Special Focus National Institutions of Renewable Energy
Providing Sustainable Future
Transforming Lives
Drying using solar radiation is one of the oldest techniques used by mankind to preserve food products. In order to maximize efficiency, appropriate technologies need to be applied to keep this technique a sustainable one. Debabandya Mohapatra discusses various solar dryers and how they work.

A school in Chandigarh will now have a solar-powered cycle stand and also generate its own power! Ravinder Singh writes about how a cycle stand will serve the dual purpose of not only providing a shaded space for parking but also generate power.

Installation of solar food processing units in India by SEED is an innovative way of utilizing solar energy. Prof. M Ramakrishna Rao takes a look at the project by SEED aiming to develop efficient methods of solar food processing.
Dear Reader,

Thank you very much for your suggestions and encouragement. The editorial team of Akshay Urja 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 improvements in the content and presentation.

Editor, Akshay Urja
Dear Readers,

The renewable energy sector is growing in leaps and bounds in our country. It has matured immensely, and economically viable technologies are now commercially available in the open market. Today, electricity produced from solar, wind, biomass, and hydro resources has reached the stage of grid parity. While the price of fossil fuel based electricity generation is increasing day by day, renewable power is becoming cheaper and more affordable. This is possible due to a strong base of technology search and innovations; research and development; lab-to-land dissemination; performance testing, capacity building, and awareness by national-level renewable energy institutions and state-level nodal agencies/departments created in our country; besides, the contribution of the private sector. Institutions play a vital role in the overall development of a sector. Renewable energy being a multi-disciplinary subject entails expertise in solar, wind, biomass, hydro, and other sectors, and these institutions carry out the subject-specific work in their respective fields.

The Ministry of New and Renewable Energy (MNRE) envisioned the importance of institutional development since the beginning. Consequently, today five national-level institutions namely the National Institute of Solar Energy (NISE) (the erstwhile Solar Energy Centre), Centre for Wind Energy Technology (C-WET), Sardar Swaran Singh National Institute of Renewable Energy (SSS-NIRE), Indian Renewable Energy Development Agency (IREDA), and the Solar Energy Corporation of India (SECI) have been created and are contributing to the development of renewable energy in the country. Besides, R&D projects on various aspects of renewable energy are also being carried out in the centres created in technology institutions such as Alternate Hydro Energy Centre in IIT-Roorkee, Biomass Research Centres at CGPL, IISc Bangalore, IIT-Bombay, IIT-Delhi, solar PV research work at IIT-Bombay and Jadavpur University; hydrogen-related work at BHU Institute of Technology, and so on.

The preservation of fruits and vegetables to enhance their shelf life is necessary for the large consumer base in our country. Food processing technologies and drying technologies play an important role for the full utilization of perishable food products. Although, sun drying has been practised since yore, with the advancement of technology, affordable solar dryers are available for agro-products and marine products in the market. A brief description of these renewable energy institutions created over the last three decades and the utilization of solar energy for food processing and drying have been presented in this issue.

We seek co-operation and valuable inputs from each of you to further enrich the content of Akshay Urja.

With best wishes,

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GOVERNMENT ALLOCATES ₹1,000 CRORE FOR ULTRA LARGE SOLAR PROJECTS, PARKS

The first budget of the Narendra Modi led government has given high priority to the renewable energy sector with an allocation of ₹1,000 crore for development of ultra large solar power plants and solar parks.

The government aims to construct ‘Ultra Mega Solar Power’ projects or high capacity plants in the radiation-rich states of Rajasthan, Gujarat, Tamil Nadu, and Jammu and Kashmir (Ladakh). At present, the Power Ministry is developing coal-based Ultra Mega Power Projects or UMPPs that have a generation capacity of 4,000 MW.

“I have set aside a sum of ₹500 crore for this [setting up of Ultra Mega Solar Power Projects] as new and renewable energy deserves a very high priority”, said Arun Jaitley, Minister of Finance, while presenting the Budget for 2014–15. He also announced launching a scheme for solar power driven agricultural pump sets and water pumping stations for energizing one lakh pumps. “I propose to allocate a sum of ₹400 crore for this purpose. An additional ₹100 crore is set aside for the development of 1 MW Solar Parks on the banks of canals,” he said.

Implementation of the Green Energy Corridor Project will be accelerated. Green Energy Corridor Project is aimed at synchronizing electricity produced from renewable sources, such as solar and wind, with conventional power stations in the grid. He added that the flat copper wire used for the manufacture of PV (photovoltaic) ribbons will be exempted from basic customs duty. “A concessional basic customs duty of 5 per cent is also being extended to machinery and equipment required for setting up of a project for solar energy production,” he said. This move aimed at benefiting solar power producers in the country.

Source: www.ndtv.com

NATIONAL SOLAR MISSION BACK WITH A BANG

The Ministry of New and Renewable Energy (MNRE) has issued guidelines for setting up 1,500 MW of solar power plants, the largest tender issued till now. It has also roped in NTPC Vidyut Vyapar Nigam (NVVN) to meet the targets of JNNSM.

“The selection of grid-connected solar photovoltaic (PV) projects of 1,500 MW total capacity shall be carried out by NVVN through a transparent, tariff (rate)-based reverse bidding process. NVVN will purchase the power from the successful developers at their bid tariff and sell bundled power to distribution companies/utilities/other bulk consumers”, say the guidelines issued by MNRE.

“We are hopeful that during this bidding, the rate would come down to at least ₹5 a unit,” said Tarun Kapoor, Joint Secretary, MNRE.

The mission guideline has divided the phase target in two portions. The total capacity of solar zPV projects to be selected in the first tranche, in FY 2014–15, will be 750 MW. The projects for the remaining capacity of 50 MW for solar PV projects will be selected in the second tranche, that is, in FY 2015–16”, say the guidelines.

Source: www.smartinvestor.business-standard.com
GAMESA AGREES TO SUPPLY 220 MW OF TURBINES IN INDIA

Spain-based Gamesa has received new contracts to deliver 220 MW of its turbines for five wind farms in India. Gamesa has further reinforced its presence in India, having signed new agreements to supply 220 MW to three of the main independent power producers companies in the wind energy market. In total, the company will install 110 of its G97-2.0 MW turbines in five wind farms located in the states of Madhya Pradesh, Rajasthan, and Karnataka. In addition, Gamesa will also handle the related O&M services of the wind farms in the long term. The scheduled is to be delivered in March 2015; the wind turbines will be manufactured at Gamesa’s local factories.

These three new contracts strengthen Gamesa’s order book from independent power producers in the Indian wind energy segment, boosting its local reputation as a leading turbine manufacturer.

“These valuable orders from independent power producers prove our expertise and clearly signify our strong market standing in the Indian wind industry,” Ramesh Kymal, Chairman and Managing Director, Gamesa India. “We are looking forward to having such esteemed collaborations in the future.”

Gamesa is present in India as technology provider and wind farm developer. The company, which ended 2013 as the leading wind turbine OEM in India by market share, has installed over 1,100 MW and manages capacity of more than 850 MW under O&M agreements. India represented 33 per cent of Gamesa’s sales in Q1 2014.

Gamesa will also supply 50 G97-2 MW turbines to a wind farm, which is being developed by a large utility in Mexico, in the first quarter of 2015.

With 20 years experience and more than 29,250 MW installed in 44 countries, Gamesa is a global technological leader in the wind industry. Its comprehensive response also includes the wind turbine’s operation and maintenance services, that manages for more than 19,500 MW. It is also a world leader in the development, construction and sale of wind farms, having installed 6,400 MW and having a portfolio of more than 18,300 MW in Europe, America, and Asia.

Source: www.windpowerengineering.com

SECI AND GIZ CONCLAVE ON SOLAR GUIDELINES

A day-long conclave was organized by the Solar Energy Corporation of India (SECI) in cooperation with Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) India on July 9, 2014 at the Ministry of New and Renewable Energy (MNRE).

The event was attended by senior government officials and experts. It showcased the Solar Guidelines, Phase II, which is a first-of-its-kind tool providing a clear pathway to the development of solar power projects and enabling ease of navigation through the legal–administrative–regulatory frameworks from concept to commissioning.

The conclave envisaged enabling investment and rapid development of the solar sector by facilitating dissemination of latest information on development of projects, policy framework announced by the respective governments, regulatory framework specified by the appropriate Electricity Regulatory Commission, Contractual Agreements (PPA/PSA), and details of approval and clearances required for timely commissioning and financial closure of solar installations, etc. Phase I was completed in Rajasthan and Phase II is scheduled to start in 10 states across the country.

Source: www.energysector.in
INDIA DOUBLES TAX ON COAL TO FUND CLEAN ENERGY, ENVIRONMENTAL PROJECTS

Around 22,000 MW solar power capacity by 2022, a dedicated national-level programme for promoting wind energy generation, implementation of the world’s largest solar power projects (with capacity of up to 4,000 MW), covering canals with solar panels, implementing dedicated transmission corridors for distributing electricity from renewable energy projects, and cleaning one of the largest rivers in India—this is just a small list of initiatives that India plans to implement in the renewable energy and the environment protection sector.

India’s finance minister has decided to double the tax on every metric tonne of coal mined or imported in the country. Coal mining companies and importers have paid $0.83 per metric tonne of coal since 2010; this tax has now been increased to $1.67. The revenue raised from this tax feeds the National Clean Energy Fund. The fund was established to provide low-cost finance to renewable energy projects and the Green Corridors transmission project.

The government has earmarked ₹ 500 crore for the initial implementation work for four ultra mega solar power projects, each with a capacity between 2,000 MW and 4,000 MW. Another ₹ 400 crore ($67 million) would be provided for installation of 100,000 solar-powered irrigation sets and water-pumping stations. The Prime Minister’s pet project, the canal-top solar power plant, would receive ₹ 100 crore ($17 million) this year.

India’s demand for coal is not likely to subside any time in the short to medium term — thus, this tax could raise massive amounts of revenue to boost India’s renewable energy and environmental protection sectors. According to some estimates, this tax could raise up to ₹ 7,400 crore ($1.2 billion) during a period of 12 months. This amount would only increase as the demand for coal in India has been increasing for several years.

Source: www.cleantechnica.com

GOVERNMENT SUPPORT TO REVITALIZE ELECTRIC VEHICLES MARKET

The electric and hybrid vehicle industry in India, which is at a nascent stage, is slowly creating opportunities for automotive original equipment manufacturers (OEMs), according to Frost & Sullivan. The subsidies from the government has supported the electric vehicle (EV) industry so far and the Indian government’s plan to re-introduce incentives for EV buyers is expected to revitalize the market. The foray of more automotive manufacturers into the Indian electric and hybrid vehicle industry too will subsidies charging infrastructure and quicken market expansion.

According to Frost & Sullivan’s new study, ‘Strategic assessment of electric and hybrid vehicles market in India’, the total electric and hybrid vehicles market is expected to grow from 125,257 units in 2013 to 1.1 million units by 2021 at a compound annual growth rate of 31.6 per cent. Domestic and international vehicle manufacturers are expected to launch more than 25 EV models by 2021.

Meanwhile, the infrastructure for electric and hybrid vehicle is practically non-existent in India, with only a handful of OEMs installing charging ports. The infusion of around ₹ 120 billion by the government for power generation as well as charging infrastructure in various cities is likely to expand infrastructure and market scope,” said a Research Analyst at Frost & Sullivan Automotive and Transportation.

Despite this support from the government, manufacturers still struggle to find price-effective local suppliers for electric and hybrid vehicle components. As a result, the cost of EV ownership is roughly 45 per cent higher than a conventional car. Besides price, OEMs must address factors like range anxiety, power, and output with better technologies to empower buyers with confidence about the product and the industry. Developing models with lesser dependence on charging infrastructure will also be crucial to hasten adoption.

Source: www.business-standard.com
C-WET/MNRE SELECT 3TIER INDIA TO DEVELOP NATIONAL ‘SOLAR ATLAS OF INDIA’

3TIER India Pvt. Ltd, a wholly owned subsidiary of Vaisala and the leading source for global renewable energy assessment and forecasting information, has been selected through a global tender for satellite data to create a Solar Atlas of India. The signed agreement is with C-WET, an autonomous research and development institution that forms a part of the Ministry of New and Renewable Energy (MNRE). Under the terms of agreement, 3TIER will work directly with C-WET to develop and disseminate critical investor-grade information that will enable India to meet its ambitious solar energy capacity targets.

“The collaboration between 3TIER and C-WET will greatly help in evaluating and prioritizing required infrastructure, such as solar generation facilities, storage technology, and transmission lines, i.e., where and how to invest in order to harness India’s solar energy potential,” said Dr S Gomathinayagam, Executive Director, C-WET. “The resulting nationwide solar study will help investors and market players clear the first hurdle in the process by filling a critical information gap.”

This state-of-the-art satellite methodology analyses the range of factors that impact surface irradiance conditions, such as cloud movement, air quality, and cyclical events like cyclone seasons and monsoons.

The Solar Atlas will provide a clearer understanding of this weather anomaly along with spatial and hourly solar irradiation variability. It will include a series of monthly solar resource maps covering the entire country and long-term solar resource and meteorological datasets at 115 locations.

“All information will be regularly updated to include the most recent months and will be validated by C-WET’s Solar Radiation Resource Assessment stations spread across the country,” said Dr G Giridhar, Director of the SRRA Mission Mode Project at C-WET.

Source: www.renewableenergyfocus.com

CHANDIGARH FIRST TO GET SOLAR POWER TOOL

You can now find out the solar power potential of your rooftop and the area required to install a plant. Chandigarh has become the first city to offer rooftop mapping facility through a web Geographic Information System (GIS), a tool launched by The Energy and Resources Institute (TERI). The announcement was made during the National Meet on Solar Cities. Representatives of TERI said Chandigarh has a total of 1.10 lakh rooftops, where 400 MW capacity solar plants could be installed.

“The GIS mapping of rooftops has added a new feather in the city’s cap. We now have date and details of each rooftop and space required for installing solar plants. Now, both government and common residents have all the details. Chandigarh is the first city to have this facility,” said Santosh Kumar, Director, Science and Technology Department, UT administration. Tarun Kapoor, Joint Secretary, Ministry of New and Renewable Energy, said, “Chandigarh has done remarkable work to install solar plants on government buildings. We are hoping for more such work in this regard.”

Source: www.timesofindia.indiatimes.com
72 PER CENT INCREASE IN VENTURE CAPITAL FUNDING IN SOLAR ENERGY SECTOR

According to a report by the Mercom Capital Group, global venture capital (VC) funding into the solar energy sector in the second quarter of 2014 increased to 72 per cent to $432 million in 21 deals, from $251 million in 26 deals in the first quarter of the year. The largest VC/PE deal during the quarter was a $150-million raise by Sunrun, a provider of residential solar-power systems. Investors included the Foundation Capital, Accel Partners, Sequoia Capital, Madrone Capital, and others.

In India, Welspun Renewables Energy, a renewable energy project developer, raised $24 million from GE Energy Financial Services for a 151 MW solar PV project in the State of Madhya Pradesh, and CaptureSolar Energy, a solar project developer, raised $125 million from PG Concept, a Cyprus-based PV solutions provider, for a 75 MW solar PV project in Pune, Maharashtra. Sunnova Energy, another provider of residential solar services, raised $145 million.

Other large deals included a $72.5 million funding raised by residential solar installer Sungevity; a $15-million deal by Siva Power (formerly Solexant), a manufacturer of CIGS solar modules; and a $14.2 million deal by Brite Energy Solar, a provider of residential and commercial solar services. Simpa Networks, a distributed energy solutions provider, which raised $2.2 million in funding and AK Surya PowerMagic, a provider of solar-based irrigation services for farmers, which raised about $0.5 million in funding from Intellecap Impact Investment Network (Icube-N) and Infuse Ventures—IIM Ahmedabad’s clean-tech focussed fund—were two Indian companies which received large Indian companies funding this quarter.

“It was a solid quarter for the solar sector in terms of fundraising. VC funding was up, public markets remained strong, and we are seeing new and innovative financial structures. Residential/commercial solar funds continue to raise record amounts,” Raj Prabhu, CEO of Mercom Capital Group, said in a statement from the company.

Source: www.timesofindia.indiatimes.com

EU CONFIRMS APPROVAL OF GERMANY’S NEW AND RENEWABLE ENERGY LAW

The European Union (EU) antitrust authorities confirmed their approval of Germany’s new renewable energy law, which aims to help the country shift away from nuclear and fossil fuel generated power. The new law “paves the way for more market integration of renewables,” Joaquin Almunia, the EU’s antitrust commissioner.

Germany’s energy and economics minister, Sigmar Gabriel, welcomed the EU decision, saying it will provide a basis for further expansion of renewable energies and implementation of the “energy revolution”, an ambitious shift away from nuclear and conventional power sources. “Companies in Germany are also being provided with the framework conditions to maintain our jobs and serve to strengthen industry in Europe,” Gabriel said. The German Bill trims subsidies for new green power plants, which range from vast wind farms to small solar panels installed on private roofs. It also spreads the power-price surcharge that has funded these subsidies more equally among businesses. Many companies had previously been exempt because they operate in energy-hungry industries or decided to build their own power plants.

The new law will come into effect from August 1. The annual support of renewable electricity is estimated to be around €20 billion ($26.9 billion).

Source: www.online.wsj.com
The wind farm is expected to generate an annual production of 460 GWh thereby offsetting 420,000 tonnes of carbon dioxide per year and providing clean renewable electricity for nearly 100,000 South African households.

The inauguration of the wind farm marks the start of operations at two of Globeleq’s solar facilities, the 50 MW De Aar and 50 MW Droogfontein installations at the Northern Cape. All installations are a part of South Africa’s renewable energy programme and are among the very first large-scale renewable power plants to be built in the country.

“The completion of these facilities is the result of a truly global partnership with the Government of South Africa and Eskom and the private sector of developers, investors, lenders, constructors, suppliers, and the local community” said Mikael Karlsson, CEO, Globeleq. “It demonstrates significant support for independent private power producers in the region and indicates the sustainability of the renewable energy sector. As the leading African private power company, Globeleq is committed to pursue further investments in clean and reliable power for the region,” said Karlsson.

The government’s renewable energy programme has prioritized job creation and skill development in order to sustain in the industry over time. More than 700 people have worked on the Jeffrey’s Bay Project during its construction, of which 45 per cent were drawn from the local community. A percentage of the revenues from the wind farm will also be reinvested into the community through socio-economic and enterprise development programmes in order to generate the skills needed to expand the growth of the renewable energy sector in South Africa.

Source: www.renewableenergy.com

The US Green Building Council (USGBC) announced the launch of an expanded online data visualization resource that will allow any user to access aggregated LEED green building project information in more than 150 countries with LEED projects under way. Following on the successful US state market briefs launched by USGBC, the international market briefs detail LEED projects by owner sector, rating system, and space type for all countries with building projects participating in the LEED green building rating system, along with in-market LEED credentialed professionals and USGBC members.

“LEED is driving innovation and sustainable development across the globe”, said Mahesh Ramanujam, Chief Operating Officer, USGBC. “These market briefs offer a global view, country by country, simultaneously representing the international demand for LEED and our commitment to making the story and the data behind it transparent.”

The global uptake of LEED has surged in the past few years. The gross commercial square footage certified by the Green Building Certification Institute outside the US rose from 156 million to 176 million square feet in a single year (2012–13). Currently, more than 648 million square feet of commercial space is LEED certified outside the US.

“Visualizing the global LEED marketplace allows us not only to see the present, but gives us a window through which we can imagine a more sustainable future for our planet,” added Ramanujam.

Source: www.interiorsandsources.com
Institutions play a vital role in the overall development of a sector. Renewable energy, being a multi-disciplinary subject, entails expertise in solar, wind, biomass, hydro, and so on. The Ministry of New and Renewable Energy (MNRE) envisioned it and focused on the establishment of institutions with expertise in respectable areas.

Consequently, the five institutions, namely, National Institute of Solar Energy (NISE) (erstwhile Solar Energy Centre), Centre for Wind Energy Technology (C-WET), Sardar Swaran Singh National Institute of Renewable Energy (SSS-NIRE), Indian Renewable Energy Development Agency (IREDA), and the Solar Energy Corporation of India (SECI) have been created by the ministry so far. These institutions are performing activities on technology search and innovations; research and development; lab-to-land dissemination; performance testing, capacity building, and awareness through seminars, workshops, etc., in the country. A brief description of these institutions is presented here.

The Solar Energy Centre — renamed as the National Institute of Solar Energy (NISE) — was established in the year 1982. The institution works towards the development of solar energy technologies and its related science and engineering. To achieve its objective, the centre has been working on various aspects of solar resource utilization and technology development, in collaboration with other research institutions as well as implementing agencies and the industry. Over the years, the centre has developed a variety of technical facilities for technology evaluation and validation, testing and standardization, performance reliability, and monitoring and data analysis, in addition to training.

The Centre for Wind Energy Technology (C-WET) is an autonomous organization under the administrative control of MNRE, and serves as the technical focal point for wind power development in the country. It is a knowledge-based institution of high quality and dedication, offers services, and seeks to find complete solutions for the kinds of difficulties and improvements in the entire spectrum of the wind energy sector by carrying out further research. It has a Wind Turbine Test Station (WTTS) at Kayathar.
NATIONAL INSTITUTIONS OF RENEWABLE ENERGY

Technical and partial financial support by DANIDA, Government of Denmark. The Sardar Swaran Singh National Institute of Renewable Energy (SSS-NIRE) is an autonomous institution of MNRE established on 31 March 1998 that is devoted to bioenergy research, design, and development. The vision of the institute is “to become an apex institution for carrying out state-of-the-art research and developmental activities in the field of bioenergy.”

The vision of the institute includes five R&D focus areas. These are biomass and energy management, thermochemical conversion, biochemical conversion, chemical conversion, and electrochemical conversion. It has been certified by Intertek and registered under ISO 9001:2008. The provision under the certificate includes provision of research, design, development, and testing activities for new and renewable energy, especially bioenergy including human resource development and other associated administrative activities.

The Indian Renewable Energy Development Agency (IREDA) is a non-banking financial institution under the administrative control of the ministry for providing term loans for renewable energy and energy-efficiency projects. It has been serving the renewable sector since 1987. The motto of the organization is ‘ENERGY FOR EVER’.

The Solar Energy Corporation of India (SECI) was been set up on 20 September 2011, as a not-for-profit company under Section 25 of the Companies Act 1956. It is an implementation and facilitation institution dedicated to the solar energy sector under the aegis of MNRE. SECI works on wide-ranging activities with an overall view to facilitate implementation of the Jawaharlal Nehru National Solar Mission (JNNSM) to achieve the targets set therein. The vision of the company is “to build a new ‘Green India’ through harnessing abundant solar radiation and to achieve energy security for the country”.

For project-specific work, the ministry has also been supporting centres of reputed institutions such as the Alternate Hydro Energy Centre which was established as a part of IIT-Roorkee, Biomass Research Centers at CGPL, IISc Bangalore, IIT-Bombay, IIT-Delhi, and Solar PV research work at IIT-Bombay and Jadavpur University, hydrogen-related work at the BHU Institute of Technology, etc.

In addition, several R&D projects from various technology and engineering institutions also have been supported by the ministry. These institutions indeed assets of our country.
The Ministry of New and Renewable Energy (MNRE), Government of India, has converted its 30-year-old Solar Energy Centre into an autonomous institution named the National Institute of Solar Energy (NISE) to assist the ministry in implementing the Jawaharlal Nehru National Solar Mission (JNNSM). It also acts as the apex national R&D centre in solar energy. NISE has assumed all technical activities of Solar Energy Centre and has also re-organized itself to undertake roles and responsibilities assigned to it by the ministry.

**ROLES AND RESPONSIBILITIES OF NISE**

The JNNSM envisions an aggressive and effective R&D programme on solar energy technologies with an objective to improve efficiencies in the existing materials, devices, and systems. The R&D programme is envisaged to address issues of hybrid co-generation, convenient and cost-effective storage, and also the constraints of variability and space intensity. The institute coordinates various S&T related tasks under the JNNSM. The institute not only assists the ministry in implementing the JNNSM, but it is also responsible for providing thrust to R&D in solar energy and related technologies under the mission including resource assessment, training, testing/standardization. It acts as the secretariat for the work of the R&D Advisory Council and facilitates the development of a technology roadmap. Also, it bridges the gap between existing R&D institutions and industry, and gets the industry on board, through partnership programmes and projects.

**FACILITIES AT NISE AND MAJOR ACTIVITIES**

**Solar photovoltaic facilities**

The photovoltaic division at NISE is maintaining a NABL-accredited PV module testing laboratory, lighting system test laboratory, battery testing facility, a water pumping system test rig, and outdoor test facilities. NISE is in the process of establishing a comprehensive power electronics laboratory for inverters, charge controllers, and MPPT evaluation.

The Photovoltaic Division (PVD) is participating in joint research work with NREL, AIST, Loughborough University, and PTB Germany. PVD is also working jointly with multinational PV module manufacturing industries by setting test beds for technology validation of their modules. PVD is also involved in a consortium project jointly executive by Indo–UK and Indo–US joint consortiums in the area of stability and reliability of photovoltaic modules. The indoor module-testing facility of NISE can undertake technical and environmental tests on commercial large-size modules.

**Solar thermal**

The centre has a fully developed testing facility for small- and large-sized solar thermal systems and Solar Resource Assessment.
The major projects include:
- National Solar Thermal Power Testing, Research and Simulation Facility
- Concentrated Solar Thermal Energy Technology Based on Parabolic Dish Collectors
- Solar Thermal Stirling Engine
- Development of a Modular Central Receiver Concentrated Solar Power Plant for Decentralized Power Generation
- High Efficiency Solar Thermal Air-conditioning Systems (a collaborative project of Thermax Limited and Solar Energy Centre)
- Cold Storage with Solar–Biomass Hybrid System

**PROPOSED ACTIVITIES AT NISE**

As per the technical responsibilities assigned to NISE and the requirements of JNNSM, it has been proposed to re-organize NISE in three technical verticals. These are the Solar Photovoltaic Division, the Solar Thermal Division, and the Resource Assessment and Information Technology Division.

**Solar Photovoltaic Division**

The SPV division will have two groups that is the R&D group and the Testing and Design group. The former would be a core activity group working on basic research, applied research, pre-commercial research, while the latter would be involved in design, testing, certification, and design. The Basic Research Activity Group for R&D is proposed to work on the development of materials, devices, designs, and simulation of new concepts in the device design; for example, high efficiency silicon solar cells using innovative concepts on a lab scale. It also undertakes the development and upgradation of characterization facilities for wafers and cells as well as reference devices and facilities for calibration solar cells.

The Applied Research Activity Group is proposed to concentrate their efforts on developmental aspects of large area solar cells, techniques, development of PV modules and systems, and performance and reliability aspects of PV modules and PV systems under actual field conditions. The group would also work on development of new modelling concepts, innovative system designs to reduce the stress on modules during long-term field operation under different environments. This group would work with other testing laboratories to gather information and collaborative research. The group is also working closely with QCI, NABL, and BIS for modification and development of SPV standards.

The group on Pre-Commercial Research is proposed to work towards the upgradation of the lab-scale devices so that they can be marketed commercially and made suitable for large-scale production by the industry. Dealing with the issues related to the scaling up of the process and techniques, this group would work closely with the industry and try to understand and find solutions for industrial problems associated with the production and process.

The Testing and Design Group consists of the Solar Cell and System Testing and the SPV Module Testing units. For the former, the SEC has already established device characterization and performance measurement facilities that can be used by research groups for their characterization and also validate their claims made under the R&D projects. The services of this unit would be chargeable. The existing power electronics laboratory, lighting system testing laboratory, and water pumping test facility will be upgraded to meet the testing requirements corresponding to PV standards. These facilities will be NABL accredited to establish suitability and acceptability of the test certificates. NISE will also set up new outdoor test beds for different module technologies at SEC as well as other suitable sites for the data collection, validation, and mapping.

SEC has also established an NABL-accredited qualification test laboratory for PV modules performance and qualification as per
IEC 61215 and IEC 61646. This will be further upgraded for testing as per other IEC standards (61730 and 61701) and other relevant or useful standards. The indoor qualification, environmental test facilities will be upgraded to be useful to conduct research and indoor studies in controlled or simulated conditions. Additional facilities will also be created for new tests as per revised and new standards. All these facilities will be available for the industry, users, and other organizations for certification and performance testing purpose at cost.

Solar Thermal Division

The R&D group of this division works on basic research, applied research, and also undertakes performance mapping.

The Basic Research Activity Group is proposed to focus on development and optimization of components of various solar thermal technologies such as reflector, collector, receiver, heat carrier, selective coating, storage system, and materials. The activities of this group would also encompass development of new end-use applications of solar thermal systems to enhance capacity utilization (use of FPC-based water heater for cooling during summer). This division would also engage in designing of solar hybrid systems for optimal utilization of solar energy and stabilization of output. It will also be working on the development of new software applications for system designing and optimization. To improve the competitiveness of solar thermal systems in comparison to conventional technologies, poly-generation employing an output management strategy will be researched. This strategy aims at overcoming thermodynamic limitations in efficiency improvement by optimizing the system in such a way that waste products are converted into useful outputs. The Applied Research Activity Group will focus on evaluation of technologies in field conditions, develop end-use applications, and related activities. Performance mapping of different solar thermal technologies and creation of a data bank for various ranges of applications for different climatic conditions would be the activity of the group which would be done by the third unit. The performance of solar thermal collectors depends heavily on a wide number of factors such as Direct Normal Irradiance (DNI), ambient temperature, wind velocity, latitude, and desired temperature. Therefore, selection of appropriate and cost effective-technology is critical. To facilitate this technology selection and minimizing the payback period, a data bank of different technologies for different operating conditions is undertaken.

Resource Assessment and Information Technology Division

Resource assessment would be an important activity of NISE. As of date, 51 Automatic Solar Radiation Monitoring Stations have been installed and 11 states have been commissioned under the Ministry’s project on Solar Radiation Resource Assessment (SRRRA) through C-WET. Each of these stations house various equipment/instruments to measure Direct Normal Irradiance (DNI), Global Horizontal Irradiance (GHI), Diffuse Irradiance (DIF) along with temperature, relative humidity (RH), wind direction and speed, and pressure (weather meteorological data) in automatic mode and transfer the data through GPRS to a Central Receiver Station at C-WET. Sixty more stations are being commissioned.

NISE will also create a Solar Radiation Calibration Laboratory along with data analysis activities and mapping of solar resources in India.

Information Technology Group

The primary objective of this group is to capitalize on the enormous power that IT and ITES has to offer by integrating all aspects of IT with the day-to-day functioning of the organization, making it more effective, economic, and efficient. The group therefore shall be responsible for all IT-related support, services, and technological development required to support and strengthen the organization.

MAKING NISE A SMART CAMPUS

A proposal to make NISE a ‘Smart Campus’ by converting it into a net zero electricity consuming centre has been made. This will ensure that it uses solar energy for buildings and for cooking. In this direction, the new building of NISE is a solar passive building. It is proposed that the electrical load of the entire building would be met through in-house power generation from solar thermal power project, SPV power projects, and a large part of cooking in the cafeteria would be done through solar steam cooking. The main aim is that the electrical load of the entire building would be met through in-house power generation either from solar thermal or SPV power or both projects. Further, a large part of cooking in the cafeteria would be done through solar steam cooking. (Dr P Saxena, Adviser, MNRE, Director-General, NISE. Email: psaxena@nic.in)
NISE: PROJECT HIGHLIGHTS

AIST LONG-TERM OUTDOOR STUDIES ON PV MODULES

A joint project between NISE (India) and AIST (Japan) was initiated at NISE in October 2009 to study the impact of climatic factors on different PV technology module outputs. Pyranometer, pyrheliometer, spectroradiometer, wind sensor, humidity, and temperature sensors are installed as part of a comprehensive weather station for measuring the different weather parameters. Three different PV technology modules used are multi-crystalline silicon modules (1.6 kWp) from M/s Sharp, amorphous silicon single junction modules (1.2 kWp) from M/s Kaneka, and HIT modules (Hetero junction with intrinsic thin layer) (1.68 kWp) from M/s Sanyo. The arrays are connected to an I−V scanner and analyser to measure I−V data once in every 10 minutes. The radiation sensors, pyranometer, and spectroradiometer, are installed coplanar with module array, and fixed at a tilt of 28 degrees, equal to the latitude of NISE. The data of environmental parameters are logged through CR1000 datalogger, once in every minute.

The project has the following features:
- Long-term performance data of three PV technologies under similar outdoor conditions
- Analysis of changes in weather patterns
- Performance degradation and reliability check on three PV technology modules
- Impact of environmental conditions on the performance of PV modules and life-cycle cost

Expected outcome of the project

Precise meteorological data will help creating the PV design suitable for the Indian weather conditions and will be used to formulate energy rating of the module. The project will lead to long-term PV reliability evaluations of different PV technologies.

SOLAR CELL TESTING FACILITY

NISE has established a facility for testing and evaluation of performance of solar cells as per IEC 60904-1:2006/IS 12762 standards (Part 1). The facility has an ORIEL’s Class AAA Sun Simulator which provides a continuous study state source and an electronic load capable of testing 6x6 inch solar cells of any type. The cell can be tested under standard test conditions (1,000 W/m², cell temperature 25 °C, air mass 1.5). The spectrum of the source qualify IEC 60904-9; 2007 Edition, or ASTM E 927-05 standards. The current–voltage (I−V curves) measurements and both dark and light conditions of solar cells can be studied at different intensities and temperatures.

The testing of solar cell at NISE consists of the following tests:
- I−V performance under STC
- Temperature co-efficients
- I−V performance at different intensities and temperatures
- Dark I−V of solar cell

The test report consists of:
- I − V Curve
- I_{sc}, V_{oc}, I_{max}, V_{max}, FF, P_{max} and efficiency under STC or required conditions

To avail these services, users are advised to refer to Order form no. 04 and complete all the formalities as per the checklist posted at MNRE’s website, www.mnre.gov.in. The tentative period for the testing of a solar cell sample is eight working days.

STANDARD OUTDOOR PHOTOVOLTAIC MODULE PERFORMANCE MEASUREMENT

NISE has the outdoor photovoltaic module testing facility comprising testing equipment and set ups for conducting the energy rating of silicon as well as thin-filmed PV modules as per international standards. The I−V measurements of PV modules under
outdoor condition that is close to standard test conditions is done by using a fixed system which can track the sun. The modules are deployed in the outdoor and performances are measured continuously, using I–V tracer. Long-term module performance and stability testing is also conducted under various weather conditions using different array fields.

The outdoor testing of PV modules consists of the following tests:
- Visual inspection
- Maximum power determination
- Low irradiance performance
- Long-term module performance and stability
- Outdoor median performance

**INVERTER TESTING FACILITY AT NISE**

As part of the Power Electronics Laboratory, NISE has established a facility for evaluation and testing of Solar Inverter/Power Conditioning Units (PCUs). This facility is used for testing and certification of PCU of capacity ranging from 100 Wp to 10 kWp, for both hybrid PCUs as well as Grid-tied Inverters (GI). NISE has a power electronics lab with solar array simulator (15 kVA), rooftop PV module array, electronic load (15 kVA), AC–DC source (6 kVA), four channel power analyser, digital oscilloscopes, and other equipment.

The testing report will contain all the parameters measured as per IEC 61683 standards, against the claims made by the manufacturer.

**SOLAR PV WATER PUMP TESTING FACILITY AT NISE**

NISE has established a test rig for testing Solar PV (SPV) Water Pumping System ranging from 0.5 HP to 5 HP with an array capacity of 200 Wp to 5 kWp, for AC as well as DC Motors, both for surface and submersible pump sets with electronics (MPPT, Inverter, etc.) as per MNRE specifications, 2013–14 and IEC standards (IEC 62253 and IEC 61702). For this purpose NISE has a sump well (4m x 2.5m x 2.5m), with head of 4 m, and an overhead platform (3.5m x 2m x 2m) with head of 7m, to create suction/delivery head for different heads pumps varying from 10m up to 70m, controlled by pressure gauge and throttle valve.

The tentative period of the testing of SPV water pumping system is 20 good sunny working days.

The qualification testing of Solar PV water pumping system as per MNRE specifications consists of:
- Estimation of total water output per day
- Water output per day per watt at desired head and maximum dynamic head

**LONG-TERM PERFORMANCE STUDIES OF MICRO-MORPH TECHNOLOGY**

With the view to validate the outdoor performance of micro-morph technology modules manufactured by M/s TEL Solar AG, Switzerland, under harsh Indian conditions, NISE and TEL Solar AG have set up an approximately 8kWp test power plant in the campus of NISE. The Test PV Power Plant (TPVPP) in the subtropical and tropical climate will establish micro-morph technology footprint in the future PV market in India. The aim of this project is to study the seasonal variation dust effect, performance ratio (PR), and economic suitability of micro-morph module in India.

**Features of the study**
- Long-term performance evaluation
- Spectral effect on micro-morph module
- Evaluation of PR energy yield
- Study of dust effect

**Outcome of the study**
- Suitability of micro-morph technology modules for Indian conditions
- Estimation of Annual Yields (Y), Performance Ratio (PR), and
Capacity Utilization Factor (CUF) under arid conditions
- Reliability in terms of performance, safety, and cost economics

LONG-TERM PERFORMANCE EVALUATION OF CdTe TECHNOLOGY
This is a joint collaborative project of NISE, India and M/s First Solar, USA. A test power plant of 3.2 kWP based on Thin Film–CdTe Technology along with a weather monitoring station was installed in June 2012. The test power plant is configured to 600V MPPT voltage and is installed at an angle of 20°. The weather station includes two pyranometers one at the horizontal plane and other one on the module plane. Other environmental sensors are wind sensor, humidity and temperature sensors, pressure gauge, and rain gauge. The generated power is fed to a local smart grid established at NISE, through a 3.3 kVA grid type inverter. Parallel to the test plant, another test setup to study the effect of dust on the performance of CdTe module(s) is also installed. The irradiance, module temperature, array current, array voltage data, and other parameters are logged, at every 10 seconds, through CR3000 datalogger from Campbell Scientific Ltd.

Parameter Monitor
- Radiation (Tilt/Horizontal)
- Module/cell temperature
- Voltage (Vmax), Current (Imax) and Power(Pmax) data
- Wind direction and speed
- Relative humidity
- Pressure
- Rain data

Project features
- Long-term performance study in composite climatic zone
- Dust effect analysis
- Transient effect on the performance
- Spectral effect on the performance of CdTe technology

Outcome of the project
- The hourly averaged PR of CdTe technology at composite climate zone of India is in the range of 0.8 to 0.9
- The average power loss due to dust effect has been found to be around 6 per cent annually

To avail these services users are advised to refer to Order form no.07 and complete all the formalities as per the checklist posted at MNRE’s website, www.mnre.gov.in or www.mnre.nic.in. The tentative period for the testing of a solar cell sample is 30 working days.

NISE INVITES INNOVATORS
Are you an Energy Innovator looking for a platform to give life to your ideas?

NISE invites proposals from researchers to carry out their research on renewable energy at the premises of the National Institute of Solar Energy (NISE). If we are convinced of your research idea, you will be given an opportunity to use our high-end laboratories and testing facilities free of cost to breathe life in to your idea.

Please send us a Technical Proposal describing your idea and why you feel that it will be a success. An updated CV should also be attached.

Please send your proposals to Dr Praveen Saxena, Director-General, NISE. Email: psaxena@nic.in
The modern wind industry is a promising source of clean energy that has gained momentum across the world. India has an installed capacity of 21 GW and ranks fifth in the world. It is also a global manufacturing hub for wind turbines with about 20 large and several small wind turbine manufacturers. Renewable energy penetrates 12.5 per cent of the total Indian energy installed capacity of 248,510 MW, of which wind energy contributes about 8 per cent with an installed capacity of 21,262 MW, as on May 31, 2014.

BIRTH OF C-WET
The Centre for Wind energy Technology (C-WET) was established in 1988 by the Ministry of New and Renewable Energy (MNRE) as a technical focal point and to extend support to the Indian wind industry and stakeholders. C-WET is an autonomous R&D institution and a forward-looking and practical organization that will take the next logical steps towards advancing wind technology in the right direction. As an integral part of C-WET, a world-class Wind Turbine Test Station (WTTS) was established at Kayathar in Thoothukudi District, Tamil Nadu, with technical support and partial financial assistance from DANIDA, Denmark.

DESCRIPTION OF C-WET ACTIVITIES
The vision of C-WET is to serve as a technical focal point of excellence to foster orderly development of wind energy in India. This is done through its different units, each of the eight working on a specific aspect of wind energy development that fulfills the overall objectives set for C-WET.

Research and Development (R&D) Unit
This unit focuses on innovations in development of components as well as sub-systems of wind turbines in association with other R&D institutions and industry. The R&D unit supports time-bound and mission-oriented R&D programmes to achieve world-class, reliable, and cost-effective technology in wind power systems. The unit continues to improve its knowledge and skills through continuous learning to keep pace with state-of-the-art technology and excels through its effective networking with other academic and research institutions. The unit carries out in-house R&D through networking in research relevant areas, with a mutually beneficial interdisciplinary approach for most of the projects. Strategic collaboration that could assist in most suitable technological developments for our country is nurtured by funding and technical support. The Research and Development Council, with the express mandate of guiding specific research in the area of gearbox, generator and grid integration, blade, condition monitoring, and tower design with its esteemed members of the scientific community of India headed by renowned scientists vet the project proposals submitted to C-WET, to work in collaboration with the industry, institution, and other interested agencies.

The unit does the performance testing of Small Wind Turbine (SWT)/Aero-generators (0.3 KW to 25 KW) as per IEC 61400-2 requirements and it is carried out on specific requests from the industry on government-subsidized rates and an empanelment...
list of SWT manufacturers is being prepared and published at regular intervals on behalf of MNRE.

The unit conducts research in areas such as power evacuation studies, grid integration, development and validation of design methodologies and design tools for low and moderate wind regimes, modelling of interconnection of wind turbines with the grid, parameterization of flow distortion around the wind turbine nacelle, installation of renewable energy devices, condition monitoring of wind turbines, and study for generating wind turbine aerofoil characteristics over the 0–360 degree angle of attack. The unit provides wind turbine Acoustic Noise Measurement services on specific request as per IEC Standards.

The unit has published a handbook titled Recommendation on Design and Maintenance of Gearboxes of Wind Turbine for the industry.

Wind Resource Assessment (WRA) Unit
The unit has been involved in the realization of a Nationwide Wind Resource Assessment (WRA) programme sponsored by the Government of India, in association with state nodal agencies for effective harnessing of wind energy and analysis of collected data to identify high wind areas at macro/micro-level and provide support in micro-siting. The unit also carries out country-wide wind resource assessment and prepares the Indian Wind Atlas.

Further, in order to extend support to the industry and developers, the unit takes up various projects such as validation studies, technical due diligence studies, micro-siting exercises, detailed project report preparation, repowering analysis, etc. MNRE has been sponsoring the WRA programmes to measure, analyse, and publish wind data in our country for the last two decades. Under these programmes, wind has been measured at 789 locations for periods ranging from one to five years. As on March 31, 2014 a total of 157 stations are in operation in 17 states.

The unit is currently in the process of exploration of offshore wind energy potential to provide authentic data for offshore wind farms and also the unit is in the process of starting the service of forecasting, which is of utmost urgency and need of the industry in the country.

Wind Turbine Testing Unit
To cater to the needs of the wind turbine manufacturers getting their models certified, the testing unit has been setup as an integral part of the centre. The unit conducts testing of complete wind power systems according to International Standards and Type Approval Provisional Scheme (TAPS-2000) at the Wind Turbine Test Station, with infrastructural facilities using sophisticated data acquisition systems and instruments and also conducts tests at wind farm sites at customer place using mobile equipment. Type testing is being carried out according to IEC standards and the services are accredited by NABL. A number of tests are carried out at WTTS, Kayathar, as well as at the customer’s site as per the requirements of IEC 61400-12-1, 61400-13, 61400-1 and Danish recommendations. Testing by C-WET has been accepted by all European certifying agencies in more than 50 countries.

Wind Turbine Research Station (WTRS)
C-WET has established the Wind Turbine Research Station (WTRS), Kayathar, which is one of the best wind sites in the world. The research station has wind electric generators of all generating capacities from 225 kW WTG to 2 MW WTG. Research work is being carried out on those wind turbines for performance improvement, condition monitoring, etc.

Standards and Certification (S&C) Unit
Type certification of wind turbines is becoming more and more relevant in India, with the wind turbine industry reaching new heights with

**TYPE TESTING IS BEING CARRIED OUT ACCORDING TO IEC STANDARDS AND THE SERVICES ARE ACCREDITED BY NABL**

**TAPS-2000 IS THE INDIAN STANDARD FOR CERTIFICATION OF WIND TURBINES PREPARED BY C-WET AND APPROVED BY MNRE. IT WILL ALSO PREPARE INDIAN STANDARDS ON WIND ENERGY**
the introduction of more new wind turbine models and increased unit size. To cater to the Wind Turbine Certification requirements, MNRE has established the S&C unit under C-WET. It accords type approval/type certification to wind turbines in accordance with the Type Approval Provisional Scheme (TAPS-2000) (amended).

The unit is also involved in the development of Indian standards and works with the Bureau of Indian Standards (BIS) Sectional Committee — Wind Turbines (ET-42) under electro-technical division which concerns itself with preparation and issue of Indian standards for wind turbines. The Executive Director, C-WET is the Chairman of the ET-42, which corresponds with IEC Technical Committee TC-88. The drafts received from TC-88 are reviewed and commented upon by C-WET’s S&C unit through the chairman of the committee.

**Information, Training and Commercial Services (ITCS) Unit**

The Information, Training, and Commercial Services Unit is engaged in dissemination of wind power related information to all stakeholders. This unit is the focal point for organizing national and international training workshops for the benefit of stakeholders.

The unit establishes and updates the data bank and serve as an information centre for selective dissemination. It also collates and disseminates information from other research activities and institutions; conducts national and international seminars, workshops and training programmes; and offers consultancy services. It also takes up other management and public relations activities.

The unit also publishes a newsletter *PAVAN* to create awareness and disseminate information on wind energy developments as well as the role and activities of the centre. The ITCS Unit has trained about 1,000 national and 280 international professionals through its 16 national and 13 international training programmes since 2004.

The unit is maintaining a resourceful library.

**ENGINEERING SERVICES DIVISION (ESD)**

The ESD unit establishes and maintains C-WET’s multi-disciplinary infrastructure and services such as civil and electrical issues as well as IT and cyber security to cater to specific scientific needs. In the long run, the unit would also showcase the possible renewable energy mix in the current scenario, and also improve and demonstrate techniques of energy conservation as well as renewable energy. Facilities on video conferencing and CCTV security system for C-WET have also been managed by the unit.

**Solar Radiation Resource Assessment (SRRA)**

As a part of the Jawaharlal Nehru National Solar Mission (JNNSM), MNRE sanctioned a mission mode project on Solar Radiation Resource Assessment (SRRA) to C-WET, Chennai.

MNRE has initiated a major project on Solar Radiation Resource Assessment (SRRA) station across the nation to assess and quantify the solar radiation availability along with weather parameters with a view to develop Solar Atlas. C-WET is implementing the project by installing a network of 115 SRRA station in two phases in different states using high quality, high resolution instruments which includes four advanced aerosol measurement systems. Each SRRA station consists of two towers of 1.5 m and 6 m height each. The 1.5 m tall tower houses a solar tracker equipped with pyranometer, pyranometer with shaded ring, and pyrheliometer to measure solar parameters, such as, global, diffused and direct radiation. The 6 m tall tower houses instruments measuring rainfall, ambient temperature, atmospheric pressure, relative humidity, wind speed, and direction.

*Dr S Gomathinayagam is the Executive Director, C-WET. Email: info@cwet.res.in*
The Sardar Swaran Singh National Institute of Renewable Energy (SSS-NIRE) is an autonomous institution of the Ministry of New and Renewable Energy (MNRE), Government of India, devoted to bioenergy research, design, and development. Located in Kapurthala, Punjab, it was established on March 31, 1998. The vision of the institute is “To become an apex institution for carrying out state-of-the-art research and developmental activities in the field of bioenergy.”

The governing council under the chairmanship of the secretary, MNRE, has been directing and monitoring the activities of the institute. At present, Prof. (Dr) Yogender Kumar Yadav, a renowned energy scientist of Chaudhary Charan Singh Agricultural University (CCSHAU), Hisar, is leading the institute in the capacity of director. The institute has a vision document approved by the 16th meeting of the governing council that created five R&D divisions in the institute.

These are Biomass and Energy Management, Thermochemical Conversion, Biochemical Conversion, Chemical Conversion, and Electrochemical Conversion.

**OBJECTIVES OF SSS-NIRE**

- Creation of research facility for basic and applied research under different R&D divisions
- Trained human resource development at all levels through R&D and regular training programmes, including post-doctoral research
- Infrastructure development and creation of scientific and support staff
- Project formulation and compliance in the thrust areas in line with the advances of research in bioenergy
- Pilot-scale facility creation of indigenous technology developed at the institute
- Dissemination and commercialization of the product and technology for the benefit of the end-users
- Organizing a national- and international-level conference, workshop, and training programme for the dissemination of knowledge and technology in the frontier areas of bioenergy

The institute has been certified by Intertek and is registered under ISO 9001:2008. The provision under the certificate includes provision for research, design, development, and testing activities of new and renewable energy, especially bioenergy, including human resource development and other associated administrative activities.

**LABORATORY AND INFRASTRUCTURE**

The R&D laboratories of the institute and facilities are subdivided under the following headings as per application point of view:

- **R&D Block-I** (Chemical and Electrochemical Conversion Laboratory, viz., Biodiesel, Hydroprocessing, Catalysis, and Fuel Cell)
- **R&D Block-II** (Biochemical Conversion Laboratory, viz., Bioethanol, Biobutanol, Biogas, Biohydrogen, and Metabolic Engineering)
- **R&D Block-III** (Thermochemical Conversion Laboratory, viz.,...
Biomass Characterization, Gasification, Pyrolysis, Cookstoves, and New and Hybrid Energy Systems

- Common Facility Building (Computer Lab, Library, Conference Hall, and Canteen)
- Workshop (Common Workshop Machines and Tools, Test Engines)
- Gasifier Shed (Biomass Gasification and Testing Facilities)

PROGRAMMES AND ACTIVITIES

The Institute is running an institutional fellowship programme under the name ‘SSS-NIRE Bioenergy Promotion Fellowship’, to attract young researcher having zeal and motivation for bioenergy research in either of the capacities JRF/SRF/PDF or RA, in a similar stature and norms of DST. The institute is regularly hosting national training programmes in the frontier areas of bioenergy and biofuel technologies since 2011, so as to bring stakeholders, entrepreneurs, researchers, and academic experts to the same platform. The institute has also organized a national conference based on ‘Recent Advances in Bioenergy Research’ as an annual event since 2011. This conference took place with a view to discuss and disseminate knowledge and research findings among the top researchers in the field.

The R&D activities under the divisions of Biochemical Conversion, Thermochemical Conversion, and Chemical Conversion are running at its full pace. Basic R&D facilities and testing facilities have been created for biodiesel production and characterization; bioethanol production, consortia isolation and characterization; green diesel production and characterization; biomass characterization; biogas production and consortia isolation; improved biomass cookstove design and testing facility, etc. A few R&D projects are also being carried out at the institute; notable among them are bioethanol production from ligno-cellulosic biomass, biocrude production from nonedible vegetable oil, and setting up a biomass cook stove testing, and certification centre. Very recently, the institute completed an R&D project on integrated technology development for biodiesel production using heterogeneous catalyst. From the findings of this work, one of the catalysts derived from Musa balbisiana colla underground stem was found very efficient for biodiesel production from Jatropha curcas oil containing high free fatty acid under elevated condition in a single step process. A pilot-scale level facility is likely to be developed soon.

The institute has been designated as the Coordinating and Managing Entity (CME) by MNRE for cookstoves to coordinate the efforts of different CPA implementers to distribute improved cookstoves within the geographical boundary of the country. The Programme is a joint venture under the Indo-German Renewable Energy (IGEN-RE) Cooperation, MNRE, and GIZ. It was registered at the United Nations Framework Convention on Climate Change (UNFCCC) on December 28, 2012. The CME now intends to bring in organizations such as NGOs, self-help groups, communities, the private sector, and state nodal agencies that are initiating the implementation of the distribution of cookstoves in households and communities to join the programme and include their projects as a Clean Development Mechanism (CDM) Component Project Activities for generation and securitization of Certified Emission Reductions (CERs). The call for proposal intends to facilitate inclusion of two projects under the PoA platform covering the costs for the following aspects:

- Development of component project activity design document, including baseline study
- Validation cost for inclusion of the CPA under the registered PoA
- The ministry has also set up a test centre for carrying out performances of improved cookstoves as per BIS

The institute is also aiming at collaborative research and has signed an Memorandum of Understanding (MoU) with premier universities and institutions of Punjab, such as NIT Jalandhar, PTU Jalandhar PAU Ludhiana, PU Chandigarh, etc., with a view to collaborate in the frontier areas of bioenergy research through joint projects and exchange of research fellows and scientists. Furthermore, the director of the Institute is pleased to invite young researchers and innovators to come forward and participate in the programmes of the institute with innovative technologies and methods for the conversion of surplus biomass in the country, such as waste and agricultural residues to eco-friendly, high-energy content fuels and chemicals.

Dr Yogender Kumar Yadav is Director, SSS-NIRE
Email: director@nire.res.in
The Indian Renewable Energy Development Agency (IREDA) was incorporated in the year 1987 under the Ministry of New and Renewable Energy (MNRE) as a dedicated financial institution (NBFC) for providing financial services to the renewable energy sector in India, with the motto ‘ENERGY FOR EVER’.

**OBJECTIVES**

- To give financial support to specific projects and schemes for generating electricity and/or energy through new and renewable sources and conserving energy through energy efficiency
- To increase IREDA’s share in the renewable energy sector by way of innovative financing
- To strive to be a competitive institution through customer satisfaction
- To maintain its position as a leading organization to provide efficient and effective financing in renewable energy and energy efficiency/conservation projects
- Improvement in the efficiency of services provided to customers through continual improvement of systems, processes, and resources

Since its inception, IREDA has played a vital role in the commercialization of renewable energy technologies in the country by providing innovative and customized financial services across the entire value chain, from manufacturing facilities to power generation to evacuation projects.

**OPERATIONAL AREAS**

- Wind energy
- Solar energy
- Hydro power
- Biomass power
- Cogeneration
- Waste-to-energy
- Energy efficiency and conservation
- Power evacuation system

IREDA has disbursed over ₹14,000 crore to over 1,000 projects using different technologies, such as solar, wind, biomass, cogeneration, hydro, and energy efficiency. This has led to the setting up of over 5,000 MW of clean power generating capacity in the country, resulting in an abatement of over five million tonnes of CO₂ eq greenhouse gases on an annual basis.

**SCHEMES**

- Project financing
- Equipment financing
- Take-over loans from banks/FIs
- Bridge loan against SDF and VGF

IREDA has recorded tremendous growth in its operations during the last five years achieving a CAGR of 38 per cent in sanctions and 44 per cent in disbursements.

**LENDING TERMS**

- Minimum loan : ₹50 lakh
- Loan : Upto 70% of project cost
- Interest : 11.50%–13.75%
- Repayment : Upto 15 years
- Moratorium : Upto 12 months
FUND SOURCES

- International lines of credit
- Taxable and tax-free bonds
- Domestic banks

NEW INITIATIVES

- Securitization against receivables
- Financing IPPs/SPVs
- Consortium/co-finance
- Performance guarantees
- Consultancy advisory services

HISTORY OF IREDA

- Indian Renewable Energy Development Agency Limited (IREDA) was established on March 11, 1987 as a public limited government company under the Companies Act, 1956, and it promotes, develops, and extends financial assistance for renewable energy and energy efficiency/conservation projects.
- IREDA has been notified as a “Public Financial Institution” under section 4 ‘A’ of the Companies Act, 1956 and registered as Non-Banking Financial Company (NFBC) with Reserve Bank of India (RBI).

OUR MISSION

“Be a pioneering, participant friendly and competitive institution for financing and promoting self-sustaining investment in energy generation from renewable Sources, Energy Efficiency and Environmental Technologies for sustainable development”.

MAIN OBJECTIVES OF IREDA

- To give financial support to specific projects and schemes for generating electricity and/or energy through new and renewable sources and conserving energy through energy efficiency.
- To maintain its position as a leading organization to provide efficient and effective financing in renewable energy and energy efficiency/conservation projects.
- To increase IREDA’s share in the renewable energy sector by way of innovative financing.
- Improvement in the efficiency of services provided to customers through continual improvement of systems, processes, and resources.

QUALITY POLICY

IREDA is committed to maintaining its position as a leading organization to provide innovative financing in Renewable Energy and Energy Efficiency/Conservation and Environmental Technologies through efficient systems and processes for providing total satisfaction and transparency to its customers. IREDA shall strive towards best quality services to its customers.

QUALITY OBJECTIVES

- Drive towards total customer satisfaction.
- Continual upgradation of capability and improvement in the professional skills of employees.
- Improvement in efficiency of services provided to customers.
- Continual improvement of systems, processes, and services.
- Implement the Quality Policy and Quality Objectives with full devotion and dedication to achieve IREDA’s Mission.

Mr. K S Popli is Chairman and Managing Director, IREDA. Email: cmd@ireda.gov.in
The Solar Energy Corporation of India (SECI) is a not-for-profit company that is dedicated to the solar energy sector. It was established under the administrative control of the Ministry of New and Renewable Energy (MNRE), Government of India, in 2011. The mandate of SECI allows wide-ranging activities to be undertaken with an overall view to facilitate implementation of JNNSM and achieving the targets set therein.

The vision of the company is to build a new ‘Green India’ by harnessing the country’s abundant available solar radiation to achieve energy security in India. It aims to become the leader in development of large-scale solar installations, solar plants, and solar parks, and promote and commercialize the use of solar energy to reach remotest corner of India.

**OBJECTIVES OF SECI**

- To develop ultra-mega and large-scale solar plants, including solar parks
- To own, operate, develop, and manage both grid-connected and offgrid solar installations
- To take up energy access programmes for rural and remote areas through solar energy
- To promote new technologies in solar and R&D leading to commercialization
- To exchange, distribute, and trade power in furtherance of JNNSM goals
- To promote integration of solar with conventional and renewable power and set up installations across the country

SECI’s Board of Directors is led by its Chairman, Shri Upendra Tripathy, IAS, who is currently serving as Secretary, MNRE. Shri Rajendra Nimje, IAS (Retd) is the Managing Director of the organization, leading a highly experienced team of four full-time directors. Shri Tarun Kapoor, Joint Secretary (National Solar Mission), MNRE, is the Part-Time Director on SECI’s Board. Since its inception, SECI has played a major role in the implementation of policies of the government in this sector and has been an anchor to the ministry’s efforts in rapid diffusion of the technology as wide as possible.

**GRID-CONNECTED PROJECTS OF SECI**

The National Solar Mission (NSM) has set an ambitious target for widespread deployment of solar technology all over the nation. This target is being envisaged to be achieved by means of setting up both ground-mounted large-scale plants and small-scale grid-connected rooftop systems. PV plants are used for electricity generation that is fed into the grid. Such systems typically consist of one or more photovoltaic (PV) panels, a DC/AC power converter/inverter, racks, mounting fixtures, and electrical interconnections. Additionally, such systems could also include Maximum Power Point Trackers (MPPT), battery systems and chargers, solar trackers, software for energy management, solar concentrators, etc. The electricity generated is either stored, used directly for self-consumption, or is fed into large electricity grids.

**Implementation of grid-connected utility-scale solar PV projects**

SECI has recently achieved successful conclusion of one of the most important targets under the second phase of the NSM. Under the Batch-I of this Phase, SECI has allocated projects having a cumulative capacity of 750 MW to the Solar Power Developers through an international competitive bidding process. The scheme is being implemented through the Viability Gap Funding mode. The 45 projects selected by
SECI are currently in various stages of implementation and are scheduled to be commissioned on or before April 28, 2015. Subsequently, SECI is also giving final shape to the next batch of allocation of projects, the bidding for which shall be completed by latter half of the year.

Installation of rooftop solar PV projects
Rooftop Solar PV installations are becoming a popular green energy option for not only meeting ones own electricity load but also injecting surplus generation into the grid. Schools, hospitals, storehouses, bus stations, railway stations, etc., provide ample spaces to set up PV projects. There is a high possibility of natural load-generation balance if rooftop PV solar systems are installed.

SECI has allotted projects of an aggregate 26 MW capacity under the MNRE scheme to set up rooftop projects of 100 kWp to 500 kWp capacities to various developers in many states covering 16 cities all over the country. SECI is in an advanced stage of concluding its fourth phase allocation of projects, aggregating 50 MWp capacity to the selected developers.

Establishment of solar parks
SECI has plans to undertake development of solar parks either unilaterally, or in collaboration with states or as a public–private partnership. Recently, SECI entered into an MoU with APIIC, Government of Andhra Pradesh, for setting up a solar park with 1,000 MW capacity.

OFFGRID PROJECTS OF SECI
JNNSM Phase II has envisaged giving a major thrust to offgrid solar power applications in areas where grid has not reached, or the areas where electricity supply is poor. SECI plans to focus on solar offgrid generating systems, solar home lighting systems and various other forms of solar-based heating/cooling/thermal applications in domestic, commercial and industrial segments, in line with the Phase II targets.

Low-cost solar lanterns
Solar lanterns are increasingly finding applications in the rural areas for lighting purpose with key features such as LEDs, mobile charging, battery backup, etc. However, the prices of such lanterns continue to be prohibitively high for the rural population and thus out of their reach. Solar lanterns can be immensely useful, particularly for children’s study besides household and other economic activities. They have a huge potential to replace current use of kerosene lamps, thus can contribute towards significant reduction in subsidy burden on this account. Solar lanterns are pollution-free and environment-friendly. With 30 per cent subsidy being extended by MNRE, these solar lanterns would be affordable to the rural population. In the first phase, about 1.5 lakh lanterns are targeted to be distributed by end of the current financial year.

Solar street lights
Solar street lighting systems are solar-powered photovoltaic modules that convert sunlight directly into electricity in the day time, which is stored in a battery and is used for the purpose of street-lighting during the night. Both stand-alone and centralized PV-based systems are being implemented. One such project consisting of 400 street lights is being
implemented in the Bokaro district in Jharkhand, under the CSR activities of Power Finance Corporation (PFC) Ltd.

**Micro-mini grid for village electrification**
SECI is planning to develop several 5–50 kW mini/micro grid projects in remote villages. These projects are proposed to be developed through appropriate business models that would encourage public-private participation. It has already empanelled agencies for a period of two years, for implementation of such projects. Recently, SECI has invited bids for setting up of 101 kWp mini-grid system in three villages in Haryana. As part of the JNNSM targets, more such projects are envisioned to be taken up in the coming months.

**Installation of solar water heating systems**
A solar water heater consists of a collector to trap the heat energy of sun rays by use of selective coating. The heat is transferred to riser pipes or tubes so that water through the tubes gets heated and is delivered to the storage tank. The total system with solar collector, storage tank, and pipelines is called Solar Water Heating System. The hot water temperature can be raised up to 800 °C by re-circulation of the same water through a collector.

**Consultancy projects of SECI**
As the benefits of solar technology are becoming popular, more and more organizations are coming forward to join hands with SECI to contribute towards a greener future. SECI has extended consultancy services to organizations such as ONGC Tripura Power Corporation, Finolex, ISBT, Planning Commission, and Indian Air Force among others. SECI has signed Memorandum of Understanding (MoUs) with several PSUs to provide them Project Management Consultancy services for deployment of solar PV systems. MoUs have been signed with (i) DMRC for setting up rooftop PV projects including a 500 kWp system on their Metro Station, (ii) PFC for utilization of their CSR funds, (iii) Delhi Development Authority (DDA) for solarization of their stadium, (iv) Airport Authority of India for implementing rooftop and ground-mounted SPV systems at their airports, (v) Rural Electrification Corporation for distribution of solar lanterns, (vi) EESL for collaboration in implementing energy-efficient systems, etc.

SECI has recently been entrusted with implementation of solar PV projects having a cumulative capacity of 1,000 MW in the complexes of various factories of Ordinance Factory Board. In order to disseminate the information to upcoming developers and the public in general, SECI is also working on development of a portal, ‘Solar Guidelines’ which shall serve as a comprehensive source for all the information related to the various prevalent state solar policies and providing guidance to developers to set up their own projects.

**THE WAY AHEAD**
As elaborated above, SECI is highly committed towards becoming a pioneer in steering the growth story of solar technology in the country. SECI has envisaged a lot of projects with a view of taking the success story forward in a rapid manner. This includes setting up of 2x50 MW Solar CSP projects to harness the thermal energy of the sun for energy production. Further, under the mission, the next batch of 1,000 MW capacity is scheduled to be allocated in this year. SECI is also in advanced stage of planning for setting up its own 10 Solar PV projects of 10 MW capacity each, demonstrating the qualities of the major technologies available in this domain. As part of development of Ultra Mega Power Plants as envisaged in the Union Budget 2014, SECI is in consultation with various states for setting up of solar parks having capacity in the range of 1,000–4,000 MW each. Continuing the success story of the rooftop projects, SECI will be rolling out more capacity allocations under the MNRE scheme of financial assistance. With a progressive solar policy and government support in place, the days ahead look sunny indeed, with SECI being the cornerstone of the progress of solar technology in the country.

Shri Rajendra Nimje, IAS (Retd) is the Managing Director of SECI. Email: rajendranimje@seci.gov.in
Drying using solar radiation is one of the oldest techniques used by mankind to preserve food products. In order to maximize efficiency, appropriate technologies need to be applied to keep this technique a sustainable one. **Debabandya Mohapatra** discusses various solar dryers and how they work.

Fruits and vegetables are an essential part of human diet providing micronutrients, vitamins, enzymes, and minerals. Most fruits and vegetables have a high moisture content and water activity. This makes them vulnerable to microbial and other spoilages due to biochemical reactions, such as enzymatic activity, respiration, and senescence. Therefore, preventive measures are taken to lower water activity; drying or dehydration is one such method. Drying is a process of removal of water from the food to inhibit biochemical processes and microbial growth. Drying increases the shelf-life of the product, so that it can be available during off season. Drying can be done at high temperature, such as hot air drying or dielectric heating, at low temperature, such as freeze drying, or at ambient temperature, such as desiccant drying. Nevertheless, it is an energy guzzling process. With the depletion of fossil fuels and hike in energy prices, more and more emphasis is being given to utilize renewable energy sources for drying.
SUN DRYING

Since time immemorial, human beings have been using sun as a source of energy. This is one of the most prevalent and cheap methods practised by most developing and underdeveloped countries, especially in tropics, where good sunshine hours prevail throughout the year. Food commodities are laid on a platform with intermittent stirring for uniform drying. The sun’s heat not only reduces the moisture level as desired, but also kills insects present in the food product. Sun drying has certain limitations as it is dependent on the weather and sunshine hours. During uncertain rain and precipitation, the materials are not dried properly, which causes microbial growth and other qualitative deteriorations. The drying process usually takes a long time, thus causing infestation from insects, birds, and animals. Also, drying requires a large area. Despite these disadvantages, sun drying is still practised in many parts of the world.

Solar Dryer

Over the years, the practice of open air drying or sun drying has become limited due to growing concern over quality of the final product. Due to high rise of fuel prices, depletion of fossil fuels, and emergence of modern and efficient but not so economic drying technologies, solar drying systems have made a place for themselves. The final product quality of a solar dried product may not be as good as freeze-dried product, but for the economically and energy deprived farmers and entrepreneurs, solar drying is the best in the business. Solar drying is achieved by direct sun radiation and greenhouse effect. The solar energy received by the drying chamber is dependent on the sunshine hours, climate, weather, atmospheric clearness, and location. According to E V Fodor, on a clear day solar radiation available to any location is dependent on the angle of the sun relative to horizon. Solar energy is free, renewable, abundant, and an environment friendly energy source. This reduces drying time due to effective utilization of solar energy. It maintains the quality of the food products and acts as an ideal substitute for fossil fuel based dryers. The two basic limitations faced by the solar dryers are sunshine hours and weather change. There are two types of solar driers; the Passive Type (natural convection) dryer and the Active Type (forced convection) or Hybrid Solar dryer. As per Ekechukwu, these solar driers may be again sub-grouped under three categories: (i) integral type (direct mode), (ii) distributed type (indirect type), and (iii) mixed mode. In a direct type, solar drying material is placed in a drying chamber having a transparent cover through which solar radiation enters and heats the food materials to be dried. In an indirect mode, solar energy is captured by a solar collector, which in turn heats the air. This heated air is then passed to the drying cabinet/chamber. In mixed mode, solar energy is collected in separate solar collector and heated air is then passed over the drying material. The drying materials absorb the solar energy directly through the transparent cover and walls.

WITH THE DEPLETION OF FOSSIL FUELS AND HIKE IN ENERGY PRICES, MORE AND MORE EMPHASIS IS BEING GIVEN TO UTILIZE RENEWABLE ENERGY SOURCES FOR DRYING

A SOLAR DRYING SYSTEM, PARTICULARLY FOR AGRO-PRODUCTS AND MARINE PRODUCTS, IS VIABLE PARTICULARLY IN DEVELOPING COUNTRIES WHERE LABOUR COSTS ARE LOW AND COST OF FOSSIL FUEL ENERGY IS VERY HIGH
Solar Natural Dryer

These are directly irradiated solar dryers, where the commodities absorb solar energy directly. The dryers are provided with transparent cover, such as glass or polyethylene. The upper layer is heated and dried by direct solar radiation and the subsequent layers are heated through conduction. Polyhouse or greenhouse drying is an example of solar natural dryers. Since the drying process is weather and sunshine hours' dependant, a constant drying temperature cannot be maintained. High outdoor temperature, low humidity, and clear skies are the ideal conditions for solar dryers. The inside air temperature of the polyhouse is about 20–30 °C warmer than the outside air temperature, which makes the drying faster as compared to open sun drying, thus reducing drying time. Pangavhane et al. have designed a solar dryer consisting of a solar air heater and a drying chamber. They observed that the drying time in a solar dryer was four days as compared to seven days in open sun drying and 15 days in shade drying for production of resins from grapes. A solar tunnel dryer designed for drying agricultural crops, by Bala et al., consisted of a transparent plastic covering the flat plate collector. The drying tunnel is connected in a series to supply hot air directly into the drying tunnel using two DC fans operated by a solar module. Bena and Fuller described that biomass-generated energy serves as a backup for such direct convection type natural solar dryers, thus improving the dryer efficiency.

Semi Artificial Solar Dryers

These are direct heated solar convective dryers. In these dryers, air is preheated by solar energy in a collector. The drying system usually consists of a solar collector and a fan for maintaining a specified air flow through the drying space. These dryers are cheap to construct and can be employed where the drying material is not sensitive to periodic changes in the drying conditions caused by periodic nature of the solar radiation and changing atmospheric conditions. K Lutz and his co-workers had developed a multipurpose solar tunnel dryer consisting of a fan, solar heater, and tunnel dryer. The use of this dryer had reduced the drying time considerably with better end product quality.

Solar Assisted or Indirect Type Solar Dryer

In this type of dryer, solar energy is used to heat a fluid or sand pebble, which in turn heats the drying air. These usually have auxiliary energy source, such as a thermo-generator fuelled by biomass, natural gas or oil, to be used in situations where solar energy collected is insufficient for drying purpose. Better control of temperature results in a better quality product. The solar dryer developed by El-Sebaii et al. consisted of a flat plate solar air heater connected to a cabinet, acting as a drying chamber. The air heater is designed to insert various storage materials under the absorber plate to improve the drying process. Sand is used as a storage material. Since heat dissipated by sand is gradual, it reduces the drying time by 12 hours and the total drying time can be achieved in eight hours with suitable pre-treatment given to the fruits.

Hybrid Dryer

These dryers are usually direct-type solar dryers, but are backed up by an auxiliary energy source, so that during the less sunshine hours and cloudy weather the energy back-up can be utilized to dry food materials without interruption. This usually results in better product quality. Bhattacharya et al. have developed a hybrid solar dryer using direct solar energy and a heat exchanger. The dryer consists of a solar collector, reflector, heat exchanger cum heat storage unit, and a drying chamber. The drying chamber is placed beneath the collector. The dryer is operated during normal sunny days as a solar dryer and as a hybrid solar dryer during cloudy days. Drying is also carried out at night using stored heat energy, in which it is collected during the
Drying is a process of removal of water from the food to inhibit biochemical processes and microbial growth. It increases the shelf-life of the product, so that it can be available during off season. Drying can be done at high temperature, such as hot air drying or dielectric heating, at low temperature, such as freeze drying, or at ambient temperature, such as desiccant drying.

CONSTRUCTION MATERIALS

For the frame, GI pipes, light-weight aluminium pipes or locally available materials such as bamboo, can be used to erect the structure. The covering material could vary from low thickness cheap polythene sheets, which is susceptible to photovoltaic degradation, erosion and wear, to expensive plastic, glass, and high density polymers that are resistant to photovoltaic degradation. Depending on the strength, the cover may last for one season to life long. Though glasses are durable, but during hailstorms they get damaged, and thus need replacement. While choosing the covering material solar transmittance should also be considered, apart from economics and durability.

MAINTENANCE

Rooftop solar collectors are very popular; they do not need extra space. The collected solar energy supplies heat energy to the drying chamber. Many a times, the collectors are mounted on the roofs which may not be suitably oriented to get maximum benefits from solar radiation. The collectors should be properly designed, considering the geographical location of the place. Proper insulation should be provided to the duct transmitting the hot air. The solar collectors should be cleaned regularly to maintain its efficiency. Maximum solar radiation reaches us during 10 am to 2 pm; hence, the temperature of drying will be more during this period. There will be a temperature variation in the drying environment as well as in the product. To maintain a constant drying air temperature, supplementary heat may be provided. A comparison of cost of different solar dryers in India is presented in Table 1.

TABLE 1: Cost of different solar dryers in India

<table>
<thead>
<tr>
<th>Types of solar dryer</th>
<th>Initial investment (₹)</th>
<th>Operating and maintenance cost per year (₹)</th>
<th>Life (Year)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Solar cabinet dryer</td>
<td>5,000</td>
<td>200</td>
<td>5</td>
</tr>
<tr>
<td>Green house crop dryer</td>
<td>2,000</td>
<td>-</td>
<td>5</td>
</tr>
<tr>
<td>Reverse absorber cabinet dryer</td>
<td>8,000</td>
<td>200</td>
<td>5</td>
</tr>
<tr>
<td>Conventional active solar dryer</td>
<td>15,000</td>
<td>200</td>
<td>5</td>
</tr>
<tr>
<td>Hybrid PVT integrated greenhouse dryer</td>
<td>43,000</td>
<td>1,000</td>
<td>35</td>
</tr>
<tr>
<td>Hybrid PVT solar dryer</td>
<td>39,000</td>
<td>200</td>
<td>30</td>
</tr>
</tbody>
</table>

Source: Tiwari and Mishra (2011)

CONCLUSION

A solar drying system, particularly for agro-products and marine products, is viable particularly in developing countries where labour costs are low and cost of fossil fuel energy is very high. In the future, larger systems could be designed utilizing solar, thermal, photovoltaic panels combined with wind power. As solar and wind energy is necessarily intermittent, advances in thermal and electrical energy storage is needed to make use of renewable energy viable in drying. To minimize use of oil or gas, biomass can be used for heating in the absence of insolation and wind. Farmers can use the locally available material for construction of solar dryers. The covering material should be carefully chosen.

Debabandya Mohapatra is with the Agro Produce Processing Division, Central Institute of Agricultural Engineering, Bhopal. Email: debabandy@gmail.com
SOLAR CYCLE STAND

A school in Chandigarh will now have a solar-powered cycle stand and also generate its own power! Ravinder Singh writes about how a cycle stand will serve the dual purpose of not only providing a shaded space for parking and but also generate power.

A solar cycle stand is a novel concept in India where green power can be generated along with a provision of parking cycles under the shaded area. Not just this, it can also be used for rainwater harvesting for recharging ground water. All this and more has been accomplished at a government-run middle school in Chandigarh city.

The first solar cycle stand in the country, the capacity of the SPV power plant is 15 Kw, which has been installed with a cost of ₹ 18.70 lakh. The covered area of this cycle stand is 1,050 square feet where more than 100 cycles can be accommodated. This solar power plant has already generated around 7,500 units of electricity as on May 28, 2014 since its inception on 23 January 2014 and has reduced 4,050 kg of CO₂ emission. The project has designed to generate more than 20,000 units of electricity per annum. The annual consumption of this school is approximately 14,000 units per annum.

The SPV power plant is designed to take the load of the school building on priority during the day time and the surplus power of approximately 6,000 units annually will be exported to the Chandigarh Electricity Department.
A bi-directional energy metre capable of measuring import and export readings has been installed in the project from where annual import of power from the Electricity Department and the export of solar power to the Electricity Department will be measured. A state-of-the-art technology inverter has been installed in this SPV power plant with the help of which we can see the power generation and other operational parameters online anywhere in the world. Data for daily generation of power for the month of May 2014 is given in Figure 1. This project has been designed and installed by Chandigarh Renewal Energy Science and Technology Promotion Society (CREST), the executing agency of Model Solar City Programme of MNRE in Chandigarh.

Ravinder Singh is the Project Director of CREST, Chandigarh. Email: crestchandigarh@gmail.com

Send us an original photograph based on the theme 'Renewable Energy in India' and you may get to see it featured here. Also, win a prize of ₹ 2,000! You can send up to 5 photographs, but don’t forget to give captions for all of them.

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Last date for sending us your entries is 10 October 2014
India is primarily an agriculture-dependent country. However, the pace at which agricultural and economic activities are changing is so fast that traditional methods of working are increasingly being considered outdated. Modernization, with many innovations, is the order of the day, such as progress in the field of information technology, which has gone forward in leaps and bounds. Indian rural economy is also improving at an accelerated rate with each passing day. The pattern of crops is changing fast with the farmers realizing that they cannot survive solely on conventional crops. This awareness is making farmers look towards horticultural crops such as fruits, vegetables, spices, etc., which yield high income. In fact, rural women have also turned into successful entrepreneurs by starting cottage industries and microenterprises that fetch attractive returns through DWACRA and other Self Help Groups (SHGs).

Installation of solar food processing units in India by SEED is an innovative way of utilizing solar energy. It is a multi-faceted technique capable of addressing various problems faced by people in the developing world. **Prof. M Ramakrishna Rao** takes a look at the project by SEED aiming to develop efficient methods of solar food processing.
In all industries, whether cottage, medium, or heavy, energy has become the highest cost contributor and paradoxically the same energy becomes a scarce product just in times of need. Hence, this necessitates alternative innovations in energy. These innovations should be cheaper and involve easily available alternative energy from sources, such as sun, wind, gas, etc. These innovations should ensure environmental protection through elimination or reduction of greenhouse gases’ emission. Out of all the available alternative sources, the only source that meets our needs adequately at zero energy cost and is available almost all the time is solar energy. It is thus time to tap solar energy for food processing in industries, particularly in rural areas.

The Government of India launched many schemes and projects for creating job opportunities through rural employment guarantee schemes, poverty alleviation programmes, Bharat Nirman, Prime Minister Grameena Sadak Yojana, Rajeev Yuva Sakthi programmes, etc. These are implemented at the village level by government agencies and NGOs. They consist of small enterprises, SHGs, and infrastructure development in several areas connected to rural development.

In rural India, the main occupation of women and youth is based on horti-agricultural operations. The horticulture crops consist of fruits, vegetables, medicinal plants, and other commercial plants, such as spices, etc. In recent times, the area of cultivable land under agriculture and horticulture has enormously increased due to the development of major and minor irrigation projects and modern methods of drip-and-sprinkle irrigation techniques. The volume of production from this sector is growing fast and post-harvest treatment of the product has become an important technology development programme for value addition and preservation.

Income generation schemes in the horti-agricultural sector are most suitable and appropriate from the view point of stability of rural habitation. The manufacturing and associated commercial activity connected with the agri-horticulture is providing proper solution for income generation and employment creation in the villages. Food processing technology is one of the priority sectors in our country. If this technology can be introduced at micro level in the villages, it would be a boon for rural women and youth.

INNOVATION OF SOLAR CABINET DRYERS

The solar powered Solar Air Dryer is designed and developed by an R&D team, headed by Prof. M Ramakrishna Rao from the Society for Energy, Environment, and Development (SEED). The product has been created with the help of grants sanctioned by the UNDP and the DST and has been commercialized in India for the first time, with financial assistance from REPSO (USAID). This Solar Cabinet Air Dryer has also been patented (Patent No. 211911).

SEED has installed around 180 solar dryers, both demonstration and commercial models, in 18 states of India, starting from Kashmir to Trivandrum and Gujarat.

RURAL WOMEN HAVE ALSO TURNED INTO SUCCESSFUL ENTREPRENEURS BY STARTING COTTAGE INDUSTRIES AND MICROENTERPRISES THAT FETCH ATTRACTION RETURNS THROUGH DWACRA AND OTHER SELF-HELP GROUPS (SHGS).

FOOD PROCESSING TECHNOLOGY IS ONE OF THE PRIORITY SECTORS IN OUR COUNTRY. IF THIS TECHNOLOGY CAN BE INTRODUCED AT MICRO LEVEL IN THE VILLAGES, IT WOULD BE A BOON FOR RURAL WOMEN AND YOUTH.

Salient Features of Solar Dryers

- Minimal thermal losses due to direct penetration of solar radiation into the cabinet through the glass window, with maximum efficiency
- The temperatures achieved in the cabinet are in the range of 40–65 °C on a clear sunny day and is maintained uniformly
- The temperature difference (ΔT) between the ambient and inside cabinet is 15–30 °C on good sunny days
- The dryer is rain, insect, dust, and rodent proof
- These dryers are modular, easily transportable/portable, and configured according to the availability of open space in user’s premises
- The scalability of the dryer is to the desired size on customer’s demand
- The dryers are guaranteed for long-term usage, i.e., for a period of 10 years
- A special blue glass filter is provided to cut off UV radiation and reduce the solar intensity for special applications (higher retention of micronutrients), thus simulating shade drying
- These driers guarantee clean and hygienically processed products, thereby meeting the international quality standards of importing countries (ASTA of USA and others)
### TABLE 1: Solar Dryers’ Specifications

<table>
<thead>
<tr>
<th>S. No.</th>
<th>Model</th>
<th>Loading capacity (Weight)</th>
<th>Solar window</th>
<th>Drying area in all trays</th>
<th>Solar photovoltaic panel</th>
<th>Electrical backup</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>SDM-8</td>
<td>8 kg</td>
<td>0.37 sq. m</td>
<td>0.56 sq. m</td>
<td>3.5 W</td>
<td>1 KW</td>
</tr>
<tr>
<td>2</td>
<td>SDM-50</td>
<td>50 kg</td>
<td>2.23 sq. m</td>
<td>3.6 sq. m</td>
<td>20 W</td>
<td>4 KW</td>
</tr>
<tr>
<td>3</td>
<td>SDM-100</td>
<td>100 kg</td>
<td>4.46 sq. m</td>
<td>7.2 sq. m</td>
<td>50 W</td>
<td>8 KW</td>
</tr>
<tr>
<td>4</td>
<td>SDM-200</td>
<td>200 kg</td>
<td>9.00 sq. m</td>
<td>14.4 sq. m</td>
<td>100 W</td>
<td>16 KW</td>
</tr>
</tbody>
</table>

About 1,000 women and SHGs, NGOs, and youth were trained in solar processing of various food products in solar dryers. SEED has been conducting training programmes at SEED, Hyderabad, and in its rural training centre at Tholkatta village for the benefit of entrepreneurs.

The hot air passes through the trays, carrying the moisture from the product to the space below the glass. The moist air is exhausted by the solar photovoltaic fans. The forced circulation of air in the cabinet is achieved through this solar fan.

Solar Photo Voltaic (SPV) fans are arranged on the top side of the cabinet. Thus, the moist air is exhausted to the outside. The solar dryer has a metal cabinet made up of an aluminium alloy (anti-corrosive material) with a glass window on the top. The inside walls of the cabinet and the trays it holds are made of stainless steel. The products to be dried are placed on these stainless steel trays. The cabinet dryer is modular in construction.

The ambient air enters from the bottom of the cabinet and gets heated up with solar radiation incident from the top window. Heat energy is trapped in the cabinet and heats up the air. As a result, the wave length of solar radiation shifts to infrared region, causing greenhouse effect.

### Solar Dehydrated Food Products

- **Fruits**: Mango bars/rolls, Guava bars/rolls, Chikku bars/rolls, Mixed Fruit bars/rolls, Khatta-Meetha bars/rolls, Papaya bars/rolls, Apple bars/rolls, Plum bars/rolls, Pineapple bars/rolls, Strawberry bars/rolls, Apricot, Grapes, Banana, and fruit slices
- **Vegetables**: Potatoes, Donda, Carrot, Tomato, Mushrooms, Bitter gourd, Onion, Coconut, etc., in the form of powders
- **Green leafy vegetables**: Curry leaves, Spinach leaves, Fenugreek leaves, Tamarind leaves, Gogu leaves, Mint leaves, Drumstick leaves, Coriander leaves, Amaranth leaves, etc., in form of powders
- **Spices**: Ginger, Mango, Garlic, Red chillies, Green chillies, Pepper, etc., in the form of powders
- **Cereals**: Millet (Ragi), Soya, etc., in the form of powders
- **Forest products**: Karaya Gum, Karakkaya, Sugandapala (*Budipalagadda*), Aloe vera, Amla, Honey, Nelavemmu, Maredugaddalu, Satavari, etc., in the form of powders
- **Medicinal and herbal products**: Rosemary, Spirulina, Tulsi leaves, etc., in the form of powders
- **Food items**: Maida, Vermicelli, Noodles, Pickled chillies, Amchur, Fish, etc.
- **Chemicals**: Silicon carbide, Cellulose, etc.

Some of these products are commercialized and are sold in supermarkets and retail outlets in Andhra Pradesh, Karnataka, New Delhi, etc.
NABARD Award for Rural Innovations 2012 for Solar Food Processing and Dryers was awarded to the Society for Energy, Environment & Development (SEED)

Innovative Solar Food Processing Technology

The need to have a sustainable energy supply necessitates the exploration of available energy sources, and among these, renewable resources are at the forefront. It is now an established fact that RE (renewable energy) can be an integral part of sustainable development because of its inexhaustible nature and environment-friendly features. RE can play an important role in resolving the energy crisis in urban areas to a great extent.

Today RE is an established sector with a variety of systems and devices available for meeting the energy demand of urban inhabitants, but there is a need to create mass awareness about their adoption. Akshay Urja is an attempt to fulfil this need through the dissemination of 20,000 copies (bilingual) in India and abroad. The magazine publishes news, articles, research papers, case studies, success stories, and write-ups on RE.

Readers are invited to send material with original photographs and statistical data. The photographs should be provided in high resolution files on a CD or through email. Akshay Urja will pay an honorarium of ₹ 2,500 to the authors for each published article of 1,500 words and above. The publication material in two copies, along with a soft copy on CD/DVD/email may be sent to:

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DEVELOPMENT OF SOLAR FOOD PRODUCTS

In the last few years, intensive R&D work taken place by SEED for processing of fruits, vegetables, spices, herbs, forest product, chemicals, etc., using solar dryers for value addition and long shelf-life on a commercial scale. The dehydration process requires pre-treatments, addition of Class II preservatives to enhance shelf-life, and fast drying to reduce the moisture levels. This process can be accomplished with zero energy cost, unlike the electrical dryers, in solar powered solar air dryers. AU

Prof. M Ramakrishna Rao is Founder and Director of the Society for Energy, Environment and Development. Email: seed@seedngo.com

THE NEW SOLAR POWERED SOLAR DRYER IS A POWERFUL TOOL IN FOOD PROCESSING TECHNOLOGY, ESPECIALLY IN THE DEHYDRATION PROCESSES. THEY ARE MULTI-PURPOSE, APPLICABLE TO MULTI-CROPS, AND WORKS 300 DAYS IN A YEAR.
The energy problems in Himachal Pradesh have become complex, challenging, and area specific. These problems need to be tackled in a decentralized manner. Increased energy consumption has led to deforestation and has adversely affected ecological balance. Moreover, the rural population also demands and desires a better quality life, which would be possible through the efficient utilization of the scarce energy sources. In regard to this, Integrated Rural Energy Programme (IREP) came into existence.

In order to give proper thrust to Integrated Rural Energy Programme (IREP) and to institutionalize the various programmes of renewable energy, the Himachal Pradesh Energy Development Agency (HIMURJA), an autonomous body registered under the Societies Registration Act, 1860 was established in February 1989 by the Himachal Pradesh government under the Chairmanship of the Hon’ble Chief Minister. The objective of HIMURJA is to promote research and development in the field of non-conventional and renewable sources of energy.

PROGRAMMES IN THE LAST FIVE YEARS

HIMURJA has made concerted efforts to popularize various renewable energy programmes throughout the state with financial support from the Ministry of New and Renewable Energy (MNRE) and state government. Efforts are continued for the promotion and propagation of renewable energy devices such as solar water heating systems, solar photovoltaic lights, etc. HIMURJA is also assisting the government...
for exploring potential for hydel in the state. HIMURJA encouraged the private sector participation in the hydro power sector during 1995–96. Since then, the allotment of project sites has been a continuous process. Till November 30, 2011, 468 Small Hydro Electric Projects (up to 5 MW capacity) with an aggregate capacity of 1,176 MW have been allotted. Out of these, 45 projects with an aggregate capacity of 177.55 MW have been commissioned. A goal of 500 MW through Small Hydel Projects by the end of 2014 has been fixed.

In consonance with the policy guidelines of MNRE and the state government, various renewable energy programmes have been promoted with the help of central/state incentives after determining cost benefits.

**SCHEMES AND PROGRAMMES OF HIMURJA**

**Solar Thermal Programme**

HIMURJA is popularizing the use of solar water heating systems and solar cookers under its solar thermal programme.

- **Solar Water Heating System**: Solar water heating systems of 1,629,970 litres per day capacity have been installed in different parts of the state up to March 2014. A target of installing solar water heating systems with a capacity of 200,000 litres per day has been proposed for the year 2014–15 under the Jawaharlal Nehru National Solar Mission (JNNSM).

- **Solar Cooker**: A total of 36,838 box type and 372 dish type solar cookers have been distributed to beneficiaries. A target of 1,000 box type and 200 dish type solar cookers has been proposed for the year 2014–15 under JNNSM.

**Solar Photovoltaic Programme**

HIMURJA is popularizing and providing solar photovoltaic systems. A package of incentives to popularize these systems throughout the state are being provided by MNRE.

- **SPV Street Lighting System**: A total of 44,338 points SPV street lighting systems, 22,586 SPV domestic lights, and 32,649 solar lanterns have been installed/distributed in the state. A target of 66,940 SPV street lighting systems and 10,000 solar lanterns have been proposed for the year 2014–15 under the JNNSM.

- **SPV Power Plant**: SPV power plant of 264.5 KWp capacity has been commissioned under the JNNSM. A target of 5 MW capacity SPV power plant under JNNSM/Tribal Sub Plan (90:10) has been proposed for the year 2014–15.

**Small Hydro Electric Projects**

The state government has entrusted the responsibility of harnessing of small hydro potential up to 5 MW by private investment through HIMURJA under the administrative control of the Non-Conventional Energy Sources Department of the Himachal Pradesh government so that optimum utilization of hydro potential in small hydro can be achieved. Till March 31, 2014, 468 projects of an aggregate capacity of 1,195.12 MW were allotted to private investors. Out of these, 62 projects with an aggregate capacity of 232.05 MW have been commissioned and 49 projects with an aggregate capacity of 173.85 MW are under construction. For the year 2014–15, commissioning of 16 projects with an aggregate capacity of 53.18 MW has been targeted.

**Hydro Electric Projects**

- **MHEPs/ SHEPs**: HIMURJA is operating Micro Hydel projects at Lingti (400KW), Kothi (200 KW), Juthed (100 KW), Purthi (100 KW), Sural (100 KW), Gharola (100 KW), Sach (900 KW), and Billing (400 KW), which are under generation. Other projects, namely Bara Bhangal (40 KW) and Sarahan (30 KW) have also been executed by HIMURJA.

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**MANAGEMENT TEAM**

- Er. Bhanu Pratap Singh, Chief Executive Officer and Director, HIMURJA
- Er. K L Thakur, Executive Engineer, Small Hydro, HIMURJA
- Er. Sunil Kumar Sood, Sr Executive Engineer, HIMURJA
- Er. Saneev Kumar Gautam, Sr Executive Engineer, HIMURJA

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**THE STATE GOVERNMENT HAS ENTRUSTED THE RESPONSIBILITY OF HARNESSING OF SMALL HYDRO POTENTIAL UP TO 5 MW BY PRIVATE INVESTMENT THROUGH HIMURJA UNDER THE ADMINISTRATIVE CONTROL OF THE NON-CONVENTIONAL ENERGY SOURCES DEPARTMENT OF THE HIMACHAL PRADESH GOVERNMENT SO THAT OPTIMUM UTILIZATION OF HYDRO POTENTIAL IN SMALL HYDRO CAN BE ACHIEVED**
From Bara Bhangal project, energy is being provided to local public and the energy generation from Sarahan is being used for community purpose. Till March 31, 2014, 315,77,320 units of energy have been generated from these projects. Tendering process for three projects having an aggregate capacity of 14.50 MW is in process and is likely to be commissioned during next three years.

**Portable Micro Hydel Generator Sets:** For meeting energy demand and to ensure uninterrupted energy supply to the tribal people of remote areas of the state, HIMURJA has commissioned 10 portable gensets of total capacity of 135 KW in Pangni Valley of Chamba District. From these gensets, electricity is being supplied to Saichu, Sahali, and Hillaur villages. There is no metering and energy is being provided to general public on a very low fixed rate. The O&M charges paid are very high compared to the revenue earned from these gensets.

### DEVELOPMENT OF SOLAR CITIES

Shimla and Hamirpur cities of the state would be developed as solar cities under MNRE. The programme aims at minimum 10 per cent reduction in projected demand of conventional energy at the end of five years, which can be achieved through a combination of energy efficiency measures and enhancing supply from renewable energy sources. Final Master Plans of both the solar cities have been approved by MNRE.

### SPECIAL AREA DEMONSTRATION PROJECT SCHEME

- **Demonstration of Renewable Energy Systems at Prominent Places:** This scheme deals with demonstration of renewable energy systems/devices at places of national and international importance, such as World Heritage sites, national parks, tourist and religious places, zoological parks, science museums, Secretariats, and collectorates, etc., where a large flow of people and tourists take place every day. The objective is to popularize the renewable energy system and devices to create greater awareness and to supplement the energy requirement. Under the scheme, MNRE has so far supported 41 proposals for World Heritage Sites, Parliament House, Raj Bhawans, State Assemblies, and places of tourist and religious importance.

- **Energy Park Scheme:** The main objective of this scheme is to create awareness and provide an opportunity to the students/teachers and rural and urban masses about the use and benefits of the renewable energy by demonstrating new and renewable energy systems and devices. Two types of Renewable Energy Parks are being supported under this scheme namely District Level Renewable Energy Parks (DLEP) and State Level Renewable Energy Parks (SLEP). DLEPs are set up at educational institutions, Krishi Vigyan Kendras, registered Consumer Forums, registered NGOs with facilities for Science and Environment Education, and in public places where there is large inflow of public. SLEP is set up in a place where large flow of people and tourists takes place every day.

Continuous efforts are being taken by the Government of Himachal Pradesh to widely publicize the various schemes/programmes undertaken by HIMURJA and create awareness about renewable energy programmes amongst general masses throughout the state including remote/tribal areas.

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This article has been developed with the help of inputs from Er Bhanu Pratap Singh, Chief Executive Officer, HIMURJA. Email: himurja-hp@nic.in
The National Meet on Solar Cities organized by the Ministry of New and Renewable Energy (MNRE), Government of India, took place on 20 and 21 June 2014 in Chandigarh. The meet brought together leading experts from a broad spectrum of energy conservation stakeholders including environmental organizations, consultants, research institutes, industries, manufacturers, among others.

The Inaugural Session had a host of dignitaries speaking at the event. A welcome speech was delivered by Shri Tarun Kapoor, Joint Secretary, MNRE. Mr K K Sharma, Advisor to the Administrator, UT of Chandigarh, then delivered his talk, followed by an Inaugural Address by Shri Naved Masood, Secretary, Ministry of Corporate Affairs. Addresses were also made by the chief secretaries of Punjab and Haryana and a special address by Shri Upendra Tripathy, Secretary, MNRE. Finally, a vote of thanks by Shri Santosh Kumar, Director, CREST, was given.

The national meet focused on issues including examining the progress of solar projects in India, identifying critical issues, latest technologies, and saving goals, thereby preparing energy conservation policies and programmes. The experts also deliberated upon methods to successfully push solar programmes across the country to achieve energy conservation goals.

At the national meet, the Union Territory of Chandigarh showcased its progress, future plans regarding a ‘model solar city’ project, and its innovative ideas adopted to promote solar energy here. Notably, the ambitious project of developing Chandigarh as a ‘model solar city’ was formally launched by the then Union Minister MNRE, Mr Farooq Abdullah, in the year 2012. Since then, the Chandigarh Renewable Energy Science and Technology Promotion Society (CREST), established for the promotion of renewable energy programme, has managed to execute a large number of solar power projects here.

Also, Chandigarh has become the first city in the country to provide its residents an opportunity to estimate the potential capacity of SPV power plant that could be installed on the rooftop of their houses. A first-of-its-kind cloud based open-source Web-GIS Tool for estimating rooftop solar power potential for Chandigarh has been recently launched and is available on CREST website.
Perovskite, a dirt-cheap material when used for making solar cells, could cut the cost of a watt of solar-generating capacity by three-quarters. This means that solar panels would cost just 10–20 cents per watt! Prof. Rohella, Prof. Panda, and Prof. Dash look into the potential of this extraordinary material.

Solar technology isn’t new. Its history spans from the 7th century BC till today. Today, we have everything from solar-powered buildings to solar-powered vehicles. Photovoltaic technology was born in 1954 in the United States when Daryl Chapin, Calvin Fuller, and Gerald Pearson developed the silicon photovoltaic (PV) cell at Bell Labs. Until now, photovoltaics solid-state junction devices, often made of silicon, have dominated the conversion of sunlight to electrical power. This dominance is now being challenged by the emergence of a new generation of photovoltaic cells, based on nano-crystalline materials and conducting polymer films, making solar power much more expensive in comparison with fossil fuels. A new type of solar cell made from a material called ‘perovskite’ is significantly cheaper to obtain and use than silicon. It could generate as much power as today’s commodity solar cells. Highly efficient solar cells using perovskite can be made using a simple and inexpensive technology.

PEROVSKITE-BASED SOLAR CELLS

Perovskite is a calcium titanium oxide mineral species composed of calcium titanate, with the chemical formula CaTiO₃. It has a formula mass of 135.96. It is available in black, reddish brown, pale yellow, and in yellowish-orange colour. While conventional silicon solar panels use materials that are about 180 micrometers thick, the new solar cells use less than one micrometer of material to capture the same amount of sunlight. When perovskites were first tried in solar cells in 2009, efficiencies were low. They only converted about 3.5 per cent of solar energy into electricity. However, replacement of a liquid electrolyte with solid materials solved this problem.

Solar cells made up of perovskites have a simple architecture and can easily be produced in large quantities because the vapour deposition process used to make them is compatible with conventional processing methods for fabricating such solar cells. Prototype solar panels incorporating nanotechnology are more efficient than standard designs in converting sunlight to electricity, promising inexpensive solar power in the future.

How a Perovskite Solar Cell works?

Organo-metal-trihalideperovskite semiconductors, with the formula (CH₃NH₃)PbX₃ — where Pb is lead and X can be iodine, bromine, or chlorine — were first employed in 2009 as the light-absorbing component in so-called dye-sensitized solar cells. In these devices, the perovskite were coated onto the surface of a film made of titanium dioxide (TiO₂) nanoparticles. When the perovskite layer absorbs light, electrons, and holes are generated. These charge carriers are subsequently transferred to different transport materials — TiO₂ for the electrons and to
another material for the holes. The transport materials then carry the charges to separate electrodes, and a voltage is produced. These solar cells have light-converting efficiencies of 12–15 per cent. These perovskite-based solar cells have entered the official tables of efficiency records published by the National Renewable Energy Laboratory (NREL). The efficiencies of different types of solar cell fabricated by NREL are shown in Figure 1.

In the series of photovoltaic cells, which convert sunlight into electric current, Quantum, Dot-based (QD) solar cells have shown great potential as next generation, high performance, and low cost photovoltaics due to the outstanding optoelectronic properties of quantum dot and their multiple excitation generation (MEG) capabilities. The recent development of organic–inorganic perovskite heterojunction solar cells has shown great future as light harvesters. Lioz Etger in his article titled ‘Semiconductor Nanocrystals as Light Harvesters in Solar Cells’ published in Materials journal has described mechanisms, procedures, advantages, disadvantages, and the latest results obtained in this field. Semiconductor QDs are promising alternatives to be used as light harvesters in solar cells. The properties of semiconductors QDs can be changed by tailoring their size. In addition, their band gap can be tuned to different wavelengths of light, allowing them to harness energy from the visible to infrared regions. QDs are inexpensive and easy to manufacture, making it possible to fabricate QD solar cells at a low cost.

Challenges Ahead

Like any other new entrant into the highly competitive solar-panel market, perovskites will have difficulty taking on silicon solar cells. Also, since cost of silicon solar cells are falling, and some analysts think they could eventually fall as low as 25 cents per watt, the financial aspect of both silicon and perovskites would have to be taken into consideration. Thus, it is better to augment perovskites rather than replace silicon solar cells to improve their efficiency. This might be an easier way to break into the solar market than trying to introduce an entirely new kind of solar cell. Dot-based (QD) solar cells have shown great potential as next generation, high performance low cost photovoltaics due to the outstanding optoelectronic properties of quantum dot and their multiple excitation generation (MEG) capabilities. The recent development of organic–inorganic perovskite heterojunction solar cells has shown great future as light harvesters.

There is however one small challenge associated with the use of perovskite. The material contains small amount of lead, which is toxic. Tests will be needed to show how toxic it is. Steps can also be taken to ensure that the solar cells are collected and recycled to prevent the materials from getting into the environment — the approach pursued now with the lead-acid starter batteries used in cars.

It may also be possible to substitute lead with tin or some other element in the cells.
Energy can be generated using solids, gas, or liquids as its a source of power. So, how do you use energy? Energy can be generated to produce light, heat or to make objects move. In this experiment, we explore how to get power from water, i.e., **hydropower**, which can be used to pick up household objects. Hydropower is mechanical energy that is generated by using the motion of water caused by gravity. It is one of the oldest known forms of energy and has been used by humans since 4000 BC! By learning how to make a water wheel with a handful of household materials, we too can harness or capture different amounts of water to generate our own power.

**MATERIALS**

- 2-litre plastic soda bottle
- Ruler
- Marker
- Craft knife (take an adult’s help to use it)
- Scissors
- 2 corks
- 1 wooden barbeque skewer
- Sewing thread (16 inches)
- Small objects to lift (small fishing sinker, an eraser)
- Sink
- Duct tape
- Large funnel
- Paper clips
WHY?

You just generated hydropower using the water from your faucet! Gravity pulls water down towards the earth and the weight of the water exerts torque (a rotational force) on the water wheel. This torque provides enough energy to turn the skewer, allowing you to raise items attached to the other cork. Did you notice that more water pressure was needed to lift heavier objects? More energy is needed to lift heavy items than lighter ones, and by increasing the flow of water you can generate more power.

Hydropower is still used as a source of electricity in the United States. Using the same concepts from your experiment, water wheels capture the force of powerful rivers, converting it into electricity and sending it into the electrical grid. Hydropower is an example of renewable energy, energy that can be continually replenished.

http://www.education.com/science-fair/article/water-produce-energy/
With an ambition to bring Solar Power to the common man, Kirloskar Integrated Technologies Ltd (KITL) has developed products employing Copper Indium Gallium (di) Selenide (CIGS) technology. These are highly portable, flexible, light-weight solar power panels that are easy to carry in backpacks. They can charge battery packs which thereafter serve as both backup and portable power to various devices ranging from basic mobile phones to laptops. A light-weight, CIGS, thin-film flexible module is integrated with the backpack. This single module is then connected to a battery pack or straight to a mobile phone, iPod, MP3 player, etc. While the user travels on a two-wheeler or walks during the day, this single module will charge these devices.

**FEATURES**
- Robust integration of flexible, lightweight solar PV panel
- Works in diffused light
- Charges all mobile phones as well as smartphones
- Compatible with other Solastica products
- Personal power pack and Togglite
- USB charging take-off point
- Ideal for charging iPods, MP3 players, FM Radios, bluetooth devices, etc.
- High efficiency inverters for conversion of DC to AC

**TECHNICAL DETAILS**
- Weight of our solar PV charging solution is approximately 120 grams, unnoticeable to the wearer
- Charging time between 4–6 hours for standard mobile devices
- Ideal for charging mobile devices with 5V DC input

**BENEFITS**
- Solar backpacks are light-weight, hence easy to carry
- Flexible solar panels also are light and portable, as well as waterproof
- Sunrise to sunset charging capability
- Green energy source on the go

A Reliable and Versatile Solar Poultry Incubator

An incredible innovation by Georgekutty Kariyanappally, this solar poultry incubator project has been approved by IIT-Madras, Chennai and financed by L-Ramp. In Jhabua district, Madhya Pradesh, a total of 50 solar poultry incubators have been supplied under a rural innovation fund from the National Bank for Agriculture and Rural Development (NABARD). Presently, this product is being promoted at veterinary colleges, agricultural universities, and villages to create awareness among people about backyard poultry farming.

FEATURES

This semi-automatic unit is capable of hatching 100 quail, 40 chicks or 25 goose eggs. It is supplied with fully automatic heat control and excellent thermal properties from the fibre glass cabinet that ensure the best possible conditions for egg incubation, particularly in rural villages. This incubator is developed exclusively for unemployed women living in rural India.
TEMPERATURE CONTROL

Precise and consistent control of temperature is essential for good hatching results. The fibre glass double-skinned box with puff insulation further improving temperature stability and operational efficiency. Adjustment to temperature can be made by turning a nob. An indicator light shows the status of the control, whether the unit is warming up, stable, or cool. The electronic proportional thermostat is well protected against power variation and also a battery is provided for power stability. A 12V/ 40 watt solar photovoltaic panel is connected to the battery with charge controller, hence 24 hour supply is assured.

EGG TURNING

This can be done manually by turning each egg 4 or 5 times in a day. There are no internal electrical moving mechanism associated with egg turning. Thus, there is no chance of injuring the chicks.

HUMIDITY AND VENTILATION

A computer grade fan will provide fresh air flow throughout the incubator. Humidity is provided manually by water bowl kept outside the incubator which is connected to a perforated PVC piping system.

FINANCIAL FEASIBILITY OF THIS KARINKOZHI FARMING UNDER THE BACKYARD POULTRY FARMING PROJECT

<table>
<thead>
<tr>
<th>Initial Investment</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Cost of the incubator including 12V/32 Ah battery, 12V/40 watt Solar Panel and the incubator unit</td>
<td>₹ 40,000</td>
</tr>
<tr>
<td>Cost of 40 eggs (₹ 50 x 40)</td>
<td>₹ 2,000</td>
</tr>
<tr>
<td>Chicken shed size (10 ft x 10 ft)</td>
<td>₹ 3,000</td>
</tr>
<tr>
<td>Feed cost for 40 chicks</td>
<td>₹ 2,000</td>
</tr>
<tr>
<td>Total initial investment</td>
<td>₹ 47,000</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Income</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>From sale of 35 chicken (Considering 90% hatchability and meat cost ₹ 600 per kg) in the first 10 months period</td>
<td>₹ 21,000.00</td>
</tr>
</tbody>
</table>

As per the data received from KVK Jhabua, these chicken will weigh up to 1.5 kg within one year. According to the report from the Acharya N G Ranga University in Ananthapur, a family investing ₹ 42,000 can get back a minimum of ₹ 30,000 in the first year.

It has been observed that illiterate women living in rural India without any source of monetary support can ensure self-employment through this project. Within one year, their investment will be returned. If local government bodies extend financial support, they can buy this solar incubator by paying 25 per cent of the cost in the first payment. The remaining fund, with the support from local government bodies, as loan or as subsidy, can be worked out.

To know more, visit www.lifewaysolar.com

Georgekutty Kariyanappally is Founder & CEO, Lifeway Solar Devices Pvt Ltd. Email: info@lifewaysolar.com
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Dealership enquiries solicited
INORGANIC METAL OXIDE NANOCRYSTAL PHOTOCATALYSTS FOR SOLAR FUEL GENERATION FROM WATER

Series: Springer Theses | Troy K Townsend (2014) | 71 pages

Nominated as an outstanding PhD thesis by the University of California, USA, this thesis gives a detailed introduction to photocatalysis. It includes over 40 illustrations and provides detailed experimental protocols. Townsend’s thesis explores the structure, energetics, and activities of three inorganic nanocrystal photocatalysts. The goal of this work is to investigate the potential of metal oxide nanocrystals for photocatalytic water splitting, which can one day provide us with clean hydrogen fuel derived from water and solar energy. Townsend’s work addresses the effects of co-catalyst addition to niobium oxide nanotubes for photocatalytic water reduction to hydrogen, and the use of iron oxide ‘rust’ in nanocrystal suspensions for oxygen production. Townsend studies a nickel/oxide-strontium titanate nanocomposite, which is a nanoscale water-splitting photocatalyst. He also examines the charge transport for this system. This book brings relevance to the design of inorganic nanomaterials for photocatalytic water splitting while introducing new directions for solar energy conversion.

ADVANCED RENEWABLE ENERGY SYSTEMS (2 VOL. SET)

Author: S C Bhatia | Publisher: Woodhead Publishing (2014) | 775 pages

Renewable energy is a natural energy having unlimited supply, as it can be used again and again and will never run out. It is derived from natural processes that are replenished constantly. In its various forms, it derives energy directly from the sun, or from heat generated deep within the earth. Included in the definition is electricity and heat generated from solar, wind, ocean, hydropower, biomass, geothermal resources, and biofuels and hydrogen derived from renewable resources. This book is a complete treatise on renewable energy sources and also includes issues relating to biofuels. It aims to serve as a text for undergraduate and postgraduate students in relevant disciplines and a reference book for all professionals in related fields.

RENEWABLES IN FUTURE POWER SYSTEMS: IMPLICATIONS OF TECHNOLOGICAL LEARNING AND UNCERTAINTY

Series: Green Energy and Technology | Fabian Wagner (2014) | 291 pages

The book examines the future deployment of renewable power from a normative point of view. It identifies properties characterizing the cost-optimal transition towards a renewable power system and analyses the key drivers behind this transition. Special attention is paid to technological cost reductions and the implications of uncertainty. From a methodological perspective, the main contributions of this book relate to the field of endogenous learning and uncertainty in optimizing energy system models. The primary objective here is closing the gap between the strand of literature covering renewable potential analyses on one side and energy system modelling with endogenous technological change on the other side. The models applied in this book demonstrate that fundamental changes must occur to transform today’s power sector into a more sustainable one. This book also provides practically relevant insights on the long-term competitiveness of renewable power generation.
3–5 September 2014 | Greater Noida  
**Renewable Energy India Expo**  
Website: http://www.eai.in/360/events/pages/366

4–6 September 2014 | Hyderabad  
**Green Buildings Congress 2014**  
Website: http://www.eai.in/360/events/pages/467

10–12 September 2014 | New Delhi  
**Wastech 2014**  
Website: http://www.eai.in/360/events/pages/434

22–24 September 2014 | Gandhinagar  
**Envirotech Asia 2014**  
Website: http://www.eai.in/360/events/pages/475

9–11 October 2014 | Mumbai  
**IFAT India 2014**  
Website: http://www.eai.in/360/events/pages/445

9–10 September 2014 | Santiago, Chile  
**The Chilean International Renewable Energy Congress**  
Website: http://www.greenpowerconferences.com/

23–24 October 2014 | Johannesburg, South Africa  
**Solar Indaba**  
Website: http://www.greenpowerconferences.com

27–28 October 2014 | London, United Kingdom  
**Wind Operator Congress, Europe**  
Website: http://www.greenpowerconferences.com

27–29 October 2014 | San Diego, United States of America  
**World Bio Markets USA**  
Website: http://www.greenpowerconferences.com

2–4 December 2014 | Istanbul, Turkey  
**Geo Power Global Congress**  
Website: http://www.greenpowerconferences.com
RENWABLE ENERGY AT A GLANCE: INDIA

**Cumulative Installed Capacity (MW) of Offgrid Solar PV Systems**

**Cumulative Installed Capacity (MW) of Grid Interactive Solar PV**

**Cumulative Installed Capacity (MW) of Grid Interactive Wind Power**

**Cumulative Installed Capacity (MW) of Grid Interactive Small Hydro Power**