable economic situation, private buyers in India cannot invest in solar photovoltaics. The individual buyer is basically concerned with financial benefit and not with the overall economic analysis. He is interested in the price that he pays for, say, a litre of diesel oil, whether it is subsidized by the Indian Government or not. He cannot be expected to understand energy economics, such as the fact that only about one-tenth of the energy content of the input diesel oil is actually converted to pumped water output in the 3 or 5 h.p. pump set used at present [8] and that there are about 3 million such pump sets in operation in Indian agriculture. In contrast, the stark reality is that the state of the art of solar photovoltaic technology is not sufficiently advanced economically to replace these highly energy-inefficient diesel pump sets. Furthermore, technically reliable and fool-proof photovoltaic water-pumping systems have yet to be developed; usually the pumping systems perform much below the manufacturers' specifications [6] . After the initial euphoria of the late 1970s, it is gradually being recognized in India that a large amount of developmental activity must precede serious attempts to produce solar photovoltaic water-pumping systems commercially. The critical question before the planners is the approach that should be taken in these circumstances. Should solar photovoltaics be ignored totally until such time as it has been developed to the level of economic viability? Should the Indian Government procure the photovoltaic systems available at present from commercial manufacturers in the industrialized countries and deploy them to study the technoeconomic and sociological impacts in the country? Should the Indian Government formulate and implement a long-term integrated plan of research, development, manufacture, deployment and demonstration of solar photovoltaic systems in the country? The Indian Government has chosen the last option with the ultimate objective of achieving self-reliance. This is a crucial decision for India, where the limitations of resources for developmental work have often been acute. This, of course, does not mean that every development has to be carried out in India, without external assistance. By virtue of their advanced technological capabilities, and the availability of adequate resources, the industrialized countries are necessarily more favourably placed for the economic utilization or renewable energy sources, and in particular photovoltaics. Therefore, India will have to cooperate closely with the industrialized countries so that the energy crisis may be solved collectively. The massive exploitation of fast-depleting conventional energy sources by the industrialized countries for their technological and economic advancement imposes on them a historical responsibility to support and augment the efforts of developing countries to develop and utilize renewable energy resources [1]. Similarly, it is absolutely essential to have close cooperation between the developing countries themselves, to enable them to assist each other and to share their experience.

There are four basic areas of activity in the development of the engineering and technology of solar photovoltaic systems: (i) basic raw material, particularly silicon; (ii) solar cells and modules; (iii) balance-of-system (BOS) components; (iv) complete system engineering. These areas need equal attention in order to effect the large-scale utilization of solar photovoltaic systems. Until recently, the majority of commercial photovoltaics manufacturers in the world were concentrating mostly only on the first two areas, hoping that someone else would tackle the other two areas. This has resulted essentially in the assembly of photovoltaic systems from off-the-shelf BOS components. The inadequacy of such an approach has recently been analysed in an international study [6] on solar water-pumping systems. Fortunately, however, most commercial photovoltaics manufacturers are now changing over to the production of photovoltaic systems. The Indian approach, in its modest way, has always been based on the efficacy of the total system. It was recognized early in the planning stage that a concerted effort must be devoted to the development of efficient BOS components, and to the system engineering, in addition to the raw materials and solar cells. The lack of a commercial market for photovoltaic systems has naturally resulted in an apathy for such developmental work by commercial manufacturers in India. Whole-hearted support and funding by the Indian Government were desired, and these have been forthcoming. The development of the manufacturing technology of solar cells and modules by a public sector company, sponsored by the Indian Government, has helped the overall systems development.

Technological developments are primarily carried out by countries for their own use. The developing countries have often been blessed with the transfer of technology from industrialized countries, but this has been motivated mainly by commercial considerations and has often resulted in the actual needs of the developing countries not being totally satisfied. This situation is likely to be repeated with solar photovoltaics. The traditional commercial approach has so far been to manufacture and sell relatively high efficiency photovoltaic water-pumping systems, with the specific objective of replacing the diesel or electric pump sets used at present for lift irrigation. An important factor that must be considered seriously is that water is needed for irrigation only during specific periods of the year. The photovoltaic energy-generating source would remain idle for the rest of the year, as do the diesel or electric pump sets [7]. Whereas with the diesel pump no generated electrical energy is wasted because no fuel is used when the pump is idle, for a photovoltaic energy source it is totally different. A solar photovoltaic energy source of, say, 1 kW capacity is capable of generating more than 1600 kW h year-1 of electrical energy in most parts of India. A rough estimate would show that the amount of energy consumed would not be much more than 800 kW h year-1 if the photovoltaic energy source was used solely for irrigation pumping. Therefore, the capacity utilization of the energy source would at best be 50%, making the photovoltaic energy source doubly unfavourable in terms of overall economics. Such wastage, in an energy-starved world, should not be permitted, especially when solar photovoltaic technology is in its infancy. In order to utilize the full capacity of the energy-generating source, it is essential to couple it to various independent loads at different times of the year. This is not an easy task because the electrical load factor in Indian agriculture is rather low, and the load is season dependent. Another possibility is energy storage, either in electrochemical batteries or as pumped water; both of these increase the cost ancl complexity of the overall system and the maintenance.

An integrated approach to increase the efficacy and utilization factor of small stand-alone photovoltaic systems, particularly water-pumping systems for lift irrigation, has not been attempted so far. Such an attempt would require a thorough assessment of the needs of the users. It is not sufficient to design, manufacture and sell the highest efficiency photovoltaic water-pumping systems; it is equally necessary to study and assess the technological and sociological conditions and the needs of the developing countries, in order to increase the efficacy of the systems and to reduce energy wastage. Discussions about the commercial aspects of solar photovoltaic water-pumping systems for lift irrigation in India have little value unless an integrated approach is consciously planned, implemented and evaluated.

How can such an objective be achieved? A purely commercial approach of selling lift irrigation systems to the users, even at a highly subsidized price, would not yield the desired result. The manufacturer or the supplier has to take a leading part in the assessment process with the full confidence of the user. Therefore, the government of the country involved has to support and foster not only the development and manufacturing activities but also the deployment and assessment activities, by means of large-scale field trials of locally produced photovoltaic systems, and in particular irrigation pumping systems. The evaluation data from the field trials must then be used objectively in local manufacturing units and research institutions to improve technology and to reduce costs.

Fortunately, India is committed to such an approach so the compulsion to sell at any cost does not at present exist in the country. This situation is totally opposite to that found in the industrialized countries. It has been recognized that, despite all overt publicity, solar photovoltaic energy sources are not yet ready for large-scale application in lift irrigation, although the potential for such application certainly exists. A large number of well-planned integrated activities have to be carried out, and a thorough assessment made, before such systems are made viable, even technically. Technological breakthroughs and innovations are not enough, socioeconomic assessments are equally important.

At present, solar photovoltaic energy sources are used commercially in remote areas of India in applications requiring low power, such as communications, telemetry, navigational aids, weather monitoring, cathodic protection and audiovisual educational aids such as radio and television receivers. The economics and the reliability criteria are important in such applications. The energy replacement in all these cases is small; none the less, benefits do accrue from such applications of photovoltaic energy sources in terms of field testing, user education and confidence etc. In the NASPED project, almost three-quarters of the efforts and products are allocated for large-scale rural applications and the remainder for small industrial applications. Major stress in the project has been on the development, manufacture, deployment and study of water-pumping systems for lift irrigation, initially at a highly subsidized price to the actual user. Efforts are also under way to integrate photovoltaic energy sources with season-dependent agricultural loads, in addition to lift irrigation, so as to improve the efficacy of the system. In addition, commercial transactions supplying complete photovoltaic systems for use in various industrial applications have also been taken up in the project. Figures 1 and 2 show some of the photovoltaic systems already installed.

4. Strategy

Historically, commercial motivation is the key driving force behind the large-scale exploitation of the innovation and development of technology. In contrast, the development of technology is largely specific to a particular country. This is likely to be even more pronounced for solar photovoltaic systems, whose designs are specific to a given location. It is also a fact that most developing countries do not have the necessary infrastructure to carry out first the technological development and then the manufacture of high and intermediate technology products entirely with local expertise. These factors, when applied to the emerging area of solar photovoltaics, have resulted in a situation where the developing countries themselves are mainly responsible for sustaining and augmenting the photovoltaic manufacturing industries in the industrialized countries.

The major portion of the world solar photovoltaic production is being sold to the developing countries, where there is a growing market. Thus these developing countries, where there is plenty of sunshine but no photovoltaics manufacturing industry, are supporting a commendable cause, sustaining the manufacturing industries in the industrialized countries in order to attain economic viability in some distant future.

(a)

(b)

Figure 1 Indian-made photovoltaic arrays (a) for a hospital, kitchen and community centre lighting system in a remote unelectrified village and (b) in a distant lighthouse.

Figure 2 A photovoltaic-powered future rural dwelling hut with a water pump (the hut has fluorescent lighting, a fan, radio, television etc.).

When such an objective is indeed realized, and no doubt it will be, the developing countries will still benefit from the improved economics. However, even at such a future date, the motivation behind every transaction would be based on commercial considerations, as it is now. The fact that, during the interim period, the vast market in these developing countries will have contributed largely to the development cost, will naturally be forgotten. The difference between the U.S. Government's technology readiness claim of U.S. $2.80 W p -1 and the actual commercial price of U.S. $10 - $17 W p -1 is far too large to be ignored.

These factors become even more disconcerting if it is taken into consideration that the technology being developed and manufactured is concerned with the area of energy supply and that this is a strategic area. It is conceivable that a time might come when the political polarization and diversity among various nations would supersede the commercial motivation behind the sale or transfer of the technology of solar energy products to developing countries. High purity silicon or, for that matter, any other solar photovoltaic material may one day become as difficult to procure, and as politically important, as enriched uranium is today. Peace-loving developing countries such as India must appreciate and analyse such a conceivable and grim outlook. It is important to realize this now while solar photovoltaic technology is still in its infancy; when it comes to maturity, solar photovoltaics will certainly have a significant impact on the energy supply in India. A determined effort towards self-reliance is the only way to counter such a grim possibility. The greatest advantage that India has, like any other developing country, is not an abundance of sunshine but the fact that solar photovoltaic technology is not yet commercially mature.

Fundamental innovation in areas of high and intermediate technology is not very common in most developing countries, including India. This appears to be the monopoly of industrialized countries which have adequate resources. Usually, technological development in India, in such an area, takes the form of the "adaptation" of technology using local resources and with traditional habits and customs in view. The so-called labour-intensive technology is an example. Nevertheless, more often than not, such technological adaptation results in an entirely new and novel technology, significantly different from the original technology. In fact, the new technology often becomes a tough competitor to the original. In the emerging area of solar photovoltaics, such a situation will probably occur.

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SOLAR TECHNOLOGICAL UPDATE

Concentrating solar power

CSP (Concentrating solar power) technologies use mirrors to reflect and concentrate sunlight onto receivers that collect the solar energy and convert it to heat. This thermal energy can then be used to produce electricity via a steam turbine or heat engine driving a generator. One way to classify concentrating solar power technologies is as to how the various systems collect solar energy such as parabolic trough systems and fresnel reflector system.

One of the CSP technologies is explained here.

Linear concentrator system

Linear concentrating solar power collectors are one of the three types of CSP systems in use today. Linear CSP collectors capture the sun's energy with large mirrors that reflects and focus the sunlight onto a linear receiver tube. The receiver contains a fluid that is heated by the sunlight and then used to create superheated steam that spins a turbine to drive a generator to produce electricity. Alternatively, steam can be generated directly in the solar field, thus eliminating the need for costly heat exchangers.

Linear concentrating collector fields consist of a large number of collectors in parallel rows that are typically aligned in a north-south orientation to maximize both the annual and summer time energy collection. With a single-axis sun-tracking system, this configuration enables the mirrors to track the sun from east to west during the day, ensuring that the sun reflects continuously onto the receiver tubes.

Parabolic trough systems

In such a system, the receiver tube is positioned along the focal line of each parabola-shaped reflector. The tube is fixed to the mirror structure and the heated fluid—either a heat-transfer fluid or water/steam—flows through and out of the field of solar mirrors to where it is used to create steam (or, for the case of a water/steam receiver, it is sent directly to the turbine). Currently, the largest individual trough systems generate 80 MW of electricity. However, individual systems being developed will generate 250 MW. In addition, individual systems can be put up in the power parks. This capacity would be constrained only by the transmission capacity and availability of contiguous land area.

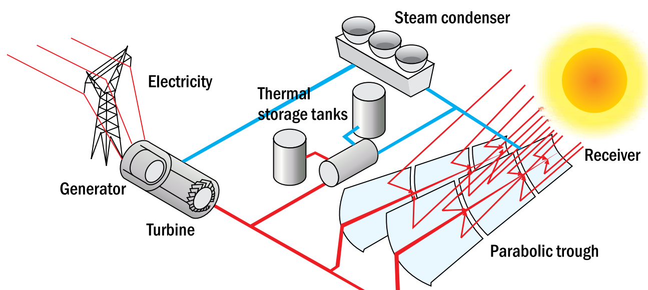


Figure 1 A linear concentrator power plant using parabolic trough collectors.

Trough designs can incorporate thermal storage. In such systems, the collector field is oversized to heat a storage system during the day that can be used in the evening or during cloudy weather to generate additional steam to produce electricity. Parabolic trough plants can also be designed as hybrids, meaning that they use fossil fuel to supplement the solar output during periods of low solar radiation. In such a design, a natural-gas-fired heater or gas-steam boiler/reheater are used. In future, troughs may be integrated with existing or new combined-cycle natural-gas- and coal-fired plants.

Linear fresnel reflector systems

A second linear concentrator technology is the linear fresnel reflector system. Flat or slightly curved mirrors mounted on

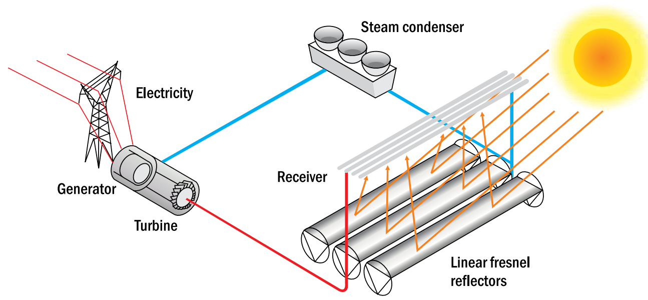


Figure 2 A linear fresnel reflector power plant.
Source http://www1.eere.energy.gov/solar/csp.html

trackers on the ground are configured to reflect sunlight onto a receiver tube fixed in the space above these mirrors. A small parabolic mirror is sometimes added atop the receiver to further focus the sunlight.

Table 1 Differentiation in solar cells				
Material	Thickness	Efficiency	Colour	Features
Monocrystalline Si solar cells	0.3 mm	15 - 18 %	Dark blue, black with AR coating, grey without AR coating	Lengthy production procedure, wafer sawing necessary. Best researched solar cell material - highest power/area ratio.
Polycrystalline Si solar cells	0.3 mm	13 - 15 %	Blue with AR coating, silver-grey without AR coating	Wafer sawing necessary. Most important production procedure at least for the next 10 years.
Polycrystalline transparent Si solar cells	0.3 mm	10 %	Blue with AR coating, silver-grey without AR coating	Lower efficiency than the monocrystalline solar cells. Attractive solar cells for various BIPV applications.
EFG	0.28 mm	14 %	Blue, with AR coating	Limited use of this production procedure Very fast crystal growth, no wafer sawing necessary
Polycrystalline ribbon Si solar cells	0.3 mm	12 %	Blue, with AR coating, silver-grey without AR coating	Limited use of this production procedure, no wafer sawing necessary. Decrease in production costs expected in the future.
Apex (polycrystaline Si) solar cells	0.03 to 0.1 mm + ceramic substrate	9,5 %	Blue, with AR coating, silver-grey without AR coating	Production procedure used only by one producer, no wafer sawing, production in form of band possible. Significant decrease in the production costs expected in the future.
Monocrystaline dendritic web Si solar cells	0.13 mm incl contacts	13 %	Blue, with AR coating	Limited use of this production procedure, no wafer sawing, and production in form of band possible.
Amorphous silicon	0.0001 mm + 1 to 3 mm substrate	5%–8 %	Red-blue, Black	Lower efficiency, shorter life span. No sawing necessary, possible production in the form of band.
CdTe (Cadmium Telluride)	0.008 mm + 3 mm glass substrate	6%–9 % (module)	Dark green, Black	Poisonous raw materials, significant decrease in production costs already becoming a reality in the First Solar plant for example
CIS (Copper-Indium-				
Diselenide)	0.003 mm + 3 mm glass substrate	7.5%–9.5 % (module)	Black	Limited indium supply in nature. Significant decrease in production costs possible in the future.
HIT (Hybrid silicon) solar cell	0,02 mm	18 %	Dark blue, black	Limited use of this production procedure, higher efficiency, better temperature coefficient and lower thickness.
http://www.pvresources.com/en/technologies.php				

BioSolar extends BioBacksheet line

BioSolar has announced plans for an extended line of BioBacksheets used to protect PV modules compatible with conventional c-Si PV modules. BioSolar bio-based backsheet materials are made from renewable plant sources that reduce the cost of solar modules and eliminate the need for dangerous toxins found in the petroleum based backsheets. Manufacturers of these modules will now have two BioBacksheet options, depending upon their durability and cost requirements. The first option for conventional c-Si module manufacturers will be a multi-layer BioBacksheet-C for conventional applications, the second a new mono-layer BioBacksheet product line for premium applications. These products have been developed so as to meet the existing and future direct needs of BioSolar's potential customers. The company aims to provide manufacturers with various backsheet grades with corresponding price points to accommodate both the durability and economic requirements of each solar panel manufacturer.

http://www.pv-tech.org/news/_a/biosolar_extends_biobacksheet_line/

Differentiation in solar cells

This is a table depicting different types of solar cells with specific thickness leading to difference in their efficiency level (Tabel 1).

Ascent Solar as the latest PV manufacturing software customer

Eyelit has landed another customer for its solar PV manufacturing software–flexible CIGS thin-film module maker Ascent Solar. The PV company is using the suite to support the production ramp of its 30 MW Fab 2 in Thornton, CO, which is slated to go live by the end of March. Eyelit said that its software will be used to track, monitor, and provide the product visibility throughout Ascent's manufacturing process, from incoming rolls to the completed PV solar modules. With the implementation of the software, the thin-film company can consolidate several homegrown Microsoft Access databases and Excel-based tracking sheets, and thus reduce paper travellers on the production floor. An asset-management solution enables improvement in managing the equipment maintenance and automation of critical processes integral to thin-film PV production, and also provides tool monitoring, management of maintenance tasks, as well as built-in warnings, alerts, and logbooks for improved communications in maintenance operations and greater efficiency in equipment utilization, according to the supplier.

Eyelit said it had recently landed a roll-to-roll CIGS thin-film manufacturer as a new customer, although it did not name Ascent at that time. The company noted that it had signed up five new solar clients from across the PV spectrum (including Ascent) in 2009.

http://www.pv-tech.org/news/

High-efficiency low-cost silicon solar sell demonstrated

IMEC, one of the leading European research centres in photovoltaics, and BP Solar, a leading energy company, demonstrated a 18% conversion efficiency for silicon solar cells made of BP Solar's newly developed Mono2TM silicon. By combining IMEC's advanced processing techniques with BP Solar's high-quality low-cost substrates, the companies demonstrated that Mono2 has a good potential to become a new base material for the low-cost highly efficient solar cells. BP Solar's Mono2 production process delivers a promising new wafer platform for solar cells with the potential to become a low-cost alternative to the more expensive CZ (Czochralski) silicon substrates, because it combines extremely low defect densities and high conversion efficiencies with production costs that are comparable to the costs of traditional multicrystalline substrates. The production of Mono2 involves a proprietary growth nucleation process for the casting of ingots used to produce single crystal bricks and wafers whereby preferred crystallographic orientations can be achieved. This feature allows further improvement in cell efficiencies. BP Solar's Mono2 was developed with support of the U S Department of Energy's Technologies Pathways Partnership. IMEC's cell production process is feasible as an industrial production process, as it only adds three processing steps to the standard industrially applied process of full aluminium back surface field. IMEC's solar cells are 130μm thick and cover an area of 156mm x 156mm. Using IMEC's advanced processes such as dielectric passivation and a localized back surface field, a conversion efficiency of 18% for the new low-cost Mono2 silicon solar cells, which is in the range of the current commercial solar cells, has been demonstrated with a dramatic reduction in cell thickness.

http://www.sciencedaily.com/releases/2009/10/091006104500.htm

Flexible solar strips light up campus bus shelter

New flexible solar cell technology developed by a group of engineering researchers at McMaster University has been installed to power lighting for the night-time transit users. The researchers are also hoping that the prototype will help boost efforts to commercialize the new technology. 'Our goal is to provide a clean, affordable power source for the bus shelters that will let transit companies run Internet-based scheduling updates,' said Adrian Kitai, a professor of engineering physics at McMaster, who guided the project. 'The solar technology can also be used to light up bus shelter signage and provide lighting for general safety.' The flexible solar cell project started as a masters thesis for Wei Zhang, who subsequently worked as an engineer in the Department of Engineering Physics. Julia Zhu, a research technician in the department, and Jesika Briones, an engineering entrepreneurship and innovation graduate, also helped develop the initiative. The ability to bend the solar cells to fit the curved roof of the bus shelter is one of the main features of this technology. The flexibility is achieved by tiling a large number of small silicon elements into an array, mounting them onto a flexible sheet, and connecting them through a proprietary method. The two solar strips installed on the McMaster bus shelter are about 90 cm long and 12 cm wide. Each strip has 720 solar cells and each of then is one-centimetre square and generates up to 4.5 Watts of power. With the help of Facility Services at McMaster, a solar strip was mounted at each end of the bus shelter roof and connected to two energy-efficient, multi-LED, light fixtures. Each light fixture uses only 600 milliwatts of power and produces about the same light output as a three-watt regular tungsten bulb or what a small night light would use. The lights are bright enough for easy reading.

http://www.sciencedaily.com/releases/2009/06/090612122011.htm

Engineers on course to make super-efficient solar-electric powered boat

A team of academics and students at the University of Southampton have begun work on a solar-electric powered boat, which they claim will be one of the most sophisticated to enter the annual Solar Splash competition so far. Team 'Tarka', led by Dr Peter Wilson at the University's School of Electronics and Computer Science, comprises experts from across the University of Southampton in Electronics, Nanotechnology, Solar Energy, and Ship Science. They have come together to design and build a light and efficient boat to compete in next year's Solar Splash event. Solar Splash is the World Championship of Intercollegiate Solar Boating. The competition takes place over five days, with technical inspections on the first day and the remainder of the time occupied by five on-the-water competitive events, when speed, manoeuverability and endurance are tested. In order to develop their ideas and materials further, the team is seeking collaboration with the local businesses interested in 'green' boats or buildings, aerospace, engineering or general manufacturing. In 2009, a number of companies sponsored key elements of the boat to a successful outcome, and the team is looking for sponsors at different levels for this year's competition. Last year was the first time that a British university entered a boat in the competition. Despite having virtually no budget for the project and having to economize so much that they bought the boat's motor on eBay, they still managed to come in the top ten, winning awards for the 'Rookie Team with the Highest Overall Score' and 'top teamwork', 'sportsmanship', and a top three finish in the qualifying event, with the result that the team qualified as one of the 'elite' boats for 2010.

http://www.sciencedaily.com/releases/2009/12/091206184628.htm

Compiled by Shantanu Ganguly, Fellow, TERI <shantanu.ganguly@teri.res.in>

CURRENT R&D SOLAR

Ruben B, Bjørn P J, Arild G. 2010. **Properties, requirements, and possibilities of smart windows for dynamic daylight and solar energy control in buildings: A state-of-the-art review.**
Solar Energy Materials and Solar Cells **94** (2): 87–105

Abstracts

A survey on prototype and currently commercial dynamic tenable smart windows has been carried out. The technologies of electrochromic, gasochromic, liquid crystal, and electrophoretic or suspended-particle devices were examined and compared for dynamic daylight and solar energy control in buildings. Presently, state-of-the-art commercial electrochromic windows seem to be the most promising of the lot to reduce cooling loads, heating loads and lighting energy in buildings, where they have been found most reliable and able to modulate the transmittance up to 68% of the total solar spectrum. Their efficiency has already been proven in hot Californian climates, but more research is necessary to validate the products for colder climates, and to improve furthermore the commercial products in order to control the indoor climate in a more energy-efficient way by reducing both heating and cooling loads.

Keywords: smart windows, electrochromic, gaspchromic, electrophoretic, solar spectrum

Calise F, Dentice d'Accadia D, and Palombo A. 2010.
Transient analysis and energy optimization of solar heating and cooling systems in various configurations.
Solar Energy **84** (3): 432–449

Abstracts

In this paper, a transient simulation model of SHC (solar-assisted heating and cooling systems) is presented. A detailed case study is also discussed, in which three different configurations are considered. In all cases, the SHC system is based on the coupling of evacuated solar collectors with a single-stage LiBr–H_2O absorption chiller, and a gas-fired boiler is also included for auxiliary heating, but only during the winter season. In the first configuration, the cooling capacity of the absorption chiller and the solar collector area are designed on the basis of the maximum cooling load, and an electric chiller is used as the auxiliary cooling system. The second layout is similar to the first one, but, in this case, the absorption chiller and the solar collector area are sized in order to balance only a fraction of the maximum cooling load. Finally, in the third configuration, there is no electric chiller, and the auxiliary gas-fired boiler is also used in summer to feed the absorption chiller, in case of scarce solar irradiation.

The simulation model was developed using the TRNSYS software, and included the analysis of the dynamic behaviour of the building in which the SHC systems were supposed to be installed. The building was simulated using a single-lumped capacitance model. An economic model was also developed, in order to assess the operating and capital costs of the systems under analysis. Furthermore, a mixed heuristic-deterministic optimization algorithm was implemented, in order to determine the set of the synthesis/design variables that maximize the energy efficiency of each configuration under analysis.

The results of the case study were analysed on monthly and weekly basis, paying special attention to the energy and monetary flows of the standard and optimized configurations. The results are encouraging for the potential of energy saving. On the contrary, the SHC systems appear still far from the economic profitability, however, this is notoriously true for the great majority of renewable energy systems.

Keywords: solar energy, evacuated collectors, absorption chiller, dynamic simulation, renewable energy

Hussain H A, Abdulsalam A A. 2010. **Low energy architecture and solar rights: Restructuring urban regulations, view from Jordan.**
Renewable Energy **35** (2): 333-342

Abstracts

The concept of solar energy based design has emerged worldwide with the growing number of high-rise apartment buildings. It is important to think of maximizing solar energy utilization in buildings through architectural design strategies. This should lead to the setting up of mandatory regulations on both urban and building design levels.

This study analyses the current building regulations of GAM (Greater Amman Municipality) from the standpoint of solar accessibility. It suggests new regulations that ensure adequate solar accessibility in new constructions of residential apartments in Amman. Computer simulations associated with the sun masks analyses have been conducted to obtain a firm judgment towards setting up new dimensions of setbacks and building heights for apartment blocks in Amman. The study gives clear and flexible guidelines for urban and architectural designers to determine the number of sunlit floors based

on the desired distances between the apartment blocks. To achieve the goals of this study, the authors suggest that the current urban regulations in Jordan be modified on energy-based design strategies.

Keywords: urban regulation, Jordan, low-energy architecture

Wei X, Xin W and Yinping Z. 2009.

Analytical optimization of interior PCM for energy storage in a lightweight passive solar room.

Applied Energy **86** (10): 013–2018

Abstracts

- Lightweight envelopes are widely used in the modern buildings, but they lack sufficient thermal capacity for passive solar utilization. An attractive solution to increase the building thermal capacity is to incorporate a PCM (phase change material) into the building envelope. In this paper, a simplified theoretical model is established to optimize an interior PCM for energy storage in a lightweight passive solar room. Analytical equations are presented to calculate the optimal phase change temperature and the total amount of latent heat capacity and to estimate the benefit of the interior PCM for energy storage. Further, as an example, the analytical optimization is applied to the interior PCM panels in a direct-gain room with realistic outdoor climatic conditions of Beijing. The analytical results agree well with the numerical results. The analytical results show the following.
- the optimal phase change temperature depends on the average indoor air temperature and the radiation absorbed by the PCM panels
- the interior PCM has little effect on average indoor air temperature
- the amplitude of the indoor air temperature fluctuation depends on the product of surface heat transfer coefficient hin and area A of the PCM panels in a lightweight passive solar room.

Keywords: energy storage, analytical, optimization, PCM, lightweight envelope, passive solar room

Anand M S. 2009.

Efficiency enhancement of stationary solar energy based power conversion systems in Canada.

Applied Energy **86** (9): 1405–1409

Abstracts

This paper presents the optimum energy conversion conditions of stationary photovoltaic panels used for electrical power generation. The results are arrived at after performing calculations for 180 days in a given year at the latitude of St. John's, Newfoundland. The latitude of this city is close to other Canadian major population centres. Various angular orientations of sun's rays on the earth are considered. On a given day, the incident energy flux of sun is resolved into three components, and the conversion efficiency is based on the flux normal to the panels. The efficiency of conversion of the incident energy is measured with respect to a solar tracking process. The number of days in a given year is divided into two groups, one between the winter solstice and the spring equinox, and another between the spring equinox and the summer solstice. The results show the existence of two maxima, one for each of the two periods. By setting the panels at each of these maxima, very significant improvement in energy conversion can be achieved.

Keywords: alternate energy, solar energy, efficiency of conversion,photovoltaic systems

Li-qun L, Zhi-xin W, Hua-qiang Z ,and Ying-cheng X. 2010.

Solar energy development in China—A review.

Renewable and Sustainable Energy Reviews **14** (1): 301–311

Abstracts

The steady and maintainable electric power provides the development momentum of a country's industrialization, which is indispensable to every country at present. It is well known that China is the largest developing country in the world. With the rapid development of economy and society, energy demand of Chinese society is increasing in an incredible speed, that is, the annual accumulative total capacity of electric energy is about 0.1 billion kW, and the most of it is provided by the fossil fuel resource, and the share is about 90% in China. Certainly, it is a very inappropriate energy structure, so the sustainable development of a country is impossible in future and the status must be improved in order to achieve sustainable development. Fortunately, China has large country area, and there are abundant solar resources. Development and application of solar energy have been regarded by the government and ordinary people, and they thought that solar energy can provide more and more electric energy in future, and more and more actual examples have been applied in the last decades, which are supported by the central government and local governments. This paper discusses the distribution zone and current developmental situation of solar energy in China. Then, some application practice is described, such as solar energy greenhouse, solar energy hearth, solar water heater, solar lighting system, solar water pump, DG (distributed generation), GPG (grid-connected photovoltaic generation) and wind–solar hybrid system. The policies and laws of Chinese central government and local governments are described in the following paragraph. At the end, the developmental prospect of photovoltaic in future, and the development barriers-cum-recommendations are introduced.

Keywords: solar energy, photovoltaic, sustainable development, application practice

Kibum K, Samir F. M, and Gregory J. K. 2010.
Experimental and simulation study on wind affecting particle flow in a solar receiver.
Solar Energy **84**(2): 263–270

Abstracts

The SPR (solid particle receiver) is a direct absorption central receiver that can provide a solar interface with thermal storage for thermo-chemical hydrogen production processes requiring heat input at temperatures up to 1000 °C. In operation, a curtain made up of approximately 697 μm ceramic particles is dropped within the receiver cavity and directly illuminated by concentrated solar energy. Since the SPR has an open aperture, the flow may be disturbed by the high ambient winds. Therefore, the objective of this study was to gain insight into the wind effect on the curtain. Experiments were conducted to understand the wind influence on the particle flow and loss. The experimental results showed that winds from certain angles of the attack could cause a critical loss of particles. A MFIX simulation model was developed to validate the experimental results and observations. The simulation has provided us with better understanding on the wind effects.

Keywords: solid particle receiver, solar energy, wind effect

Evanthie M, Yiannis T. 2010. **Contribution of the solar energy in the sustainable tourism development of the Mediterranean islands.**

Renewable Energy, **Volume 35**, Issue 3: 667–673

Abstract

The purpose of this work is to examine specific features of thermal and photovoltaic solar systems and their contribution to the sustainable tourism development in the Mediterranean Islands. In doing so, the best practices are studied and the factors which influence the transfer of these practices in other geographic regions are examined. We take under consideration the sensitiveness of many islanders in the Mediterranean regions in relation to the climate changes and the perspective of their economic development through thematic tourism forms and differentiated tourism products and services. Furthermore, we present currently developed innovative applications which are specially adapted to the needs identified within this research, and we propose marketing strategies for their further expansion. The marketing approach followed is based on an innovative concept, which suggests that solar energy systems could constitute a driver for the development of specific forms of tourism. These systems are mainly the ICS solar water heaters, the coloured flat plate-collectors, the CPC collectors, and the hybrid PV/T collectors. Apart from these, the use of booster reflectors that achieve a higher energy output in all cases of the above-mentioned collectors is also suggested. We conclude that turning solar energy systems into a driver for specific types of tourism development and consequently of a local economic development is possible, if we take into consideration specific social needs and aspirations.

Keywords: sustainable tourism development, mediterranean islands, marketing strategies, CPC collectors

Fausto C. 2010. **Fuzzy TOPSIS approach for assessing thermal-energy storage in CSP (concentrated solar power) systems.**
Applied Energy, **Volume 87**, Issue 2: 496–503

Abstract

The energy produced by thermal solar plants does not have to be limited solely to hours of sunlight. It is possible to conceive a storage system and it is possible to extend the production of heat beyond the hours of full sunshine. The main aim of this paper is to propose and test the validity and effectiveness of the proposed fuzzy multi-criteria method (TOPSIS fuzzy), to compare different HTF (heat transfer fluids) in order to investigate the feasibility of utilizing a molten salt. The thermal processes involved in CSP are not analysed.

Keywords: thermal solar plants, TOSIS fuzzy, HTF, CSP

G. T, G. M. 2010. **Thirty years of domestic solar hot water systems use in Greece – energy and environmental benefits – future perspectives.**
Renewable Energy, **Volume 35**, Issue 2: 490-497

Abstract

The effort to reduce the dependence on imported crude oil in Greece, after the oil crises in the 1970s, has resulted, among other things, in a total installed area of 3.57 million m^2 solar collectors in 2007, making Greece one of the pioneers in the use of DSHWS (domestic solar hot water system) worldwide. In the present work, the contribution of DSHWS to the reduction of conventional energy and greenhouse gases and other air pollutant emissions in Greece from its early years in mid '1990s up to now is assessed. DSHWS market penetration, solar system technological changes and development, and demographic changes in association with the climatic conditions in all regions of the country have been taken into account in order to calculate energy conservation and emissions reduction. The results show that the conserved energy ranges from 21.27 GW hel (0.1% of the domestic sector energy use) in 1978 to 1513 GW hel (2.4%) in 2007, resulting in an abatement of CO_2 emissions, which for the year 2000 was 1.67 Mt, exceeding by 76% the objectives of the Greek Programme of 'Climatic Change', which indicated savings of 0.95 Mt CO_2 for 2000.

Keywords: Greece, DSHWS, Greek programme, climate change

Compiled by Shantanu Ganguly, Fellow, TERI <shantanu.ganguly@teri.res.in>

DEPARTMENT OF ENERGY AND ENVIRONMENTAL STUDIES: DEVI AHILYA VISHWAVIDYALAYA, INDORE

Devi Ahilya University, also called Indore University, is a major university in Indore, Madhya Pradesh, India. The university was established in 1964 by an act of legislative assembly of Madhya Pradesh and named as Devi Ahilya University: Indore University. The jurisdiction of the university was limited to Indore district. In 1988, the university was renamed after Devi Ahilya Bai Holkar as Devi Ahilya Vishwavidyalaya.

The university has a very vibrant department for energy and environmental studies. It is known as the Department of Energy and Environmental Studies.

SEES (School of Energy and Environmental Studies),Devi Ahilya Vishwavidyalaya, Indore , is a University teaching department under the Faculty of Engineering Sciences. It was established in 1990. It also has an autonomous sister unit—CESR (Centre of Energy Studies and Research). The school offers Ph D, M Tech., (regular), M Tech. (distance learning), and M Phil. programmes. It is housed in the Takshashila Campus on Khandwa Road.

Mission

'To provide the country with world class manpower and capabilities for dealing with energy and environment related issues.

Dr S P Singh, Head, School of Energy and Environmental Studies.

Development, planning, implementation, and evaluation of energy conservation, renewable energy and environment programmes in the country are to a great extent limited by the availability of trained personnel at research, design, and engineering level. Hence, there is a need to train engineers/scientists in energy planning, conservation technologies, renewable energy systems, and their linkages with environment.

Aim and objective

The school aims to provide trained manpower with strong engineering and research and development capabilities in the following energy and environment related areas.

- Renewable energy technologies
- Energy and environment auditing
- Energy conversion technologies and their impact on environment.
- Energy and environment instrumentation and control systems.
- Economics of energy and environmental technologies
- Socio-cultural and behavioural aspects of energy production and environmental changes

- Environmental impact analysis
- Resource assessment and waste management
- To undertake research and development and consultancy project work in the energy and environment related fields
- To introduce to the industry various environment-friendly and energy-efficient technologies and help in implementing energy-conservation measures.

To provide the users testing and calibration facilities required in the energy and environmental files.

Activities

- Academic Programmes: Ph.D., M.Tech., M. Phil.and PG advance diploma
- Energy and environmental auditing
- Design, development and installation of renewable energy systems
- Design and simulation of energy-efficient buildings
- Testing of solar thermal, solar photovoltaic and combustion systems
- Solar radiation and daylight measurements
- Third party evaluation of project on energy conservation, demand management and planning
- Development of energy and computer softwares
- Feasibility studies and project evaluation
- Environmental impact analysis studies
- Training programme for implementing agencies, manufacturers, users, teachers, and students
- Testing of fuels, water (drinking, industrial), effluents, and so on.

Centre of energy studies and research

An autonomous unit for R&D and extension activities in the field of renewable energy and energy conservation was established by MPUVN (Madhya Pradesh Urja Vikas Nigam Limited) in the year 1989 with the following main objectives

- To undertake extension programmes for energy conservation and energy substitution in Madhya Pradesh
- To formulate guidelines for integrate rural energy programme in Madhya Pradesh.
- To conduct programmes for energy education in Madhya Pradesh.

Regional test centre-cum-technical backup unit for solar thermal devices

One of the six units in the country established by Ministry of New and Renewable Energy, Government of India, with the following objectives.

- To provide testing facilities of solar thermal devices and systems to the users, promoters, manufacturers, and R&D organizations.
- To act as a testing centre for Bureau of Indian standards for solar cooker and solar flat plate collectors.
- To provide technical back up services to entrepreneurs, manufacturers on aspect of fabrication, monitoring, installation, and system engineering.
- To provide third party inspection, monitoring, and evaluation services.
- To organize seminars, workshop, business meets, and training programmes for users, promoters, technicians, and manufacturers of solar thermal devices.

Biogas development and training centre

A unit funded by Ministry of New and Renewable Energy with the following objectives.

- To provide technical and training support to state nodal departments.
- To organize training courses for developing entrepreneurs and for staff of the state nodal departments and implementing agencies, banks, representatives of panchayats, women's organizations, masons, users, and so on.
- To identify, develop, and establish BECs (Biogas Extension Centres), organize training of their personnel, and oversee their functioning.
- To carry out field inspections of at least 500 biogas plants in a year for performance monitoring in association with state nodal departments and agencies and suggest measures for improving quality of programme implementation.
- To carry out field testing/ adaptive trials on new models of biogas plants and diversified uses of biogas plants effluents and determine users response.

In addition to technical support, the unit also provides testing Facility for Solar cooker and solar flat plate collectors for Bureau of Indian Standards and Ministry of New and Renewable Energy, Government of India.

Solar Radiation and Meteorological Data Measurement Facility

The Department has a full-fledged automatic data recording station for measurement of global irradiance, diffused irradiance, ambient temperature, relative humidity, wind velocity, wind direction, and rainfall on hourly basis.

Technical Back-up Unit for National progamme of Improved Chulha

A unit funded by MPUVN with the following objectives.

- Research and development of improved *chulha.*
- To provide training at various levels.
- To adopt village for large scale diffusion of improved *chulha* technologies.
- Fuel wood conservation.
- Elimination / reduction of smoke.
- Reduction in drudgery of women and children from cooking in smoky kitchen and collection of fuel woods.
- Environmental upgradation and check on deforestation, and employment generation in rural areas.

This programme has now been transferred from the Central Government to the state governments. Continuation of the programme is under consideration by the M. P. Government.

National institute–industry forum for energy

On schools initiative 'National Institute–Industry Forum for Energy' was established in 1995. Industries from in and around Indore (Pithampur, Dewas, Dhar, and Ghata Billod) and faculty from schools and engineering colleges are the members of the forum. Through the forum, school staff and students are in direct contact with the energy and environment related problems of the industries. Technical experts from the industry are invited to schools for lectures, selection, and evaluation of the students, while school's expertise and laboratory facilities are made available to the member industries. Forum regularly organizes training programme seminars, workshops, business meets,and so on for the industry on energy and environment topics/issues.

Field Visits

A unique feature of our academic programmes is that every alternate week of the semester, students are taken for field visit to various sites of renewable energy system installations and industries of different types and efficiency levels (from energy use and environment protection point of view). Indore is very ideal centre for this purpose as it has large number of renewable energy system installed in and around Indore—50 000 lpd solar water heating system, 20 MW wind power generating station, 239 KW solar photovoltaic system, 80 M3 biogas plant, and so on. It also has old as well as modern industries of various types (textiles, oil extraction, steel, cement, pharmaceuticals, automobiles, tyre, and so on with related ancillary units). These visits are highly beneficial for the students as they are exposed to various aspects of renewable energy and industries. They also come to know the current energy and environment related problems of the industries and recent technologies being used for their mitigation.

Foreign Collaboration

SEEShas signed a memorandum of understanding with Kun Shan University (Tainan, Taiwan) with the following objectives.

a) Faculty exchange for the purposes of delivering lectures, engaging in research, and participating in ongoing joint projects in various subject areas.
b) Mutual participation of faculty in conferences, congresses, and symposia sponsored by each institution.
c) Sharing of research and published materials in disciplines and areas of interest to both institutions.
d) Join projects in research and curriculum development.
e) Assistance with institution and official networking in the country of each institution and in appropriate international frameworks and organizations.
f) Student exchanges for languages acquisition or diploma-oriented purpose.
g) General academic cooperation.

Academics

PG Programmes and Doctoral Academic Programme

Research leading to Ph D degree is being conducted in the following fields

a) Energy conservation technologies
b) Energy-efficient building design strategies
c) Evaporative air conditioning
d) Thermal performance of earth coupled structures

e) Solar thermal systems with and without storage
f) Solar drying
g) Air, noise, and water pollution
h) Energy conversion from biomass
i) Thermal storage in refrigeration/air conditioning systems
j) Hazardous waste management

Minimum Duration: 2 Years
Eligibility: Post graduate degree in science or engineering with a minimum of 55% marks or equivalent grade.

Postgraduate Academic Programme

1) M.Tech (energy management)
   a) Regular mode – (AICTE Approved)
   b) Distance Education mode-(DEC–Distance Education Council, IGNOU, New Delhi approved)
2) M. Phil. in Energy and Environment. (UGC Sponsored)

This is not a multidegree programme. Candidate at the time of admission will have to give his/her option whether he/she is applying for PGAD in energy auditing or M. Tech. Candidate can change his/her option to higher degree/ diploma option before third semester examination as the case may be.

Infrastructure

SEES is having 5 kW solar power plant to cater to the needs for lighting and other needs of electricity of class rooms, seminar hall, labs, and so on. The infrastructure is excellent in the school and also equipped with latest computers (pentiums), internet connection to most of the computers. All the class rooms are equipped with multimedia projection system.

Laboratories

Under FIST (Fund for Improvement of Science and Technology Infrastructure) programme, the department has procured organic carbon analyser and atomic absorption spectrophotometer. The following laboratories are well equipped with equipments/instruments worth more than Rs one crore

Solar thermal and photovoltaic laboratory

- Energy conservation laboratory
- Heat transfer laboratory
- Biomass/waste management laboratory.
- Thermal energy storage laboratory
- Day and artificial lighting laboratory
- Computer laboratory
- Air, water, and noise pollution laboratory

Library

SEES is fully equipped with recourses in terms of books in library, CD's, computers, and internet facilities. About 5000 books, reports, 150 educational video, CD, and relevant softwares on various aspects of energy and environment are available. The students also have access to the university central library.

Faculties

Some of the well known faculties in SEES are the following.

Dr S P Singh—Professor and Head

Qualifications: Ph D (IIT Delhi, 1989)
Research Interests

- Solar passive buildings and energy systems
- Rural development
- Municipal solid waste management
- Energy and environment
- Energy conservation

Dr Dharam Buddhi—professor

Qualifications : Ph D (IIT Delhi, 1989)
Research Interests

- Thermal storage
- Materials and systems
- Thermal modelling, solar energy
- Energy conservation
- Underground air pipes for heating and cooling of buildings
- Day lighting, control systems
- Air conditioning with storage
- Fuel cell
- Air and water pollution

Dr Rubina Chaudhary—Senior Lecturer

Qualifications: Ph D (AMU Aligarh, 1993)
Research Interests

- Water and waste water pollution
- Hazardous waste management (solidification/stabilization process)
- Solar detoxification

Admission procedure

Admission notice for all the programmes is published in employment news and selected national and local newspapers in the month of April/May.

Admission procedure for Ph.D, M. Tech, M. Phil

Application form can be obtained by sending a demand draft in favour of 'Registrar, DAVV', payable at Indore along with duly stamped (for ordinary, registered, or speed post mail) self addressed envelope. Short listed applicants are selected on the basis of their marks in qualifying examination, and their performance in the interview held in second week of July, separately for each course.

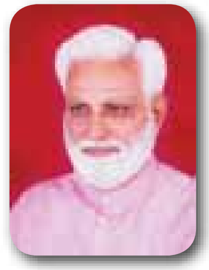
Admission procedure for M. Tech (distance education)

Application form can be obtained by sending a demand draft in favour 'M. Tech Energy Management-Distance Education', payable at Indore. Students will be selected on the basis of their marks obtained in B.E. / B.Tech / Engineering Associations equivalent degree/M.Sc.

Applications along with the details can also be downloaded from the website, www.sees. dauniv.ac.in.

All information has been gathered from the Devi Ahilya Vishwavidyala website: http://www.dauniv.ac.in/teledir/teledir.php
Photo credit: http://www.dauniv.ac.in/teledir/teledir.php

EXPERT SPEAK



Answers to questions on solar energy

DR R L SAWHNEY
Professor, TERI University
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Solar energy is a promising source of future energy supplies because not only is it clean, but also remarkably abundant. Not only is the potential of solar power enormous, we also have the technologies to take advantage of it. We can design our homes to take the maximum benefit of solar energy. Solar water heaters can reduce our electricity bills and solar electricity can power our homes, and even our cars. Solar energy technologies are sooner or later going to take every one by a sheer surprise. Sizeable numbers can come through only by opening up new commercial vistas of applications alongside an increased market deployment of traditional uses. PVT collector use is one such novel application with a ready ability to fulfil multiple energy needs. It can also ensure a maximum possible use of the available roof space. All we have to do is start using it on a wider scale. However, there are many questions in the minds of a consumer who wants to use solar energy in his day-to-day life. This section attempts to answer some such questions, however basic they may be. Dr R L Sawhney, Professor, TERI University fields questions on solar thermal and PV (photovoltaics).

Q. Does solar energy have any effect on the environment?

Ans: Till date there is no proof of any negative effect of solar energy on plants, animals, humans, and the entire ecosystem. However, when solar energy is converted to other usable forms, say thermal or electrical, depending on the conversion technology used, it may affect the environment to a lesser or larger extent. For making the equipment used in the conversion technology, say solar flat plate collectors or solar photovoltaic panels, fossil fuel based energy resources will normally be used which will effect the environment.

Q. What are some of the problems that limit the availability of solar energy as an alternative energy source?

Ans: As far as solar energy is concerned, there are no such problems that limit its availability both from quantity and quality point of view. The amount of solar energy which the earth receives is about 15 000 times more than we require. Although, approximately one-third of it is reflected back by the earth's atmosphere. The balance reaching the earth's surface is virtually inexhaustible to meet the present requirements of human civilization. From quality point of view because it is coming from the sun, which is at about 5500 ^{0}C, by concentrating it through concentrators, theoretically we can achieve this temperature for any high quality application on the earth.

Yes, of course there is problem of temporal mismatch as it is available only during the day time and is not available during the night time for its direct use. But as it is available in abundance during the day time, it can be and is stored in thermal or electrical form to meet the night time energy use requirements.

Q. What is photochemical solar energy?

Ans: When a chemical change occurs as a result of absorption of solar energy in ultraviolet and visible part of the solar spectrum, the energy used is called photochemical energy and the reaction is known as photochemical reaction. Photosynthesis in plants, sensation of light in retina, formation of ground level ozone from the reaction of oxygen and NOx pollutants in the atmosphere are some of the examples of photochemical reactions.

Q. Does solar energy really offer the potential to displace conventional sources of energy?

Ans: As far as the potential of solar energy is concerned, yes it has the potential of replacing all conventional energy sources. It must also be understood that the energy content even in all conventional energy sources has come from the sun.

Of course, there are problems in its wide spread use mainly because of its high cost, lack of awareness, and lack of technical maturity. Also, inertia of the society to adopt new technologies is also one of the main problems. As the number of users of the solar system will grow, the cost of these systems will come down and the technology of these systems will also mature.

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HEATING AND COOLING LOAD OF BUILDINGS FOR DIFFERENT CLIMATIC ZONES OF INDIA USING TRNSYS SOFTWARE

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Introduction

TRNSYS is a complete and extensible simulation environment for the transient simulation of systems, including multi-zone buildings. It is used by engineers and researchers around the world to validate new energy concepts, from simple domestic hot water systems to the design and simulation of buildings and their equipment, including control strategies, occupant behaviour, alternative energy systems (wind, solar, photovoltaic, hydrogen systems), and so on. Over the last 25 years, one of the key factors in TRNSYS' success is its open, modular structure. The source code of the kernel as well as the component models is delivered to the end users. This simplifies extending the existing models to help them fit to the user's specific needs. The DLL-based architecture allows users and third-party developers to easily add custom component models, using all common programming languages (C, C++, PASCAL, FORTRAN, and so on). In addition, TRNSYS can be easily connected to many other applications, for pre- or post-processing or through interactive calls during the simulation (Microsoft Excel, Matlab, COMIS, and so on). TRNSYS applications include the following.

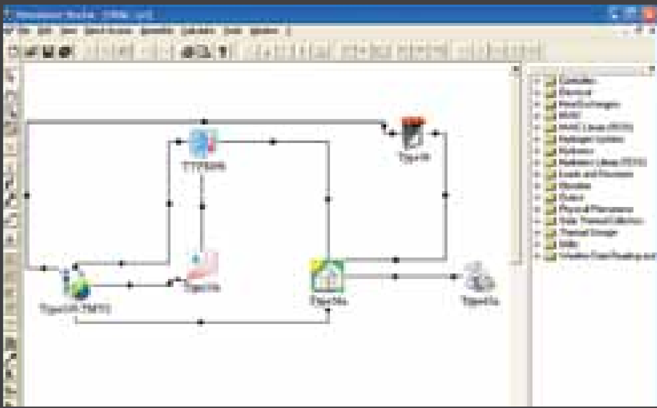
- Solar systems (solar thermal and PV)
- Low energy buildings and HVAC (heating ventilation and air-conditioning) systems with advanced design features (natural ventilation, slab heating/cooling, double façade, and so on)
- Renewable energy systems
- Cogeneration, fuel cells
- Anything that requires dynamic simulation

TRNSYS consists of a suite of programmes: The TRNSYS simulation studio, the simulation engine (TRNDll.dll) and its executable (TRNExe.exe), the building input data visual interface (TRNBuild.exe), and the programmer creates stand-alone redistributable programmes known as TRNSED applications (TRNEdit.exe).

The main visual interface is the TRNSYS simulation studio (formerly known as IISiBat). From there, you can create projects by drag-and-dropping components to the workspace, connecting them together and setting the global simulation parameters. The simulation studio saves the project information in a Trnsys Project File (*.tpf). When you run a simulation, the studio also creates a TRNSYS input file (text file that contains all the information on the simulation but no graphical information). The simulation studio also includes an output manager from where you control the variables that are integrated, printed and/or plotted, and a log/error manager that allows you to study in detail what happened during a simulation. You can also perform many additional tasks from the simulation studio: generate projects using the 'New Project Wizard', generate a skeleton for new components using the Fortran Wizard, view and edit the components proformas (a proforma is the input/output/parameters description of a component), view output files, and so on.

The TRNSYS simulation engine is programmed in FORTRAN and the source is distributed. The engine is compiled into a Windows Dynamic Link Library (DLL), TRNDll. The TRNSYS kernel reads all the information on the simulation (which components are used and how they are connected) in the TRNSYS input file, known as the deck file (*.dck). It also opens additional input files (weather data) and creates output files. The simulation engine is called by an executable programme, TRNExe.exe, which also implements the online plotter, a very useful tool that allows you to view dozens of output variables during a simulation. The online plotter provides some advanced features such as zooming and display of numerical values of the variables at any time step, as shown in the zoom part of Figure B.

TRNBuild (formerly known as Prebid) is the tool used to enter input data for multizone buildings, as shown in Figure C. It allows you to specify all the building structure details, as well as everything that is needed to simulate the thermal behaviour of the building, such as windows optical properties, heating,



◀ *Figure A: The TRNSYS simulation studio*

◀ *Figure C: TRNBuild*

◀ *Figure B: The online plotter in TRNExe*

and cooling schedules, and so on. TRNBuild creates a building description file (*.bui) that includes all the information required to simulate the building. TRNSYS also offers a broad variety of standard components, and many additional libraries are available to expand its capabilities.

TRNSYS and transfer function method

Wall transfer coefficients have been studied for more than three decades to estimate the heat flow into and out of walls when driven by heat flow or temperature sources, usually specified at hourly intervals. Transfer function method is the baseline procedure adopted by ASHRAE and is considered one of the most accurate methods for calculating heating and cooling loads. TRNSYS is transient building simulation software based on transfer function method and finds application in almost all research activities. Whole-building dynamic TRNSYS modelling was employed for energy analysis of the one-room residential building.

Case study: analysis of heating and cooling load of building for different climate zones in India

Walls are basic configuration elements, the transient thermal behaviour of which is an issue of fundamental importance in load control, passive solar control, and energy conservation applications. Economical alternatives to conventional burnt clay bricks are: fly ash brick, hollow block, aerated concrete blocks. In our study, six characteristic exterior wall configurations are considered— conventional burnt clay brick wall, BCBW; Insulated burnt clay brick wall, BCBW(I); cavity wall, CW; fly ash brick wall, FABW; insulated fly ash brick wall, FABW(I) and aerated concrete brick wall , ACBW. For multi layer walls, the insulation is considered in between walls. Here, air insulation, expanded polystyrene insulation and aerated concrete bricks are chosen as insulation medium. Three types of whole building performance data were compared for each type of wall: viz. annual heating loads annual cooling load, and total annual energy load. The economic thickness of insulation material has been discussed already in many papers and in this study, 25 mm is the thickness of expanded polystyrene considered. A window

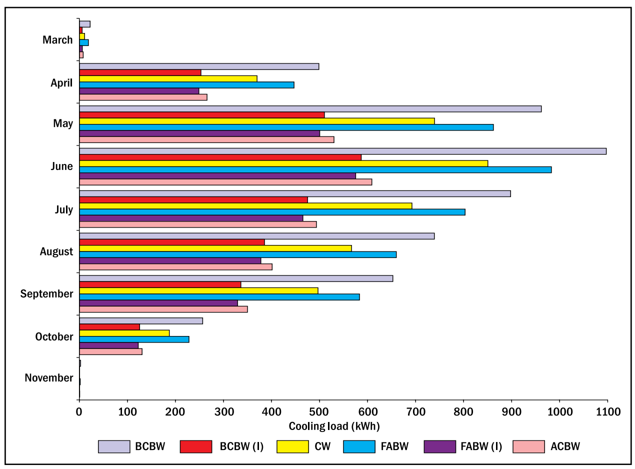


Figure 1 Effect of different wall configurations on cooling load of buildings for New Delhi

Table 1 Details of roof and wall

Roof / Wall	Different layers	Thickness of each layer (m)	Conductivity (Wm-1K-1)	Resistance (m^2KW-1)	U-value (Wm-2K-1)
Roof	Broken tile	0.025	0.811	0.0308	2.28
	RCC	0.1	1.58	0.0633	
	Mudphuska	0.08	0.519	0.1541	
	Plaster	0.015	0.721	0.0208	
Insulated roof	Broken tile	0.025	0.811	0.0308	0.87
	RCC	0.1	1.58	0.0633	
	EPS*	0.025	0.035	0.7143	
	Mudphuska	0.08	0.519	0.1541	
	Plaster	0.015	0.721	0.0208	
Burnt clay brick Wall [BCBW]	Plaster	0.015	0.721	0.0346	2.02
	Brick wall	0.23	0.811	0.2836	
	Plaster	0.015	0.721	0.0208	
Insulated burnt clay brick wall [BCBW(I)]	Plaster	0.015	0.721	0.0208	0.52
	Brick wall	0.11	0.811	0.0863	
	EPS*	0.05	0.035	1.4286	
	Brick wall	0.11	0.811	0.1356	
	Plaster	0.015	0.721	0.0208	
Cavity wall [CW]	Plaster	0.015	0.721	0.0208	1.22
	Brick wall	0.11	0.811	0.0863	
	Air	0.05	-	0.1692	
	Brick wall	0.11	0.811	0.1356	
	Plaster	0.015	0.721	0.0208	
Aerated concrete brick wall [ACBW]	Plaster	0.015	0.721	0.0208	0.61
	Cellular bricks	0.23	0.16	1.4375	
	Plaster	0.015	0.721	0.0208	
Fly ash brick Wall [FABW]	Plaster	0.015	0.721	0.0208	1.49
	Fly ash brick	0.23	0.5	0.46	
	Plaster	0.015	0.721	0.0208	
Insulated fly ash brick wall [FABW(I)]	Plaster	0.015	0.721	0.0208	
	Fly ash brick	0.07	0.5	0.14	
	EPS*	0025/ 0.05/ 0.075	0.035	0.7143	0.72/ 0.48/ 0.36
	Fly ash brick	0.11	0.5	0.22	
	Plaster	0.015	0.15	0.0208	

ho = 25 W^{m-2K-1} and hi = 7.7 W^{m-2K-1} ; *EPS – Expanded polystyrene insulation

of size 2.5m × 1 m is considered on south facing wall. Different types of windows, taken in the study are, single glass window, SG; air filled double glass window, DG(air), krypton filled double glass window, DG(Kr) and low-e coated, argon filled double glass window, low-e DG(Ar). During summers, window is completely shaded in order to avoid the undesirable solar gain and vice versa for winter season. Tables 1 and 2 give details about wall elements and windows respectively.

A simple one room model of a building, 4 m × 4m × 3m, exposed to hourly variation of solar radiation and temperature, is analysed to illustrate the effect of material and its configuration on the cooling and heating load. It also gives some insight into the complicated problems of real buildings. Initially heating and cooling load analysis has been done only for the New Delhi station. Different energy-efficient measures considered are: (i) different wall configuration (ii) effect of thickness of insulation (iii) effect of ventilation (iv) effect of different type of windows. In all cases except burnt clay brick wall and fly ash brick wall, roof is considered with 25mm thick insulation of expanded polystyrene. Finally, after selecting suitable insulation thickness, ventilation and window type, its effect on cooling and heating load has been studied for four different weather stations—New Delhi, Chennai, Guwahati, and Shillong. Figure 1 shows the effect of different wall configurations on cooling load of buildings for New Delhi. Here insulated single glass window and ventilation of three air changes per hour have been used. In insulated walls, expanded polystyrene insulation of thickness 50mm is considered in-between walls.

Among all types of walls, insulated fly ash brick wall, FABW(I) is found to be most energy efficient. The requirement of cooling is for seven months, from April to October, and the maximum cooling load is in the month of June. The ambient temperature of Delhi in cooling months ranges from 17 °C to 44.3 °C. FABW(I) consumes nearly half the cooling load of normal conventional brick wall, BCBW. BCBW (I) and aerated concrete brick wall have performed equally well as compared to FABW(I). The effects of ventilation and different windows have been studied only for FABW(I). The effect of

Table 2. Details of window

Window type	Filling gas	U-value (W^{m-2K-1})	Solar heat gain coefficient	Solar transmittance
Single Glass	-	5.68	0.855	0.83
Double glass	Air	2.83	0.755	0.693
Double glass	Krypton	0.81	0.632	0.462
Low-e, double glass	Argon	1.26	0.212	0.138

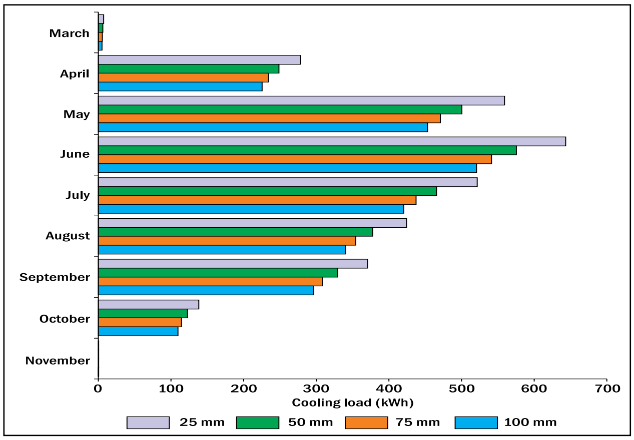


Figure 2 The effect of different insulation thickness

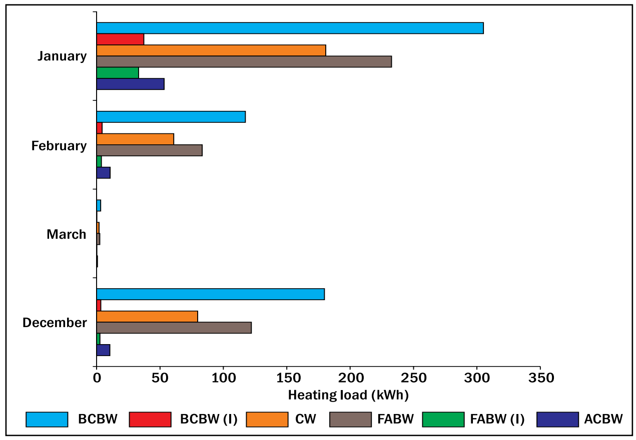


Figure 5 Heating load requirement for different wall configurations

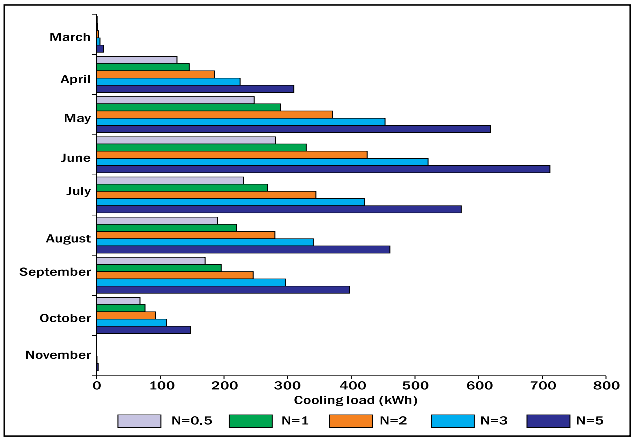


Figure 3 Results for ventilation

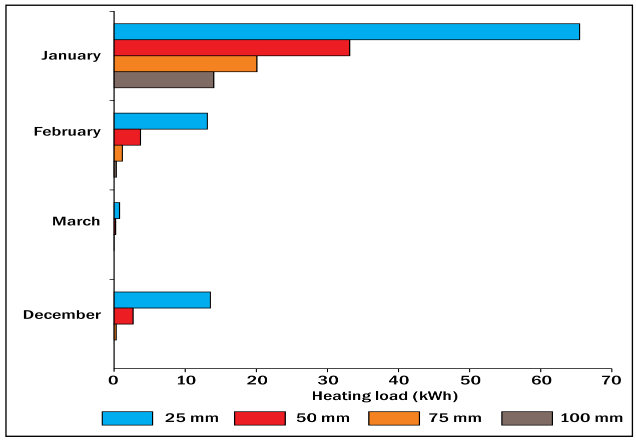


Figure 6 Effect of insulation thickness

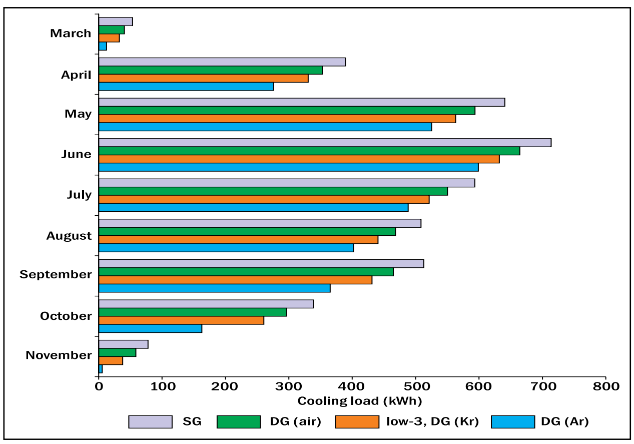


Figure 4 Low-e coated, argon filled double glass windows perform better than other windows during summers

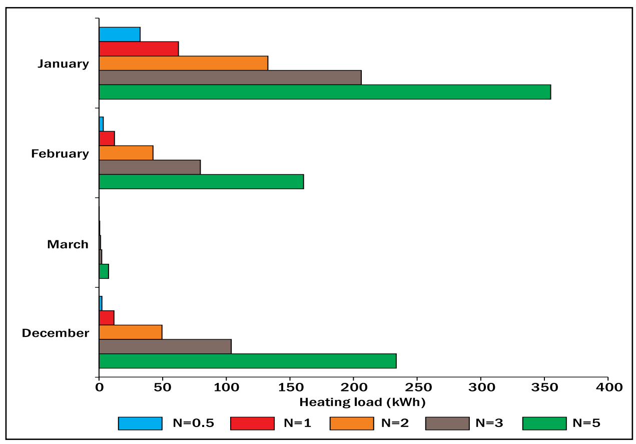


Figure 7 Effect of ventilation

different insulation thickness analysed is considered and it is shown in Figure 2. It is found, that there is no marked decrease in cooling load, if insulation thickness is beyond 50 mm. So, further simulation has been carried out with FABW (I) type wall having 50 mm of insulation. Results for ventilation are shown in Figure 3. And it is found, that the cooling load increases with increase in ventilation, For selected 3 ACH, the effect of different types of windows on cooling load has been analysed. Low-e coated, argon filled double glass window performs better than other types of window during summers, because of lack of solar

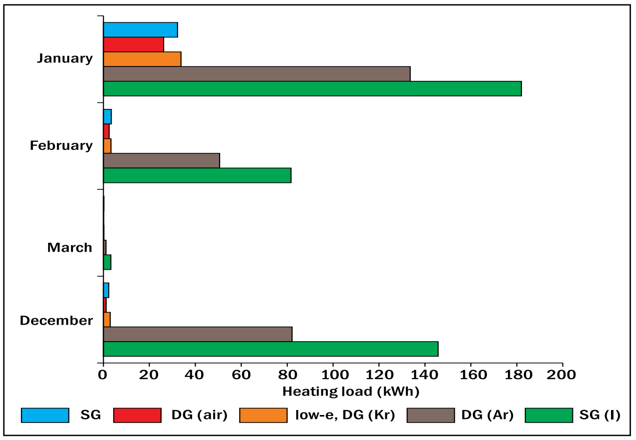


Figure 8 Effect of different windows

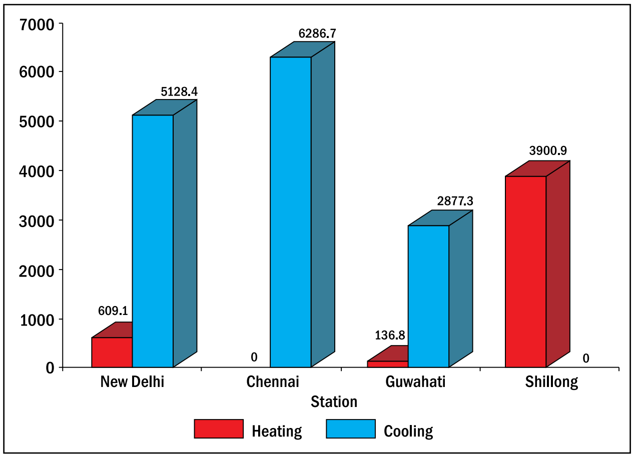


Figure 9 Heating and cooling load of conventional burnt clay brick wall building for different stations

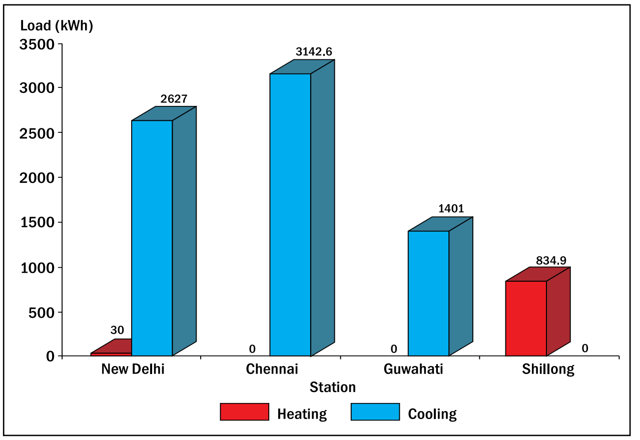


Figure 10 Heating and cooling load of insulated fly ash brick wall building for different stations

gain and less thermal transmittance. And this effect is shown in Figure 4. Similar analysis has been done for heating load also.

The total month consumption of heating load is three, from December to February. The cooling load requirement is negligible in the month of March for conventional BCBW. The heating load requirement for different wall configurations is shown in Figure 5. Here insulated single glass window, ventilation of 0.5 ACH and 50 mm EPS insulation in between wall have been taken. FABW(I) building consumes 8%–10 % of total heating consumed by BCBW building. Further the effect of insulation thickness, effect of ventilation and effect of different windows are shown in Figures. 6, 7, and 8 respectively.

The average temperature of Delhi in summer months ranges from 5 °C to 34 °C. As there is more requirement of direct solar gain and the gained heat should be retained inside the room, double glass window with air filled is found to be more efficient than other types of window with ventilation of 0.5 ACH. Here also more air changes per hour would lead to more heating loss from the room. Finally for selective energy-efficient measures the cooling load and heating load are analysed for four different stations and its effect is shown for BCBW and FABW(I) in the Figures 9 and 10 respectively.

The EPS insulation thickness, ventilation, and window type selected for summer climatic condition are 50mm, 3 ACH and Low-e coated, argon filled double glass window respectively. Similarly for winters, 50mm EPS insulation, ventilation of 0.5 ACH and window of type double glass with air filled are taken. Insulated fly ash brick wall is more efficient for winter climatic condition compared to summer climatic condition. It is clearly inferred that there is no cooling load requirement for Shillong, and no heating load requirement for Chennai. In a year, the ambient temperature of Chennai varies from 20 °C–40 °C and 1 °C–25 °C for Shillong station. Once FABW(I) is selected, there is no heating requirement for Guwahati, saving almost all heating load. And there is 95% reduction in heating load for New Delhi. The ambient temperature of Guwahati varies from 8 °C to 30 °C in a year. There is about 50 % reduction in cooling load for Delhi, Chennai, and Guwahati. Among all stations, Chennai requires more cooling load because of hot and humid climate. New Delhi requires maximum cooling load and very low heating load. Annual heating and cooling load of Delhi is reduced by roughly 50%–55% for Delhi, Chennai, and Guwahati. There is huge reduction in heating, about 80% in case of Shillong. It is very clear that FABW(I) is more energy-efficient for winter season.

Conclusion

1. By putting 50mm of EPS insulation in FABW, there is reduction of 80%–90% in the heating load and 50%–55% reduction in cooling load.
2. It has been found that 0.5 ACH for winter and 3 ACH are adequate for proper ventilation
3. Among different types of window. Low-e, double glass, with Argon filled performs better in summer climate, and double glazed window with air filling, which performs better in winter climate.

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HALONIX PRISM SOLAR LANTERN

Halonix Technologies Ltd

Energy is a basic requirement for the existence and development of human life. The commercial sources such as fossil fuels, hydroelectric power and nuclear power provide the energy needs of a country. The demand for energy is growing at an alarming rate year after year. The fossil fuels are rapidly depleting and the era of fossil fuel is gradually coming to an end. In addition, the release of greenhouse gases into the atmosphere is causing problems for all living organisms. The fear of release of radioactivity into the atmosphere in the unlikely event of an accident or from nuclear waste has forced people to reconsider the use of nuclear power. In view of problems associated with conventional energy sources, the focus is now shifting to conservation and search for renewable sources of energy that are also environmentally friendly.

There are 7 000 000 villages in India and most of them are still unelectrified. Electrification of all villages is anticipated within a decade, requiring substantial capital investment. In India nearly 500M million people are using kerosene for their day to day lighting needs and an estimated billion people in the world have no access to electrical power.

Use of electricity and kerosene for lighting in rural areas is inefficient due to, large transmission and distribution losses and use of low efficiency devices such as incandescent bulbs and kerosene lanterns. The kerosene fumes are slow poison causing serious diseases including cancer.

The alternative lighting provided by solar photovoltaic power could increase the quality of life by offering good quality light for education and work during the night while minimizing air emissions that can create health problems. Sun has abundance of energy and potential to feed the all energy requirements irrespective of geographical location. Solar powered lantern is one of the lighting solutions which can reach the remotest part of the country and globe.

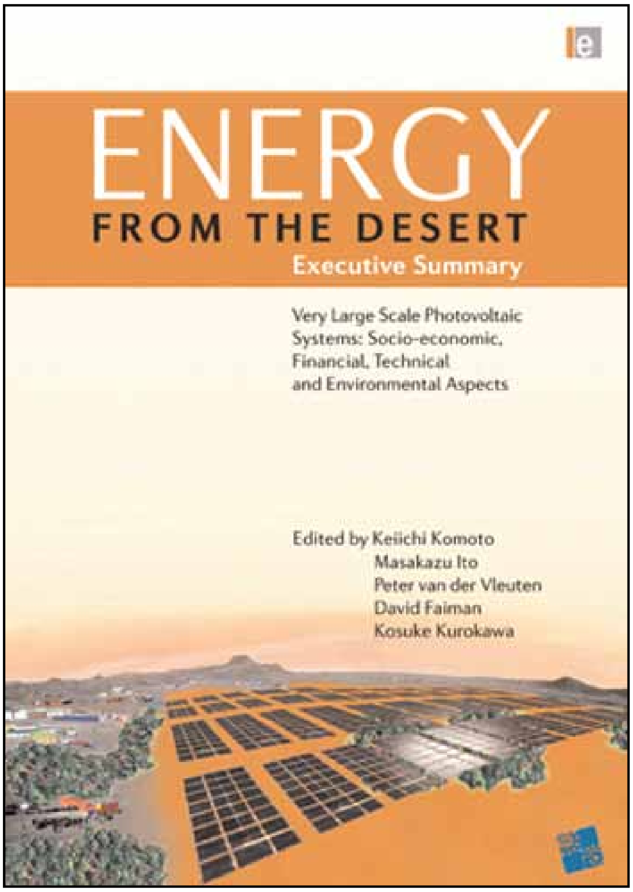
Halonix Limited (formerly known as Phoenix Lamps Limited), got promoted in the year 1991 as an Indo-Japanese Joint Venture. We have pioneered cutting edge energy saving lighting technologies like HALOGEN and CFL (Compact Fluorescent Lamp) in India. We are privileged to have dominant market shares as the first entrant in India. We take pride in introducing Solid State Lighting technology as the future lighting source in India. We have been accredited with ISO 9001: 2000, ISO/TS 16949: 2002, ISO 14001: 2004 and OHSAS 18001: 2007 certificates, which is a clear evidence of our superior performance and commitment towards achieving excellence. Halonix has received several patents and many are under consideration.

The Halonix Prism Solar Lantern designed for LaBL project in collaboration with TERI incorporates

- Highly efficient LED over 100 lumen per watt to give 3600 white light soothing to the eyes.
- A sealed maintenance-free battery stores generated electricity for use at night-time.
- Charge controller efficiently charges the battery and protects the battery from overcharging and deep discharging.
- The driver to provide multimode light output by efficiently converting the power.
- A Battery monitor display indicates the status of the battery. Two LEDs indicate charging and low battery status.
- High tensile strength of polycarbonate casing provided for robust applications.

Energy from the Desert

Very Large Scale Photovoltaic Systems: socio-economic, financial, technical and environmental aspects



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The world's deserts are sufficiently large that, in theory, covering a fraction of their landmass with PV systems could generate many times the current primary global energy supply. When the International Energy Agency's Photovoltaic Programme IEA PVPS Task 8 – Study on Very Large-Scale Photovoltaic Generation Systems – was set up in 1999, VLS-PV (very large-scale photovoltaic systems) were seen as a futuristic concept with little relationship to reality. However, in the last ten years a lot of things have changed. And VLS-PV has become closer to reality. Through international co-operation of experienced nations, Task8 has achieved a comprehensive analysis of all the major issues of such large scale applications, based on latest scientific and technological developments. The first concrete set published in 2003 was titled—*Energy from the Desert -Feasibility of Very Large Scale Photovoltaic Power Generation (VLS-PV) System*. The publication is well-known in all over the world, especially, in desert countries. Furthermore, Task 8 studied and proposed more in-depth, realistic, practical, and demonstrative approaches toward the realization of VLS-PV in different deserts of the world. The results were published in 2007 titled—*Energy from the Desert - Practical Proposals for Very Large Scale Photovoltaic Systems*. This publication showed how to make Very Large Scale PV Systems happen in the desert. In September 2009, Task8 published the latest report titled *Energy from the Desert –Very Large Scale Photovoltaic Systems, Socio-Economic, Financial, Technical and Environmental Aspects*.

Thus, *Energy from the Desert –Very Large Scale Photovoltaic Systems, Socio-Economic, Financial, Technical and Environmental Aspects* is the 'Energy from the Desert' series and is one step forward towards realization of VLS-PV. It provides detailed coverage of technology and financing options (including recent and future trends in PV technology), potential social benefits such as desalination and agricultural development, and environmental and ecological impacts of systems and how these can be monitored, illustrated by case studies from the Sahara and Gobi Deserts.

The book has been able to achieve a comprehensive analysis of all major issues involved in such large-scale applications based on the latest scientific and technological developments and by means of close international cooperation with experts from different countries. This book provides detailed coverage of technology and financing options (including trends in PV technology), and potential social benefits such as desalination and agricultural development.

The book is divided into eight chapters and deals with technical, social, financial, environmental aspects separately. It gives detailed case studies of Gobi and Sahara Deserts. The concluding section consists of a roadmap outlining the options and opportunities for future implementation of VLS-PV. Building on the key concepts and case studies of previous volumes, this will be a key text for policy-makers and investors in the field.

Global Solar Energy, Inc.

The official website of Global Solar Energy, Inc. provides comprehensive information on the company and on solar energy. The website has four main sections—company, products, technology, and press. It has a section for news and a separate section for events. The section on company provides information on the company. The section on products gives information on various products that the company is manufacturing. The section on technology carries all the technical innovations at Gobal Solar Energy, Inc.

http://www.globalsolar.com/en/technology/innovations.html/

Solar Electric Power Association

TSEPA (Solar Electric Power Association) is a not-for-profit association for information on solar technologies, policies, and programmes. SEPA's website has news section, which provides elaborate news on solar energy, and works undertaken by SEPA. The website also provides information on utilities, stakeholders, and solar companies. The website has a separate section for consumers to gather information on various solar products and their cost, and solar companies. The section, 'Member Centre', is the personalized portion of the SEPA website. In this section, one can manage profile, purchase products, and search the membership directory. Utilize this site to get the most out of your SEPA experience! The website also contains member benefits, directory by organization, transactions, and so on for members. The website has a separate section on SEPA events.

http://www.solarelectricpower.org/

SolarEnergyLive.com

This site is for all those people who are interested in protecting nature and its resources by using devices that are eco-friendly in sustaining our daily work. The website has articles on solar energy systems such as solar panels, news on the latest inventions in what concerns solar energy capturing, and tips on how to save money on the electricity bills. The site also contains videos, photos on solar panels and solar system homes, and a guide on how to install a solar panel on someone's property, how to test it, how to repair it, and so on.

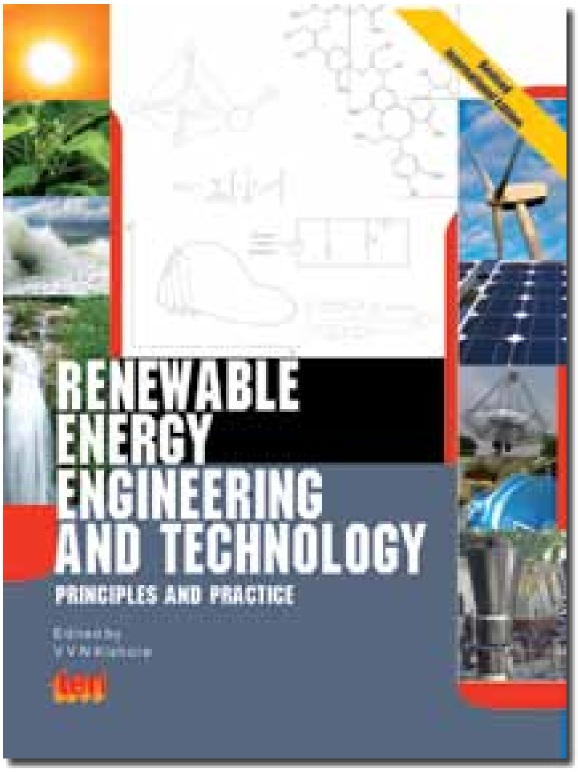
http://solarenergylive.com/

Solar Heating and Cooling Programme

The Solar Heating and Cooling Programme was established in 1977 as one of the first programmes of the International Energy Agency. The programme is accomplished through the international collaborative effort of experts from Member countries of European Union and the European Commission. The official website contains detail information on the programme, industry collaboration, newsletter, calendar of events, and other related sites. As of now, 'The Solar Heat Worldwide 2009 Report' is available.

http://www.iea-shc.org/

NEW BOOK INFORMATION



Renewable Energy Engineering and Technology: Principles and Practice

Revised international edition

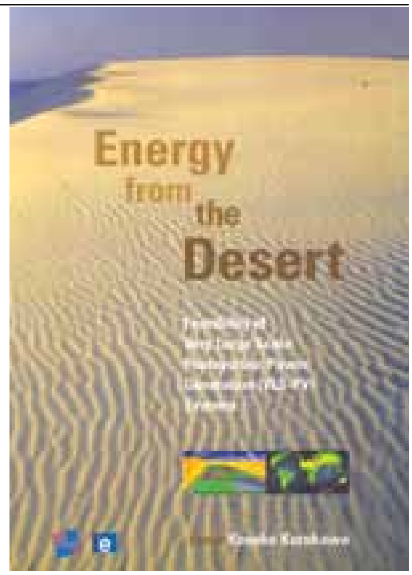
Renewable Energy Engineering and Technology: Principles and Practice is a comprehensive guide to renewable technologies and engineering, intended to cater to the rapidly growing number of present and future engineers who are keen to lead the renewable energy revolution.

All the main sectors are covered – photovoltaics, solar thermal, wind, bioenergy hydro, wave/tidal, geothermal – progressing from the fundamental physical principles, through resource assessment and site evaluation, to in-depth examination of the characteristics and deployment of the various technologies. All the authors are experienced practitioners, and thus recognize the cross-cutting importance of system sizing and integration. Lucid diagrams, photos, tables, and equations make this an invaluable reference tool, and thus an essential read for students and professionals.

Edited by V V N Kishore
New Delhi: TERI Press, ISBN: 978-81-7993-221-6
Year : 2009 • Price: Rs. 2250/-

Energy from the Desert: Feasibility of Very Large Scale Photovoltaic Power Generation (VLS-PV) Systems

The world's deserts are sufficiently large that, in theory, covering a fraction of their landmass with PV systems could generate many times the current primary global energy supply. Moreover, the energy produced is from solar radiation—a clean and renewable source. Hence such systems would have the potential to contribute massively to the protection of the global environment. This book is an extensive and high-level internationally study, representing the accumulated research of the world experts involved in Task VIII of the IEA PVPS programme. To date, the market focus for photovoltaics has been on small to medium, stand-alone or building-integrated power systems, which have proven, but as yet not realized, the great potential of this technology. This definitive study evaluates the feasibility, potential, and global benefits of VLS-PV (very large-scale photovoltaic power generation) systems deployed in desert areas and each generating from 10 MW to several gigawatts. In addition, the study provides specific case study options for VLS-PV in desert areas, including the Sahara, Gobi, and Negev deserts, and three in-depth scenarios are used to demonstrate that sustainable economic growth, sustainable technological-environmental development, and sustainable financial support are possible when a long term perspective is developed and maintained.



Kosuke Kurokawa
Hardback, 195 pp.
ISBN 978-1-90291-641-5

NATIONAL AND INTERNATIONAL EVENTS

Power Gen India and Central Asia
21–23 April 2010
Bombay Exhibition Centre
Goregaon, Mumbai
URL: www.power-genindia.com

Empower India 2010
25–27 June 2010
Chennai Trade Centre
URL: www.empower-india.com

Delhi International Renewable Energy Conference
27–29 October 2010
Expo Centre - Expo XXI, National Capital Region of Delhi
URL: www.direc2010.gov.in

International Green Energy Expo Korea 2010
7–9 April 2010
Daegu, South Korea
Tel: 82 53 6015 082
Fax: 82 53 6015 372
E Mail: green@energyexpo.co.kr
URL: www.energyexpo.co.kr

International Conference on Concentrating Photovoltaic Systems
7–9 April 2010
Freiburg, Germany
Tel: 49 0761 4791448
Fax: 49 0761 4791444
E Mail: info@cpv-conference.org
URL: www.cpv-conference.org

ENERSOL Expo 2010
7–10 April 2010
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Fax: 216 71 79 4200
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URL: www.exposervicestunisie.com/enersol

6th International Congress & Exhibition on Energy Efficiency and Renewable Energy Sources
14–16 April 2010
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URL: www.viaexpo.com

2nd PV Summit Asia
15–16 April 2010
Beijing, China
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Fax: 86 21 624788 38
E Mail: info@merisis-asia.com
URL: www.merisis-asia.com/pv2010

Conference: SolarTech' Leadership Summit Summit.
21–22 April 2010
San Ramon, California, USA
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E Mail: frodet@solartech.org
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Thin-Film Industry Forum
22–23 April 2010
Berlin, Germany
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E Mail: info@solarpraxis.de
URL: www.solarpraxis.de

PHOTON's 8th Solar Silicon Conference
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Stuttgart, Germany
Tel: 49 241 4003-102
Fax: 49 241 4003-302
E Mail: office@viaexpo.com
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5th European PV-Hybrid & Mini-Grid Conference
29–30 April 2010
Barcelona, Spain
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URL: www.otti.de

Conference: Photovoltaics Summit 2010
3–5 May 2010
San Diego, California, USA
Tel: 1 207 781 9635
E Mail: christopher.smith@pira-international.com
URL: www.photovoltaicssummit.com

SNEC PV Power Expo 2010
5–7 May 2010
Shanghai, China
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E Mail: cathychu2007@163.com
URL: www.snec.org.cn

Solarexpo and Greenbuilding 2010
5–7 May 2010
Verona, Italy
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URL: www.greenpowerconferences.com

Solar 2010
17–22 May 2010
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E Mail: ases@ases.org
URL: www.ases.org

2010 International Renewable Energy Fair
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Exhibition: Semicon Singapore 2010
19–21 May 2010
Singapore
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E Mail: dtracy@semi.org
URL: www.semiconsingapore.org

PV America
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Tampa, Florida, United States
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E Mail: info@seia.org
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4th Renexpo Central Europe 2009
27–29 May 2010
Budapest, Hungary
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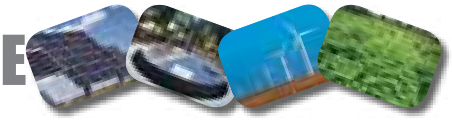
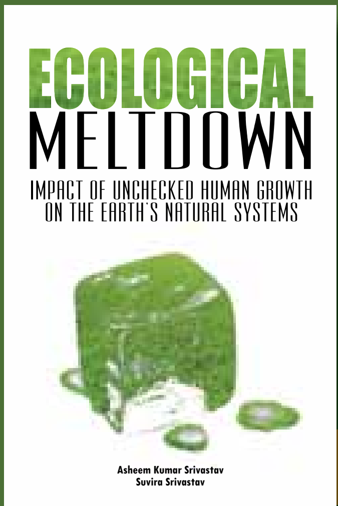
RENEWABLE ENERGY AT A GLANCE



S.No.	Source/system	Estimated potential	Achievement as on 31 December 2009
I	**Power from renewables**		
A	**Grid-interactive renewable power**	(MW)	(MW)
1	Wind power	45 195	10925.00
2	Bio power (agro residues and plantations)	16 881	834.50
3	Bagasse cogeneration	5 000	1 302.00
4	Small hydro power (up to 25 MW)	15 000	2 558.92
5	Energy recovery from waste (MW)	2 700	65.01
6	Solar photovoltaic power	—	9.13
	Sub total (A)	**84 776**	**15694.56**
B	**Captive/combined heat and power/distributed renewable power**		(MW)
7	Biomass/cogeneration (non-bagasse)	—	210.57
8	Biomass gasifier	—	109.62
9	Energy recovery from waste	—	37.97
10	Aero generator/hybrid systems		0.95
	Sub total (B)	**—**	**359.11**
	Total (A+B)	**—**	**16053.67**
II	**Remote village electrification**	—	5554 villages/hamlets
III	**Decentralized energy systems**		
11	Family-type biogas plants	120 lakh	41.42 lakh
12	Solar photovoltaic systems	50 MW/km^2	120 MWp
	i. Solar street lighting system	—	88 297 nos
	ii. Home lighting system	—	550 743 nos
	iii. Solar lantern	—	792 285 nos
	iv. Solar power plants	—	2.39 MW_p
	v. Solar photovoltaic pumps		7247 nos
13	Solar thermal systems		
	i. Solar water heating systems	140 million m^2 collector area	3.12 million m^2 collector area
	ii. Solar cookers		6.57 lakh
14	Wind pumps		1347 nos
IV	**Awareness programmes**		
15	Energy parks	—	511 nos
16	Aditya Solar Shops	—	284 nos
17	Renewable energy clubs	—	521 nos
18	District Advisory Committees	—	560 nos

MW – megawatt; kW – kilowatt; MW_p – megawatt peak; m^2 – square metre; km^2 – kilometre square

NEW ARRIVAL



The Ecological Meltdown:

impact of unchecked human growth on the earth's natural systems

By

Asheem Kumar Srivastav is a senior civil servant (Indian Forest Service) professionally trained in environment and natural resource management

Suvira Srivastav is a development communicator and an environment journalist

ISBN: 978-81-7993-278-0; Number of Pages: 250 (approx)
Year: 2010; Size: 6 x 9 inches

Description

The book rings alarm bells of the ecological meltdown, footsteps of which are getting louder with every passing day. The difference between the current recession, and the one mentioned in the book is that there are ways and means to recover from a financial crisis. However, the picture that emerges from the exhaustive analysis of international data drawn from the most reliable sources clearly indicates that we have reached a point of no return: humanity has gained access to the gateway of extinction where the other biological species will disappear first followed by humans.

The book reinforces the key findings of the millennium ecosystem assessment report of the UN that humans have made unprecedented changes to the ecosystems and this pressure will increase globally, in coming decades, unless human attitudes and actions change.

Features

- Thoroughly researched and analytical
- Authoritative and up-to-date data from the most authentic sources
- Scientific data supported by graphs, figures, and tables
- Offers a global as well as Indian perspective on the issues
- A must read for all those who are concerned for the planet's future

Contents

- Humanity's ecological footprints: the ecological meltdown
- Earth's carrying capacity; co-relation between population dynamics and biodiversity; India in 2050
- State of global forests; Global wood fuel analysis; grazing impact in India
- Global Protected area assessment
- Wild species and challenges of illegal trade
- Conservation funds, impact of wars and civil strife; Global military budget
- Relevance of International legal agreements concerning biodiversity
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