We train our engineers as social engineers who create special rapport with the rural community they serve. Our engineers sit with local leaders, and teachers and hold demonstration meetings in schools, colleges, mosques, and other public places. We also organize special programmes for schools to create awareness among students, who in turn spread the knowledge among the parents and neighbours about renewable energy technologies.

understanding of the needs, likes, and dislikes of the local people and are better trusted. One of our key strategies is to include women in promotion, repair, and maintenance of the installed systems. We do this by training rural women to assemble, repair, and maintain the systems in their community. The women are trained to take care of the systems in their homes.

We have developed an innovative installment-based financial mechanism, which reduces the cost of a system to monthly kerosene cost. We blend this with effective and strong grassroots level after-sales service. For example, our engineers undertakes monthly visit to each customer's home to provide free after-sales service for nearly 2–3 years.

All these translate into well-kept systems and happy customers who every day demonstrate to their neighbours the effectiveness of Solar Home Systems. We are of the opinion that once a solar system is installed in a community, it promotes itself and sells on its own.

Q2 You have been one of the pioneering figures in revolutionizing the sustainable energy future of Bangladesh. And, the result is that today, solar energy is a household name in Bangladesh. With what specific objectives did you start this movement and has it transformed itself into a market driven pursuit in the field of solar energy?

As I have mentioned earlier, I wanted to give rural people better opportunities to change their lives and circumstances. One of my goals was to replace kerosene and rescue the rural people from the dim and smoky light and provide them with modern amenities such as bright lights, access to television, and mobile phones, with a focus on energy savings and income generation. We wanted to do this by developing a financial and technical package, which would reduce the cost of a Solar Home System to the monthly cost of kerosene. Initially, the cost was high and growth was slow. However, over time we gained the confidence of the people and our sales increased, which meant that we were able to reduce the cost and offer better credit terms to our customers. Technological innovations also helped to reduce the cost.

We have successfully achieved a unique blend of market and community forces to make solar energy a household name. For example , we offer soft credit coupled with 2–3 years of free after-sales service, which translates into better utility at the same cost as that of kerosene. Our systems lasts for more than 20 years and need very little repair and maintenance. Hence, as the price of kerosene goes up, the price of solar systems goes down. Our programmes create clean green jobs, for the local youth, especially for rural women. Many rural women are earning more than their counterparts in the garment factories by assembling and repairing solar accessories, such as charge controllers, mobile chargers, invertors,and so on in their homes. We have rejuvenated rural businesses by extending working hours, providing easy access to mobile phones, and especially attracting more customers through bright light, television, and mobile phones in rural shops. Solar light means rural children can study for longer hours,

We have broken the myth that renewable energy technologies are not appropriate for the rural people on a mass scale. We have demonstrated that if an appropriate business model is followed, renewable energy technologies can bring revolutionary changes in the lives of rural people.

and our mothers and sisters do not have to work under dim kerosene light, suffer from indoor air pollution or fire hazards. We take up social programmes such as creating awareness about renewable energy among rural school children, offering scholarship to children of solar system owners, and organizing free training camps for rural women.

Solar has become part of the rural way of life, touching every corner of their lives. We are installing more than 24 000 solar systems each month, with more than 500 000 systems already installed.

We are on the threshold of a solar revolution. If we can accelerate the momentum that has already been generated, we will be able to create a solar nation by 2015.

Q3 You are also credited with the exponential growth and profitability of Grameen Bank. Could you elaborate on how you used micro-credit to finance the solar energy project? Also, in your opinion, should the other developing countries continue with a subsidy driven market, which does not always work as a catalyst for the real growth of low cost technologies?

My experience with Grameen Bank gave me vast knowledge of the needs and aspirations of the rural people. I used this experience to develop a unique financial and technical package to reach out to the rural people with renewable energy technologies. I cannot call this micro-credit. Unlike micro-credit, soft credit is just one element, which must be blended with other key elements, such as long-lasting durable technology, cost-effective and strong after-sales service, availability of spare parts, and especially participation and acceptance of the local community, to create a viable model for the rural people.

My success lies in the fact that I was able to device a financial mechanism which helped rural people to replace kerosene, have bright lights, power their television and mobile phone while saving costs, and create opportunities for income generation. Rural people realized that it was more practical and economical to install a solar-backed light in their homes and shops instead of lighting up a kerosene lamp.

Currently, we reach a slightly higher target group than that of micro-credit. However, we are in the process of popularizing Pico systems, which will allow us to reach out to people from all income groups.

We have broken the myth that renewable energy technologies are not appropriate for the rural people on a mass scale. We have demonstrated that if an appropriate business model is followed, renewable energy technologies can bring revolutionary changes in the lives of rural people. So, I suggest that renewable energy companies in developing countries should develop market-based models for their people, instead of a subsidy-based model. Instead of subsidies, they should focus on designing financial and technical packages, which will meet the basic needs of the people, allow them to generate income, and save costs. They should also focus on quality products and strong, grassroot-level after-sales service, instead of just focusing on low cost.

Q4. Could you elaborate on the reasons for choosing Solar Photovoltaic Home Lighting Systems (SHLS) despite these being expensive in comparison to other technologies that are more acceptable in the rural areas such as biomass? Are there still any serious concerns vis-à-vis the actual field operating performance of SHLS?

Bangladesh receives a lot of sunshine. That is why I started with the Solar Home Systems. Solar Home Systems are easy to install, need very little repair and

maintenance, and last for nearly 20 years. Over the years, we were able to offer more efficient systems at lower costs, thanks to technological upgradation and scaling up of our programmes. Continuous supply of biomass (cow dung, straw) can be a problem, while solar power is free. Similarly, installation and maintenance of biomass-based technology is a challenge and it is difficult to achieve uniform standard. Solar Homes Systems gives a customer plug and play options, such as adding more power, and moving the system from one place to another.

Solar Home Systems are increasingly becoming more efficient and cost effective. People in the rural areas are installing solar systems to light up their homes, businesses, schools, and health centres. Many people are installing more than one Solar Home System. There is huge demand for solar and this is increasing each year. There is no concern with the actual performance of Solar Home Systems.

Q5. You have taken the servicing facility of solar systems right at the doorstep of the rural people. Is that a convenient approach for the urban-based PV manufacturing companies to emulate on a large scale?

In urban areas, stand alone systems cannot be cost-effective. We need to develop special models for grid-connect systems. I am in the process of developing 1–10 MW system linked with bank financing. I am also working with the government to develop an appropriate tariff policy, which would make solar attractive in the urban areas. We can utilize 50%–75% of the urban rooftops for harnessing solar energy.

Q6. On the one hand, in the rural areas of Bangladesh, the illiterate women trained in the local centre are adept at assembling and repairing of the solar systems installed in these areas. But, on the other hand, many a times the solar systems deployed in the urban areas await the services of trained technicians for several days despite an easy accessibility. What is your opinion regarding this dichotomy?

We have few Solar Home Systems in the urban areas, and therefore, we have few after-sales service providers. We will need to develop and localize our capacity in the urban areas, based on the number of rooftop households that we have reached. More skilled technicians are available in the urban areas, as people want to live in urban areas. On the other hand, cost would be higher in the urban areas as wages, travel, and other related costs would be higher. It is also true that urban people have the ability to pay more, especially if quality service is offered.

Q7. Your initiatives and achievements in the field of solar energy are unparalleled in the world. You have also received numerous awards for the exemplary work. In your opinion, what is your greatest achievement in the field of renewable energy and sustainable development?

I feel my greatest achievement is that I have been able to create an integrated, sustainable market-based model to take renewable energy to the rural people who live without grid electricity and are deprived of all the related benefits.

My initial success attracted policy-makers and a programme was taken up through Infrastructure Development Company Limited (IDCOL) to initiate and scale up my model in Bangladesh during 2002/03. This greatly inspired me and was a milestone for the renewable

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I plan to take renewable energy, especially solar energy to the next stage of growth in Bangladesh through an innovative entrepreneur based-business model. By 2015, I want to reach to 7.5 million people in Bangladesh by creating 100 000 rural-based entrepreneurs, especially women who will assemble, install, repair, and maintain the systems.

energy sector in Bangladesh. Currently, Bangladesh has one of the largest and fastest growing Solar PV technology programmes in the world with more than 15 rural-based RET organizations working all over the country. One of my key achievements has been to change the mindset of our policy-makers who did not believe that renewable energy was a viable option for the rural people, especially through a market-based model.

However, what makes me most happy is that we have been able to integrate rural women in our success story. We have trained more than 1000 rural women as solar and improved cooking stove technicians who are working in the rural areas. We are implementing this programme through rural-based technology centres. When we started this programme, we were not sure whether we would be able to attract enough rural women or whether they would be able to operate independently.

Q8. After an illustrious career spanning more than 33 years, you have now set up the Green Energy Foundation. Are you contemplating on any new methods and approaches to promote renewable energy technologies, specifically solar, not only in Bangladesh but also in other developing countries?

I plan to take renewable energy, especially solar energy to the next stage of growth in Bangladesh through an innovative entrepreneur based-business model. By 2015, I want to reach to 7.5 million people in Bangladesh by creating 100 000 rural-based entrepreneurs, especially women who will assemble, install, repair, and maintain the systems. These entrepreneurs will work in coordination with 25 000 rural offices and 100 green technology centres to reach every nook and corner of Bangladesh. We will invest in modern technology such as installment payment through mobile phones, prepaid cards to cut transaction costs, localize our services, and give our customers more options. We will replace traditional systems with Pico and LED-based systems to reduce costs and increase efficiency. We will also design special packages for market places, income generation, as well as disaster management. We also plan to popularize solar pumps to replace traditional pumps. I strongly believe that our model will increase efficiency, help to cut cost, and be more flexible and dynamic than the traditional model.

Q9. Would you like to convey any special message to the readers of *The Solar Quarterly* especially in the backdrop of the recently launched Jawaharlal Nehru National Solar Mission?

I believe that the Jawaharlal Nehru National Solar Mission is an inspiration for the whole world. India has taken a very innovative and bold decision for scaling up renewable energy. This is especially inspiring and encouraging for me as my vision is to make Bangladesh one of the first solar nations of the world.

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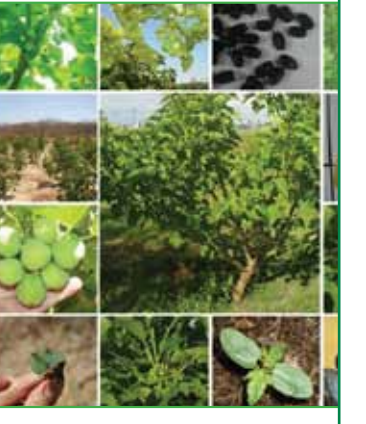

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DEVELOPING SOLAR POWER PROJECTS

Shiv Shukla started his career in a refinery, in the operations unit, and has experience of more than 24 years in various fields ranging from operations, design, project management, marketing, and general management functions. He has earlier worked in the refinery and fertilizer industries and is now involved in the renewable energy sector. Since the last seven years, he is heading Abengoa in India. He holds top management positions in the two Abengoa companies located in India. He is the president of Abengoa Solar India and is also the president and CEO of the Abener Engineering.

Shiv Shukla is responsible for strategy and business growth of the Abengoa group companies in India and Middle East with special focus on renewable energy, mainly solar power. He has presented papers, given talks in several national/international conferences such as renewable energy conferences, sulphur conference, ACHEMA, IFA, and so on. These days he is focusing on developing solar power projects in the country to meet the huge energy needs of our country and is working together with various regulatory bodies, research institutes, and non-government organizational in this direction. In an interview with Arani Sinha, Shiv Shukla talks about his plans, vision, and thoughts regarding the growth of renewable energy in India.

Q1. The entire issue of climate change seems to occupy centre stage in your scheme of things and woven around the beautiful concept of solar energy utilization. Could you kindly elaborate on this scenario from the perspective of the end-use?

We are quite optimistic about the future of solar thermal power in India, considering the fact that India is blessed with abundant sunshine almost throughout the year. With the scale of operations going up in the range of 100–200 MW, solar thermal power will provide a real and good alternative to conventional polluting power even in the commercial scale. Solar thermal can prove to be very attractive if used as peaking power during the peak load period in the afternoon hours.

Q2. You seem to believe in churning out the best possible know-how on solar energy technologies through sustained research and development efforts and investment. Could you please inform us as to what extent has this practice yielded positive results?

We are proud to say that the world's first two solar tower-based power plants of Abengoa Solar, PS-10 and PS-20, have been put to commercial operation in Seville, Spain. And, they are successfully supplying electricity through a grid to several households. Besides this, Abengoa has successfully demonstrated integrating solar thermal power along with the conventionally-combined cycle power in Algeria and Morocco in Africa.

Q3. Leaving aside the urban potential of solar technologies in the residential

sector for a moment, what is the reason for the industrial and commercial sectors for not adopting the mode of solar thermal power generation especially in developing countries such as India?

Currently, solar technology is in the development phase of its life cycle. As is the case with any developing technology, costs are higher. It needs proper enabling environment and suitable policies, which will allow it to grow and achieve long-term cost reduction to be used as a substitute for conventional power. Thus, I feel that once these things are put in place, slowly but surely solar thermal will be adopted in the developing countries.

Q4. The Jawaharlal Nehru National Solar Mission (JNNSM) is now being perceived as a very large window of opportunity for both solar photovoltaic (PV) and solar thermal technologies to make sharp inroads into the national energy scene. To what extent are you optimistic about the expected outcome of this mission?

The JNNSM definitely provides a large platform for development of solar power in the country. In my opinion, in the first phase there will be many non-serious players who will submit their bids and are likely to get the capacity allocation. But, whether such players have the strength to achieve financial closure of the projects is an issue to be pondered upon. In the long run, I do believe that the mission will achieve its objectives, but there will be many phases of trial and error for everyone to go through the learning cycle involved with the development of advance technologies.

Q5. Solar PV systems offer lower solar to electric conversion efficiencies in direct comparison to the solar thermal power systems. It being so, what is the plausible explanation for PV to edge past the thermal, more so in the developing regions of the world?

The costs involved are lower in terms of per project cost. So, there are many players who can develop and build solar PV power plants. The ease of installation, its modular concept, and the matured technology are the prime reasons for making PV more popular in the developing regions. Also, PV can be easily installed even on the rooftop without having much technical expertise.

Q6. The issue of large capacity solar energy storage is still regarded as a vexing affair. We would like to know your expert opinion on any such technically sound and economically viable storage mediums developed/ promoted by your company so far.

There are many companies that are doing research and development in the field of large thermal storage, but the costs are still higher. I am of the opinion that we need to give it some time and with the research that is being undertaken, we will have a suitable solution in future.

Q7. Quite often, those advocating the cause of renewable energy bring to the fore the hidden subsidies enjoyed by the conventional power, which subsequently becomes visible in terms of the lower cost of power generation. In the event of such subsidies being removed, would the cost of producing the solar energy equipment not go up simultaneously?

Not exactly. In my opinion, if conventional power is adjusted for the amount of pollution and the subsidies, it will reflect its true cost. In that situation, cost of solar power will look more attractive in comparison to conventional power.

Q8. The readers of *The Solar Quarterly* would be quite keen to know the cost of each unit of both solar thermal and solar PV power generated for India, which is really attainable with your technology range within the next five years?

I cannot comment on solar PV, however, as far as the tariff for solar thermal is concerned, it can be expected to be in the range of Rs 14–15 per kwh.

Abengoa is a well diversified company with interests in renewable energy such as solar power, bio-fuels, engineering construction, water desalination, and IT. Climate change is intensifying weather extremes, such as hurricanes, floods, droughts, and desertification, and is radically changing ecosystems. If we do not develop alternatives to existing patterns of energy use, the consequences will only get worse. With this thought in place, Abengoa Solar as a company is committed to developing PV, CSP, and industrial heat technologies for commercial, industrial, and utility applications. It has developed Concentrated Thermal Solar Power technology, which is being commercially used. There are also two commercial solar power plants of >100 MW capacity being built by Abengoa.

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CURRENT R&D SOLAR

Levinson R, Akbari H, and Berdhal P. 2010. **Measuring solar reflectance (Part I): defining a metric that accurately predicts solar heat gain**. *Solar Energy* 84(9): 1717–1744

Abstract

A widely used solar reflectance metric, based on the ASTM Standard E891 beam-normal solar spectral irradiance, underestimates the solar heat gain of a spectrally selective 'cool coloured' surface because this irradiance contains a greater fraction of near-infrared light than found in unconcentrated global sunlight. At mainland US latitudes, the metric R_{E891BN} can underestimate the annual peak solar heat gain of a typical roof or pavement (slope ≤ 5:12 [23°]) by about 89 W/m^2, and underestimate its peak surface temperature by up to 5 kelvin (K). Using R_{E891BN} to characterize roofs in a building energy simulation can exaggerate the economic value *N* of the annual cool roof net energy savings by as much as 23%. We define clear sky air mass by one global horizontal (AM1GH) solar reflectance $R_{g,0}$, a simple and easily measured property that more accurately predicts solar heat gain. $R_{g,0}$ predicts the annual peak solar heat gain of a roof or pavement within 2 W/m^2, and overestimates *N* by no more than 3%. $R_{g,0}$ is well suited for rating the solar reflectances of roofs, pavements, and walls. It is shown in Part II that $R_{g,0}$ can be easily and accurately measured with the help of the pyranometer, a solar spectrophotometer or version 6 of the Solar Spectrum Reflectometer.

Badran O, Al-Salaymeh A, El-Tous Y, Abdala W. 2010. **Design and testing of an innovative solar radiation measurement device.** *Energy Conversion and Management* **51**(8):1616–1620

Abstract

After reviewing the studies conducted on the solar radiation measuring systems, a new innovative instrument that would help in measuring the accurate solar radiation on horizontal surfaces has been designed and tested. An user-friendly, advanced instrument with high precision that would enable the user to take the readings in terms of solar intensity (W/m^2) has been tested. Also, the innovative instrument can record instantaneous readings of the solar intensities as well as the averages value of the solar radiation flux during certain periods of time. The design of the instrument is based on it being programmed by programmable interfacing controller (PIC). Also, the power supply circuit is fed by the solar energy cells without the help of any external power source.

Reich N H, Van Sark W G J H M, Turkenburg W C, Sinke W C. 2010. **Using CAD software to simulate PV energy yield: the case of product integrated photovoltaic operated under indoor solar irradiation**. *Solar Energy* **84**(8): 1526–1537

Abstract

In this paper, we show that photovoltaic (PV) energy yields can be simulated using standard rendering and ray-tracing features of the Computer Aided Design (CAD) software. To this end, three-dimensional (3-D) sceneries are ray-traced in CAD. The PV power output is then modelled by translating the irradiance intensity data of the rendered images back into numerical data. To ensure accurate results, the solar irradiation data used as input is compared to numerical data obtained from rendered images, showing excellent agreement. Also, the ray-tracing precision in the CAD software proves to be very high. To demonstrate PV energy yield simulations using this innovative concept, solar radiation time course data of a few days was modelled in 3-D to simulate distributions of irradiance incident on flat, single- and double-bend shapes and on a PV- powered computer mouse located on a window sill. Comparisons of measured to simulated PV output of the mouse show that simulation accuracies can be very high. Theoretically, this concept has great potential, as it can be adapted to suit a wide range of solar energy applications, such as sun-tracking and concentrator systems, building integrated PV (BIPV) or product integrated PV (PIPV).

Ghandehariun S, Naterer G F, Dincer I, Rosen M A. 2010. **Solar thermochemical plant analysis for hydrogen production with the copper–chlorine cycle.** *International Journal of Hydrogen Energy* **25**(16): 8511–8520

Abstract

In this article, a solar-based method of generating hydrogen from the copper–chlorine water-splitting cycle is developed and evaluated. Solar plants with different hydrogen production capacities at three locations across Canada are analysed. Operating parameters of the solar field and the storage units are presented. The thermal efficiency and cost parameters of the hydrogen plant are also examined. A binary mixture of 60% $NaNO_3$ and 40% KNO_3 is used as the molten salt for solar energy storage. Different hydrogen production rates are analysed. Since

the solar irradiation in Calgary is much less than in Toronto and Sarnia in the winters, it is found that a much larger storage unit is required. For larger hydrogen production rates, the size of the storage unit increases. The results support the feasibility of solar thermochemical Cu–C_l cycle as a promising and efficient pathway for large-scale production of hydrogen.

Hocaoglu O F.2010. **Novel analytical hourly solar radiation models for photovoltaic- based system sizing algorithms.** *Energy Conversion and Management* **51**(12): 2921–2929

Abstract

Though the importance of renewable energy is increasing, yet its applications and systems are still very expensive. The critical step is the cost and efficiency optimized planning of the system components, also known as sizing. The pre-requisite of sizing is the accurate measurement of the renewable energy potential of a given region. In this work, the solar potential measurement problem is considered and a 2-D surface approach is adopted for accurate determination of the renewable potential. More specifically, hourly behaviour of the solar radiation is modelled using an analytical 2-D surface approach. The 2-D rendered solar radiation data is examined and several functions are tested for fitting the data, including combinations of sinusoids, gaussian and polynomial functions, and extraterrestrial radiation models. The accuracy of the models are compared and discussed. Moreover, the models are tested on the basis of the data gathered from various geographical locations and the robustness of each model is discussed. It is argued that the models generated provide information on how to reduce cost and increase energy reliability of the renewable energy applications and systems.

Kaneshiro J, Gaillard N, Rocheleau Richard, Miller Eric. 2010. **Advances in copper-chalcopyrite thin films for solar energy conversion.** *Solar Energy Materials and Solar Cells* **94**(1): 12–16

Abstract

Promising alternatives to crystalline silicon as the basic building block of solar cells include copper-chalcopyrite thin films, such as copper indium gallium diselenide, a class of thin films exhibiting bandgap-tunable semiconductor behaviour, direct bandgaps, and high absorption coefficients. These properties allow for the development of novel solar-energy conversion configurations like ultra-high efficiency multi-junction solar cells, utilizing combinations of photovoltaic and photoelectrochemical junctions for hydrogen production. This paper discusses the current worldwide status as well as the development and optimization of copper-chalcopyrite thin films deposited onto various substrate types for different photovoltaic and photoelectrochemical applications at the Hawaii Natural Energy Institute.

Zhai H, Dai Y J, Wu J Y, Wang R Z, Zhang LY.2010. **Experimental investigation and analysis on a concentrating solar collector using linear Fresnel lens.** *Energy Conversion and Management* **51**(1): 48–55

Abstract

A concentrated solar collector based on linear fresnel lens is investigated in this paper. This solar collector is expected to acquire a higher thermal efficiency at a relatively high temperature level than the commonly used flat-plate or evacuated tube solar collectors. Experimental results show that thermal efficiency is about 50% when the conversion temperature (water) is 90 °C. The test indicates that the loss of energy is 0.578 W/m^2 K, which is much less than that of commonly used non-concentrated, evacuated tube solar collector. For the sake of analysis, a mathematical model for evacuated tube absorber heated by linear Fresnel lens has been built. The validation shows that the model is in agreement with the experimental data. The analysis indicates that Fresnel lens collector with evacuated tube absorber has good efficiency (50%) in clear days, even when the conversion temperature approaches 200 °C. Also, the influence of ambient conditions and the percentage of energy loss are also analysed.

Gupta M K, Kaushik S C. **Exergy analysis and investigation for various feed water heaters of direct steam generation solar–thermal power plant.** *Renewable Energy* **35**(6): 1228–1235

Abstract

The energy and exergy analysis has been carried out for various components of a proposed conceptual direct steam generation (DSG) solar–thermal power plant (STPP). It has been found that maximum energy loss is in the condenser followed by the solar collector field. The maximum exergy loss is in the solar collector field. The possibilities to further improve the plant efficiency are identified and exploited. For minimum exergy loss in the receiver, the inlet temperature of water to the receiver, which is governed by the number of feed water heaters (FWHs), bleed pressure, and mass fraction of bleed steam, must be optimum. Only one FWH has been proposed in conceptual DSG STPP. In order to evaluate the optimum bleed pressure and mass fraction of bleed steam to maximize the STPP efficiency, the investigations are carried out for various bleed pressure and mass fractions of bleed steam of proposed conceptual DSG STPP having one FWH. The investigations for bleed pressure and mass fraction of bleed steam are also carried out by incorporating two and three FWHs. It has been found that efficiency level can be improved by using three FWHs and further gain in efficiency is possible by making provision for more FWHs.

Akpinar E Kavak. 2010. **Drying of mint leaves in a solar dryer and under open sun: Modelling, performance analyses**. *Energy Conversion and Management* **51**(12): 2407–2418

Abstract

This study investigated the thin-layer drying characteristics in solar dryer with forced convection and under open sun with natural convection of mint leaves, and, performed energy analysis and exergy analysis of solar drying process of mint leaves. An indirect forced convection solar dryer consisting of a solar air collector and drying cabinet was used in the experiments. The drying data were fitted to the different mathematical models. Among the models, Wang and Singh model for the forced solar drying and the natural sun drying were found to best explain thin-layer drying behaviour of mint leaves. Using the first law of thermodynamics, the energy analysis throughout solar drying process was estimated. However, exergy analysis during solar drying process was determined by applying the second law of thermodynamics. Energy utilization ratio (EUR) values of drying cabinet varied in the range of 7.826%–46.285%. The values of exergetic efficiency were found to be in the range of 34.760%–87.717%. The values of improvement potential varied between 0–0.017 kJ s–1.

Al-Hinti I, Al-Ghandoor A, Maaly A, Abu Naqeera I, Al-Khateeb Z, Al-Sheikh O. 2010. **Experimental investigation on the use of water-phase change material storage in conventional solar water heating systems**. *Energy Conversion and Management* **51**(8): 1735–1740

Abstract

This paper presents an experimental investigation of the performance of water-phase change material (PCM) storage for use with conventional solar water heating systems. Paraffin wax contained in small cylindrical aluminium containers is used as the PCM. The containers are packed in a commercially available, cylindrical hot water storage tank on two levels. The PCM storage advantage is firstly demonstrated under controlled energy input experiments with the aid of an electrical heater on an isolated storage tank, with and without the PCM containers. It was found that the use of the suggested configuration can result in a 13–14 °C advantage in the stored hot water temperature over extended periods of time. The storage performance was also investigated when connected to flat plate collectors in a closed-loop system with conventional natural circulation.

Chow T T, Pei G, Fong K F, Lin Z, Chan ALS, He M.2010. **Modeling and application of direct-expansion solar-assisted heat pump for water heating in subtropical Hong Kong**. *Applied Energy* **87**(2): 643–649

Abstract

Direct hot water production consumes about 4% of the total energy use in Hong Kong, and about 20% when only the domestic sector is taken into consideration. For water heating the energy sources are mostly town gas, liquefied petroleum gas, and electricity. The use of heat pump or solar water heating, particularly the solar-assisted heat pump options, is not popular. In this paper, the potential application of a unitary type direct-expansion solar-assisted heat pump (DX-SAHP) system was examined. A numerical model of the DX-SAHP system was first introduced. From the simulation results with the use of the Typical Meteorological Year (TMY) weather data of Hong Kong, the system was found achieving a year-average coefficient of performance (COP) of 6.46, which is much better than the conventional heat pump system performance. Therefore, the potential use of DX-SAHP deserves further evaluation.

Azoumah Y, Ramdé E W, Tapsoba G, Thiam S.2010. **Siting guidelines for concentrating solar power plants in the Sahel: case study of Burkina Faso**. *Solar Energy* **84**(8): 1545–1553

Abstract

Selecting a site that meets the technical requirements for a concentrating solar power plant (CSP) is a very critical exercise. This paper points out crucial factors and provides guidelines regarding the selection of suitable sites. It especially focuses on Sahelian countries which have their own climatic peculiarities. These countries, characterized by low access to electricity, are well endowed in solar resources. They are potentially good locations for concentrating solar power plants since their mean daily solar radiation exceeds 5.5 kWh/m^2. Therefore, CSP presents a good opportunity for them to increase in a sustainable manner, their energy supply. The guidelines developed in this paper are applied to Burkina Faso as a case study.

Mokhtar Marwan, Ali Muhammad Tauha, Bräuniger Simon, Afshari Afshin, Sgouridis Sgouris, Armstrong Peter, Chiesa Matteo.2010. **Systematic comprehensive techno-economic assessment of solar cooling technologies using location-specific climate data.** *Applied Energy* **87**(12): 3766–3778

Abstract

A methodology for assessing solar cooling technologies is proposed. The method takes into account location specific boundary conditions such as the cooling demand time series, solar resource availability, climatic conditions, component cost, and component performance characteristics. This methodology evaluates the techno-economic performance of the solar collector/chiller system. We demonstrate the method by systematic evaluation of 25 feasible combinations of solar energy collection and cooling technologies. The comparison includes solar thermal and solar electric cooling options and is extended to solar cooling through concentrated solar power plants. Solar cooling technologies are compared on an economic and overall system efficiency perspective.

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

SOLAR TECHNOLOGICAL UPDATE

Graphene: solar cells of the future?

A South California University team has come up with what could be the alternative new breed of economic and flexible solar cells. For the last few decades, organic photovoltaic cells (OPV) have been acclaimed as the new solar cell prototypes and extolled for their light weight, flexible substrates, low cost, and easy manufacturability. Further research is now being conducted on them.

Source: http://www.alternative-energy-news.info/technology/solar-power/

First factory built solar charging station

International Green Energy Expo Korea 2010 was chosen as the venue for the display of SunPods SP-300 for the first time. SunPods are the first factory built solar photovoltaic (PV) power arrays. The SunPods solar systems are utilized in a wide range of applications and across multiple industries. However, although a versatile solution, the SunPods are all designed and manufactured to arrive at the job site ready to power-up, with minimal site preparation and no on site construction. The modular SunPods units can be interconnected to scale from small energy projects to large utility size solar farms. This is the first factory built-to-order, solar-powered, integrated electric-vehicle charging station, ready for use. This ready-to-use solar power platform from SunPods is called EV Plug-N-Go.

Source: http://www.alternative-energy-news.info/technology/solar-power/

Hybrid organic solar cells now more efficient

The research team comprising of researchers from National Research Council's National Institute for Nanotechnology (NINT) and the University of Alberta have been met with success. The plastic solar cells now have an operating life of eight months instead of mere hours. And, they are low-cost, environment efficient, unsealed plastic dollar cells—a green energy source. Given that the cost of ultra high-purity silicon used in the traditionally manufactured solar cells is quite prohibitive, developing economically viable plastic solar panels and producing them in large numbers has been a long-time goal for the scientists. These are solar cells of future, easily accessible for the common man.

Breakthrough in thin-film solar cells

Scientists at the Johannes Gutenberg University Mainz (JGU) have come up with positive news about the increased efficiency of thin-film solar cells. They are trying to increase the efficiency of the solar cells so that they could be considered as serious alternatives to the fossil fuels. Researchers at the Johannes Gutenberg University Mainz (JGU) too are working on this. They opted for computer simulations to probe deeper into the indium/gallium combination to increase the efficiency of copper indium gallium (di)selenide (CIGS) thin-film solar cells. Till now, CIGS has shown only about 20% efficiency, though theoretically they can attain efficiency levels of 30%.

Source: http://www.alternative-energy-news.info/technology/solar-power/

Concentrating solar energy technologies

There are two main types of concentrating solar energy technologies

1. concentrating photovoltaics (CPV) and
2. concentrating solar thermal electric power (CSP).

1. **Concentrating photovoltaics (CPV)** uses lenses or mirrors to focus or increase the Sun's light on a photovoltaic solar cell or panel. This technology includes both a low-concentration approach, which increases the sun's magnification by less than five 'suns', and a high concentration approach, which can increase the magnification by hundreds of suns. High-concentration CPV uses focusing lenses to concentrate the Sun's rays in a single, high efficiency solar cell that is very small, on the order of 1cm^2.

   When we hear about a new world record for PV efficiency that exceeds 40%, it is generally this type of technology they are utilizing. CPV's better mousetrap uses less photovoltaic material (tiny, high efficiency cells), concentrates the Sun, and increases performance, hopefully enough to offset any additional costs.

2. **Concentrating solar thermal power (CSP)** technology uses mirrors to focus the Sun's light on a heat capturing point, the heat from which can then either be used directly or converted into electricity. The three basic designs of CSP are troughs, towers, and dish-engine systems.

Troughs are set-up in large horizontal fields that contain long loops of piping (many kilometres for large installations). The pipes collect the 600+ degree (F) heat from light reflected off the mirrors that concentrate the sunlight in a line on the pipes. Troughs have the longest proven operating history and the least number of unknowns for CSP technology project development.

Towers use a mirror field that is set up around the tower. The mirrors focus sunlight on a heat receiver at the top that collects the heat and transfers it to the pipe inside the tower where is it circulated and used to generate electricity. The design minimizes the field of piping to the vertical tower height to a few hundred metres and can reach temperatures in excess of 1000 degrees (F). While currently there are very few commercially operating tower installations, this technology may grow rapidly.

Dish-engine systems look like satellite dishes and focus light on a sterling engine mounted on an arm in front of the mirrors. Each dish-engine is an autonomous generator—unlike the other CSP technologies that use a central power plant design—and utilizes the temperature and pressure difference to produce kinetic movement inside the engine, which is then converted to electricity.

An interesting development for troughs (and possibly towers in the future) is the interest on the part of utilities in 'hybrid-solar power plants,' which include the pairing or retro-fitting of natural gas or coal power plants with thermal input or boost from CSP.

The one thing that is common among different kinds of concentrating solar power technologies is that unlike traditional photovoltaic panels, they need 'direct normal' solar radiation, that is, sunlight that can cast a shadow. A certain percentage of solar radiation is made up of diffuse or scattered light, caused by clouds, humidity or particulates. Solar resource measurements are reported as either 'direct' normal radiation (no diffuse light) or total radiation (diffuse + direct).

The American South West has the highest percentage of 'direct normal' radiation almost anywhere in the world, making this one of the best regions for development of CSP. However, there is one CSP trough project in Florida—a hybrid CSP plant that will augment a natural gas plant—and a number of trough and tower projects in Spain. CSP will work in both areas, but performance will be commensurately reduced depending on direct normal radiation profiles.

The CSP industry is growing fast in Spain and the US, and SEPA is tracking over 5000 MW worth of new project announcements that are slated for development over the next five years. Not all of them will be built—permitting, financing, technology, and other factors need to fall into place first—but the industry is poised for rapid growth regardless of any individual project's outcome.

Source: http://www.renewableenergyworld.com/rea/news/article/2009/05/concentrating-solar-energy-technologies-explained

Are solar panels the next e-waste?

In recent years the electronics industry has been creating an endless stream of disposable products that make their way to developing countries, where poor people without safety gear cut and burn out valuable materials, spilling contaminants into their water, air, and lungs. Solar modules contain some of the same potentially dangerous materials as electronics, including silicon tetrachloride, cadmium, selenium, and sulphur hexafluoride. Thus, as solar moves from the fringe to the mainstream, insiders and watchdog groups are beginning to talk about recycling, in an attempt to sidestep the pitfalls of electronic waste and retain the industry's green credibility. Solar modules have an expected lifespan of at least 20 years, therefore, though most have not yet reached the end of their useful lives. But now, before a significant number of dead panels pile up, is the perfect time to implement a responsible and good programme.

Silicon Valley Toxics Coalition, a non-profit environmental group, has been a leader in recognizing the problems of e-waste. Last year, the group published a report calling for a 'just and sustainable' solar industry, and this year, it issued a scorecard of solar companies. The scorecard evaluates recycling and extended producer responsibility for the product's end of life, called take back; supply chain and green jobs; chemical use and lifecycle analysis; and disclosure.

SolarWorld, which received 88 out of 100 on the toxic coalition's scorecard, has been recycling its own panels since 2003 at its main factory in Freiberg, Germany.

Solar modules employ a variety of technologies, and models within the same technology can have different ingredients. These materials may or may not be classified as toxic depending on who is regulating them. Dustin Mulvaney is a scientist who works on solar issues at the University of California, Berkeley, and serves as a consultant to the Silicon Valley Toxics Coalition. He has analysed solar modules currently available in the market and has outlined for each its key ingredients, potentially toxic elements and materials that are valuable and should be recovered through recycling.

Some materials in solar modules such as silicon and rare metals could be valuable in the future, providing an additional incentive to recycle. Material price spikes have caused turmoil in the industry in recent years. For example, polysilicon shot to $400 per kg between 2006 and 2008. Now the price stands at $55.

The First Solar currently harvests cadmium and tellurium from its recycling programme to use in new modules, even though buying it from a supplier is currently less expensive. Mulvaney said that the industry would do well to plan for the recovery of rare metals such as indium and tellurium.

Source: http://www.guardian.co.uk/environment/2010/sep/03/solar-panels-ewaste

Green machine: perfecting the plant way to power

Take sunlight, add water, and there you have it—free energy. Plants have been doing this for quite some time, splitting the hydrogen in water from the oxygen, but our efforts to turn water into a source of free hydrogen fuel by mimicking them have borne no fruit. The problem is that splitting water requires more energy than conventional solar-cell technology can realistically deliver. But now we may have economically viable sun-powered water splitters, and with it all the clean-burning fuel we want.

In 2008, Daniel Nocera at the Massachusetts Institute of Technology and his team unveiled a revolutionary approach to splitting water. They used a cheap cobalt-phosphate catalyst and titanium oxide electrodes that need far less electricity than conventional electrolysis to split water.

That raised the possibility of stealing plants' trick and using sunlight to power the reaction. However, the number of PV cells needed for such devices mean that they cannot compete in price with fossil fuels, says Daniel Gamelin, a chemist at the University of Washington in Seattle.

But, Gamelin and his team thought they could bring down the costs by incorporating some elements of the PV technology in Nocera's water-splitting device, creating a so-called photoelectrochemical (PEC) water splitter.

Rusty electrode

Nocera's electrode was an indium-tin-oxide strip, coated with cobalt and phosphate. Gamelin's team also used cobalt and phosphate, but they started with hot glass, onto which they sprayed an iron solution. Iron oxidizes when in contact with air, forming a crystalline rust. The rust crystals give the electrode a large surface area, and it also happens to have PV properties.

The team then immersed their rust electrode in a solution containing cobalt and phosphate, and applied a current to electrochemically deposit the compounds on the surface. This created a PEC electrode that can, at once generate current and catalyse the water-splitting process.

So far, the electrode cannot generate enough power to do this on its own, but even so it could reduce the amount of solar cells needed, making the process far cheaper, says Gamelin.

Synchronized splitting

Gamelin is also investigating the possibility of a so-called 'tandem' device, which can generate enough energy from sunlight to power the water-splitting process on its own.

This device would have two cells housing electrodes, one on top of the other, with a rust electrode coated in cobalt and phosphate on top. Sunlight would strike the top electrode, which would absorb photons and catalyse the water-oxidation process. But, not all of the sunlight would be absorbed by this electrode. Light with a wavelength longer than 600 nanometres is not absorbed by the rust-coloured water in the top cell, and thus, would pass through to strike the lower electrode, powering the production of hydrogen. Like Nocera's original device, Gamelin's technology is also only able to produce oxygen gas and hydrogen ions. Teams around the world are searching for suitable cathode materials ,which can efficiently turn hydrogen ions into hydrogen gas, says Gamelin.

Efficiency targets

Meanwhile, other teams are working on alternative water-splitting devices. For example, a team led by Licheng Sun at the KTH Royal Institute of Technology in Stockholm, Sweden, is working on a system that uses a photosensitized anode, similar to those used in dye-sensitized solar cells.

Unlike Gamelin's system, Sun's device is already producing both oxygen and hydrogen gas. However, the current version uses an expensive, and externally powered, platinum cathode. To produce a commercially viable device, Sun is exploring the use of carbon and cobalt-based cathodes, with which he hopes to ultimately reach a solar-to-hydrogen efficiency of about 10%.

But, almost all of the electrode materials studied to date are impractical, says John Turner at the National Renewable Energy Laboratory in Golden, Colorado. "The efficiency is abysmal," he says.

Instead of using titanium oxide or iron oxide, researchers need to explore advances in PV devices, in which 27% efficiency has been achieved till now, he says.

Space power

Turner and his team were inspired by the solar cells used on spacecraft, which use gallium-indium alloys.

His team has created a PEC water splitter that is 12% efficient. The downside is that the electrodes are stable in water only for a few days. His team is now using computer models to identify other electrode alloys that have the right combination of efficiency and durability.

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

Honeywell presents 30% lighter PowerShield PV270 backing system

Honeywell has expanded its line of PowerShield backing systems, with the introduction of the PowerShield PV270 at the 25th EU PVSEC exhibition. The PV270 is 30% lighter than the more traditional backing systems, yet, it reportedly provides the same level of protection and insulation. PowerShield PV270 is certified by TUV Rheinland to meet IEC 1000 volt standards and is also a recognized component by Underwriters Laboratories (UL) for modules produced for installations in North America.

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

Life of plastic solar cell jumps from hours to eight months

The research groups' development of an inexpensive, readily available plastic solar cell technology hit a wall because of a chemical leeching problem within the body of the prototype.

A chemical coating on an electrode was unstable and migrated through the circuitry of the cell.

The team, led by the University of Arizona and the National Institute for Nanotechnology (NINT) chemistry researcher David Rider, developed a long lasting, polymer coating for the electrode. Electrodes are key to the goal of a solar energy technology, extracting electricity from the cell. Prior to the polymer coating breakthrough, the research team's plastic solar cell could only operate at high capacity for about 10 hours. When Rider and his research co-authors presented their paper to the journal, Advanced Functional Materials, their plastic solar cell had performed at high capacity for 500 hours. But, the unit kept working for another seven months. The team says that the unit eventually stopped working when it was damaged during transit between laboratories.

http://www.sciencedaily.com/

New solar prediction system gives time to prepare for the storms ahead

Solar storms involve the release of huge amounts of hot gas and magnetic forces from the surface of the Sun into space at about a million miles an hour. The next major solar storms are expected in 2012/13 as part of the Sun's 11-year weather cycle. A 2008 US National Academy of Sciences report estimated that modern reliance on electronics and satellite communications means a major storm could cause 20 times more economic damage than Hurricane Katrina. Although major solar eruptions (coronal mass ejections) normally take several days to reach the Earth, the largest recorded in 1859, took just eighteen hours. Solar flares, which can also cause significant disruption to communications systems, take just a few minutes. So, advance warning is of vital importance to enable steps to be taken to avoid the worst effects of solar activity.

Until now, solar weather prediction has been done manually, with experts looking at 2D satellite images of the Sun and assessing the likelihood of future activity. But, the team from the University of Bradford's Centre for Visual Computing have created the first online, automated prediction system, using 3D images generated from the joint National Aeronautic and Space Administration (NASA)/ESA Solar and Heliospheric Observatory satellite (SOHO). Already in use by both NASA and the European Space Agency (ESA), the Bradford Automated Solar Activity Prediction system (ASAP) identifies and classifies sun spots, and then feeds this information through a model, which can predict the likelihood of solar flares. The system is able to accurately predict a solar flare six hours in advance and the team is working to achieve a similar accuracy for the prediction of major solar eruptions in the near future.

The ASAP model is based on historical data, which was analysed to identify patterns in the Sun's activity. The model is now being applied for more funding to further improve the system and ensure that it can be adapted to work with the latest sun monitoring satellites.

http://www.sciencedaily.com/

Off-the-shelf dyes improve solar cells

Like most technologies, work on solar devices has proceeded in generational waves. The first generation was bulk, silicon-based solar cells built with techniques that borrowed heavily from those used to make computer chips. The next generation was thin films of materials specifically tailored to harvest the Sun's energy, but still more or less borrowed from the realm of microelectronics manufacturing. Then came the third generation, described by one researcher and blogger as 'the wild west', which among other objectives aims to build inexpensive next-generation solar cells by relying on decidedly low-tech wet chemistry. In a paper in the Journal of Renewable and Sustainable Energy, which is published by the American Institute of Physics, Prof. Ram Mehra of Sharda University in Greater Noida, India, reports success in boosting the ability of zinc oxide solar cells to absorb visible light simply by applying a blended mixture of various off-the-shelf dyes, commonly used in food and medical industries. Working with colleagues from the University of Delhi, Mehra doused cells with a variety of dyes in a soak-then-dry procedure, not unlike the procedure used to colour a tee-shirt in a home washing machine.

The best result came from a blend of dyes, including Fast Green, a food dye used in canned vegetables, jellies, and sauces and Rose Bengal, used in diagnostic eye drops to stain damaged cells and identify eye injuries, which together boosted the efficiency of zinc oxide solar cells by nearly 8%. Mehra and his colleagues argue that in the future, specific dye blends might be formulated to make solar cells targeted for specific uses, much as custom mixing of dyes today yields products as diverse as adhesives, cosmetics, and perfumes. They write that "by changing the composition of the mixture, its properties will change to more or less suit the particular useful application."

http://www.sciencedaily.com/

Major hurdle cleared for organic solar cells

The basis for solar energy is absorbing light and then effectively disassociating electrical charges. As Yana Vaynzof, a University of Cambridge researcher, reports in the American Institute of Physics' Applied Physics Letters, conjugated polymers are excellent materials for such a system, thanks to their light absorption and conduction properties. Unfortunately, poor charge disassociation in these materials tends to inhibit their performance. Photo-induced charges remain closely bound and recombine before they can be collected for electricity.

With a goal of working around this, Vaynzof and colleagues studied the charge disassociation at an interface between an organic polymer, in which the light is absorbed, and an inorganic oxide layer.

This has significant implications for the organic solar cell industry because it offers an interesting solution to one of the field's most significant problems.

http://www.sciencedaily.com/

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

CENTRE FOR NON-CONVENTIONAL ENERGY RESOURCES, UNIVERSITY OF RAJASTHAN

I P Jain, Professor, Emeritus Scientist CSIR, Prof Centre for Non-Conventional Energy Resources, University of Rajasthan, Jaipur

Introduction

The University of Rajasthan is the oldest institution of higher learning in Rajasthan. It was established on 8 January 1947 as the University of Rajputana with the main objective of disseminating knowledge and catering to the needs of the students of Rajasthan. It had jurisdiction over the entire state. In the year 1956, the Rajputana University was renamed as the University of Rajasthan, keeping intact its enveloping jurisdiction. University of Rajasthan is a multi-faculty university and is recognized under 2f and 12B of UGC, since its inception. It has 36 post-graduate departments, 15 recognized research centres, six constituent colleges, and 500 affiliated colleges spanning across six districts.

Centre for Non-Conventional Energy Resources

Catering to the growing energy demand is a key issue of this century. With the aim to achieve this need of human life, Centre for Non-Conventional Energy Resources was established in the year 2000 at Vigyan Bhawan, University of Rajasthan, Jaipur. The main objective of the centre is to work for green power so as to provide better quality of life to humans and better environment to the planet Earth.

In year 2006, UGC has sanctioned an innovative programme for a one year M Phil degree course in energy. This course deals with the issues of alternative energy sources and sustainable energy sources. The intent is to perform an objective cost-benefit analysis on each form of alternative energy in order to determine what is practical on a large scale, as well as on the scale of the individual homeowner. The course perticularly focuses on efficiency of each alternative energy source as well as what are the limitations that exist in terms of extracting useable energy. This course will provide a chance to the young generation to solve energy problems of our country by providing them training in both theoretical and experimental aspects.

The centre has 11 research staff and one emiretus scientist. Prof I P Jain was the director of the centre from 2000-2007. From 2007, Prof Y K Vijay is the director of the centre.

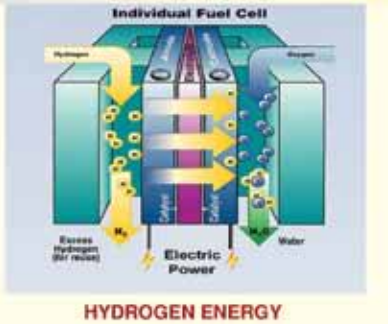
Infrastructure facilities

The centre has a research laboratory equipped with many important equipments such as electron gun thin-film deposition unit under UHV conditions, thermal evaporation unit under high vacuum condition, UV-Vis spectrophotometer, electrometer,

AN ANNOUNCEMENT MADE BY THE UNIVERSITY

WIND ENERGY

SOLAR ENERGY



HYDROGEN ENERGY

TIDAL POWER SYSTEM

UNIVERSITY OF RAJASTHAN (NAAC A+), JAIPUR
CENTRE FOR NON CONVENTIONAL ENERGY RESOURCES
Admission Notice for M. Phil Energy 2007-2008
(Under UGC Innovative Program)

The Centre for Non Conventional Energy Resources (CNER), at the University of Rajasthan, Jaipur, established in 2000 is involved in research in Solar Energy, Hydrogen Energy and other Renewable Energies. The University Grants Commission, has given a UGC innovative program for post graduate students to take up M. Phil. Energy for bright and excellent carrier in energy for jobs in research, Academics and Industries.

An Exciting Future with Green Energy

Alarming Situation of Global Warming and Decreasing Fossil Fuels: Energy Conservation, Research, Management and Applications have become important

Development of Society related to Energy Utilized

Scope of Course: This course will meet the global requirements in hi-tech and emerging thrust areas as well as it is a proposal to solve energy problems of our country at top priority by providing training and research to the young generation

NAAC 2004 reported: Rajasthan University has a top class Centre for Non Conventional Energy Resources

Duration: One Year (Course work, three papers, laboratory and project)
Eligibility: M. Sc. (Physics, Chemistry, Material Science & Applied Physics)
No of seats: 20
Course Fee: Rs. 10,000/- pa
Sale of Prospectus and Admission Forms : June 14, 2007
Last date for depositing Admission Forms: June 28, 2007
Last date with late Fee of Rs. 50/- : July 04, 2007
How to Apply: Admissions will be made on merit basis of qualifying Examination.
Details may be found at website www.uniraj.ernet.in
For more information Please contact: 0141-2701602, 2711049, 9414042415 (M)

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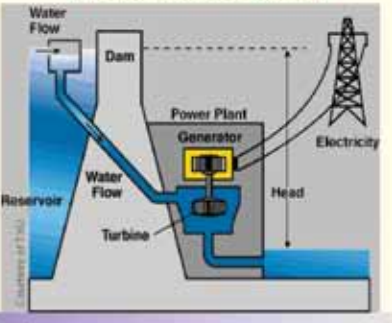
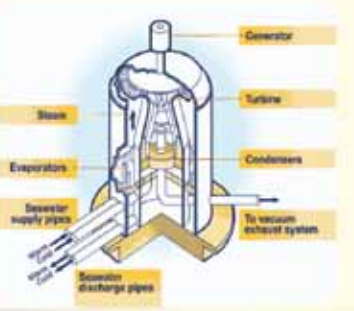
HYDROELECTRIC POWER



OCEAN ENERGY



ultrasonic cleaner, ball milling under inert atmosphere, heating furnace, sievert type hydrogen storage measurement unit, depth selective conversion electron mossbauer spectrometer. The centre has a computer laboratory with Internet facility and a library having several important books.

Academics

The research group at the centre consists of the following people.

- I P Jain, Emeritus Scientist CSIR
- M Vashistha, Asstt Prof. Physics
- Pratibha Sharma, Asstt Prof. Energy, IITB
- Veenu Sisodia, Dr D S Kothari PDF
- Rajkumar Jain, Asstt Prof. Physics
- Ankur Jain, DST Young Scientist, Dr D S Kothari PDF
- Garima Agarwal, Dr D S Kothari PDF, CSIR RA
- Vaibhav, DST Young Scientist, Dr D S Kothari PDF, Scientist
- Shivani Agarwal, Post Doctorate Fellow
- C L Saini, CSIR RA
- Renu Dhunna, DST Woman Scientist
- Pragya Jain, IUAC Research Scholar
- Reena Verma, Research Scholar
- Devendra Vyas, UGC JRF
- Jameel Khan, CSIR JRF
- Rimpy Shukla, Project Fellow
- Neetu Sharma, Project Fellow

Master's programme

M Phil (Energy)
Seats: 20
Duration: 1 year
Eligibility: M Sc (Physics, Chemistry, Material Science and Applied Physics, Electronics)

Admission procedure: Admissions is made on merit, based on the qualifying examination. For more details please contact at the Centre for Non-Conventional Energy Resources.

The course comprises of three theory papers, one dissertation paper, and practical. The dissertation paper provides an opportunity to make students aware of the industrial and research needs as well as provides training for using different techniques.

Students awarded Ph D in the year 2000–2009 from the centre

Name	Year	Field of Research
A Williamson	2000	Surface Science, DSCEMS
M Vashistha	2000	H_2 Energy, Thin Film Hydride
A Pandey	2000	High TC Superconductors
Babita	2000	H_2 Energy, Thin Film Hydride
Mohammed I S	2000	H_2 Energy, Bulk Hydride
J Vijayvargia	2001	Semiconductor Physics
Pratibha Sharma	2006	Amorphous Semiconductors
Veenu Sisodia	2006	Metal / Si Surface and Interface
Raj Kumar Jain	2006	H_2 Storage in Bulk and Thin Film
Ankur Jain	2007	H_2 Storage in Bulk and Thin Film
Garima Agarwal	2007	Metal / Si Surface and Interface
Chhagan Lal	2007	Metal / Si Surfaces and Interfaces
Shivani Agarwal	2007	Metal / Si surfaces and interfaces
Renu Dhunna	2009	Metal Nitride surfaces $ and Interfaces

Ph D programme

- Hydrogen energy: storage and applications
- Solar energy: materials and devices
- Thin films, surfaces, and interfaces
- Amorphous semiconductors

Main research areas

- Hydrogen energy storage materials and applications
- Solar energy materials and devices
- Material science research
- Surface science and thin films
- Ion beam mixing at metal/Si interfaces
- Solid state mixing at metal/Si interfaces
- DSCEMS Technique
- Ultra high vacuum (UHV) CEMS
- Gas flow counter (GFC) CEMS
- Amorphous semiconductors

Research facilities at centre

- Thin film deposition at 10 –9 Torr vacuum system: Varian USA
  a) E-Gun Telemark 4- pocket 3 kW, at 10-11Torr
  b) Thickness Monitor
- Thin film deposition at 10 –6 Torr vacuum
  a) Thermal Evaporation
  b) E-Gun Deposition
- Ball Miling Machine
- DSCEMS
  a) UHV-CEMS
  b) GFC-CEMS
- UV-Vis Spectrophotometer: 190 to 1100 nm
  I-V measurements:
  a) Keithley Electrometer Model - 6517 A
  b) Keithley software for I-V studies
  c) LabView software
  d) Hall-Effect Measurement Set Up.
- Hydrogen Storage Techniques
  a) Thin films storage technique: developed in laboratory
  b) Precision quartz crystal monitor
  c) Seivert type instrument : developed in laboratory

The UGC-NAAC Committee in 2004 commented that the "Rajasthan University has a top class Centre for Non-Conventional Energy". The centre also has an Emeritus Scientist CSIR— Prof I P Jain. Also four people received the UGC Dr D S Kothari PDF award in 2008. In 2005, Dr Pratibha Sharma now an assistant professor at IIT received the Best Thesis IPA Award 2005.

For more details contact: http://www.uniraj.ac.in/

ANNOUNCEMENT

The Product Update section

The *Solar Quarterly* magazine invites updates and information on all new products in the solar energy sector. The update and information provided will be featured in the 'Product Update' section of the magazine.

Send in your write ups to

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www.teriin.org

EXPERT SPEAK

Answers to questions on solar energy

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Professor, TERI University
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Solar energy is a promising source for 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 everyone by sheer surprise. Sizeable numbers can come through by opening up new commercial vistas for 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 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. What is the fundamental difference between a solar collector and a solar panel?

Solar collectors are used for collecting solar energy for thermal applications. The black surface of the absorber in a solar collector absorbs all the radiations present in the solar spectrum, ranging from very short ultraviolet (UV) radiations to very long far-infrared radiations (IR), and transforms these absorbed radiations into usable thermal energy. Although part of this converted thermal energy is lost to the surroundings, yet major part of it is transported into a thermal storage tank built specially for the purpose. Hence, the collection and conversion efficiencies of the solar collector are quite high generally, ranging between 50%–60%.

In contrast, solar panels are used to convert sunlight present within the incident solar radiation into direct current (DC) electricity. This type of panel is normally made from a combination of individual solar cells. However, in this case, radiations falling mainly in the UV region and part of the visible region get converted into some useful electricity via these solar cells. A definite part of this energy is converted into heat. As such, the efficiencies of solar panel in

Courtesy: DOE/NREL

direct comparison to the solar collectors are quite low, usually of the order of 7%–17%.

Q. Why is solar energy, as an alternative form of energy, so expensive?

The cost of any technology is decided by its technology maturity level and its accompanying demand. The maturity level of a technology is decided on the basis of how long it has been in use and how many users are actually using it. The demand for any new technology is created by the additional advantages that it is capable of offering to the society. It is also related to the level of awareness present about the techno-economic advantages vis-à-vis the existing technology (ies) in the society at large. In fact, research and development initiatives geared at cost reduction of any technology are also a determinant of its ultimate acceptance by the society. It is equally true that a wide range of technologies would be expensive during the early stages of market adoption. Take for example the solar technologies, which have come a long way since their market inception facilitated by the following few advantages.

- They are environmentally friendly.
- They have zero fuel cost.
- They very low running cost.

However, the same is not quite true of solar water heating, biomass energy conversion, and wind energy conversion. These resources have now become increasingly popular due to technological advancement resulting in an expansion of the user base.

On the other hand, the cost of manufacturing solar cells is still high, mainly due to the energy intensive nature of silicon purification (electronic grade) process. The major reduction in the cost of PV technology will come from reduced intake of expensive silicon material and cost-effective up-scaling of solar to electric conversion efficiencies associated both with the thick and thin-film PV cell materials. Governments across the world are offering a number of financial and fiscal incentives to make solar energy technology use truly affordable.

Q. How does a typical solar cell work?

A solar cell is a p-n junction semiconductor device that converts incident solar energy into electricity by the photovoltaic effect. The solar cell is made of two layers of silicon, doped with different but specific materials joined together to form a junction in the middle. The silicon layer on one side is doped with boron and the silicon layer on the other side is doped with arsenic. The layer containing boron, called n-type, has a surplus of free electrons. The other layer, called p-type, has a deficit of electrons. These deficiencies are called holes, which behave like a positive charge with mass equal to that of an electron. All the three regions, that is, n, p, and junction in the middle are charge neutral.

As the radiation from the solar spectrum with sufficient, that is, ultraviolet region and part of the visible region, is absorbed in the junction region, it creates an electron–hole pair in the junction. The generated electrons are attracted by the holes near the junction of the n-type layer making it negatively charged. While the generated hole in the junction is attracted by electrons near the junction of p-type layer, thus making it positively charged. The number of electron hole pairs created in the junction and moved to respective sides will depend on the intensity of incident solar radiation. The negatively charged n region and positively charged p region together behave like two terminals of an ordinary battery.

Q. Is Solar Evacuated Tube Collector a viable alternative to gas or electricity and with what maintenance requirements really?

Solar Evacuated Tube Collector, more commonly known as the ETC is part of a Solar Water Heating System, which is used for supplying hot water. Where ever hot water is currently being generated by gas or electricity, solar ETC-based solar water heating system is definitely a good alternative. This is evident from its growing popularity in the households, hotels, hospitals, hostels, restaurants, commercial buildings, industries, and so on, to meet their hot water requirements of about 80 ^{o}C. It is not only more energy-efficient but also environment friendly.

ETC collector does not need much of maintenance. The shape of the tubes is such that it can withstand hailstorms and is easy to clean if some scaling occurs in the tubes. However, if, the tubes break, these need to be replaced. This, however, is an inexpensive and easy job.

Q. What is PV conversion efficiency?

The conversion efficiency of a PV cell/panel is the ratio of sunlight incident on a solar cell/panel to the electrical power delivered by the cell/panel to an electrical load. This efficiency of the cell/panel is the function of the current drawn by the load. As current drawn by the load is increased, this efficiency first increases, becomes maximum at some current value and then starts decreasing. Such an efficiency of the cell/panel (known as peak efficiency) depends on the incident solar radiation and the ambient temperature. The peak efficiency under the standard test conditions (corresponding to 1000 W/m^2, 25 ^{0}C) is the efficiency, which is always referred to by the manufacturers. These conditions may or may not be met by a PV device under the actual field operating conditions.

HOMER

THE OPTIMIZATION MODEL FOR DISTRIBUTION OF POWER (PART II)

Dr Suneel Deambi, Consultant, TERI <sdeambi@airtelmail.in>

Introduction

Renewable energy (RE) utilization for a variety of end-use applications is growing by the day. Alongside, there is a genuine need for designing appropriately sized systems, which can deliver effectively on all key fronts like technology, performance, economic viability, and so on. For a long time now, energy simulation softwares have been in use with each having their specific merits and ease of convenience. HOMER is one such widely used analysis tool, which has been the outcome of the research and development pursuits undertaken at the National Renewable Energy Laboratory (NREL) of the US Department of Energy. A sound beginning for HOMER was initiated as early as in 1993, while simulating the energy needs of a in-house village power system. This was followed by HOMER being made available publicly for the Window applications in 1998. Since then, several value additions have been made in this free software. Presently, version no. 2.67 is available with an added ability to model up to 10 generators and compete up to 10 battery types against one another. In this second part of our article, we will try to run through the various problems for which HOMER offers a solution and also what are those solutions.

Cost effectiveness of the technology

RE technologies usually comprise of solar, wind, biomass, and small hydro power resources. Each of these technologies offers its distinctive advantages and limitations too. Those who are interested in such technologies, for the residential, commercial, institutional, and industrial needs, want to know which technology can deliver the maximum in a cost-effective manner. HOMER answers this basic question with a fair degree of certainty in a user-friendly and interactive mode of operation. Hybrid combination of these technologies may also be weighed in the backdrop of the most convenient technology choice(s). Once the technology selection is made, other considerations attached to it become easier to simulate. However, there is no easy way of choosing any one particular technology. The choice is normally dependent upon the following few factors.

- Site-specific resources
- Load profile
- Cost of the equipment
- Expected performance from the equipment to be installed

Simulation, optimization, sensitivity analysis

Simply put, simulation refers to the various possibilities of process flows and accompanying features. In this case, HOMER deals with an accurate analysis of time varying loads and available resources on an hour-to-hour basis throughout the year. It is then followed up by a simple yet quite important process of system optimization. The immediate intention is to find the least cost solution. The next logical guidance that HOMER provides is to undertake a sensitivity analysis. It is basically a technique, which is used to determine how different values of an independent variable will influence a specific dependent variable, under a given set of assumptions.

Other parametric elements

In a RE project, there are several other important parameters that a system designer or those involved in the financial analysis needs to cater to. HOMER helps to know the annual averages, both for the resources and loads, together with the cost per kW or unit for equipment. It also provides the readings of measured hourly data along with the cost curves, which gives the vital inputs in any system design exercise.

Cost segmentation

It goes without saying that the project developer or a prospective customer is concerned about the cost of the system. HOMER gives the cost breakdowns and accompanying comparisons in the following manner.

- Cost of various components, for example, PV array, battery, inverter, diesel (in case of PV-diesel hybrid system)
- Initial capital cost ($)
- Annualized capital ($ per year)
- Annualized replacement cost ($ per year)

- Annual operation and maintenance ($ per year)
- Annual fuel ($ per year)
- Total annualized cost ($ per year)

Homer also looks closely at the policy analysis issues, for example, the cost of emission constraints, in addition to the operational analysis. The objective of the latter analysis is to know when the backup is needed. Likewise, net metering, time of the day rates, associated emissions, and so on also comes within the purview of HOMER. To sum up, HOMER offers the following key service attributes.

- resource analysis
- technology development targets
- optimal system design
- policy analysis
- operational analysis
- cost breakdowns and comparisons

Case specific use of HOMER in India

The Sunderbans region, located between India and Bangladesh, is the world's largest inter-tidal delta. It comprises of about 100 islands, out of which nearly 54 islands are inhabited. The total area of the Sunderbans on the Indian side is about 4262 kms, with a population of two million. There seems to be little hope of extending grid to about 0.8 million people in the near future. Till date, the West Bengal Renewable Energy Development Agency (WBREDA) has been able to deploy about 300 kW capacities of PV power plants, meeting the need of about 1500 consumers. In addition, 6000 solar home lighting systems are working satisfactorily so as to benefit about 30 000 customers. In addition, biomass gasifiers with a capacity of 1000 kW are benefiting about 1000 customers. The installation of a grid-connected 1000 kW capacity wind farm is also helping raise the living standards of people in this region. HOMER was used to simulate and analyse a large number of alternative configurations. The aim was to find out the best possible sizing and an optimum mix of technologies for each location. The successful application of HOMER at these difficult locations is proof enough of its growing popularity.

Case specific use of HOMER in different parts of the world

As per the latest available information, HOMER is now being used by more than 47 000 customers across 193 countries. These mainly include the system integrators, equipment manufacturers, utilities, facility managers, government, and non-governmental organizations to design hybrid power systems.

Renewable and Sustainable Energy Institute (RASEI) at the University of Colorado, USA, will be working closely with HOMER Energy to model new energy scenarios specific to the city of Boulder in Colorado. Simulation modeling seems to be an essential tool for energy planning owing to the complex nature of a wide range of future energy options. The city of Boulder has been chosen mainly due to the following few reasons.

- Strong political mandate to propagate and integrate clean energy resources
- Existence of new smart-grid capabilities
- Smooth technical characteristics of the existing electric grid

Significant objective of this alliance is to outline scenarios that can combine micro-grid and smart-grid technologies with multiple types of distributed and renewable power generation including storage technologies. The underlying rationale is to test if the smart micro-grids could permit an increased reliance on RE resources in the city of Boulder. The immediate purpose is also to understand the implications vis-à-vis the energy costs, CO_2 emissions and importantly, the grid reliability. It is important to mention here that the micro-grids are attracting the interest of quite a few organizations. The researchers will be exploring the effects of the smart-micro grid technologies with the help of HOMER energy modeling software. In essence, it will work out an optimal combination of power sources in terms of a ready comparison of the following few parameters.

- capital costs
- operating costs
- emissions spread over the lifetime of a system

This exercise will result in bigger gains when it will be understood that RE along with micro-grids and smart-grids can offer electricity. It should be mentioned here that there is a growing interest, on the part of policy-planners to evolve a strong focus on RE due to the following reasons.

- decreasing cost of the prominent RE technologies like wind and solar
- rapid advancements in the area of energy storage
- enabling the power systems with the information technology

The research goal of the Boulder project is to analyse the RE scenario, in accordance with the latest available RE standard applicable in Colorado.

Area-wise, Alaska is the largest state in the United States of America. It is located in the North West extremity of the North American continent. The Alaska Energy Authority plans to analyse the hybrid systems like those based on wind-diesel with HOMER Energy. Till very recently, diesel was the most important source of energy for the remote rural communities in Alaska. However, now slowly the communities in Alaska are shifting towards hybrid energy due to the rising price of diesel. The HOMER software is expected to play a significant role in realizing the maximum possible potential of RE resources, like the wind energy, in these regions. It is quite interesting to note here that PV also makes a suitable combination both with wind and diesel energy sources in many parts of the world, including India. Alaska has some decade old installation of the hybrid systems, but the renewed purpose is to design the new generation systems much more efficiently with the support of HOMER. One of the unique applications is space heating, for which HOMER will model the ways and means to reduce the diesel use, which is currently being used for the purpose. The simple idea is to replace the diesel with renewable energy such as wind.

This type of applications can be put to use in various parts of the world for the benefit of various communities.

MAXIMIZING POWER

THE SUNFLOWER TRACKER

The solar photovoltaic (PV) market in India anticipates new incremental efficiency gains in terms of improved modules, inverters, and batteries originating from selected research laboratories. Yet, a new solar platform is poised to deliver substantial efficiency gains from the most unexpected source—the people of India. Sunflower Solutions has developed the *SunChaser*, a fascinating 'precision' manual tracking solar system that utilizes full-time unskilled workforce to calibrate its simple 2.5kw dual-axis operation for up to 42% more output on clear days than a comparable fixed crystalline system. With clear days being represented at solar farms between 75%–85% on an annual basis, the practical *SunChaser* efficiency advantage versus a fixed system has been projected between 29%–36%, according to independent testing conducted in June/July 2010 by IIT-Madras Chemical Engineering Department Prof. Ramanathan Srinivasan.

In order to generate about 29%–35% more power than a fixed type crystalline system, the SunChaser, a 2.43 kW dual-axis tracker, is adjusted five times everyday with the help of the patented NREL/NASA researched formula. It customizes tilt, rotation, and calibrations along with their operation scheduling windows in accordance with the site-specific latitude and longitude parameters. The SunChaser's efficiency claims have been validated by independent testing conducted by the IIT-Madras in June/July of 2010.

Calibration instructions feature colour and number coded indicators, which aligns, tilts, and rotates the tracking positions by a sliding collar with the help of a simple leverage. Manual calibration operation for about 15–20 sec/unit is easy and intuitive, and the operators need not have any formal training or special physical ability. The SunChaser requires no mechanical, electrical, and/or hydraulic parts. It requires maintenance after every 1-2 years, which involves a five minute replacement of the high grade plastic bushings inside the clampable sliding collar. Also, there is no risk of costly equipment malfunction or specialized labour for repairing purposes.

The SunChaser is versatile and scaleable enough to provide service to the grid-connected solar farms by leveraging the routine security and maintenance workforce into 'human power plants'. This is possible because their manual tracking calibrations will generate 29%–35% extra feed-in tariff revenue from similar extra energy unit generation from tracking. Each megawatt requires a calibration workforce of 5 people, 5.8–6.5 acres and between 412–425 tracking units. Off-grid applications include telecom towers, water pumps, mini-grids, and community electrification. The SunChaser's design and technique are targeted for the Indian market. Galvanized MS steel and anodized aluminium material mix provides a robust frame for windload resistance and anti-corrosion. The mounting frame array is module brand/company-neutral. The installation process is streamlined with a pre-assembly option and thus, no specialized labour or heavy equipments are required. The SunChaser was the result of an unprecedented contribution of skill sets from independent academic, solar, manufacturing, structural engineering and marketing sectors from the company's hometown of Cleveland, Ohio, the USA.

Sunflower Solutions is committed to positioning itself as an India-centric company. A domestic manufacturer has been recruited to ensure about 25-year warranty enforcement, quick turnaround time of orders and, the cost-efficiencies associated with local production. Sunflower Solutions has demonstrated a commitment to positioning itself as an Indian-centric company. Sunflower Solutions Indian incorporation and patent protection filings have been initiated. An established domestic manufacturer has been recruited to provide 25 year warranty service, quick order turnaround, transparent quality control and of course, cost-efficiencies associated with local production. Sunflower Solutions remains vigilant in its quest for third party validation of its tracking performance, with new testing recruitment confirmed with the following.

- One of the three architects of the National Solar Mission, Prof. N Kumaravel from IIT-Madras
- Center for Green Excellence Prof. H Saha of Bengali Engineering and Science University in Kolkata
- Renewable energy consultant to Ministry of New and Renewable Energy (MNRE) and The Energy and Resources Institute (TERI) in Delhi
- Pilot programmes have been confirmed with a number of private solar manufacturers and developers as well.

In less than two months of entering the Indian solar market, the company COO Steve Belkin has already met with top officials at MNRE, IREDA, State Nodal agencies, and over 50 solar supply chain companies. Sunflower Solutions precision manual tracking system was featured at the SOLARCON's 'Novel Innovations in Solar' panel and has secured exhibition space at DIREC 2010. Sunflower Solutions has set a precedent by introducing the capex minimization pricing methodology, whereby a portion of the cost is paid upfront with the balance coming after the first year of the operation from the excess feed-in tariff revenue earned by the NTPC Vidyut Vyapar Nigam Limited (NVVN) or state utility from the tracker's excess energy generation. This is the proof of Sunflower Solution's confidence in the validity of its representations.

The SOLAR QUARTERLY

FEEDBACK FORM

Your views about *The Solar Quarterly* are invaluable to us. Kindly take some time off to complete this feedback form and send it to the Editorial Team, *The Solar Quarterly*, TERI (The Energy and Resources Institute), Library Block, India Habitat Centre Complex, Lodhi Road, New Delhi—110003 or fax it to (011) 2468 2144/45 or e-mail it to arani.sinha@teri.res.in.

1. Why do you read *The Solar Quarterly*?

☐ To know more about solar energy related issues
☐ Acquire knowledge about issues in general
☐ Like to read the views of people working in this field
☐ The contents are exceptional
☐ Others (please specify)

2. How do you go about reading the magazine?

☐ Read all sections thoroughly
☐ Read certain sections
☐ Read only the main articles
☐ Glance at it generally
☐ Share with family, friends, and colleagues

3. Which section do you find the most interesting?

☐ Features
☐ Interviews
☐ From the archives
☐ Technical corner
☐ Current research and development
☐ University focus
☐ Expert Speak
☐ Learning Package
☐ Others (please specify)

The Energy and Resources Institute

4. Which new section do you feel is the most informative?

☐ From the archives
☐ Technical corner
☐ Current research and development
☐ Web updates

5. What do you think about the new look and feel of *The Solar Quarterly*?

☐ Brilliant
☐ The previous look was better
☐ Needs more work
☐ Design is not a priority, content is
☐ Others (please specify)

6. How do you rate the magazine overall?

☐ Best in the business
☐ Informative and interesting
☐ Marginally useful
☐ Not useful at all
☐ Others (please specify)

7. Which other solar based/renewable energy based magazine do you read?

☐ _____
☐ _____
☐ _____
☐ None

8. What issues would you like *The Solar Quarterly* to cover?

☐ _____
☐ _____
☐ _____
☐ _____
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☐ _____

10. Any other suggestion?

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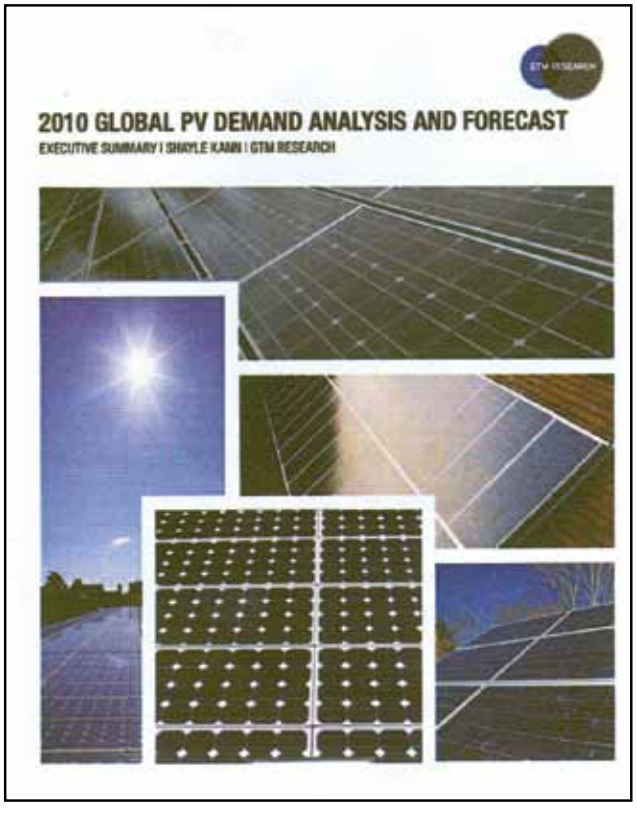
The Energy and Resources Institute

2010 global PV demand analysis and forecast



Editor: Shayle Kann
Year: 2010
Price: $2995
Publisher: GTM Research

Between 2000 and 2009, global photovoltaic (PV) demand grew at an average annual rate of 51%, rising from 170 MW to 7059 MW. Despite this impressive rate of growth, the past two years have witnessed a fundamental and difficult market shift for manufacturers. Previously, burgeoning European feed-in tariff markets enabled global demand to exceed available supply, driving up feedstock prices and attracting new entrants across the value chain. But, the combination of an ensuing rapid capacity build-out and the financial crisis of 2008 and early 2009 shifted market power downstream into the hands of project developers and financiers. Today, global manufacturing capacity greatly exceeds global demand. With an estimated total of 16.1 GW of module manufacturing capacity online by the end of 2010, the global PV market is no longer constrained by supply.

In addition, 2010 will mark the beginning of a global PV market diffusion. Over the past few years, PV demand has been characterized by a series of gold rushes in which the majority of production flows into a single uncapped feed-in tariff market (Spain in 2008, Germany in 2009). But the gold rush is necessarily followed by the government reducing, and often capping incentives in order to constrain market growth. This leads manufacturers and developers to seek the next gold rush, and new markets are suddenly flooded with additional inventory. But, as Germany's star begins to fade in the second half of 2010, no individual market will emerge to soak up excess inventory in sufficient volume to become the singular focus of global demand. Instead, demand will be spread amongst a growing class of markets around the world.

Making strategic decisions in the new global market requires a deep understanding of emerging growth markets and the interplay among demand centres. This 246-page report represents the latest annual comprehensive analysis of global PV demand. It examines the characteristics that led the global PV market to grow in 2009 despite the global financial crisis, and applies these lessons in order to forecast demand and market conditions through 2013. The report scrutinizes demand drivers, market constraints, and project economics in 11 key national PV markets, and develops a global market outlook through 2013. In sum, this report provides a roadmap for the near-term future of global PV demand for developers, suppliers, and investors.

One focus of the report is an examination of 11 key national markets. The report looks at the policy environment, historical developments, and country-specific technological factors. It also includes economic project models for selected projects, an analysis of project financing, and a demand forecast through 2013.

For the global PV market, the report contains an analysis of conditions in 2009 as well as supply curves and demand projections through 2013, including the impact of Germany's feed-in tariff cuts on the global market. The report includes a forecast of module pricing in different technologies and a prediction of market share by technology through 2013.

The GTM Research report is one of the studies that have been released in the past few weeks that makes predictions about the future of the PV industry, which are different in important aspects from its current state. Many researchers suggest that demand will no longer be dominated by a single market, however, widely-recognized researchers including Paula Mints from Navigant Consulting have predicted that policies will continue to drive the market in the near future.

2010 Global PV Demand Analysis and Forecast contains critical intelligence for any consultant, market analyst, or investment professional. You can download your free executive summary from the report's website: http://www.gtmresearch.com/report/2010-global-pv-demand-analysis-and-forecast.

http://www.gtmresearch.com/report/2010-global-pv-demand-analysis-and-forecast

El Paso Solar Energy Association

El Paso Solar Energy Association aims to further the development and application of solar energy and related technologies keeping in the context of the ecological, social, and economic fabric of West Texas, Southern New Mexico, and Northern Mexico. The website gives full information in this regard. The website provides information on various meeting and conferences to be held, solar related news, work that is in progress in National Renewable Energy Laboratory (NREL), and so on. The website has a newsletter, calendar of events, and even a home design section. The website also provides links to various solar-based technologies and application and general information on difference solar energy associations and societies.

http://www.epsea.org/

Solar Energy Development Programmatic EIS (Information Centre)

The website is an online centre giving information and involvement for developing and implementing agency-specific programmes for solar energy development in the Programmatic Environmental Impact Statement. The website also provides full information for public participation in the Solar Energy Development PEIS. The website has a separate section catering to frequently asked questions and one on solar energy study area map. It provides detail information on EIS, the background, and how to get involved with EIS. An interesting feature of the website is that it provides full information on utility-scale solar energy and electric transmission.

http://solareis.anl.gov/eis/index.cfm

Green-Energy-Solar-Planet.com

This website gives us all the information about solar energy. It provides various facts, answers, information, data on solar energy. It has a separate section on solar news, frequently asked questions, home electricity, electricit rebates, cheap solar panels, solar gardens, solar pools, solar camping, and solar gadgets. It also has a separate section titled solar energy blog. The website has a section on environment, which gives various information on environment, greenhouse effects, future actions, and so on. Interestingly, the website has a dedicated section for kids. The website also gives information about buying and investing in the renewable market.

http://www.green-planet-solar-energy.com/

Solar Energy Technologies Programme

Solar Energy Technologies Programme is all about providing the world with new solar-based technologies and this website provides the best knowledge on this. The website gives full information about the latest research in the field of solar energy, market transformation, financial opportunities, information resources, news, and events. It also provides links to other websites on solar energy and solar news. The website also provides detail information on the various programmes undertaken in the field of solar energy.

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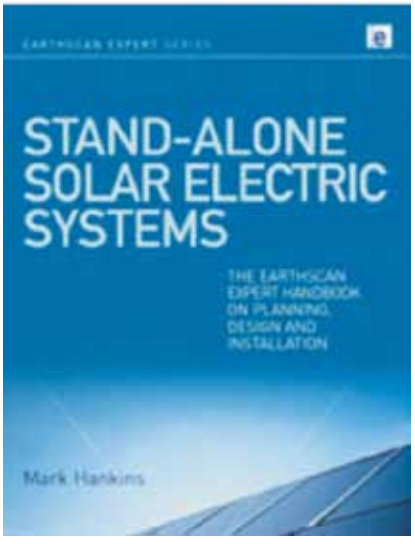
http://www1.eere.energy.gov/solar/

NEW BOOK INFORMATION



Mark Hankins
London: Earthscan, 232 pp.
Year: 2010

Stand-alone solar electric systems: the Earthscan handbook for planning, design, and installation

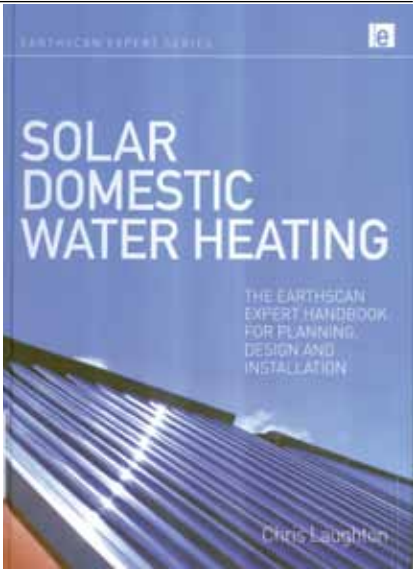
Off-grid solar electricity is a way of life. It is gratifying to be able to switch on solar-powered lights, laptop, music or internet in a wild remote location, far from power lines and diesel generators. This smugness is even more complete when a person has fixed the array, laid the cables, filled the batteries, and bolted the charge controller to the wall by himself/herself. This book is dedicated to three off-grid PV practitioners who have helped in spreading PV technology around the world. Each of them taught the world about the nuts and bolts of off-grid solar and helped lay the groundwork for this book.

The following are some of the important areas covered in this book.
▪ Solar energy basics ▪ Components of solar electric systems (modules, batteries, regulators, invertors, and appliances) ▪ Installation practice ▪ Details on planning and servicing systems ▪ Rural electrification ▪ Larger systems ▪ Water pumping

This book is for people who want to learn how to design and install small off-grid solar PV systems. This is the must-have guide for electric technicians and designers, development workers, and anyone who wants to install their own off-grid system.

Solar domestic water heating: the Earthscan expert handbook for planning, design, and installation

Solar water heating technology is the most environment-friendly way of heat water. This illustrated and easy-to-follow guide, which shows how solar water heating systems work, the different types of systems, types of collectors (both flat plate and evacuated tube), types of storage tanks and other accessories. It also shows how systems are installed. The book also explains the ways in which solar water heating can be integrated into existing water heating systems. Numerous examples from around the world have been included. The book is an ideal guide for plumbers, heating engineers, builders and architects, housing and property developers, home owners and DIY enthusiasts, and anyone who needs a clear introduction to solar water heating technology. This book entitled "Solar High quality components, design, and installation are at the core of the book, which gives a great overview of good and bad practice with solar heating systems.



Chris Laughton
(Series Editor: Frank Jackson)
London: Eathscan, 245 pp.
Year: 2010

NATIONAL AND INTERNATIONAL EVENTS

National

Green Energy World Expo'2010
14–16 October 2010
Chennai, India
E mail: daisy@gsnaworldwide.com
URL: www.gsnaworldwide.com

Intersolar India
14–16 December 2010
Mumbai, India
Tel: 49 7231 58598-0
Fax: 49 7231 58598-28
E Mail: info@intersolar.in
URL: www.intersolar.in

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

International

Solar Power 2010
12–14 October 2010
Los Angeles, California, USA
Tel: 1 202 857 0898
Fax: 1 202 682 0559
E Mail: info@solarelectricpower.org
URL: www.solarelectricpower.org

4th POWER Bangladesh 2010
14–16 October 2010
Dhaka, Bangladesh
Tel: 1 347 543 5543
Fax: 1 347 242 2657
E Mail: cems@cemsonline.com
URL: pv-expo.net

Solar Industry Conference (CIS-ES)
21–22 October 2010
Madrid, Spain
Tel: 49 30 72629630-0
Fax: 49 30 72629630-9
E Mail: info@solarpraxis.de
URL: www.solarpraxis.de

5th International Exhibition Energy-Photovoltaic '10
21–24 October 2010
Athens, Greece
Tel: 30 210 6141164
Fax: 30 210 8024267
E Mail: info@leaderexpo.gr
URL: www.leaderexpo.gr

PV Taiwan 2010
26–28 October 2010
Taipei, Taiwan
Tel: 886 2 2725 5200
Fax: 886 2 2725 7324
E Mail: pv@taitra.org.tw
URL: www.pvtaiwan.com

International Renewable Energy Congress (IREC) 2010
5–7 November 2010
Sousse, Tunisia
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URL: www.irec.cmerp.net/comite

3rd EPIA International Thin-Film Conference
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Munich, Germany
Tel: 32 2 4001057
E Mail: k.timaru@epia.org
URL: www.epia.org

Photovoltaic System and Grid Integration Forum 2010
9–10 November 2010
Beijing, China
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Fax: 86 21 51720-088
E Mail: marketing@jfpsgroup.com.cn
URL: www.pvgridintegration.com

11th Forum Solarpraxis
11–12 November 2010
Berlin, Germany
Tel: 49 30 72629630-0
Fax: 49 30 72629630-9
E Mail: conferences@solarpraxis.de
URL: www.solarpraxis.de

PVTech
17–19 November 2010
Milan, Italy
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Fax: 39 02 66 305510
E Mail: info@zeroemission.eu
URL: www.hitechexpo.eu

11th China Solar PV Conference and Exhibition 2010
18–20 November 2010
Nanjing, China
Tel: 86/21/3428-0006
Fax: 86/21/3428-5006
E Mail: nuogaisi2004@126.com
URL: www.ch-solar.com

International Green Energy Conference and Exhibition
22–23 November 2010
Kuala Lumpur, Malaysia
Tel: 60 3 7880-0413
Fax: 60 3 7880-2817
E Mail: stkoh@asifgroup.com
URL: www.greenenergyconference.org

3rd Thin Film Summit USA
30 November–1 December 2010
San Francisco, California, USA
Tel: 44 207 375 7500
URL: www.thinfilmtoday.com

PV Power Plants 2010 USA
1–2 December 2010
Las Vegas, Nevada, USA
Tel: 49 30 72629630-4
Fax: 49 30 72629630-9
E Mail: miriam.hegner@solarpraxis.de
URL: www.solarpraxis.de

Solar Canada 2010
6–7 December 2010
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RENEWABLE ENERGY AT A GLANCE

S.No.	Source/system	Estimated potential	Achievement as on 30 June 2010
I	**Power from renewables**		
A	**Grid-interactive renewable power**	(MW)	(MW)
1	Wind power	45 195	12 009.48
2	Bio power (agro residues and plantations)	16 881	901.10
3	Bagasse cogeneration	5 000	1 411.53
4	Small hydro power (up to 25 MW)	15 000	2 767.05
5	Energy recovery from waste (MW)	2 700	72.46
6	Solar photovoltaic power	—	12.28
	Sub total (A)	**84 776**	**17 173.90**
B	**Captive/combined heat and power/distributed renewable power**		(MW)
7	Biomass/cogeneration (non-bagasse)	—	238.17
8	Biomass gasifier	—	125.44
9	Energy recovery from waste	—	52.72
10	Aero generator/hybrid systems		1.07
	Sub total (B)	**—**	**417.40**
	Total (A+B)	**—**	**17591.30**
II	**Remote village electrification**	—	6867 villages/hamlets
III	**Decentralized energy systems**		
11	Family-type biogas plants	120 lakh	42.60 lakh
12	Solar photovoltaic systems	50 MW/km^2	120 MWp
	i. Solar street lighting system	—	119 634 nos
	ii. Home lighting system	—	603 307 nos
	iii. Solar lantern	—	797 344 nos
	iv. Solar power plants	—	2.92 MW$_p$
	v. Solar photovoltaic pumps		7334 nos
13	Solar thermal systems		
	i. Solar water heating systems	140 million m^2 collector area	3.53 million m^2 collector area
	ii. Solar cookers		6.72 lakh
14	Wind pumps		1347 nos
IV	**Awareness programmes**		
15	Energy parks	—	511 nos
16	Aditya Solar Shops	—	302 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