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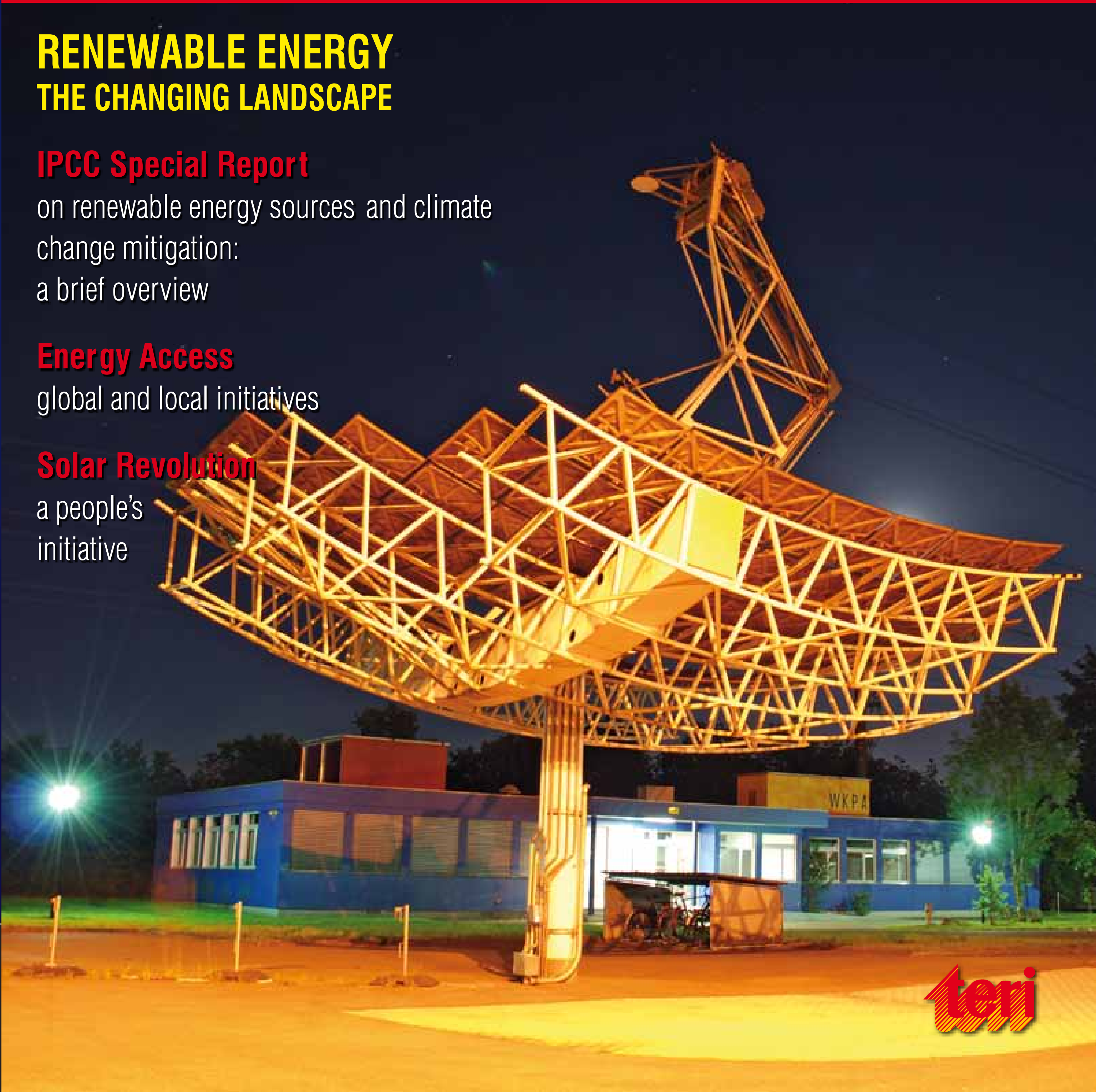

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THE CHANGING LANDSCAPE

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on renewable energy sources and climate change mitigation: a brief overview

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From the editor's desk...

The current space in the off-grid sector is dominated by solar manufacturers who supply systems, against the tenders floated by the state energy development agencies. In this business-as-usual (BAU) scenario, the end-user or the beneficiary does not always get the best of technologies at a competitive price. In fact, the end-user or beneficiary may not even be aware of what he/she should expect from the energy development agency or the solar manufacturer for the amount that is spent by him/her and/or by the government on his/her behalf. The Jawaharlal Nehru National Solar Mission (JNNSM), thus, calls for a shift from this BAU scenario, succinctly stating the following as it objectives; 1) to encourage innovation in addressing market needs and promoting sustainable business models; 2) to provide support to channel partners and potential beneficiaries; and 3) to create a paradigm shift needed for commodification of such application.

The Mission also places strong emphasis on human resource developments with plans for countrywide training programmes and specialized courses for technicians to meet the requirement of skilled manpower for field installations and after-sales service network. While the skilled human resources will be required for both large centralized applications of solar PV as well as the decentralized solar sector, the requirement is more crucial for implementation of the decentralized/off grid applications as this will be primarily taken up in rural and remote areas.

The above objectives point at the critical requirement of entrepreneurs, those who will take up the challenge of implementation of off-grid projects with a different approach. These will essentially be enterprises that will make efforts at understanding market needs, at conceptualizing and venturing into new business models, at matching technological advancements with functionality to create new products and systems, and will demand the best technologies at competitive prices from the manufacturers. Drawing parallel from the grid-connected sector, the off-grid sector needs project developers to take the agenda of the Mission forward and, in-turn, benefit from the huge opportunity that this sector offers. The recently released statistics from the Ministry of New and Renewable Energy (MNRE) mentions that the off-grid projects sanctioned so far under the JNNSM in 2010/11 total up to 40 MWp, more than the cumulative achievement of grid-connected power till date (37 MWp).

The new thinking towards implementing off-grid projects has to encourage local entrepreneurship for designing, development, customization, and assembly of products/ systems with an aim to improve their reliability and reduce their costs, and at the same time, to empower communities through knowledge-based tools and techniques so that they can derive direct and indirect benefits from electricity services.

Akanksha Chaurey
Director, TERI

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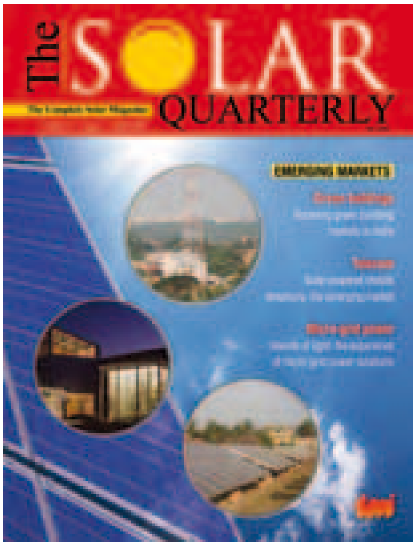

I am a regular reader of *The Solar Quarterly* magazine, and I appreciate the amazing work that the entire team is doing. Each and every article in the magazine is extremely informative and comprehensive. The articles give a complete overview on various aspects of solar energy.

Also, I find the news section of the magazine to be very informative as it not only covers all updates at the national level but also at the international level. The news section gives us an estimation of how far renewable energy has reached all over the world; from a small rural area of a developing country to a hi-tech city of a developed country.

Though I loved reading all the articles of the April issue of the magazine, but my personal favourite was the features section covering a detailed information on Rajasthan as the future energy hub of India and how various efforts are being made to improve the lives of the people in the remotest areas of the country.

I once again congratulate the whole team and hope that they will continue to keep up the good work!

Ankita Singh
Uttar Pradesh

I am a regular reader of *The Solar Quarterly* magazine. I really like the sections on research and development and technological development. These two sections help us to get an overview of various kinds of research work taking place in the area of solar energy. I also like the layout and presentation of these two sections.

Hope the magazine continues to provide us with information and knowledge in the area of solar energy.

Ramesh Nayar
Karnataka

I am a student and find *The Solar Quarterly* magazine to be extremely informative. I really liked the idea of theme-based articles. I would request the team to publish about 5–6 theme-based articles in a particular issue of the magazine. Under thematic articles, I found the article titled 'Islands of light: the experiences of micro-grid power solutions' to be extremely informative and well written.

All the best to the entire team of *The Solar Quarterly* magazine.

Kalpana Verma
Bihar

I am a teacher and a renewable energy enthusiast. I am also a regular reader of *The Solar Quarterly* magazine published by TERI. The magazine is comprehensive and gives a holistic understanding of solar energy. I really like the way each issue is approached. Each article gives expert opinion, and yet written in a very lucid and simple manner. Therefore, an expert as well as a common person can pick up the magazine and gain knowledge on solar energy. In the April issue of the magazine, I found the article titled 'Booming green building markets in India' to be very informative and well written.

I congratulate the entire team of the magazine!

Keya Sharma
Madhya Pradesh

Thank you very much for your encouragement. The editorial team of The Solar Quarterly will make every effort to make this magazine highly informative and useful to all our readers. We welcome your suggestions and valuable comments to make further improvement in terms of content and presentation.

Editor
The Solar Quarterly

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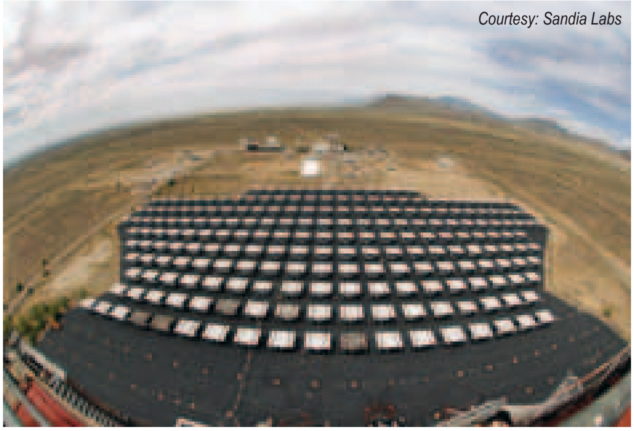

Courtesy: Sandia Labs

DOE offers $2 billion in conditional loan guarantee commitments for two California concentrating solar power plants

The Department of Energy (DOE) loan guarantee programme is really pushing the concentrating solar power (CSP) projects. This programme has so far disbursed $30.7 billion and claims to have created or saved 62,350 jobs. Add $2 billion more to the dollar total and 1,800 to the jobs total with this news. The US Energy Secretary Steven Chu just announced the offer of conditional commitments to provide loan guarantees to support the following two 250-MW CSP projects.

The Mojave Solar Project, sponsored by Abengoa Solar in San Bernardino County, California, is being offered a $1.2 billion loan guarantee.

The Genesis Solar Project, sponsored by NextEra Energy Resources on land managed by the Bureau of Land Management (BLM) in Riverside County, California, is being offered up to $681.6 million loan guarantee.

Both these projects utilize parabolic trough solar thermal technology. Power from both projects will be sold to Pacific Gas and Electric (PG&E). Brett Prior, Greentech Media Research's CSP expert, made the point that although the loan guarantee programme has been criticized for moving too slowly, it looks like the DOE is finally granting approvals for these large projects.

Source *Greentech Solar*

Second solar power auction to raise scale limit

India plans to open the second round of bidding for licenses to build solar power plants and may change rules that limited the size and amount of projects awarded to the companies. The government wants to raise the maximum scale of solar photovoltaic (PV) project to 20 or 25 MW from the 5-MW limit set during the first solar auction in December 2010. The Ministry of New and Renewable Energy (MNRE) is asking for feedback from the industry by 30 June 2011 to possibly change the rules that prevent awarding multiple projects to a developer.

Source Infra News

Cooler, smarter options for hot CSP technologies

Increasing water scarcity is a big concern for the CSP developers, given the sheer volume of water required by certain technologies for cooling and mirror washing, and communities' growing concern over water use. Smart solutions are in demand. Alternatives for CSP cooling are still few and far between, with wet and dry cooling methods the only feasible options today, both of which have drawbacks. But, developers and researchers are exploring different configurations for hybrid cooling systems that could combine the best of both worlds. Dry cooling has been around for the last 15 years, but research and development have not evolved the process beyond its faults during that time, particularly in the problem-area of ambient temperature, says Babul Patel, principal consulting engineer in renewable energy for Nexant. With CSP plants focused on dry, sunny areas of the US, during the summer months when CSP must perform, it suffers from dry cooling because of intense solar radiation. "It is a double-edged sword, in the sense that dry cooling is feasible, but it impacts plant output exactly when CSP has the ability to deliver the maximum output," Patel said. At the top of the list for new cooling approaches, at least in terms of feasibility, are varied approaches to a hybrid cooling system. A recent study by NREL found that climate factors play an important role in how a parabolic trough plant's efficiency and cost outputs are affected by hybrid cooling. The minimal use of water, primarily in an air-cooled condenser, may prove to be the best way to lower the amount of water used, while still harnessing its benefits as a cooling agent, says Jordan Macknick, energy and environmental analyst with NREL. "Options could be misting of the air, or flooding the (cooling) area before pushing the air through," Macknick said. "We found that optimizing the size of the air-cooling condenser, making it much larger than what has been considered before, may increase the upfront capital costs, but increase the output in the plant. We predict a lower performance penalty and lower cost penalty over time by adjusting the size of the air-cooled condenser," says the study. Further, it found that dry cooling would generally achieve a 90%–92% decline in water consumption, with an increase in the cost for generating electricity of 3%–8%, depending on the climate.

Source *CSP Today*

Moser Baer to commission India's largest solar PV project with capacity of 30-MW in Gujarat

According to the market reports, India's largest solar power project will be commissioned very soon. This project has been taken up by a leading photovoltaic (PV) manufacturer Moser Baer and offers a total thin film capacity of 30-MW. The twin solar projects of 15 MW each have entailed an investment of about ₹450 crore. "The combined capacity of our projects in Patan, Gujarat makes it by far the largest solar project in the country. Many projects with similar size and slightly larger are coming up, but they may take time," said, K N Subramanium, Chief Executive Officer, Moser Baer Solar Systems."The PV project using thin-film technology is expected to give better yield. This requires 7–8 acres for generating one megawatt, depending on the technology of thin film and land profile available at a specific site," he added. According to him, the Patan project will remain the largest in the solar sector, in the country, at least till the end of this year. Recently, major electricity distribution company Torrent Power Ltd, entered the solar sector and is building a 50-MW project in Gujarat.

Source: Panchabuta Newsletter

Solar plane expected to make a stopover in India on its world tour

The world's first solar plane hopes to make a stop over in India when it completes its first round-the-world tour three years from now. The plane would fly south of the Himalayas and hopes to make a stop over in India, if invited to do so, Bertrand Piccard, the President of the Solar Impulse project, told *Business Line* at the hangar of the Swiss firm's HB-SIA prototype. "We are looking for partners," he said. Solar Impulse, which unveiled the world's first plane powered by solar energy last year, will complete construction of a second updated plane in 2013 and take it on a three-day, three-night, round-the-world journey the following year. "It will be more comfortable, more efficient than the first one," said Andre Borschberg, CEO and co-founder of the company. Standing at a corner of Le Bourget to the north of Paris, the Solar Impulse aircraft has been billed as the star attraction of an air show, eager to tout its green credentials amid the smell of jet fuel and roar of military aircrafts parading the skies. Piccard says he first came up with the idea of the plane following his first non-stop, round-the-world trip in a balloon 10 years ago, disturbed by the vast amounts of fossil fuel it guzzled up. Work on the project began eight years ago following a feasibility study, and the first flight took place in 2010. It also completed a night flight and a non-stop journey of over 26 hours. Weighing 1,600 kg, similar to a small sports car, and with the power of a small scooter (four 10 HP electric engines), Solar Impulse's founders insist that it does not use any new revolutionary technology to power the plane, but simply what is readily available. "We are not trying to create an aviation revolution, but change the way people think about clean technology and how it can be used in society," says Borschberg. The plane itself is made of composite materials. However, when it comes to the round-the-world tour, the biggest challenge will be integrating into the busy air traffic routes. The plane needs 3,000 feet of separation from other crafts, nearly three times what regular aircrafts need, which poses major challenges to air traffic control operations.

Source *The Hindu Business Line*

Courtesy: NASA

IFC invests $4 million to build solar thin-film power plant in India

International Finance Corporation (IFC) has announced an investment of $4 million to build the country's first large scale, grid-connected, thin-film solar power plant. It will help bolster clean energy, locally, and provide additional electricity to about 11,000 people. The investment by IFC, a member of the World Bank Group, into Sapphire Industrial Infrastructures, a subsidiary of Moser Baer Clean Energy, will support the construction of a 5-MW solar plant at Sivaganga in Tamil Nadu. "IFC recognizes the potential of large-scale solar power generation to help meet India's enormous energy needs," country head-Solar Farms at Moser Baer Clean Energy, Rajya Ghai said. The learning from this project will help us replicate similar projects in other Indian states, Ghai added. The solar plant will have the capacity to produce eight million units of power annually. Further, it is expected to avoid about 6,600 tonnes of greenhouse-gas (GHG) emissions per year. So far, grid-connected solar electricity has received lukewarm response from the private sector in India, due to higher initial investment and generation costs as compared to conventional energy sources. "The successful commissioning of this first large scale, thin-film solar photovoltaic plant demonstrates the private sector's ability to rise to the challenges associated with achieving a balanced energy mix," IFC director, Infrastructure Asia, Anita George, said.

Source *The Live Mint*

Solar module prices come down another 20% in just five months

Solar module prices have dropped by another 20% during the first five months of 2011. Modules belonging to top brands are now available at $1.40 per watt and sometimes even less. Half-way through 2008, the sales price still stood at about $4 per watt. Last year, the global solar PV market grew by an astonishing 100%. For any industry, in the midst of a global economic crisis, this is not a bad result. And, it was not the first time this spectacular growth occurred, it first occurred in 2008. Only in 2009 did the global crisis hit the PV market, slowing down the growth to close to 15%. Since 2001, the global PV market showed an average growth rate of 50% of new installations per year. No wonder the solar industrial players invested heavily in some capacity expansion. After a decade of continuous growth, it does not look that there is any turbulence for the solar PV market. After all, governments will continue to seek sustainable energy solutions and fossil fuel independence. As for the end user, the majority would definitely prefer clean solar energy, if available at competitive prices. Even more stimulated by the glorious market demand figures in 2010, the solar industry invested heavily in capacity expansion. This will bring down cost and sales prices, helping it to reach the holy grail of grid parity even sooner. But, besides the

rapid growth of the existing industry leaders, many new players have been attracted too by the growth figures and market forecasts. New small companies and very large (Asian) corporations have started to produce silicon, cells, and solar modules, mainly because the market is far from being saturated. It does seem that the solar energy market will stop growing, apart from the odd temporary slow-down. In the light of general budget cuts and economic problems, Germany, France, the Czech Republic, and Italy decided to cut back the feed-in tariffs and other grants for 2011. The purpose of this move is to cool down the explosive market growth and excessive budget claims. Not only did they lower the tariffs (subsidies); the revised schemes mean that the smaller roof systems are favoured over big ground-mounted power plants. The subsidy reductions are forcing the solar industry to reduce cost and system prices in order to remain attractive to its customers, ensuring that it still provides an attractive return on investment. Besides, in terms of sales efforts, the shift from fewer large-scale power plants to more smaller-scale systems will prove to be costlier job.

Source *Solar Plaza Blog*

European solar heating and cooling market in decline

The market for solar heating and cooling in the European Union (EU) and Switzerland has dropped for the second consecutive year. The overall European solar heating and cooling market declined in 2010, according to the latest available market statistics for the 27 EU member states and Switzerland released by the European Solar Thermal Industry Federation (ESTIF) at Intercooler 2011. It is the second year that the solar heating and cooling market has declined, although it still remains above its 2007 level with a total 2,586 MWth (3 694 940 m²) of newly installed capacity. The German market, while still being the largest in Europe, dropped by nearly 29% in 2010. It is now almost back to its 2007 level, with 805 MWth of newly installed capacity (1,150,000 m²).

The other main solar heating and cooling markets, including Italy, Spain, Austria, France, and Greece (between 200,000 and 500,000 m² of newly installed capacity), behaved very differently in 2010. The Greek and Italian markets increased slightly, but Austria, Spain, and France suffered a decline. It was the second year in a row for the French market. A group of developing markets—Portugal, Poland, Switzerland, Czech Republic, Denmark, and the UK—grew a total of 8.8%. However, their combined increase of 40,000 m² does not quite compensate for the decrease recorded in larger solar heating and cooling markets.

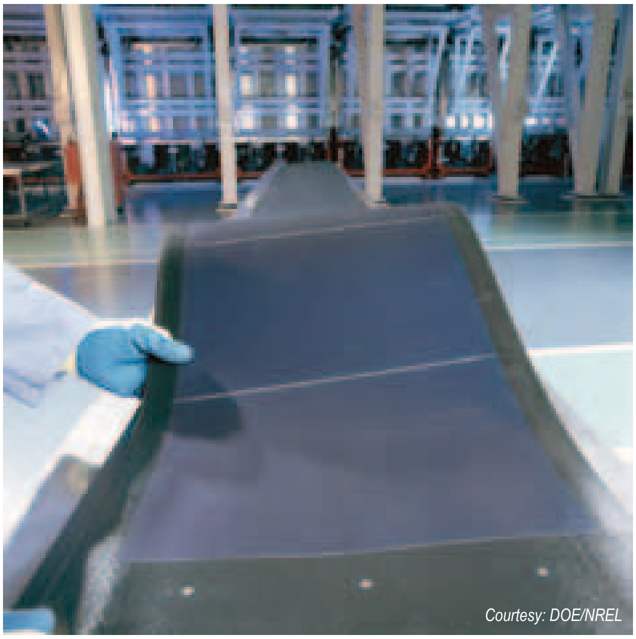
Xavier Noyon, ESTIF Secretary General, says: “One of the factors contributing to this downturn is the lack or unpredictable nature of incentive frameworks. The resulting stop-go cycles and deferred decisions have adversely affected sales and undermined the investor and consumer confidence to some extent. However, there is ground for optimism: the analysis of the consolidated National Renewable Energy Action Plans, submitted by each (EU) member state earlier in the year, reveals that over the next decade the share of solar thermal should rise by 15% per annum.”

Robin Welling, President of ESTIF, adds: “The solar thermal industry has experienced the full impact of the 2008 financial crisis as the construction sector has been particularly affected by the economic recession that followed. We expected to derive some benefit from the combined implementation of the binding renewable targets and higher energy performance standards, but this process is just beginning to take place.”

Source *Renewable Energy Focus*

Du Pont Apollos claims first LEED gold rating for thin-film PV manufacturer

DuPont Apollo’s Shenzhen, China PV module manufacturing facility has claimed to being the first Leadership in Energy and Environmental Design (LEED) Gold certified for Existing Buildings, Operations and Maintenance (EB, O&M), thin-film PV site in the world. The LEED certification was granted by the US Green Building Council (USGBC), which


Courtesy: DOE/NREL

pointed to several of the company's environmentally friendly designs as a basis for their certification.

"We believe that DuPont Apollo's thin-film solar modules should come from a facility designed with environmental responsibility in mind," said David Chu, CEO of DuPont Apollo. "We are very pleased to know that our efforts to maximize energy efficiencies in the daily operation of our production facility were recognized by USGBC, and we hope this is one of the many actions by DuPont Apollo that sets an important example for other businesses. Thinking globally and acting locally to affect positive environmental change helps create a healthier working environment for our employees and the larger community, and becomes the main principle for a continued, sustainable growth and reduce dependence on fossil fuels." The Shenzhen facility's top claim to the LEED certification lies on its rooftop with its 1.3 MW amorphous silicon PV module installation. The modules, manufactured by the plant itself, produce about 1.5 million KW hours of electricity per year to offset the facility's daily operational energy needs.

Other environmentally sound practices that the plant has introduced include an upgraded heating, ventilating, and air-conditioning (HVAC) system, water saving features, a sustainable buying plan that sources materials and supplies locally, and an EnergyStar solid waste management system.

Source *PV-TECH*

Kings Cross Station first for new solar test technology

For the first time, a new hand-held PV electrical test instrumentation has been used as part of the installation of one of UK's largest solar panel systems. Cumbria-based Sundog Energy became the first installer to use the new Seaward Solar Installation PV100 tester, as part of its contract with Network Rail to provide a huge solar PV system on the roof of the Kings Cross Station in London. The Kings Cross project is one of the biggest solar PV systems in the UK. The PV cells are integrated into nearly 1,400 glass laminate units that will form part of the new glass roofing structure over the platforms and concourses. The roof area that will be covered with the solar PV glass laminate is about 2,300 m^2. By using the Seaward PV100 on the Kings Cross contract, Sundog Energy became the first solar installer to utilize the new instrument on a major project. The PV100 electrical tester is the first dedicated multi-function tester for solar panel installation. It is capable of carrying out all electrical tests required by IEC 62446 on grid-connected PV systems and eliminates the need for multiple test instruments for PV panel electrical installation and connection. With the push of a single button, the new combination tester carries out the required sequence of electrical tests in a safe and controlled manner, avoiding the risk of contact with exposed live direct current (DC) conductors.

Source *Solar Daily*

Solar signals for traffic in the dark in Jharkhand

Blackout capital has discovered the sunny side of things. In a pioneering move, it is now using solar energy to uninterruptedly light up its power-starved traffic intersections, thus, minimizing the risk of road accidents in the dark. A joint initiative of the road construction department and traffic police, solar panels have been installed at as many as 22 intersections across

the capital at a cost of ₹35 million over the past couple of months. A Bengaluru-based agency, Bharat Electronics, has been roped in for the eco-friendly project, which debuted at Kokar Chowk during the National Games in February. "Till now, we have covered about 22 traffic signals in Ranchi, the capital of Jharkhand. We are identifying some more traffic points, where solar panels will be installed soon", says Umesh Sinha, executive engineer, road construction department. At all the designated intersections, the panels have been fixed atop poles.

In pockets like Kanta Toli, Sujata Chowk, and Argora Chowk in Ranchi, which see heavy flow of traffic every day, two pairs of panels have been installed, whereas sparsely populated intersections have a single pair. The panels are auto-tuned, which means as soon as electricity trips, the traffic signals automatically switch to the solar mode. "Sun beams penetrate the panels, which have control boxes that convert DC current into AC current for storage in batteries. The energy stored in the cells is currently powering a signal uninterruptedly for at least 10 hours." While on a sunny day, traffic signals are being run by solar power, an overcast sky connects the signal back to the normal power grid. There were some minor glitches like placing of panels and controlling signal time. Installing solar panels is an intricate job. Any obstruction, even partially blocking sunlight, can reduce efficiency. For instance, at Jail More and Sarjana Chowk, trees and buildings are shielding the panels from receiving

maximum sunlight. However, experts are working overtime to "synchronize things" at the earliest. Independent time consoles have been fixed at all the 22 intersections so that signal pulse can be set as required when in solar mode. A select group of traffic cops have been trained to handle the system efficiently.

Source: The Telegraph

Rooftop solar project to generate thousands of jobs in 28 states

Rooftop solar generation takes a giant leap forward as a consortium of companies, Bank of America Merrill Lynch, Prologis, and NRG Energy, announce an offer of a conditional commitment from the US Department of Energy's Loan Programmes Office to help finance the largest distributed rooftop solar generation project in the world.

According to a release, the loan guarantee supporting $1.4 billion of debt facilitates a total project size of about $2.6 billion, which is being financed entirely by the private sector over the next four years.

This distributed solar project will generate employment across 28 states and will create the equivalent of more than 10 000 full-year jobs. Once fully funded and completed, these installations are expected to provide about 733 megawatts (MW) of distributed solar energy. Having received this offer of a conditional commitment from the Department of Energy, the three firms are working to finalize the financing documentation for the distributed solar project and begin the first phase of installation. Of this first phase, 15 MW of solar capacity is ready immediately for construction and installation in Southern California, where the power generated will be sold to a local utility under long-term power purchase agreements that have been approved and executed. NRG Energy has committed to be the lead investor for the first phase of the project over the next 18 months.

Source: www.powergenworldwide.com

Howbery Park near Wallingford becomes UK's first solar-powered business park

THE return of sunny weather has been an added bonus for the launch of the UK's first solar-powered business park—Howbery Business Park near Wallingford.

More than 3,000 solar panels have been installed there and is generating enough electricity to power the entire site.

The installation was developed at a cost of more than £2 million by water and environmental consultancy HR Wallingford. Chief executive John Ormston said, "We use power generated by the panels on the park during the day, and then in the evenings and at weekends it is exported to the National Grid. "The recent good weather has meant we have been able to power the entire park using solar electricity and through the course of the year, we expect to produce more than 25% of our needs."

It is estimated that more than 350 tonnes of carbon


Courtesy: LaBL, TERI

dioxide emissions will be cut in a year at the park, which houses almost 1,000 staff in 20 different organizations. While Howbery Park is the first solar park in the UK to go live, others are in the pipeline in Oxfordshire.

www.heraldseries.co.uk

Solar energy market in India poised for stupendous growth

The solar energy market in India has witnessed an impressive growth during the past few years, with solar photovoltaic segment emerging as the major contributor towards the growth of the industry. This is mainly due to the increasing electricity demand, high irradiation levels, favourable government policies, and investments worth billions of dollars being made in this sector. Further, the government is keen to augment the solar energy share by concurrently enhancing infrastructural conditions in the nation, particularly with products, such as solar water heating systems and solar street lights, says the new research report "Indian Solar Energy Market Analysis". The solar street lighting systems is expected to reach 160,000 units by the end of 2013.

Apart from huge investments in solar power plants and the obligatory modification of the governmental buildings with solar technology, the demand for solar off-grid systems will quickly increase across several remote and un-electrified rural regions of the nation. However, only inexpensive products that can compete with the domestic low-cost solar products in India will have an opportunity to get into the rural regions.

Also, thin film technology is attracting huge amount of investments by the manufacturers worldwide. Moreover, presence of several big players with many years of experience and diversifying production capacities coupled with the entrance of new players, which have the prospective to develop into important players, would eventually result into growth in coming years.

www.sbwire.com

ADB says Asia solar energy needs $10 billion investment

Asia needs to invest about $10 billion in the next few years to make solar power generation competitive with conventional energy sources, the Asian Development Bank (ADB) said recently as it called for radical steps to fight climate change.

The ADB wants Asia, home to about two-thirds of the world's population, to add 3,000 MW of solar energy capacity by the end of 2013. Already this year it has helped countries add 500 MW, doubling the region's solar capacity.

It will launch the Asia Accelerated Solar Energy Development Fund with $2.25 billion as it targets solar power projects in countries including China, India, Pakistan, Uzbekistan, and Thailand to add another 1000 MW next year and 1500 MW in 2013.

"By providing an enabling environment for commercial lending and private investment in the solar energy market, we hope to encourage its rapid growth and bring solar energy nearer to grid parity, making solar energy competitive in price to conventional sources," ADB President Haruhiko Kuroda said at a clean energy forum in Manila.

af.reuters.com

Bosch plans new solar manufacturing site in Malaysia

The Bosch Group has announced plans for a new solar manufacturing site in the Batu Kawan region in Penang, Malaysia. "With this investment, Bosch is moving further along the path of internationalization, it has already set for its photovoltaics business," said Franz Fehrenbach, chairman of the Bosch board of management, in Stuttgart. The new manufacturing site in Batu Kawan will mainly serve Asia's solar energy market, which is growing strongly. In the coming years, the Asian market is set to see average annual growth of 30%. Components for manufacturing sites in other countries will also be produced at the new Malaysian site, said Fehrenbach.

The company plans to invest around ₹520 million for the new manufacturing

site. Construction of the new site is set to begin before the end of this year.

"The planned facility will cover the entire value-added chain, from silicon crystals known as ingots and solar cells to the modules which can be installed on roofs or in solar power plants," said Holger von Hebel, chairman of Bosch Solar Energy AG.

www.istockanalyst.com

India's solar mission visionary: Australian report

The Jawaharlal Nehru National Solar Mission launched by Prime Minister Manmohan Singh last year has positioned India "to become a global leader in the growth of concentrating solar power (CSP) technologies," according to a new report. This is, however, subject to the mission being "implemented in a pragmatic manner" and initiation of new measures "aimed at assisting Indian companies through tax incentives, soft loans or a revolving equity fund". The report, commissioned by the Australian government, analyses the context, barriers, and policy options for the growth of the CSP industry in India.

As opposed to photovoltaic (PV) technologies, the CSP technologies use systems of mirrored concentrators to focus direct beam solar radiation to receivers that convert the heat energy to mechanical energy through a steam turbine and then into electricity.

India's solar mission launched in January 2010 has an ambitious target of 20 GWe of installed solar power by 2022. In the first phase, 1 GW of grid-connected solar energy is targeted for 2013 with an approximate 50:50 split between CSP and PV technologies.

The report has made a few more recommendations to reduce the project timelines and make the solar mission a success.

"For a country embarking on growing its involvement with CSP, a pilot plant of some kind is needed," the report says. "CSP has been discussed in India for many years but there has been no significant pilot plant constructed."

A promising way to go ahead is by establishing solar parks in areas where the direct incidence solar radiation is high. The solar park concept could be applied to advantage in a manner tailored for small-scale demonstrations to facilitate commercially driven pilot plants in the 1 to 5 MW size range, the report says.

www.siliconindia.com

IPCC SPECIAL REPORT ON RENEWABLE ENERGY SOURCES AND CLIMATE CHANGE MITIGATION

A brief overview

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About IPCC

The Intergovernmental Panel on Climate Change (IPCC) is a leading international body for assessing climate change. It was established by the United Nations Environment Programme (UNEP) and the World Meteorological Organization (WMO) to provide the world with a clear scientific view on the current state of knowledge in climate change and its potential environmental and socio-economic impacts. The United Nations (UN) General Assembly endorsed the action by WMO and UNEP in jointly establishing the IPCC. The IPCC is a scientific body. It reviews and assesses the most recent scientific, technical, and socio-economic information produced worldwide relevant to the understanding of climate change. It does not conduct any research nor does it monitor climate related data or parameters. Thousands of scientists from all over the world contribute to the work of the IPCC on a voluntary basis. Currently, 194 countries are members of the IPCC. Governments participate in the review process and the plenary sessions, where main decisions about the IPCC work programme are taken and reports are accepted, adopted, and approved. The IPCC Bureau Members, including the Chair, are also elected during the plenary sessions. Currently, Dr Rajendra K Pachauri is the Chairman of this highly accredited world body.

SPECIAL WORDS FROM DR R K PACHAURI, CHAIRMAN, IPCC

One of the most significant events that I have been associated with this month was the release of IPCC's Special Report on Renewable Energy Sources and Climate Change Mitigation. This report was originally requested by the German government and was resisted by some countries initially (whom I would prefer not to identify), but in the end the entire Panel agreed to its production, and the German government provided significant resources to make it happen. The report examined 164 different scenarios available in the literature assessing different levels of penetration of renewable energy. The most optimistic scenario involved a 77% share of renewables in the total world consumption of energy in 2050. Without going into the substance of the report, may I say that one of the important features that come out of this product is the importance of long-term policies and prices, which can make an enormous difference to the kind of energy mix that the world is going to see in the years ahead. In particular, a price on carbon would be critical in ensuring adequate expenditure on research and development and market initiatives by which renewable energy can start replacing conventional sources within a reasonable period of time. Renewable energy also has a huge potential in creating energy access opportunities, which certainly do not exist, currently, for over 1.4 billion people who have no access to electricity and well over two billion people who still use biomass, often of low quality, for cooking purposes. The Energy and Resources Institute's (TERI) campaign for Lighting a Billion Lives (LaBL), though, not mentioned in the report, provides substance to this reality.

One major concern I have is related to our own poor record in development of renewable energy options in India, even though we have had, for almost 30 years, a special department dealing with this sector in the Government of India and for quite some time now a separate ministry. Unfortunately, our highly bureaucratic structure and inability to bring about changes, which are required for moving away from business as usual are a major constraint and barrier to rapid development. The National Solar Energy Mission gives us an opportunity to bring about change, which has to be preceded by some institutional innovation which, unfortunately, is also being impeded by existing institutional structures and individuals. If we are serious about meeting the target of 20,000 MW of solar capacity in the next ten years approximately, we need a very different organizational structure for conceptualizing, spreading, implementing, and monitoring such a programme. All stakeholders, including industry and business would have to be part of this major national effort. If we succeed, then similar organizational innovations can be implemented in other sectors as well. If we do not, then this country would have to pay a very high price in the years ahead, when our dependence on fossil fuels will reach levels, which are even more unsustainable than is the case today.

Source: *http://intranet.teri.res.in/*

Introducing IPCC Special Report on Renewable Energy Sources

Today, renewable energy (RE) technologies are amongst the most talked about technologies worldwide for a variety of reasons. With due consideration to its growing importance, IPCC released a special report on Renewable Energy Sources and Climate Change Mitigation (SRREN) on 9 May 2011 in Abu Dhabi. This was followed by the release of a final version of this report on 14 June 2011. The final report has 11 chapters dealing with bio-energy, on one hand, to policy, financing, and implementation issues, on the other hand, apart from annexures (I–VI). The report assesses the existing literature on the future potential of renewable energy for the mitigation of climate change. It covers the six most important renewable energy technologies, as well as their integration into present and future energy systems. It also takes into consideration the environmental and social consequences associated with these technologies, the cost, and

Courtesy: Hauke Dressler

strategies to overcome technical as-well-as non-technical obstacles to their application and diffusion. Chapter 3 on Direct Solar Energy has eminent coordinating lead authors like Dan Arvizu (USA) and Palani Balaya (Singapore/India, along with a number of lead authors and contributing authors from several other countries.

This thematic write-up attempts to sum up several key policy, technology, and implementation issues as presented in Chapter 3 (Direct Solar Energy) of this special report. The main purpose of this article is to give a brief overview of the information available in the IPCC report.

Solar energy utilization

Solar energy is abundant and offers significant potential for near-term (2020) and long-term (2050) climate change mitigation. There are a wide variety of solar technologies of varying maturities that can, in most regions of the world, contribute to a suite of energy services. Even though solar energy technologies still represent a small fraction of the total energy consumption, markets for solar energy technologies are growing rapidly. The cost of solar technologies has been reduced significantly over the past 30 years and technical advances and supportive public policies continue to offer potential for additional cost reductions. The potential deployment scenarios range widely from a marginal role of direct solar energy in 2050 to one of the major sources of energy supply. The actual deployment achieved will depend on the degree of continued innovation, cost reductions, and supportive public policies. The following elemental considerations merit special attention.

Solar energy: the actual potential

The rate at which solar energy is intercepted by the earth is almost 10,000 greater than the rate at which humankind consumes energy. Although, not all countries are equally endowed with solar energy, a significant contribution to the energy mix from direct solar energy is possible for almost every country. Currently, there is no evidence indicating a substantial impact of climate change on regional solar resources.

Solar energy conversion

Solar technologies can deliver heat, cooling, natural lighting, electricity, and fuels for a host of applications. Conversion of solar energy to heat (thermal conversion) is comparatively easier. This is because any material object placed in the sun will absorb thermal energy. However, maximizing the energy that is absorbed and stopping it from escaping to the surroundings can take specialized techniques and devices, such as evacuated spaces, optical coatings, and mirrors. Which particular technique is used depends on the application and temperature at which the heat is to be delivered? This can range from 25 ^{0}C, for swimming pool heating, to 1,000 ^{0}C, for dish/stirling concentrating solar power and even up to 3,000 ^{0}C in solar furnaces.

Electricity generation can be achieved in two ways. In the first, solar energy is converted directly into electricity in a device called a photovoltaic (PV) cell. In the second, solar thermal energy is used in a concentrating solar power plant to produce high temperature heat. It is then converted to electricity via a heat engine and generator. Both approaches are currently in use.

Budding solar technologies

In certain locations, some technologies are already competitive with market prices and, in general, the overall viability of solar technologies is improving. Solar thermal can be used for a wide variety of applications, such as domestic solar water, comfort heat of buildings, and industrial process heat. This is significant as many countries spend up to one-third of their annual energy usage for heat. Solar hot water heating for domestic and commercial buildings is now a mature technology growing at a rate of 16% per year. It is employed in most countries across the world. The total installed capacity of solar thermal systems, at the end of 2009, was estimated at 180 GWth.

Passive solar and day lighting conserve energy in buildings at a highly significant rate, but the actual energy is difficult to quantify. Well-designed passive solar systems decrease the need for additional comfort heating requirements by about 15% for existing buildings and about 40% for new buildings.

Generating electricity with the help of PV panels is also a worldwide phenomenon. Assisted by supportive pricing policies, the compound annual growth rate for PV production from 2003 to 2009 was more than 50%. Thus, it makes for one of the fastest growing energy technologies in percentage terms. In the end of 2009, the installed capacity for PV power production was about 22 GW. Estimates for 2010 give a consensus value of about 13 GW of newly added capacity. Most of the installations are roof-mounted and grid connected. In the last few years, electricity production from concentrated solar power (CSP) installations, in planned capacity, has seen a large increase. Several countries are beginning to experience significant new installations.

Integrating solar energy

Energy provided by PV panels and solar domestic water heaters can be especially valuable; mainly because maximum energy is produced at the time when there is peak load on the grid. PV and solar domestic water heaters are very user friendly, mainly because they are modular, quick to install, and can, sometimes, delay the need for costly construction or expansion of transmission grid. At the same time, solar energy has a variable production profile with some degree of unpredictability that must be managed and central station solar electricity plants may require new transmission infrastructure. Given CSP can be readily coupled with thermal storage, the production profile can be controlled to limit production variability and enable dispatch capability.

Solar technologies inducing social change

Solar technologies have low lifecycle greenhouse gas (GHG) emissions, and quantification of external cost has yielded favourable values as compared to fossil fuel based energy. Potential areas of concern include recycling and use of toxic materials used in PV manufacturing, water usage for

CSP, energy payback, and land requirement for both. An important social benefit of solar technologies is the potential to improve the health and livelihood opportunities of the world's poorest. It can provide electricity to about 1.4 billion people who, even today, do not have access to electricity. There are 2.7 billion people, who rely on traditional biomass for cooking and heating. On the downside, some solar projects have faced public concerns regarding land requirements for centralized CSP and PV plants, perceptions regarding visual impacts and for CSP, cooling water needs. Land use impacts can be minimized by selecting areas with low-population density and low-environmental sensitivity. Similarly, water usage for CSP could be significantly reduced by using dry cooling approaches. Till date, studies, suggest that none of these issues present a barrier against the widespread use of technologies.

Decreasing costs

The current levelized costs of energy (electricity and heat) from solar technologies vary widely depending on the upfront technology cost, available solar irradiation, as well as the applied discount rates. The levelized costs of solar thermal energy at a 7% discount rate range between less than USD$_{2005}$10 and slightly more than USD$_{2005}$ 20/GJ, for solar hot water generation with a high degree of utilization, in China, to more than USD$_{2005}$ 130/GJ for space heating applications in Organization for Economic Cooperation and Development (OECD) countries, with relative low irradiation levels of 800 kWh/m^2/yr.

The cost of electricity generation for utility scale PV in regions with high solar irradiance, in Europe and the USA, are in the range of about 1.5–4 US cents$_{2005}$/kWh, at a 7% discount rate. However, it may be lower or higher depending on the available resources and on other framework conditions. Current cost data are limited for CSP and are highly dependent on other system factors, such as storage. In 2009, the levelized costs of energy for large solar troughs, with six hours of thermal storage, ranged from less than 20 to nearly 30 US $cents_{2005}$/kWh. Technological improvements and cost reductions are expected, but the learning curves and subsequent cost reductions of solar technologies depend on production volume, research and development, and other factors, such as access to capital. Private capital is flowing into all the technologies, but government support and stable political conditions can lessen the risk of private investment and help ensure faster development.

Wide range of potential deployment scenario for solar energy

Although, it is true that even today direct solar energy provides only a very small fraction of global energy supply, it has the largest technical potential among all energy sources. Given technological improvements and cost reductions, the solar market has the potential to expand dramatically. Achieving continued cost reductions is the central challenge that will influence the future deployment of solar energy. Moreover, as with some other forms of renewable energy, issues of variable production profiles and energy market integration as well as the possible need for new transmission infrastructure will influence the magnitude, type, and cost of solar energy deployment. Finally, the regulatory and legal framework, which is in place, can either foster or hinder the uptake of solar energy applications.

Let us now take a quick look at how solar energy use originated in the first place and gradually expanded its role.

Timeline of solar energy

- During the late 19th century, solar collectors for heating water and other fluids were invented and put into practical use for domestic water heating and solar industrial applications, for example, large scale solar desalination.
- Later, mirrors were used (for instance, by Augustin Mouchot in 1875) to boost the available fluid temperature, so that heat engine, driven by solar energy, could develop motive power and, hence, electrical power.
- In the late 19th century, a device for converting sunlight directly into electricity was discovered. Called the PV device, it bypassed the need for a heat engine. The modern silicon solar cell attributed to Russel Ohl working at the American Telephone and Telegraph's (AT&T) Bell Laboratory was discovered around 1940.
- The modern age of solar energy research began during 1950s with the establishment of International Solar Energy Society (ISES) and an increase in research and development efforts, in various industries. For example, advances in the solar water heater by companies, such as Miromit in Israel and efforts of Harry Tabor at the National Physical Laboratory in Jerusalem helped to establish solar energy as the standard method for providing hot water for homes in Israel by the early 1960s. At about the same time, national and international networks of solar irradiance measurements were being established.


Courtesy: Põllö

- With the oil crisis of the 1970s, most countries in the world worked towards research and development programme in the field of solar energy. This involved immense work in various industry, government laboratories, and universities. These policy support efforts (continued up to the present time) have borne fruit.

Many years later, solar energy came to be known as a GHG mitigation tool. Solar energy's potential to mitigate climate change is equally impressive. Except for modest amounts of carbon dioxide emissions produced at the manufacturing stage of conversion devices, the direct use of solar energy produces very little greenhouse gases, and it has the potential to displace large quantities of non-renewable fuels. Several solar technologies, such as domestic water heating and pool heating, is very competitive and used in places where they offer the least cost option. In places where governments have taken steps to actively support solar energy, very large solar installations (both CSP and PV), approaching 100 MWp of power, have been realized, in addition to large number of rooftop installations.

Possible impact of climate change on resources

Climate change may influence atmospheric water vapour content, cloud cover, rainfall, and turbidity and this can impact the resource potential of solar energy in different parts of the world. Changes in major global climate variables, including cloud cover and solar irradiance at the earth's surface, have been evaluated using climatic models to assess the anthropogenic impacts. These studies found that the pattern of variation of monthly mean global solar irradiance does not exceed 1% in some regions of the globe and it varies from model to model. Currently, there is no other evidence indicating a substantial impact of global warming on regional solar resources.

Technical issues

Solar technologies are now at the forefront of global attention, be it academic, research or a policy-cum-programme implementation-related consideration. These are available on a laboratory/pilot scale and, more importantly, on a commercial level. According to the just released IPCC report, the technical issues for a range of solar technologies can be organized under the following categories.

Passive solar and day lighting technologies

Passive solar technologies absorb solar energy, store and distribute it in a natural manner (for example, natural ventilation) without using mechanical elements (for example, fans). The term passive building is often employed to emphasize use of passive energy flows, in both heating and cooling, including redistribution of absorbed direct solar gains and night cooling. Day lighting technologies are primarily passive including, windows, skylights, shading, and reflecting devices. A worldwide trend, particularly in technologically advanced regions, is for an increased mix of passive and active systems, such as forced-air system that redistributes passive solar gains in a solar house or automatically controlled shades that optimizes daylight utilization in an office building.

The following are some of the basic rules for optimizing the use of passive solar heating in buildings.

- Buildings should be well insulated to reduce overall heat losses.
- Buildings should have a responsive efficient heating system.
- Buildings should face the equator, that is, sun glaze should be concentrated on the equatorial side as should be the main living rooms such as bathrooms on the opposite side.
- Buildings should avoid shading by other buildings to benefit from the essential mid-winter sun.

Buildings should be thermally massive to avoid overheating during summers and on certain sunny days during winters

Thus, passive technologies cannot be separated from the building. The passive solar design process itself is in a period of rapid change. These are driven by the new technologies becoming affordable, such as the recently available highly efficient fenestration at the same prices as ordinary glazing. For example, in Canada, double glazed low emissivity argon filled windows are, presently, the main glazing technology used. However, until a few years back, this glazing was about 20%–40% more expensive than the regular double glazing. These windows are now used in retrofits of existing homes as well.

Passive solar cooling has the capacity to reduce CO_2 emissions. Experimental work demonstrates that adequate

insulation can reduce by up to 50% the cooling energy demand of a building during the hot season. Moreover, phase change materials in the already-insulated building can reduce the cooling energy demand by up to 15%. This could save about 1 to 1.5 kg/yr/m^2 of CO_2 emissions compared to the insulated building without phase-change material.

In 2010, passive technologies played a prominent role in the design of net zero energy solar homes. These are homes that produce as much electrical and thermal energy as they consume, in an average year. Passive technologies are essential in developing affordable net zero-energy homes. Passive solar gains, in homes, based on the passive house standard, are expected to reduce the heating load by about 40%. Another passive application is natural drying. Grains and many other agricultural products have to be dried before being stored so that insects and fungi do not render them unusable, for example, wheat, rice, coffee, copra (coconut flesh), certain fruits, and timber.

Courtesy: Lance Cpl. M C Nerl

Active solar heating and cooling applications

Solar heating for industrial processes is at a very early stage of development. Worldwide, less than 100 operating solar thermal systems for process heat are reported with a total capacity of 24 MWth (34,000 m^2 collector area). Most of the systems are at an experimental stage and, relatively, are of small scale. However, significant potential exists for market and technological developments. In a short span of time, solar heating for industrial processes will mainly be used for low temperature processes ranging from 20 ^{0}C to 100 ^{0}C. With technological development, an increasing number of medium-term applications up to 250 ^{0}C will become feasible within the market. Amongst the industrial processes, desalination and water treatment (for example, sterilization) are, particularly, promising applications for solar thermal energy. This is because these processes need large amounts of medium temperature and are often necessary in areas with high solar irradiance and energy costs. Some process heat applications can be met with temperatures delivered by ordinary low-temperature collectors, namely from 80 ^{0}C to 250 ^{0}C.

Solar cooling is a specific area of application for solar thermal technology. High efficiency flat plates, evacuated tubes or parabolic troughs can be used to drive absorption cycles to drive cooling. A number of closed heat-driven cooling systems have been built using solar thermal energy as the source of heat. Often, these systems have large cooling capacities of up to several hundred kW. Since the beginning of the 21st century, a number of systems have been developed in the small capacity range, less than 100 kW and, in particular, less than 20 kW and down to 4.5 kW. These small systems are single-effect machines of different types, used mainly for residential buildings and small commercial applications. Solar stills are widely used in some parts of the world to supply water to households of up to 10 people. In solar drying, solar energy is used either as the sole source of the required heat or as a supplemental source and the air flow can be generated by either forced or free natural convection. Solar cooking is one of the most widely used solar applications in developing countries. However, in comparison to other cooking needs, it might still be considered as an early stage commercial product due to limited overall deployment.

Existing PV technologies

Existing PV technologies mainly include wafer-based crystalline silicon cells as well as thin-film cells based on copper indium/gallium disulfide/diselenide, cadmium telluride, and thin film silicon (amorphous and microcrystalline silicon). Mono and multi-crystalline silicon wafer PV (including ribbon technologies) are the dominant technologies on the PV market, with a 2009 market share of about 80%, thin film (primarily CdTe and thin-film Si) has the remaining 20% share. Organic PV (OPV) consists of organic absorber materials and is an emerging variant of solar cells. Wafer-based silicon technology includes solar cells made of mono-crystalline or multi-crystalline wafers with a current thickness of about 200 microns, while the thickness is decreasing down to 150 microns. Under standard test conditions (STC), single-junction wafer-based C-Si cells have been independently verified to have record conversion efficiencies of 25% for monocrystalline silicon cells and 20.3% for multicrystalline cells.

Wiring together a PV system

A PV system is composed of the PV module, as well as the balance of system (BOS) components. These mainly include an inverter, storage devices, charge controller, system structure, and the energy network. The system must be reliable, cost-effective, attractive, and match with the electric grid in future. At the component level, BOS components for grid-connected applications are not yet sufficiently developed to match the lifetime of modules. Additionally, BOS component and installation costs need to be reduced. Moreover, devices for storing large amounts of energy (over 1 MWh or 3600 MJ) will be adapted to large PV systems in the new energy network. As new module technologies emerge in future, some of the ideas related to BOS may need to be revised. Furthermore, the quality of the system needs to be assured and adequately maintained according to defined standards, guidelines, and procedures. To ensure system quality, assessing performance is important, including on-line analysis (for example, early fault detection) and off-line analysis of PV systems. The knowledge, thus, gathered can help to validate software for predicting the energy yield of future module and system technology designs.

For penetrating the energy network, PV systems must use technology that is compatible with the electric grid and energy supply and demand. System designs and operation technologies must also be developed in response to demand patterns by developing technology to forecast the power generation volume and to optimize the storage function. Moreover, the inverters must improve the quality of grid electricity by controlling reactive power or filtering harmonics with communication in a new energy network that uses a mixture of inexpensive and effective communication systems and technologies as well as smart meters.

Using off-grid PV

PV applications include PV power systems classified into two major types, that is, those not connected to the traditional power grid (off-grid applications) and those, that are connected (grid-connected applications). In addition, there is a much smaller but stable market segment for consumer applications. Off-grid PV systems have a significant opportunity for economic application in the un-electrified areas of developing countries. Figure 1 shows the ratio of various off-grid and grid-connected systems in the PV power systems (PVPS) programme in the OECD countries. Of the total capacity installed in these countries, during 2009, only about 1.2% was installed in the off-grid systems that can now make up to 4.2% of the cumulative installed PV capacity of the International Energy Agency Photovoltaic Power Systems Programme (IEA PVPS) countries.

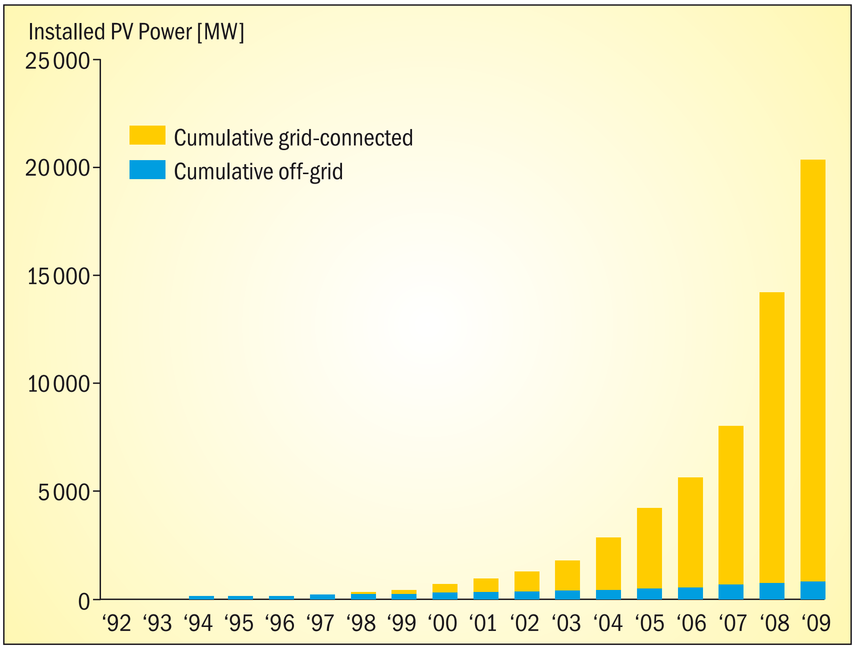

Figure 1 Historical trends in cumulative installed PV power of off-grid and grid-connected PV systems in the OECD countries (IEA, 2010e).

Over the last few years, the off-grid centralized PV mini-grid systems have become a reliable alternative for village electrification. In a PV-mini-grid system, energy allocation is possible. For a village located in an isolated area and with houses not at great distance, the power may flow in the mini-grid without considerable losses. Centralized systems for local power supply have different technical advantages concerning electrical performance, reduction of storage needs, availability of energy, and dynamic behaviour. For a given level of service, centralized PV mini-grid systems could be the least cost options, and they may have a diesel generator set as an optional balancing system or operate as a hybrid PV-wind diesel system. These kinds of systems are relevant for reducing and avoiding diesel generator use in remote areas.

Using on-grid PV

Grid-connected PV systems use an inverter to convert electricity from direct current (DC) as produced by PV array to alternating current (AC). And then, supply the generated electricity to the electricity network. Compared to an off-grid installation, system costs are lower because energy storage is generally not needed, since the grid is used as a buffer. The annual output yield ranges from 300 to 2,000 kWh per kW, for several installation conditions across the world. The average annual performance ratio, which is, the ratio between average system AC efficiency and standard DC module efficiency ranges from 0.7 to 0.8 and gradually increases further to about 0.9, for specific technologies and applications. Grid-connected systems are classified into two types of applications a) distributed and b) centralized. The distributed systems are installed to provide power to a grid-connected customer or directly to the electricity network. Typical sizes are 1 to 4 kW for the residential systems and 10 kW to several megawatt for rooftops on public and industrial buildings. The idea of the net zero-energy solar buildings has sparked recent interest. Such buildings send as much excess PV generated electrical energy to the grid as the energy they draw over the year. Smart solar building control strategies may be used to manage the collection, storage, and distribution of locally produced solar electricity and heat to reduce and shift peak electricity demand from the grid.

Concentrating more for power

CSP technologies produce electricity by concentrating direct-beam solar irradiance to heat a liquid, solid or gas that is then used in a downstream process for electricity generation. The majority of world's electricity, today, whether generated by coal, gas, nuclear, oil or biomass comes from creating a hot fluid. CSP simply provides an alternate heat source. Therefore, this technology builds on much of the current know how on power generation in the world today. As far as the flat plate system is concerned, a concentrating solar system depends on direct beam irradiation as opposed to global horizontal irradiation. Thus, the sites must be chosen accordingly and the best sites for CSP are in near-equatorial cloud free regions, such as the North African desert. The average capacity factor of a solar plant will depend on the quality of the solar resource. Centralized CSP benefits from the economies of scale offered by the large scale plants. Based on conventional steam and gas turbine cycles, much of the technological know how of large power station design and practice is already in place. The earliest commercial CSP plants were the 354-MW solar electric generating stations in California, the US, deployed between 1985 and 1991. These continue to operate commercially, today. As a result of positive experiences and lessons learnt from these early plants, the trough systems tend to be the most sought after technology.

Thermal energy storage integrated into a system is an important attribute of CSP. Until recently, this has been primarily for operational purposes, providing 30 minutes to 1 hour of full load storage. This eases the impact of thermal transients such as clouds on the plant, assists start-up and shut-down, and provides benefits to the grid. Trough plants are now designed for 6 to 7.5 hours of storage, which is enough to allow operation well into the evening, when peak demand can occur and tariffs are high. Trough plants in Spain are now operating with molten-salt storage. In the US, Abengoa Solar's 280-MW Solana trough project, which is planned to be operational by 2013, intends to integrate six hours of thermal storage.

Global and regional status of market and industry development

Five frontline technologies, that is, passive solar, active solar heating and cooling, PV electricity generation, CSP electricity generation, and solar fuel production have been considered by the IPCC.

Passive solar technologies

At present, no estimates are available for the installed capacity of passive solar or the energy generated or saved through this technology.

Active solar heating

The total installed capacity worldwide was about 149 GWth in 2008 and 180 GWth in 2009. In 2008, new capacity of 29.1 GWth corresponding to 41.5 million m^2 of solar collectors was installed worldwide. In 2008, China accounted for about 79% of the installations of glazed collectors, followed by the European Union with 14.5%. The overall new installations grew by 34.9%, as compared to 2007, and the growth rate in 2006/2007 was 18.8%. The main reasons for this growth were the high growth rates of glazed water collectors in China, Europe, and the US. In 2008, the global market had high growth rates for evacuated tube collectors and flat plate collectors as compared to 2007. The market for unglazed air collectors also increased significantly, mainly due to the installation of 23.9 MWth of new systems in Canada. Compared to 2007, the 2008 installation rates for new unglazed, glazed flat plate, and evacuated tube collectors were significantly up in countries like Belgium, Canada, Cyprus, Germany, Ireland, Jordan, Macedonia, Poland, Slovenia, South Africa, Tunisia, and new installations in China. The world's largest market increased significantly in 2008 compared to 2007, reaching 21.7 GWth. After a market decline in Japan, in 2007, the growth rate was once again positive in 2008. The main markets for unglazed water collectors are still found in the US (0.8 GWth), Australia (0.4 GWth), and Brazil (0.08 GWth). Markets are also present in Austria, Canada, and Mexico. In 2008, the Netherlands, South Africa, Spain, Sweden, and Switzerland had values between 0.07 and 0.01 GWth of new unglazed water collectors.

Comparing the markets of various countries is difficult due to a wide range of designs used for different climates and demand requirements. In Scandinavia and Germany, a solar heating system will typically be a combined water heating and space heating system, known as a solar combisystem. It has a collector area of 10 to 20 m^2. In Japan, the number of solar domestic water heating systems is large, but most installations are simple integral pre-heating systems. The market in Israel is large due to favourable climate as well as regulations mandating installation of water heaters. The largest market is in China, where there is a widespread adoption of advanced evacuated tube solar collectors. In terms of per capita use, Cyprus is the leading country in the world with an installed capacity of 527 kWth per 1000 inhabitants. The type of application of solar thermal energy varies greatly in different countries. In China (88.7 GWth), Europe (20.9 GWth), and Japan (4.4 GWth), flat plate and evacuated tube collectors mainly prepare hot water and provide space heating. However, in the US and Canada, swimming pool heating is still the dominant application with an installed capacity of 12.9 GWth of unglazed plastic collectors.

Courtesy: Anna Regelsberger

The biggest reported solar thermal system for industrial process heat was installed in China in 2007. The 9-MWth plant produces heat for a textile company. About 150 large scale plants (more than 500 m^2, 350 kWth) with a total capacity of 160 MW are in operation in Europe. The largest plant for solar-assisted district heating are located in Denmark (13 MWth) and Sweden (7MWth). In Europe, the market size increased three times between 2002 and 2008. However, even in the leading European solar thermal markets of Austria, Greece, and Germany, only a minor portion of the residential homes use solar thermal. For example, in Germany, only about 5% family homes are using solar thermal energy. The European market has the largest variety of different solar thermal applications, including systems for hot water preparation, plants for space heating of single and multi-family houses and hotels, large-scale plants for district heating, and a growing number of systems for air-conditioning, cooling, and industrial applications. Advanced applications, such as solar cooling and air-conditioning, industrial applications, and desalination/water treatment plants are in early stages of development. Only a few 100 first-generation systems are in operation.

PV electricity generation

The newly installed capacity in 2009 was about 7.5 GW with shipments to first point in the market at 7.9 GW. This addition brought the cumulative installed PV capacity worldwide to about 22 GW; a capacity able to generate up to 26 TWh (93600 TJ) per year. More than 90% of this capacity is installed in three leading markets—the EU27 with 16 GW (73%), Japan with 2.6 GW (12%), and the US with 1.7 GW (8%). These markets are dominated by grid-connected PV systems and growth within PV markets has been stimulated by various governments around the world. Examples of such programmes include feed-in tariffs in Germany and Spain and various mechanisms in the US, such as buy-down incentives, investment tax credits, performance-based incentives, and RE quota systems. For 2010, the market is estimated between 9 and 24 GW of additional installed PV systems with a consensus value in the range of 13 GW.

Figure 2 illustrates the cumulative installed capacity for top eight PV markets through 2009, including Germany (9,800 MW), Spain (3,500 MW), Japan (2630 MW), the US (1,650 MW), Italy (1,140 MW), Korea (460 MW), France (370 MW), and the Peoples Republic of China (300 MW). By far, Spain and Germany have seen the highest amount of growth in installed PV capacity in recent years, with Spain seeing a huge surge in 2008 and Germany having steady growth over the last five years.

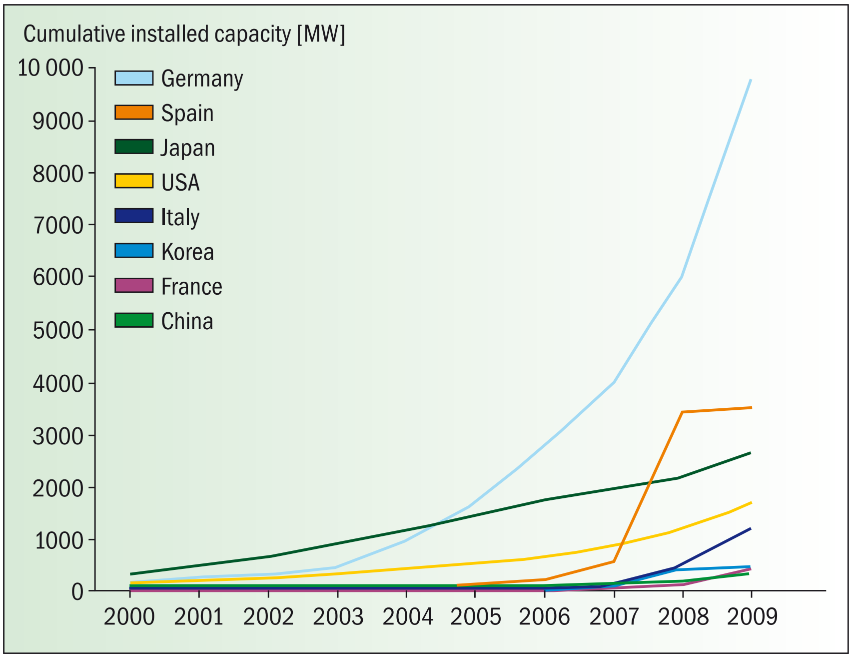

Figure 2 Installed PV capacity in eight markets
Sources EurObserv'ER 2009, IEA, 2009, REN 2009

Concentrating PV (CPV) is an emerging market with about 17 MW of cumulative installed capacity at the end of 2008. The two main tracks are high concentration PV (more than 300 times or 300 suns) and low to medium concentration PV with a concentration factor of 2 to about 300 (2 to 300 suns). To maximize the benefits of CPV, the technology needs high direct-beam incidence and these areas have a limited geographical range. The market share of CPV is still very small, but an increasing number of companies are focusing on CPV. In 2008, about 10 MW of CPV were installed and market estimates for 2009 are in the 20 to 30 MW range and for 2010, about 100 MW is expected.