Solar Water Heating Solutions

www.electrathermal.com
Dear Readers,

The Brundtland Commission Report ‘Our Common Future’ published by the World Commission on Environment and Development (WCED) in 1987 released by the United Nations defines sustainable development as “the development that meets the needs of the present without compromising the ability of future generations to meets their own needs”. Since then, sustainable development has been defined in many fora and renewable energy qualifies as a contributory factor towards sustainable development. With about 30,000 MWp installed capacity of grid interactive renewable power in the country, India has been moving towards sustainable development in power generation. In addition the target set under the National Action Plan on Climate Change in 2008, to increase the share of renewable energy in the country’s energy mix to 15 per cent by 2020, underlines the country’s commitment towards sustainable development.

The supply of renewable electricity in the rural part of India in a decentralized manner has been found to be a sustainable and economic solution to the energy crisis. Immediate steps are required by all concerned parties, particularly the states, to replace kerosene based lamps with solar lighting systems in a ‘mission mode’. The time has come to get rid of the inefficient, polluting and out-dated kerosene lamps. This will not only provide quality light but will also save foreign exchange and Government subsidy, besides being environmentally benign.

The solar water pump is another device which can provide a solution not only for irrigation, but it can also help in energizing the area with solar lights, and be used for other energy requirements in the area and households. Rajasthan has shown the way by implementing a large solar water pump programme, which is evident from the article by Shri Dinesh Goyal in the present issue. Purification and bottling of biogas, and its comprehensive utilisation has been well presented by Shri Bamboriya in his article in this issue.

I would like to thank our readers for their continuous support, and I seek their valuable suggestions to make Akshay Urja useful and informative.

I wish a very happy and prosperous 2014 to all.

Happy reading.

Arun K Tripathi
Greetings from the Manav Rachna International University! We are in receipt of a copy of your publication 'Akshay Urja'. We have found the publication very useful for our students, researchers and academic community. We request you to please add our name to your mailing list for both the editions in Hindi as well as in English.

The Central Library
MRI University, Faridabad.

I am a Professor in the Commerce Department in Shivaji College, Akola, Maharashtra. I have a great interest in solar energy. I found 'Akshay Urja' very useful for us. Kindly send your bi-monthly magazine to us regularly.

Dr. Ulhas Medshikar,
Jyotinagar, Maharashtra.

The Renewable Energy, 'Akshay Urja' newsletter is a good source of regular information, achievements, technology, developments on the renewable energy. I appreciate your good effort.

U. K. Rastogi,
Meerut, Uttar Pradesh.

With due respect and the subject cited above, we on behalf of P.B. Tent and Traders, want to acknowledge that we have been receiving the newsletter 'Akshay Urja' for a long period. We really, appreciate good work and request you to continue our subscription for the next year.

Bineet Kumar Modi,
P. B. Tent & Traders, Assam

Dear Reader, Thank you very much for your suggestions and encouragement. The editorial team of Akshay Urja will make every effort to make this newsletter highly informative and useful to all our readers. We welcome your suggestions and valuable comments to make further improvements in terms of content and presentation. Editor: Akshay Urja
DECISION 2013

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With 4000 solar systems in 2012-13, Rajasthan’s solar pump programme is the largest in the world.

Biogas bottling plants are one of the most potent tools for mitigating climate change by preventing black carbon emission.

When power cuts started affecting academics, NIT Trichy decided to go the solar way.
RENEWABLE ENERGY NEWS

TARGET TO DEVELOP 10,000 MW POWER THROUGH SOLAR ENERGY BY 2017

Ministry of New and Renewable Energy has set a target of generation of 10,000 MW of power through solar energy by the year 2017. Addressing the Solar Power Developers Meet in the capital, the Minister for New and Renewable Energy Dr. Farooq Abdullah said that the Phase I of the Jawaharlal Nehru National Solar Mission (JNNSM) has been very successful wherein 1685 MW of solar power capacity was set up as against the target of 1100 MW. The Minister informed that large tracks of land have been identified in Rajasthan, Kargil and Ladakh which have immense potential of generation of solar power. Dr. Abdullah said that the main challenge was installing a transmission line in the areas of Kargil and Ladakh so that power could be evacuated to the other parts of the country. He also focused on the need for breakthrough in new research to ensure storage of solar energy for greater time period. The Minister highlighted the new initiatives for ensuring greater use of solar power in the government buildings and also said that the Ministry planned to use mobile towers in a way that they could generate power through solar and wind energy. On the occasion, the Minister gave awards to 13 organisations/companies for having done commendable work in the first phase of the JNNSM.

INDIA TOPS IN PRIORITY TO TAP RENEWABLE ENERGY POTENTIAL: BRYSON

John Bryson, former US secretary of Commerce and head of The Bryson Climate Initiative said that his top concern is to explore potential for adoption of renewable energy in India, China and Taiwan. At an interactive session on ‘Renewable Energy and Climate Change’ organized by Confederation of Indian Industry (CII) in Bangalore, he said that energy efficiency, role of green building concepts and larger penetrations of renewable energy will boost growth also. Aroon Raman, former chairman, CII Karnataka and managing director of Raman Fibre Science, Padu S Padmanaban, founder member,
CII-Green Business Centre and former programme director and senior energy advisor, USAID, India, K Krishan, chairman, CII task force on bio-energy and chairman, Envitec Biogas India and Syed Mohamed Beary, chairman, Indian Green Building Council, Bangalore and CMD and chairman, Bearys Group, provided valuable insights on the subject of energy efficiency and climate change vis-a-vis India.

Aroon Raman said that the issues of climate change and renewable energy discussion involve best minds globally, however there is still much confusion on the ground. He said that currently there was a trade-off between the standard of living and climate change and similarly there was also a trade-off between sustainability and energy efficiency which needs to be addressed.

timesofindia.indiatimes.com, October 7, 2013

SETTING UP OF 750 MW OF GRID CONNECTED POWER CAPACITY UNDER JNNSM

The Cabinet Committee on Economic Affairs has approved the implementation of a scheme for setting up of 750 MW of grid-connected solar PV power projects under Batch-1 of Phase-II (2013-17) of the Jawaharlal Nehru National Solar Mission (JNNSM) with viability gap funding (VGF) support from the National Clean Energy Fund (NCEF).

The total VGF requirement for implementation of the scheme is estimated as Rs. 1,875 crore at the rate of Rs. 2.5 crore/ MW. The actual requirement will, however, depend on the bid prices. This VGF support is estimated to leverage private investment to the tune of Rs. 5000 crore in setting up of the projects.

The VGF scheme will facilitate setting up of the 750 MW grid connected solar power projects, in mainly the private sector on build, own and operate (BOO) basis at various locations, which will help supplement grid power generation in the country. These projects will also lead to an associated development of their surrounding areas with positive impact on the socio-economic conditions of the local population. The scheme will be implemented through the Solar Energy Corporation of India (SECI), a Section 25 company set up by the Ministry, in close association with NTPC Vidyut Vapar Nigam Limited (NVVN). The power generated shall be purchased by SECI at a fixed levelised tariff of Rs. 5.45 per kWh for 25 years and sold to willing state utilities/discoms at a fixed tariff of Rs. 5.50 per unit for 25 years. The selection of projects would be done through a process of open competitive bidding for their VGF requirement in order to enable them to supply the solar power to SECI at the fixed tariff of Rs. 5.45 per kWh for 25 years.

Press Information Bureau, October 3, 2013

RENEWABLE ENERGY CERTIFICATES CONTINUE TO PILE

The September trading session at Indian Energy Exchange, featured trade of 38,195 N-Solar and 5,880 Solar RECs with supply far exceeding demand. In the non-solar segment, buy bids of 38,195 RECs and sell bids of 23,25,171 RECs were received against which 38,195 were cleared at Rs. 1,500 per REC. In the solar segment, buy bids of 5,880 RECs and sell bids of 37,028 RECs were received against which 5,880 RECs were cleared at Rs. 9,300 per REC. The trading session featured 658 participants of which 601 participated in the non-solar segment while 159 participated in the solar segment.

On an overall basis, a total of 1969 participants are registered in the REC segment at IEX. Of this, 504 are eligible entities (RE generators), 1452 are obligated entities - discoms and open access consumers and captive generators and 13 are registered as voluntary entities.

ET Bureau, October 4, 2013
GREEN CORRIDOR TO SEE WIND AND SOLAR FARMS IN RAJASTHAN, TAMIL NADU

The government will set up wind and solar farms in Rajasthan and Tamil Nadu in the first phase of the Rs. 43,000-crore green energy corridors project that aims to add 30,000 MW to the national grid by 2020. The first phase of the Indo-German project is expected to cost Rs. 18,000 crore, of which Rs. 10,000 crore will be invested in two states, a senior official told ET. The initial funding for the project will be finalised by the month end and the first tranche of Rs. 2,500 crore is expected to come from Germany, the official added. Germany has committed technical and financial assistance of euro 1 billion for the green energy corridors under the Indo-German bilateral development cooperation programme.

“We have appointed a sub-group that will soon write to the finance ministry to seek the first tranche of Rs. 2,500 crore from Germany,” the official, who did not wish to be named, said. “Meanwhile, it is also in talks with the PowerGrid and the National Cooperative Consumers Federation of India to fund the remaining part of the initial phase.”

India aims to channel renewable energy from wind and solar projects into the national grid to help narrow the country’s power deficit and reduce its dependence on coal. A massive grid failure last summer had left millions of people without electricity in several parts of the country.

The country has 27,541.71 MW of installed renewable energy capacity, excluding hydropower stations, but its integration with the national grid is difficult due to variations in supply and voltage. The green energy corridors will comprise of both inter-state and intra-state schemes for evacuation of power from wind and solar projects.

Integration of these projects with the national grid will require intra-state grid upgradation and inter-state networks that will be taken up by PowerGrid and the state utilities, respectively. The Power Grid Corporation of India, the central transmission utility, operates five grids—northern, western, southern, eastern and northeastern—which together transmit nearly 1,29,980 MW during peak demand.

The Economic Times, October 9, 2013

INDIA OFFERS EXPERTISE TO CHILE FOR RENEWABLE ENERGY SECTOR

India has offered its support and expertise in setting up renewable energy projects for Chile, which is almost entirely dependent on imports for its energy needs. The offer was extended during a meeting between visiting Indian Minister of New and Renewable Energy Farooq Abdullah and Chile’s Energy Minister Jorge Bunster. Both the countries have agreed to enhance their cooperation in the renewable energy sector.

“Abdullah offered India’s support and expertise to Chile in setting up renewable projects. He offered the services of Indian experts and institutions...training of personnel and also preparation of projects for exploiting these technologies in Chile,” an Indian government statement said here. The Indian minister also offered training slots in India to Chilean scientists, engineers and technicians through ITEC programme, while expressing India’s desire to cooperate with the Latin American country in renewable energy, it added.

Abdullah is visiting Chile along with a high level delegation to explore greater opportunities for cooperation and collaboration between India and Chile.

He said India is planning to add over 30 GW of renewable energy to its energy mix in next 5 years, detailing the success of programmes on wind and solar energies.

Noting India’s progress in the sector, Bunster said Chile is almost entirely dependent on imports for meeting its energy requirements and is looking to diversify by
solarisation would enable a 24-hour supply, along with a 12-hour backup.

**The Hindu, October 7, 2013**

500 MILLION USD LOAN FOR RENEWABLE ENERGY TRANSMISSION PROJECT IN RAJASTHAN

The Asian Development Bank (ADB) will provide 500 million USD to build a power transmission system needed to deliver clean electricity from wind and solar power projects in Rajasthan in Northwest India to the state and national grids.

The Bhadla park in Western Rajasthan is the first solar park that is under development by the Rajasthan Renewable Energy Corporation, the state’s renewable energy agency, to house solar PV and solar thermal projects and is part of Rajasthan’s aim to reach about 8,000 MW of solar and wind generation capacity by 2018, largely from the private sector.

Work has already started on 75 megawatts of solar PV power at the Bhadla park after competitive bidding in early 2013 under the Rajasthan solar policy and a further 200 MW will be added annually starting 2014. The new power transmission system will involve about 1,850 km of transmission lines, mostly in western Rajasthan, three new 400 kilovolt substations and nine new 220 kilovolt grid substations. The funds will also be used to boost the transmission capacity of seven existing substations. Apart from serving the Bhadla park, the infrastructure supports solar and wind power developments in Western Rajasthan.

The funds comprise a 498 million USD multi-tranche financing facility including funds from the concessional Clean Technology Fund, and a further 2 million USD in technical assistance grant that finances infrastructure planning for the Bhadla park, transmission system studies and a community development plan to set up solar power electricity and clean water equipment for small communities. The government of Rajasthan and state transmission utilities will provide counterpart financing of about 300 million USD.


OPEN JAIL TO BE POWERED BY THE SUN

The open jail at Nettukalthery in Tiruvananthapuram, Kerela, will take a huge stride forward in energy conservation and utilisation of non-conventional energy with the launch of a number of projects on its premises. The state home minister Thiruvancheer Radhakrishnan will inaugurate the projects. Alexander Jacob, Director General of Prisons and Correctional Services, said the most important project was the solar one, comprising solar plants of 180 kW capacity, readied by ANERT at a cost of Rs.6.35 crore. A solar project at Thevancode State Institute of Correctional Administration (SICA), Poojappura, too would be launched. ANERT had installed plants of 146 kW capacity there at a cost of Rs.4.51 crore. These, Mr. Jacob said, were part of the entire Prisons Department moving towards use of solar energy, a first for any department in the country. The solar power scheme for the department had been initiated by former Additional Director General of Prisons K.P. Somarajan in 2008, for which the department had received Rs.25.26 crore. Apart from the huge savings in power bills — which ran into Rs.1,27,57,524 last year, solarisation would address security concerns during unscheduled power supply disruptions, Mr. Jacob said. Total
280 MW SOLAR PLANT IN ARIZONA CAN PRODUCE POWER 6 HOURS AFTER THE SUN GOES DOWN

The Solana solar station in the Arizona desert is one of the first large-scale solar plants with thermal storage that allows it to keep producing power even when the sun doesn’t shine, allowing it to better match output to peak demand. The three-square-mile facility near Gila Bend uses concentrated solar power (CSP) technology to heat up oil that is piped through the solar collectors (up to 735 degrees Fahrenheit). The heat transfer fluid is pumped to steam boilers, where it heats water to create steam. The steam drives two 140 MW turbines to produce electricity, much like a traditional power plant.

But what’s special is that “in addition to creating steam, the heat transfer fluid can be heated by the molten salt to create steam by running it through the tanks instead of the field of parabolic mirrors.”

GIANT MIRRORS REFLECT WINTER SUN INTO NORWEGIAN TOWN OF RJUKAN

Residents of the small Norwegian town of Rjukan have finally seen the light. Tucked in-between steep mountains, the town is normally shrouded in shadow for almost six months a year, with residents having to catch a cable car to the top of a nearby precipice to get a fix of midday vitamin D. But on 30th October faint rays from the winter sun for the first time reached the town’s market square, thanks to three giant mirrors placed on a mountain.

Cheering families, some on sun loungers, drinking cocktails and waving Norwegian flags, donned shades as the sun crept from behind a cloud to hit the mirrors and reflect down onto the faces of delighted children below. TV footage of the event showed the centre of the crowded square light up a touch, but not as if hit by direct sunlight. Still, residents said the effect was noticeable.

“Before when it was a fine day, you would see that the sky was blue and you knew that the sun was shining. But you couldn’t quite see it. It was very frustrating,” said Karin Roe, from the local tourist office. “This feels warm. When there is no time to get to the top of the mountains on weekdays, it will be lovely to come out for an hour and feel this warmth on my face.”

Like much of Scandinavia, Rjukan often is freezing throughout the winter, but on Wednesday it was 7° C.

ETHIOPIA OPENS AFRICA’S BIGGEST WINDFARM

A windfarm billed as the biggest in sub-Saharan Africa has been opened by Ethiopia’s prime minister, Hailemariam Desalegn, a potentially crucial step for the continent’s renewable energy industry.

The 210 million euro Ashegoda windfarm consists of 84 hi-tech turbines towering above an arid region where villagers herd cattle and ride donkey-drawn carts as they have for generations.

The project, outside Mekelle in Tigray state, about 475 miles north of the capital, Addis Ababa, has a capacity of 120 MW and will produce about 400 million KWh a year. It was completed in phases over three and a half years and has produced 90 million KWh for the national grid.

The farm, inaugurated by Desalegn on Saturday, was supervised by German company Lahmeyer International and
defended building the UK’s first nuclear station in a generation as “a very good deal for Britain.” French giant EDF will lead a consortium to build the Hinkley Point C plant in Somerset. But environmentalists said the money could be better spent on renewables. The government estimates that energy bills will be £77 lower by 2030, but Davey could not guarantee this because of the “uncertainties.”

When running at full capacity the new Hinkley plant is expected to generate around 7 per cent of the UK’s electricity. The consortium and the government have agreed a “strike price” of £92.50 for every MW hour, almost twice the current wholesale cost of electricity. This will fall to £89.50 for every MW hour of energy if EDF Group goes ahead with plans to develop a new nuclear power station at Sizewell in Suffolk. Doing both would allow EDF to share costs across both projects.

“In terms of the per-MW hour price - which is what people are talking about today - the solar industry is asking for less than what the nuclear industry’s getting,” said Greenpeace’s chief scientist Doug Parr. www.bbc.co.uk, October 21, 2013

SPAIN’S SUNSHINE TOLL: ROW OVER PROPOSED SOLAR TAX

“We will be the only country in the world charging for the use of the sun,” says Jaume Serrasolses. “Strange things are happening in Spain. This is one of them.” Mr Serrasolses, the secretary of an association promoting the use of solar energy, SEBA, is referring to the government’s proposal for a tax solely on those who generate their own electricity.

They would pay a backup toll for the power from their solar panels, in addition to the access toll paid by everyone who consumes electricity from the conventional grid. Although the tolls vary, if you pay an access toll of 0.053 euros per kWh, you could face a backup toll of 0.068 euros per kWh.

The new tax would extend the average time it would take for solar panels to pay for themselves from eight to 25 years, according to the solar lobby. The government says that with increasing “self-consumption”, the income for conventional energy systems will decrease, but grid maintenance will cost the same.

“If I produce my own energy, but am connected to the grid, for backup in case my production fails, I have to contribute to the cost of the entire system,” says Energy Secretary Alberto Nadal.

The government is hoping the energy reform will settle a debt of 26 billion euros, which has built up over years as a result of regulating energy costs and prices. www.bbc.co.uk, October 6, 2013

implemented by France’s Vergnet with French funding. But the Ethiopian government insisted there were also local spin-offs.

“The project has provided very important experience-sharing for Ethiopia’s national companies, who have been involved in the construction of civil works such as geotechnical investigations, roads, turbine foundations, sub-station erection and electro-mechanical erection works,” it said.

Ethiopia aims to become the region’s leading producer of renewable energy. In the past two years it has built two smaller wind farms near Adama, south-east of Addis Ababa, with a capacity of 51MW each. It urgently needs new energy to fuel economic growth that has averaged more than 10 per cent over the past decade. Power cuts are still a regular occurrence in major cities and about half the country still has no access to electricity.

theguardian.com, October 28, 2013

NUCLEAR POWER PLANT ‘GOOD DEAL’ FOR UK

Energy Secretary Ed Davey has
RAJASTHAN SOLAR WATER PUMP PROGRAMME
SUSTAINABLE FUTURE FOR FARMERS

With 4000 solar pumps installed in 2012-13, Rajasthan’s solar pump programme is the largest in the world. The solar powered pumps are creating sustainable livelihoods in dry areas by integrating water harvesting and drip irrigation innovatively, increasing the resiliency of rural areas.

DINESH KUMAR GOYAL
cent of the population depends for livelihood on agriculture or horticulture, often marred by low productivity due to unreliable, inadequate or non availability of irrigation. About 70 per cent irrigation is done through wells or tube-wells energised mainly by grid-power or diesel generators. Approximately 60,000 farmers are waiting for grid-based electricity connections for irrigation. Extension of electric-grid is not feasible in far-flung areas; almost 70 per cent area in the State is classified as desert. Moreover, ground water has deteriorated rapidly in the last two decades. Out of 249 blocks, nearly 200 are in the highly critical zone. Almost 90 per cent of groundwater withdrawal in the State is utilised through flood or furrow-irrigation methods with mere 35 to 45 per cent water-use-efficiency. Rajasthan is blessed with one of the best solar insolation on earth (6-7 kWh/m²/day) combined with maximum sunny days in a year, about 325, which makes it one of the most attractive destinations for harnessing solar energy for various purposes, especially irrigation (Fig. 1). It was thus envisaged that an integrated solar water pump scheme formulated by combining various stand-alone government schemes would be indeed beneficial for the region as well as its farmers. Subsidies available under various programmes were clubbed and the State committed to grant the total subsidy upto 86 per cent of the capital cost. The departments of agriculture, finance and energy of the State, and Union government’s ministries for Agriculture (MoA) and New and Renewable Energy (MNRE) worked in tandem along with various stakeholders to make it is seamless and successful project.

IMPLEMENTATION
The solar water pump scheme was scaled up from a mere target of 50 in 2010-11 to 500 (900 per cent increase) in 2011-12; to 2,200 (over 340 per cent increase) for 2012-13; and, to 10,000 (354 per cent increase) for 2013-14. Implementation at large scale was initiated in year 2011-12 when out of 33 districts, 14 districts were covered. Next year i.e. 2012-13 the scheme covered all the 33 districts in the State. Plans are being made to install a total of 100,000 solar water pumps in the next five years. Year-wise target, achievement, etc., are depicted in table 1.

PROJECT GOALS, SUSTAINABILITY AND EFFICIENCY

Project goals
• Enhancing irrigated area in the State
• Increasing productivity of the irrigated area
• Enabling farmers to diversify to remunerative high-value horticulture crops
• Conserving water by utilisation of efficient irrigation methods
• Narrowing the gap between grid-power demand and supply in the State

TABLE 1: Year-wise Target, Achievement, etc.
• Reducing the queue of aspirant farmers for grid connection for irrigation
• Harnessing solar-energy resources available in abundance in the State
• Replacing the expensive and polluting diesel pump-sets
• Providing irrigation facility to farmers living in remote locations where grid is less likely to be extended in near future
• Saving farmers from the drudgery of night or erratic irrigation schedule
• Making environment sustainable and reducing the State’s carbon footprint

By installing solar water pumps, many farmers who are ‘off grid’ are able to access electricity which allows them to enjoy modern amenities from watching television, using computers and studying at night to recharging cell phones. Also special vocational activities have been created with the advent of the solar power. Refrigeration has become a reality which expands the ‘shelf life’ of perishable food and is extremely important for life saving medicine. Plans for incorporation of solar powered water purification system for drinking is on the anvil in Rajasthan. The increased income generation provides a strong economic incentive for end-users to keep the systems in operation. Further, the farmers are being motivated through education and training to keep the pump in good working condition.

INNOVATIVE ASPECTS

Convergence of schemes and subsidies: A large number of Government of India (GoI) schemes are being implemented by the State’s horticulture department, comprising of National Horticulture Mission (NHM), National Mission on Micro Irrigation (NMMI), National Mission on Medicinal Plants (NMMP), National Bamboo Mission (NBM), Jawaharlal Nehru National Solar Mission (JNNSM), Rashtriya Krishi Vikas Yojana (RKVY), and State Plan Programmes. All these schemes were studied in detail and various permutations and combinations were examined. Finally, the water harvesting structure (WHS) schemes for creation of surface water resources like farm ponds and drip irrigation under NHM were combined with JNNSM, RKVY, and the State resources. Functionally, the base was the JNNSM on which other schemes were made to ride. Financially, the resources were tied; 30 per cent subsidy under MNRE and 56 per cent subsidy from RKVY; if RKVY support dwindled, the State government...
was to fill the gap to make the total subsidy total 86 per cent. Presuming that the cost of a solar pump system is about Rs. 5,00,000, the farmer would need to pay only Rs. 70,000 (14 per cent of solar pump system cost) - equivalent to the cost of the pump. The figure of 86 per cent subsidy was thus arrived at.

**Political will:** The solar pump programme targets were made part of the Chief Minister’s Budget announcements so that the initiative gets acceptance, and focused efforts were made at all levels, particularly for arranging funds through MNRE, RKVY, or the State through its finance department. The RKVY is an additional and almost untied source of funding for state schemes. The horticulture department could prevail over RKVY source once the solar pump programme started showing significant progress; the initiative proved to be an efficient utiliser of RKVY funds, and subsequent funding from RKVY came more easily.

**Decentralization:** Earlier, sanctions, payments, etc. were released only from the State headquarters but, with large scale enhancements of targets, the system of issue of sanction, release of funds to firms, etc. was decentralised and the district authorities were empowered to issue the same. The District Horticulture Development Societies (DHDS) under chairmanship of District Collectors were made effective entities in implementing the scheme. Initial reservations at the State headquarter were removed with the gradual success of the programme and close interactions with field functionaries, collectors, and public representatives. The decentralisation freed the skeletal state level staff and allowed them to concentrate on policy and its implementation; the beneficiaries too did not need to come to State capital for work related to the scheme.

**Solar panel manufacturers:** Initially, there was a great debate whether manufacturers of solar panel alone, or motor alone, or suppliers of solar panels or motors be permitted to bid. After a lot of deliberations it was decided that only manufacturers of solar panels could bid. The overall average cost of the solar pump system of about Rs. 5,00,000, almost 80 per cent of which if for the solar panels, and remaining 20 per cent accounts for motor and allied equipment. It was decided that only solar panel manufacturers, who could actually maintain the system after supply, could bid.
STRUCTURAL PROVISIONS FOR SUSTAINED SUPPORT

Maintenance: It is mandatory for the firms to guarantee free-of-cost maintenance for five years from the date of installation and then after-sales service for another five years. This condition was borrowed from earlier experience of the public works department, that the condition and quality of roads constructed by the contractors with a five year maintenance clause was more superior than the roads constructed with one year maintenance. Thus larger the maintenance period obligation the better the quality, as the contractor tries to save himself from future problems. The maintenance is ensured with the arrangement of technical and other staff.

Insurance: The equipment is insured against natural calamities etc.

Civil work: The solar pump system must be supported on six legs firmly entrenched through civil structures that can primarily bear wind load. The supplier should provide an additional light outlet of 100W for lighting during pump operation and one home lighting system, as an integral part of the system.

Testing: One major snag in the solar pump scheme was unreliable test reports about solar panel and pump performance. The facilities of MNRE viz. solar lab at Gurgaon, was visited by the authorities to see the testing procedures and reporting of results, under various conditions.

Management information system: A 43-column format has been developed, to be maintained by manufactures, and district and state authorities, which will be helpful in development of an integrated system.

TRANSPARENCY AND STAKEHOLDER PARTICIPATION

Transparent selection of beneficiaries: The applications from the prospective beneficiaries were obtained by district authorities in widely advertised campaigns so that every farmer had equal accessibility and opportunity to apply. When number of applications received was larger than the target for the district, then selection of beneficiaries was made by a draw of lottery, and the list of the selected beneficiaries was declared publicly.

Transparent e-tendering: In order to establish transparency, e-tendering was resorted to. Adequate time-line, pre-bid conferences and removal of confusions ultimately led to short-listing of 4 manufacturers for 2011-12 and 12 for 2012-13. Two stage bidding, technical and financial, was adopted. Once the vendor for L-1 was declared, most of the other bidders agreed to supply at L-1 price which became a benchmark for the whole State. The installations being widely dispersed, short-listing of a large number of manufacturers proved to be a boon.

Involvement of farmers in supplier selection: The selection of a supplier for the solar pump system, out of the empanelled firms was left to the beneficiary i.e. farmer.

Farm yields are found to be increasing with the use of solar water pumps
A interaction between the beneficiary and prospective supplier indirectly imparted considerable technical knowledge and prompt after-sale service arrangements to the beneficiary. This liberty to beneficiaries brought in transparency in the whole process, and the suppliers competed to win the trust of the beneficiaries.

**ECONOMIC AND SOCIAL IMPACTS**

**Impacts on livelihood:** The initiative has made far-reaching desirable impacts to the lives of farmers and their families, conserved the resources precious to the State (groundwater and energy), and harnessed the clean and free solar energy. This stand-alone initiative has been contributing effectively towards addressing the multiple challenges of:

- enhancing the total irrigated area under cultivation in Rajasthan while reducing groundwater and grid-connected electricity consumption/requirements by utilising solar power available in abundance and deploying drip-based micro-irrigation systems at large scale.
- addressing some of the most crucial challenges being faced by Rajasthan viz. need for efficient utilisation of water resources; reducing the gap between power demand and supply; enhancing irrigated area thereby agriculture productivity; harnessing solar-energy resources available in abundance.
- making agriculture a remunerative occupation for farmers by way of replacing the requirement of expensive grid-power with solar power and by facilitating enhancement of farm productivity,
- saving precious groundwater by promoting drip-based efficient irrigation system that has 90 per cent water-use-efficiency compared to 30-45 per cent in case of flood or furrow method.

Successful deployment of integrated solar water pumps has increased the availability of water for irrigation and the cultivable land as compared to the flood irrigation. Access to water has increased agricultural production. Yield of crops, particularly horticulture crops, increased substantially (3-4 times) by incorporating additional agricultural technologies like greenhouse, polynet, shade-net and fertigation, and cultivating exotic produce like pomegranate, coloured capsicum, and gerbera flowers. Thousands of farmers, especially small holding farmers have significantly improved their quality of lives.

**Service delivery time:** Earlier the Department was catering to only about 50 solar pump systems in 2010-11, but it increased to about 4,500 units in 2012-13. As a corollary, the service time per unit has reduced correspondingly.

**Evaluation:** Rakesh Dalal, Indian Institutes of Technology (IIT), Mumbai, ‘Assessment of Solar Pump Scheme in Rajasthan’, June 2013, concluded “more than 50 per cent of the farmers were able to recover the invested amount within 1 to 2 years…100 per cent farmers are satisfied with the performance of the solar pump(s)” Nidhi Prabha Tewari in her research supported by IWMI-TATA in 2012 ‘Solar Irrigation Pumps - The Rajasthan Experience’ concluded “…solar pumps are seen as a potential powerful solution to government’s inability to provide agriculture power connections and farmers are seeing solar pumps as both a pumping and an energy solution”. Institute of Public Auditors of India’s independent evaluation states that the “…department has done a commendable job towards developing solar energy of approximately 50,000 kWp capacity by the end of 2013-14 in a very short span of almost three years (2011-14)”.

**REPLICATION POTENTIAL**

Rajasthan has become a world leader in the area of integrated solar water pump systems. The technology, systems, and models have been well proven in Rajasthan, where more
than 6,000 solar water pumps in all the 33 districts of the State have been successfully installed, a national record as certified by the ‘Limca Book of Records’. The experience and learnings of installations in Rajasthan can be leveraged for significant scale up elsewhere on similar lines. Now that the technology; and administrative, financial, and regulatory systems have been tried and firmed up, replication everywhere will be limited mainly by the resources available.

Rajasthan was the lone State which had innovated, scaled up and implemented the programme successfully. Presentations of Rajasthan’s experience were done in the states of Tamil Nadu and Maharashtra. Presentations are to be made in Assam, Himachal Pradesh, Karnataka and Uttar Pradesh. Planning Commission, GoI, too is to be given a presentation relevant to secretaries to GoI. The scheme was also presented in the Michigan State University, USA, which is supporting proposals under USAID for countries like Liberia, Kenya and Malawi.

A huge potential exists for bringing the costs down with economies-of-scale and thereby creating a self-sustaining market with minimal governmental support. The solar technology is foolproof and large scale replication of the scheme for the farmers of India is possible. The manufacturers may operate the project on build operate transfer (BoT) basis with the assistance of the government. Large scale adoption and production of solar energy will lead to further cost cutting. The feasible costing and the assistance from the state or central government will encourage more farmers to opt for the technology. With the partnership of state energy departments and corporations, and private partners, the technology can be disseminated at a large scale. Private entrepreneurs can invest in agriculture and rural sector through BoT. In India, there is vast scope of replication, with estimated 2,00,000 solar pumps (on surface or ground water bodies, depth up to 100 m, power up to 5 HP) in next 5 years. The expected total investment, at Rs. 5,00,000 a system, is Rs. 10,000 crore (1.6 billion USD).

It is estimated that the Rajasthan initiative, with 1,00,000 solar pumps installed in next 5 years, will extend the irrigation facility to additional 3,00,000 hectare resulting into a productivity enhancement.

**ENVIRONMENTAL IMPACT - EMISSIONS/CLIMATE PROTECTION**

The improvements owing to solar initiative are estimated in table 2. With 4,000 solar pumps, most of them of 3000Wp each, the installed capacity is about 12 MWp during 2012-13. This has resulted in replacing the generation of grid-electricity, generated mainly through consuming conventional fuels like coal and gas. Many of the solar
water-pumps have been installed in the areas where grid-electricity is unavailable or inadequate.

An estimated 12,000 ha of additional land has been brought under irrigation. With at least two crops every year compared with the earlier scenario of having just one monsoon-fed crop in entire year, 24,000 ha has been irrigated. Many farmers have growing three crops a year and have opted to far more remunerative horticulture/cash crops including vegetables and fruits.

Migration to mandatory drip irrigation (it has at least twice the water use efficiency viz-a-viz furrow method) has saved 48 million cubic meter water. Also 2.4 million litre diesel; Rs. 24 million diesel subsidy; Rs. 48 million foreign exchange is saved annually. Estimated emission of 3,480 kg of CO$_2$ has been avoided.

**TABLE 2: Measurable Indicators – Rajasthan Solar Pump Programme 2012-13**

<table>
<thead>
<tr>
<th>ITEM</th>
<th>UNIT</th>
<th>TOTAL</th>
</tr>
</thead>
<tbody>
<tr>
<td>No. of pumps in 2012-13</td>
<td>no.</td>
<td>4,000</td>
</tr>
<tr>
<td>Average solar pump capacity</td>
<td>Wp</td>
<td>3,000</td>
</tr>
<tr>
<td>Equivalent electric power saved (4000x3000 Wp)</td>
<td>MWp</td>
<td>12</td>
</tr>
<tr>
<td>Duration in hours a pump runs/day</td>
<td>hrs.</td>
<td>6</td>
</tr>
<tr>
<td>No. of units (kWh) saved per day</td>
<td>kWh</td>
<td>18</td>
</tr>
<tr>
<td>No. of days a pump runs in a year</td>
<td>days</td>
<td>200</td>
</tr>
<tr>
<td>No. of electric units saved per pump per year 18x200</td>
<td>kWh</td>
<td>3,600</td>
</tr>
<tr>
<td>Cost per kWh of electricity</td>
<td>Rs.</td>
<td>5</td>
</tr>
<tr>
<td>Money saved by solar pump per year 3,600x5</td>
<td>Rs.</td>
<td>18,000</td>
</tr>
<tr>
<td>Conventional grid, distribution capital cost saved (not considered)</td>
<td>Rs.</td>
<td>–</td>
</tr>
<tr>
<td>Diesel cost saved per year (diesel generation twice costly than electric)</td>
<td>Rs.</td>
<td>36,000</td>
</tr>
<tr>
<td>Diesel saved per pump per day</td>
<td>litre</td>
<td>3</td>
</tr>
<tr>
<td>Diesel saved per pump per year</td>
<td>litre</td>
<td>600</td>
</tr>
<tr>
<td>Diesel saved total, per year (4000x600)</td>
<td>million litre</td>
<td>2.4</td>
</tr>
<tr>
<td>Foreign exchange saved per year, crude price @ Rs. 20/litre</td>
<td>Rs. million</td>
<td>48</td>
</tr>
<tr>
<td>Diesel subsidy saved by Govt. per year (24,00,000 x Rs. 10/litre)</td>
<td>Rs. million</td>
<td>24</td>
</tr>
<tr>
<td>Diesel subsidy saved by Govt. in 15 years (Rs. 2.4 Cr x 15 years)</td>
<td>Rs. million</td>
<td>360</td>
</tr>
<tr>
<td>Area irrigated per pump per crop</td>
<td>Ha</td>
<td>3</td>
</tr>
<tr>
<td>Area irrigated total, 2 crops a year (4000 pumps x 2x 3)</td>
<td>Ha</td>
<td>24,000</td>
</tr>
<tr>
<td>Water required for surface irrigation per Ha</td>
<td>cubic meter</td>
<td>5,000</td>
</tr>
<tr>
<td>Water saved per Ha due to drip irrigation (40 per cent of 500)</td>
<td>cubic meter</td>
<td>2,000</td>
</tr>
<tr>
<td>Total water saved, 24,000x2,000</td>
<td>MCM</td>
<td>48</td>
</tr>
<tr>
<td>Additional production value due to irrigation through solar pumps</td>
<td>Rs.</td>
<td>1,00,000</td>
</tr>
<tr>
<td>Total additional production value due to irrigation through solar pumps</td>
<td>Rs. million</td>
<td>2,400</td>
</tr>
<tr>
<td>CO$_2$ Emission for one 1 kWh electricity produced by diesel</td>
<td>kg</td>
<td>0.29</td>
</tr>
<tr>
<td>Total CO$_2$ generation avoided, 12,000 kWh x 0.29 kg</td>
<td>kg</td>
<td>3,480</td>
</tr>
<tr>
<td>Curtailment in farmers’ wait-list for electric connection</td>
<td>Nos.</td>
<td>4,000</td>
</tr>
</tbody>
</table>

The scheme, with 1,00,000 solar pumps installed in next 5 years, will significantly curtail the long queues of farmers waiting for electric connection.
ISSUES AND CHALLENGES
The Rajasthan initiative has identified a number of important challenges and opportunities, for the central and state governments, manufactures, scientists, and so on, which can drastically change the scenario for the use of solar energy in rural areas. The major challenges are storage of unused solar energy, increasing usage of solar energy in domestic and community lighting, agriculture, and small scale industry; connecting with the conventional grid; low cost funding through UN agencies, federal/state governments, CSR; linkages with MNREG etc; mass manufacturing and cost reduction.

The possible opportunities are integration of schemes in the country; national MIS; maintenance, insurance, control room, BPO service; R&D for solar in agriculture/horticulture; solar parks dedicated to use of solar energy in horticulture/agriculture; sharing of experiences with countries such as the Netherlands and Israel for efficient use of water and solar energy.

The author is Addl. Chief Secretary to Govt. of Rajasthan, Horticulture Department, Secretariat, Jaipur, Rajasthan, Email- dineshkumargoyal@gmail.com

Dr. Agnihotri has recently joined the Ministry of New & Renewable Energy (MNRE) as Secretary to the Government of India. He was previously the Director General (Acquisition) in the Ministry of Defence. He coordinated and managed the entire capital acquisition programmes for the Indian Army, Navy, Air Force and the Coast Guard. This assignment involved addressing a wide range of policy, commercial and operational issues relating to capital acquisition, including a host of bilateral defence cooperation issues. Dr. Agnihotri, prior to that had a short stint as Additional Secretary in the Ministry of Agriculture discharging the role of Financial Advisor from June to October 2012. He was the Director General of Shipping during 2010-12. He has worked as Joint Secretary in the Cabinet Secretariat, Transport Commissioner, Odisha and Secretary, Women and Child Development and General Administration Department. He was Vice Chairman, Cuttack Urban Development Authority, Odisha. CEO of the Odisha Renewable Energy Development Agency, Director, Industries and District Magistrate in Dhenkanal District. He also worked with UNICEF, Kolkata as consultant on Child Nutrition and Health.

An IAS officer of Odisha cadre of the 1980 batch Dr Agnihotri has done his Master's degree in Physics followed by M.Tech in Environment Science and Engineering from IIT, Bombay. He later did an MA in Rural Development followed by a Ph.D on Sex Ratio Patterns in Indian Population from School of Development Studies, University of East Anglia, Norwich, UK. His research on declining sex ratios in India has been cited by scholars including Prof. Amartya Sen. He also writes satire and science fiction in Hindi. He is Visiting Professor at IIT, Mumbai in its Center for Technology Alternatives for Rural Areas. He belongs to Dharangaon in the Jalgaon District of Maharashtra.

‘Akshay Urja’ welcomes Dr. Agnihotri, Secretary, MNRE.
The solar bottle bulb was invented by Alfredo Moser, a Brazilian mechanic, in 2002. In this experiment, the solar bottle bulb and a regular bulb were compared at different times of day to analyse their brightness using a luxmeter.

ADARSH MOHAN DIXIT

Solar products include a variety of technology related options but in Manila, Philippines, electricity and solar was both put to use in making a solar bottle bulb. Taking cue from this project we set out to compare and analyse the brightness of a regular light bulb and a solar bottle bulb using a luxmeter, at different times of the day. We hypothesized that the brightness of the solar bottle bulb when compared to the average brightness of a regular bulb, would be brighter during the day. The materials used were a water/soda bottle, 1 inch x 1 inch roof sheet material, purified water, chlorine/bleach, rubber sealant, and a lux meter.

TABLE 1: Comparing Bottle Bulb to Regular Bulb

<table>
<thead>
<tr>
<th>DAY</th>
<th>TIME</th>
<th>BOTLE BULB (LUX)</th>
<th>SUN (LUX)</th>
<th>ELECTRIC BULB (LUX)</th>
</tr>
</thead>
<tbody>
<tr>
<td>First</td>
<td>3:30 pm</td>
<td>328.6</td>
<td>285.9</td>
<td>528.3</td>
</tr>
<tr>
<td>Second</td>
<td>3:10 p.m.</td>
<td>424.3</td>
<td>164.3</td>
<td>274.6</td>
</tr>
<tr>
<td></td>
<td>4:00 p.m.</td>
<td>455.5</td>
<td>389.0</td>
<td>413.9</td>
</tr>
<tr>
<td>Third</td>
<td>3:10 p.m.</td>
<td>345.3</td>
<td>297.4</td>
<td>276.6</td>
</tr>
<tr>
<td></td>
<td>4:00 p.m.</td>
<td>280.8</td>
<td>309.9</td>
<td>214.2</td>
</tr>
<tr>
<td>Fourth</td>
<td>3:10 p.m.</td>
<td>287.0</td>
<td>389.9</td>
<td>249.6</td>
</tr>
<tr>
<td></td>
<td>4:00 p.m.</td>
<td>285.0</td>
<td>289.1</td>
<td>201.8</td>
</tr>
<tr>
<td>Fifth</td>
<td>3:10 p.m.</td>
<td>162.2</td>
<td>260.0</td>
<td>413.9</td>
</tr>
<tr>
<td></td>
<td>4:00 p.m.</td>
<td>235.0</td>
<td>145.6</td>
<td>404.6</td>
</tr>
</tbody>
</table>

Once the bottle bulb is in place, made in accordance to well publicized material over the internet, the bulb was tested at different times of the day for the efficacy of its brightness. It is understood that this simple innovation is not perfect. The water needs to be replaced regularly and without any provision for energy storage, the bulb does not work at night. However, the bottle bulb was found to be brighter during daylight compared to the regular bulb. Therein lies the advantage for communities that are daylight deprived. The power of the sun allows the poor in congested settlements to use the solar bottle lamp to make their homes more lighted. The bulb does not have or produce any pollutants and also reduces fire hazard.

The author is Student of Mechanical Department of Malwa Institute of Technology, Indore, Madhya Pradesh. Email: amdixit11@gmail.com
When power cuts started affecting academics, NIT Trichy decided to go the solar way. With no dearth of roof tops on the sprawling campus, a proposal was initiated for a 100 kWp roof top, grid interactive SPV power plant.

A K BAKTHAVATSALAM

N IT (formerly REC) Trichy is a premier T-School in the country which is ranked consistently amongst the top 10 institutes in India. The sprawling 800 acre campus is in a geographical location which is blessed with abundant solar power with an average insolation of about 5.8 kWh/m²/day. Trichy is hot and dry for at least eight months of the year.

At a time when the Institute was marching towards its golden jubilee year, the state of Tamil Nadu was going through an acute shortage of power. With 10-12 hours of power cut in a day, this was adversely affecting academics. Diesel generators were pressed into
service to overcome the power outages imposed by the electricity board. This in turn led to concerns of rising energy costs and adverse impacts on the environment in terms of both air and noise pollution. It was then that the Institute decided to go the solar way and avail benefits under the Jawaharlal Nehru National Solar Mission (JNNSM) scheme. With no dearth of roof tops on the sprawling campus, a proposal was initiated for a 100 kWp roof top grid interactive SPV power plant. The lecture hall complex was chosen for the project. As the proposal was shaping up, the Tamil Nadu Government unveiled its Solar Energy Policy, 2012 which covered a specific policy on solar purchase obligation (SPO). The SPO mandates 6 per cent of consumption by January 2014 for all high tension consumers including educational institutions.

The complete engineering, procurement and construction services (EPC) was done by BHEL Electronic Division (BHEL EDN), Bangalore. The entire design, erection, installation, commissioning and operation were completed within a short time and the power plant was commissioned on June 21, 2013. Mono crystalline solar panels (240 Vp) have been used in this power plant manufactured by BHEL EDN. The complete online data is being stored in a data logger and remote monitoring of the data has also been enabled. The power plant has generated around 48,000 units in about four months with an average generation of about 400 units per day. Apart from savings in energy charges, the plant has also helped in shaving peak consumption, as the actual consumption was exceeding the contractual demand of 1250 kVA on some occasions. The plant is estimated to generate around 1.4 lakh units every year and also to help reduce CO₂ emissions by about 112 tonnes annually. The only maintenance work which is done regularly is panel cleaning as the air in Trichy region is often dust laden.

A simple economic comparison of the SPV with a diesel generator shows that about 45000 litres of diesel is required to produce 1.4 lakh units (at 3 kWhr per litre). With the price of diesel increasing by the day, the payback of the SPV power plant vis-a-vis a DG set works out to around two and half years only. Encouraged by the success of this project, NIT Trichy is actively considering increasing its solar generation substantially. Besides the financial and environmental benefits, the plant has become a live demonstration of renewable energy and an inspiration for students to embrace solar energy as a way of life.

The author is Professor, NIT, Trichy. Email: baktha@nitt.edu
A solar cell (SC) is a device that converts sunlight energy directly into electricity by the photovoltaic effect. Photovoltaics have the potential to make a large contribution for solving the problem of climate change and hence, require highly efficient solar cells. SCs can be divided into three different generations. The first generation SCs are made from crystalline semiconductor wafers, typically silicon with a thickness of 200-300μm. Currently 90 per cent of the solar cell market is based on first generation SCs and around 40 per cent of the cost of a solar module is due to thick silicon wafers. Second generation SCs based on thin film technology have thickness usually in the range 1-2μm, deposited on cheap substrates such as glass, plastic or stainless steel. These SCs focus on lowering the amount of material used as well as increasing the energy production. They are made from a variety of semiconductors including cadmium telluride and copper indium diselenide, as well as amorphous and
polycrystalline silicon. A major limitation in thin film SCs technology is their ineffective absorbance near bandgap, in particular for the indirect bandgap semiconductor silicon. Therefore, it is very important to trap light inside the SC in order to increase the absorbance. Third generation SCs are currently being researched with the goal to increase the efficiency using second generation SCs. They are envisaging to improve absorption and hence efficiency by increasing the light trapping of desired frequency. A part of third generation SCs that has emerged recently is the use of scattering from noble metal nanoparticles excited at their localized surface plasmon resonance (LSPR) which is discussed here in detail.

**BASIC PRINCIPLES**

When a photon hits a semi-conductor, one of three things can happen: (i) The photon (lower than Si band gap energy) can pass through the material; (ii) The photon can reflect off the surface and (iii) The photon (higher than Si band gap energy) can be absorbed by the silicon.

When a photon is absorbed, its energy is given to an electron in the crystal lattice. Usually, this electron is in the valence band and is tightly bound in covalent bonds with neighbouring atoms and hence, unable to move far. The energy given to it by the photon “excites” it into the conduction band, where it is free to move within the semiconductor and hence, deficiency of one electron called “hole” is created. The presence of a missing covalent bond allows the bonded electrons of neighbouring atoms to move into the “hole” leaving another hole behind, and in this way a hole can move through the lattice. Thus, it can be said that photons absorbed in the semiconductor create mobile electron-hole pairs. Once the electrons and holes are separated, they need to recombine, since they are of opposite charge. The SCs are pretty efficient if the electrons can be collected before this happens. The way to collect the electrons quickly would be to make the conducting material very thin. If the surface is made very thin, there will be less light absorbed by the device. Much of the solar radiation reaching the earth surface is composed of photons with energies greater than the silicon band gap. These higher energy photons will be absorbed by the solar cell, but the difference in energy between these photons and the silicon band gap is converted into heat via lattice vibrations called phonons rather than into useful electrical energy which can damage the cell. Different types of the SCs are:

- Crystalline silicon solar cells
- Thin-film solar cells
- Plasmonic solar cells

**SURFACE PLASMONS**

A noble metal nanoparticles exhibit a strong optical extinction (absorption + scattering)
cross-section due to the collective oscillation of free electrons called LSPR. The resonance wavelengths are reported to be sensitive to the size, shape and surrounding medium of the nanoparticle. For the light to be trapped the absorption is not important, but the scattering of the light by metal nanoparticles is important, to utilize the light energy for highly efficient SCs.

**Plasmonics: Scattering and Absorption by Metal Nanoparticles**

The basic principle for the functioning of plasmonic SCs includes scattering and absorption of light due to the deposition of metal nanoparticles. A thin silicon sheet does not absorb light very well. For this reason, more light needs to be scattered across the surface in order to increase the absorption of Si to convert it into the useful electrical energy. It has been found that metal nanoparticles help to scatter the incoming light across the surface of the Si substrate at resonance wavelengths. The equations that govern the scattering and absorption of light for particles, which have dimensions less than the wavelength of light can be written as:

\[
\sigma_{sc} = \frac{k^4}{6\pi} |k|^2 \quad \text{&} \quad \sigma_{abs} = k \text{Im}(\alpha)
\]  

The polarizability \( \alpha \) of the particle is given by:

\[
\alpha_{sc} = \frac{4\pi}{3} \frac{a^2}{b}, \quad \epsilon_p(\omega) - \epsilon_n
\]

\( \bar{\epsilon}_p \) is the dielectric function of the metal particle, \( \epsilon_m \) is the dielectric function of the embedding medium and \( L_x \) is the depolarization factor, which is the function of the particle shape. For spherical particles, when the polarizability of the particle becomes maximum resonance occurs. The dielectric function for metal with low absorption can be defined as:

\[
\epsilon_p = 1 - \frac{\omega_p^2}{\omega^2 + i\gamma_p}
\]

\( \omega_p \) is the bulk plasmon frequency and defined as:

\[
\omega_p^2 = \frac{N e^2}{m \epsilon_0}
\]

\( N \) is the free electron density, \( e \) is the electronic charge and \( m \) is the effective mass of an electron. \( \epsilon_0 \) is the dielectric constant of free space. Many of the plasmonic solar cells use nanospheres to enhance the scattering of light in such a case LSPR frequency in free space can be given as:

\[
\omega_{psp} = \sqrt{3} \omega_p
\]

LSPR frequency for spherical particles primarily depends on the free electron density in the particle. The order of densities of electrons for different metals shows the type of light, which corresponds to the resonance.

✦ **Aluminum** - Ultra-violet
✦ **Silver** - Ultra-violet
✦ **Gold** - Visible
✦ **Copper** - Visible

If the dielectric constant for the embedding medium is varied, the resonant frequency can be shifted. Higher indexes of refraction will lead to a longer wavelength and broaden the resonance range. Gold is highly stable and shows the resonance peak broader than silver. Though silver is cheap in comparison to gold, it is highly unstable and gets oxidized, which affects the resonance frequency. On the other hand, copper is cheaper than silver,
and more absorbent than gold. Aluminium shows the resonance frequency in the UV range and also shows oxidization effect. Plasmonic SCs are considered the future of the industry in comparison with any type of solar cells due to their high efficiency at the approximate cost of second generation of solar cells.

**PLASMONIC SOLAR CELLS**

Plasmonic Solar Cells (PSCs) have great potential to drive down the cost of solar power. To make SC a viable energy source, trapping of light is crucial for thin film SCs. So, plasmonic nanoparticles would be used to increase the efficiency of thin film SCs. The scattered light from plasmonic nanoparticles excited at LSPR make them efficient. The design of a PSC varies depending on the method being used to trap light through the material. A common design is to deposit metal nanoparticles on the top surface of the thin film SC. When light hits these metal nanoparticles at their surface plasmon resonance, it is scattered in many different directions. This allows light to travel along the SC and bounce between the substrate and the nanoparticles enabling the SC to absorb more light.

**RECENT ADVANCES IN PSCs**

There has been some pioneering work in the field of PSCs. One of the main focuses has been on improving the thin film SCs through the use of metal nanoparticles distributed on the surface. The increased scattering provides more photon availability, which causes electron excitation and hence, generates current.

**Catchpole and Polman**: In thin film SCs, path length enhancements up to a factor of 30 were found for optimized shapes as particle shape is a crucial parameter determining the light trapping efficiency.

**Westphalen**: Enhancement for silver clusters incorporated into indium tin oxide and zinc phthalocyanine solar cells.

**Derkacs**: Gold nanoparticles on thin-film silicon gaining 8.3 per cent of conversion efficiency.

**Stenzel**: Enhancements in photocurrent by a factor of 2.7 for indium tin oxide-copper phthalocyanine structures.

**Stuart and Hall**: Achieved enhancement in the photocurrent by a factor of 18 for a 165 nm thick silicon on insulator photo-detector at a wavelength of 800nm using silver nanoparticles on the surface of device.

**Schaadt**: Enhancements up to 80 per cent at wavelengths around 500nm was obtained.
APPLICATIONS OF PSCs
The applications for PSCs are endless. The need for cheaper and more efficient SCs is very high. In order to be considered cost effective, SCs need to provide energy for a smaller price than that of traditional power sources such as coal, gasoline or nuclear. The movement toward a greener world has helped to spark research in the area of PSCs. With new technologies (third generation), efficiencies of up to 40-60 per cent can be expected in comparison to first generation SCs whose efficiencies are 30-40 per cent. With a reduction of materials through the use of thin film technology (second generation), prices can be driven down. Certain applications for PSCs are given below:

Space Exploration Vehicles: the main contribution for this would be the reduced weight of the SCs. An external fuel source would also not be needed if enough power could be generated from the PCs. This would drastically help to reduce the weight also.

Rural Electrification: An estimated two million villages near the equator, with approximately 80 per cent of the world population, have limited access to electricity. When the cost of extending power grids, running rural electricity and using diesel generators is compared with the cost of solar cells, many times the solar cells win hands down. If the efficiency and cost of the current solar cell technology is decreased even further then many rural communities and villages around the world could obtain electricity. Specific applications for rural communities would be water pumping systems, residential electric supply and street lights.

Power Stations: If SCs could be produced on a large scale and be cost effective, then entire power stations could be built in order to provide power to the electrical grids. With a reduction in size, they could be implemented on both commercial and residential buildings with a much smaller footprint. The SCs could help to power high consumption devices such as automobiles in order to reduce the amount of fossil fuels used and to help improve environmental conditions.

Low Power Electronics: Essentially, SCs could be used to replace batteries for low power electronics. This would save everyone a lot of money and it would also help to reduce the amount of waste going into landfills. SCs could also provide power to lighthouses, or even battleships out in the ocean. It can also be applied to other electronic devices to make them self-power driven when the sun is out. There are solar cell phone chargers, solar bikes, solar cars that people can adopt for daily use.

CONCLUSION
Research in PSCs is rapidly exploiting the benefits offered by plasmonics in tandem with those of thin film technology. The advantages of using plasmonic particles is to use them on any thin film SC (silicon or organic). The metal nanoparticles of different size, shape and embedding medium can enhance the efficiency of the solar cells over a large range of the electromagnetic spectrum. Hence, PSCs are promising candidates to drive down the cost of solar energy generation with high efficiency. ☀

The author is Professor, Department of Physics, Sant Longowal Institute of Engineering & Technology, Longowal, Sangrur, Punjab. E-mail: ssverma123@rediffmail.com
SOLAR PV PUMPING SYSTEMS

Solar photovoltaic water pumping systems are useful for irrigation and drinking water in rural areas, particularly during summer, when power failures are frequent.

PRABIR KUMAR NAIK

Solar energy based dual pump/drinking water scheme is the most suitable option for rural India. In such a scheme a solar PV based submersible pump is installed in the bore well as well as a hand pump is fitted for supplying clean water on days when little or no solar power is available - for example on rainy days. The water supply scheme should have a bore well of yield not less than 2800 litres per hour (0.77 litre per second). Solar PV submersible water pump of 900 W with required PV panels and a 5000 litres HDPE (high density polyethylene) tank mounted on a 3m high pre fabricated steel structure need to be put in place. What a vast country like India needs is a de-centralised solar energy system such as solar water heaters, cookers, driers, lighting systems, disinfection systems for safe drinking water and solar and wind battery chargers. Generation of solar energy based electricity can reduce the demand for thermal power. As burning of fossil fuel has the major impact on climate change, such schemes can reduce the impact of climate change.

The author is Scientist, Rajiv Gandhi National Ground Water Training & Research Institute, Central Ground Water Board, Raipur. Email: pkr_pitha9@rediffmail.com

INTERESTING FACTS: BIOFUEL

- Henry Ford originally designed the Model T to run on ethanol, a biofuel.
- During World War II, the demand for biofuel increased as fossil fuels became less abundant.
- Biofuels are often broken into three generations - 1st generation biofuels (conventional biofuels), 2nd generation biofuels (produced from sustainable feedstock) and 3rd generation biofuel (derived from algae).
- Most biofuels are as energy dense as coal, but produce less carbon dioxide when burned.

Source: biofuel.org.uk
Biogas bottling plants are one of the most potent tools for mitigating climate change by preventing black carbon emission from biomass chulhas, since biogas is used as a cooking fuel. Also, methane emissions from untreated cattle dung and biomass waste are also avoided. The purified biogas is bottled in CNG cylinders and wherever CNG is currently used, bottled biogas can be used as an alternative.

M.L. Bamboriya

Biomass resources such as cattle dung, agricultural waste and other organic wastes have been one of the main energy sources for mankind since the dawn of civilization. There is a vast scope to convert these energy sources into biogas which is a clean, low carbon technology for efficient management and conversion of fermentable organic wastes into a cheap and versatile fuel and bio/organic manure. It has the potential for leveraging sustainable livelihood development as well as tackling local and global land, air and water pollution. Biogas obtained by anaerobic digestion of cattle dung and other loose and leafy organic matter/biomass waste can be used as an energy source for applications like cooking, heating, space cooling/refrigeration, electricity generation and as gaseous fuel for vehicular application. Based on the availability of cattle dung from about 304 million cattle, there exists an estimated potential of about 18,240 million cubic meter of biogas generation annually.
India is implementing one of the world’s largest programmes in renewable energy. The country ranks second in biogas utilization. Biogas can be generated and supplied round the clock in contrast to solar and wind, which are intermittent in nature. Biogas plants provide three-in-one solution of gaseous fuel generation, organic manure production and wet biomass waste disposal/management.

Biogas is a product of bio-methanation when fermentable organic materials such as cattle dung, kitchen waste, poultry droppings, night soil waste, agricultural waste etc. are subjected to anaerobic digestion in the presence of methanogenic bacteria. This process is better as the digested slurry from biogas plants is available for use as bio/organic manure in agriculture, horticulture and pisciculture as a substitute or supplement to chemical fertilizers. In contrast, when biomass is subjected to combustion or gasification process, it ends up in the destruction of biomass and only ash is left after extraction of energy. Therefore, the bio-methanation process of converting biomass into gaseous fuel is superior and sustainable process that to be preferred for such biomass material that can be processed in biogas plants.

India has been a pioneering country in developing simple and easy to operate biogas plants. The Khadi Village Industries Commission (KVIC) model, developed and promoted in India, has withstood the test of time and is also being promoted in a large number of Asian, Pacific and African countries. Latest in the efforts for technology improvement is the development and launch of fixed dome and portable, prefabricated high density polyethylene (HDPE) based ‘complete and portable family size biogas plants’ suitable for rural, semi-urban and urban areas. These portable biogas plants help to achieve the twin objectives of energy generation and better sanitation with the bonus of enriched bio/organic manure while meeting emergency lighting needs using biogas gensets and lamps. Initially, biogas plants were developed for digesting cattle dung. However, over a period of time technology has been developed for bio-methanation of various types of biomass materials and mixed feed. Biogas plant designs are now available from 0.5 m³ to higher unit sizes and multiples of that can be installed for achieving higher biogas plant sizes depending on availability of the raw material for family, community, institutional, industrial and transport applications.

**BIOGAS TECHNOLOGY DEVELOPMENT**

Biogas eliminates drudgery of women and girl children from diseases caused by indoor air pollution arising due to direct burning of cattle dung and biomass in rural hearths. The history of biogas technology development in India is given as below:

1897: Biogas from human waste to meet lighting needs at the Matunga Leper Asylum, Bombay.

1939: Principle of biogas production from cattle dung was first evolved at the Indian Agricultural Research Institute, New Delhi.

1951: Field-worthy model of floating drum type biogas plant developed

1961: Khadi and Village Industries Commission (KVIC) took up floating drum type biogas plant for extension.

1979: Fixed dome Janta model biogas plant developed by the biogas research station, Ajitmal, Etawa, U.P.

Late 1980s: UASB (Upflow Anaerobic Sludge Blanket) technology developed for medium and large size biogas plants for processing urban and industrial biomass wastes.

1981-82: National Project for Biogas Development (NPBD) to cater to family size biogas plants launched.

1986: Deenbandhu model fixed dome biogas plant developed by Action for Food Production (AFPRO), New Delhi.
RE FEATURE

1988: BIS standard adopted for biogas stoves.
1989-90: BIS standards adopted for KVIC type Pragati and Deenbandhu with brick- masonry models of biogas plants.
2002-03: NPBD modified and renamed as National Biogas and Manure Management Programme (NBMMP).
2006: Biogas based decentralized power/energy generation programme launched.
2008-09: New initiative taken for technology demonstration on biogas bottling (BGFP) under RDD&D.
2011: MNRE supported first biogas bottling project commissioned.
2013: Indian Standard on Biogas (Biomethane) IS:16087 adopted.
2013: Scheme launched on biogas bottling under programme on energy from urban, institutional and agricultural waste/ residues.

BIOGAS COMPOSITION AND PROPERTIES

Biogas comprises of 60-65 per cent methane, 35-40 per cent carbon dioxide, 0.5-1.0 per cent hydrogen sulphide, rest being water vapour etc. Biogas is a non-toxic, colourless and flammable gas. It has an ignition temperature of 650 - 750°C. Its density is 1.214 kg/m³ (assuming about 60 per cent methane and 40 per cent CO₂). Its calorific value is 20 MJ/m³ (or 4700 kcal). It is almost 20 per cent lighter than air. Biogas, like liquefied petroleum gas (LPG), cannot be converted into the liquid state under normal temperature and pressure. It liquefies at a pressure of about 47.4 kg/cm² at a critical temperature of -82.1°C. Removing carbon dioxide, hydrogen sulphide, moisture and compressing it into cylinders makes it easily usable for transport applications as well as for stationary applications. Already CNG technology has become easily available and therefore, bio-methane (purified biogas) which is nearly same as CNG, can be used for all applications for which CNG is used. Purified biogas (bio-methane) has a higher calorific value in comparison to raw biogas.

BIOGAS PROGRAMMES

The main schemes being implemented by the MNRE under biogas programmes are given below:

National Biogas and Manure Management Programme (NBMMP): The NBMMP, which mainly caters to setting up of family type biogas plants, has been implemented since 1981-82. NBMMP provides for central subsidy in fixed amounts; turnkey job fee linked with five year’s free maintenance warranty; financial support for old, non-functional plants for repair; training of users, masons, entrepreneurs etc.; publicity and extension; administrative charges or staff support and Biogas Development and Training Centres (BDTC). In order to provide training support and technical back-up, 13 BDTCs have been set up in universities, Indian Institute of Technology (IITs) and other technical institutes.

Under this programme about 4.67 million biogas plants have been installed against the potential of 12 million biogas plants in the country for cooking, lighting and pumping application; it has 39 per cent of the potential estimated for installation of biogas plants in the country. Various models were developed indigenously and installed such as prefabricated model biogas plant, floating dome type biogas plant, bag type biogas plant and fixed dome biogas plant.

Biogas Based Distributed/Grid Power Generation Programme (BPGP): BPGP was launched in January, 2006 for installation of biogas based power projects in the capacity range of 3 kW to 250 kW to provide electricity to individual or community or grid. So far, such projects having total capacity of about 3.5 MW have been installed in the country.

Programme on energy from urban, industrial and agricultural wastes/residues (including production of bio-CNG for filling into gas cylinder): The Ministry is
promoting energy recovery from a variety of waste, such as municipal solid waste, sewage treatment plant, cattle dung, agricultural waste or residue, urban and industrial waste. So far, such projects having total capacity of about 212 MW have been installed in the country.

**R&D programme on biogas:** The Ministry also supports research, design, development & demonstration (RDD&D) to develop new and renewable technologies, processes, materials, components, sub-systems, products and services, standards and resource assessment so as to indigenously manufacture renewable energy products and develop systems. Thirteen R&D projects on biogas have been supported by the Ministry.

**Technology demonstration on biogas bottling under RDD&D:** In 2008-09, a new initiative was taken for technology demonstration on biogas bottling projects in entrepreneurial mode, for installation of medium size mixed feed biogas plants for generation, purification and bottling of biogas under RDD&D policy of MNRE. Installation of such plants aims at production of CNG quality of compressed biogas (CBG) to be used as vehicular fuel in addition to meeting stationary and motive power, electricity generation, thermal application etc. needs in a decentralized manner through establishment of a sustainable business model in this sector. There is huge potential for installation of such plants in various areas. Under the demonstration phase, the Ministry has sanctioned central financial assistance for a limited number of such projects for implementation following an entrepreneurial mode in Chhattisgarh, Gujarat, Haryana, Karnataka, Maharashtra, Punjab, Madhya Pradesh, Andhra Pradesh and Rajasthan.

So far, eight biogas bottling projects of various capacities and technologies have been commissioned in the country for filling and storage of compressed biogas in CNG cylinders, after obtaining required licenses from Petroleum and Explosives Safety Organization (PESO), State Pollution Control Board (PCB) etc. The biogas obtained has more than 90 per cent methane; this has been corroborated through tests conducted by National Accreditation Board for Testing and Calibration Laboratories (NABL). The biogas is compressed to 150 bar pressure for filling in cylinders. The purified biogas is equivalent to CNG.

The purified biogas is filled in a CNG cylinder and supplied to mid-day meal scheme, community kitchen, mess, hotels, industries etc. for various purposes such as cooking and heating. The slurry which comes out of the biogas plant is directly or after drying used as bio/organic manure for improving soil-fertility and is free from weed-seeds, foul smell and pathogens. The slurry is rich in primary nutrients such as nitrogen, potassium and sodium (NPK) along with micronutrients - iron and zinc etc. The field trials have indicated excellent growth in agro-production and substantial improvements in quality. This biogas bottling project will be able to replace fuel and manure worth about Rs. 35 lakh annually. The full cost of the project would be recovered within four to six years. The separation and bottling of CO2 and extraction of humic acid from slurry would further improve viability of biogas bottling plants.

**BIOGAS DIGESTER**

Different types of high rate bio-methanation digester viz. Upflow Sludge Anaerobic Blanket (USAB), Modified USAB, BARC-NISARGRUNA, Induced Bed Reactor (IBR) and Continuous Stirred-Tank Reactor (CSTR) etc. were installed in various parts of country under technology demonstration of biogas bottling.

**BIOGAS PURIFICATION TECHNOLOGY**

Different types of biogas purification technology such as water scrubbing - using low or high pressure and pressure swing adsorption (PSA) - were installed in the country for
purification of biogas. All required statutory clearances / permissions have to be obtained by promoters from the concerned authorities.

**INDIAN STANDARD ON BIOGAS (BIOMETHANE)**

Bureau of Indian Standards (BIS) has prepared Indian Standard on biogas (biomethane) – specification (IS 16087:2013) on the request of MNRE and the same has been published. The biogas (biomethane) for automotive application and piped network shall also comply with the requirements given in Table 1, when tested in accordance with the methods given in table 1 column 4. This biogas (biomethane) may also be used for applications such as stationary engines or power generators.

**TABLE 1: Requirements for Biogas (Biomethane)**

<table>
<thead>
<tr>
<th>CHARACTERISTIC</th>
<th>REQUIREMENTS</th>
<th>METHOD OF TEST, REF TO.</th>
</tr>
</thead>
<tbody>
<tr>
<td>CH₄, Percent, Min</td>
<td>90</td>
<td>IS 15130 (Part 3) : 2002</td>
</tr>
<tr>
<td>Moisture, mg/m³ Max</td>
<td>16</td>
<td>IS 15641 (Part 2) : 2006</td>
</tr>
<tr>
<td>H₂S, mg/m³ Max</td>
<td>30.3</td>
<td>ISO 6326-3 : 1989</td>
</tr>
<tr>
<td>CO₂+N₂+O₂, Percent, Max (v/v)</td>
<td>10</td>
<td>IS 15130 (Part 3) : 2002</td>
</tr>
<tr>
<td>CO₂, Percent, Max (v/v), (When intended for filling in cylinders)</td>
<td>4</td>
<td>IS 15130 (Part 3) : 2002</td>
</tr>
<tr>
<td>O₂, Percent, Max (v/v)</td>
<td>0.5</td>
<td>IS 15130 (Part 3) : 2002</td>
</tr>
</tbody>
</table>

**INTERNATIONAL WORK AT ISO**

At the international level, Institutional Organization for Standardization (ISO) is formulating standards on biogas through its committee TC 255- Biogas (anaerobic digestion, AD) with the secretariat at standardisation administration of China (SAC, China). India is a participating member on this Committee.

**CONCLUSION**

Biogas bottling plants are one of the most potent tools for mitigating climate change. The purified biogas can be bottled in CNG cylinders and wherever CNG is currently used, compressed biogas (CBG) can provide a better and safer alternative. There is a vast potential for the production of biogas in the country. In addition to the energy production, biogas plants also provide bio-manure and are help in dealing with the problems of waste management, providing clean environment and mitigating pollution in urban, industrial and rural areas. Biogas is also a prominent alternative to petroleum fuel like LPG, CNG and diesel. Therefore, it is highly desirable to promote biogas bottling plants and R&D activities for further development in the country.

*The author is Director, MNRE. Email: mlbamboriya@nic.in*
The January 2013 ‘Renewable energy country profile’ report of the International Renewable Energy Agency (IRENA) gives an overview of the status of renewable energy in each country with details about energy supply, electrical generation and grid capacity and access.

The energy statistics provided in the International Renewable Energy Agency (IRENA) report, released in January 2013, span from 2009 to 2012 with the latest available data. The statistics are compiled by IRENA's specialists from available country data and additional information from a variety of sources like the International Energy Agency, World Bank, World Trade Organisation, United Nations, United Nations Framework Convention on Climate Change etc. The report profiles 29 Asian countries including India.

The Report gives an overview of the status of renewable energy in each country with details about energy supply, electrical generation and grid capacity, and access. Energy policies, targets and projects are also considered, along with each country's investment climate and endowment with renewable energy resources. The Report is a starting point for a series of reports on individual countries.
INDIA
The per capita consumption of electricity in India, which has a population of 1,170.9 million, was 617 kWh. In the same year the per capita consumption for South Asia was 540 kWh, for Asia was 1,755 kWh and it was 2,728 kWh for the world. In 2009, 26.5 per cent of the 28,269.1 PJ total primary energy supply, 13.7 per cent of the 906.8 TWh of electricity generation and 27.9 per cent of 189.3 GW electricity capacity came from renewables. All the sources of renewable energy – solar, wind, hydro, geothermal, biomass and ocean, made a ‘high’ contribution to the energy profile.

BRUNEI DARUSSALAM
Brunei Darussalam, the second least populated country in Asia (399,000), has the highest per capita consumption of electricity at 8652 kWh. However, renewables did not play any part in the energy profile of Brunei Darrusalam in 2009. The country has set a target of reaching 10 per cent electricity generation from renewables by 2035. It did not have any policies for renewable energy before 2011.

AFGHANISTAN
Afghanistan, with a population of 34.4 million, has the lowest per capita consumption of electricity – 49 kWh. In 2009, 30.2 per cent of total primary energy supply, 82.6 per cent of electricity generation and 76.5 of electrical capacity came from renewables. The Report does not contain any data on targets for role of renewables. There is ‘high’ contribution from solar, hydro and geothermal energy sources; and, none from the ocean. Afghanistan started devising policies for renewable energy in 2006.
MALDIVES
Maldives, the least populated country in Asia (316,000) reported 2283 kWh per capita consumption. Renewables played a negligible part in the energy profile of Maldives in 2009, with solar being the biggest contributor. Maldives hopes to generate 50 per cent electricity from renewables by 2015; 60 per cent electricity from solar by 2020; and carbon neutrality in the energy sector by 2020. Solar is the highest contributor to the energy profile. Policy interventions for renewable energy began in 2004.

CHINA
China, with a population of 1,345.4 million, the most populated country in the world, has a per capita consumption of 2,650 kWh. In 2009 11.9 per cent of the total primary energy supply, 17.1 per cent of electricity generation, 24.3 of electricity capacity came from renewables. The contribution of renewable sources in energy production is ‘high’. China has had policies to promote renewable energy since the Rio Conference, beginning with the Brightness Programme in 1996.
HEAT PUMPS

Heat pumps for heating and cooling were first commercialised in the second half of the 20th century, but applications in cold climates were limited to ground-source heat pumps because of the low temperatures of outdoor air.

Today’s air-source heat pumps are able to supply heat even with outside air temperatures of -25°C. The market share of heat pumps for both heating and cooling applications is growing rapidly due to improved performance in terms of energy efficiency and CO₂ emissions in the residential, commercial and industrial sectors.

PROCESS AND TECHNOLOGY STATUS

The physics of heat pumps is well-known. While heat (thermal energy) tends to flow naturally from high-temperature sources to low-temperature heat sinks, heat pumps can move heat from low-temperature to high-temperature heat sinks. The heat pump principle is based on the four phases of the reverse Carnot cycle. Therefore, a heat pump can typically be used to extract heat from a refrigerator or an air-conditioner and provide heat for water or space heating.

The basic configuration of a heat pump consists of the evaporator (i.e. outdoor unit) where the process fluid evaporates, absorbing heat from the heat source (e.g. air), a compressor to compress the fluid and increase its temperature, a condenser (i.e. indoor unit), which releases heat by condensing, and an expansion valve to reduce the pressure and temperature of the process fluid to below the level of outside air temperatures in order to restart the cycle. The energy for the process is provided by the electric energy to run the compressor and circulate the fluid.

Heat pumps are highly efficient devices, as they can move and supply six units of thermal energy for each unit of electrical energy consumed. The ratio of the thermal energy provided for space cooling or heating to the energy consumed is the heat pump’s coefficient of performance (COP), one of the heat pump performance indicators. Another performance indicator for heat pumps is the seasonal performance factor. Because definitions of heat pumps’ energy performance differ between Asia, North America and Europe, the International Organisation for Standardisation (ISO) is working to define a global standard - the annual performance factor (APF) - which is the ratio of the total amount of heat, the device can remove from, or add to, space concerned during the cooling and heating seasons (respectively) to the total amount of energy consumed for both heating and cooling services. The high efficiency of heat pumps can provide advantages in terms of energy and CO₂ emissions, saving in comparison to other approaches (e.g. combustion) to space/water heating and cooling.

As a primary heat/cold source and sink, heat pumps can use outdoor air, river/lake/sea water or even ground (underground) heat and cold. All these sources can be regarded as renewable heat/cold sources, which can be used for residential, commercial and industrial applications. There may be, for example, air-to-air or air-to-water heat pumps or even water-to-air and ground-to-water/air heat pumps. The efficiency of heat pumps based on water sources is generally high because surface water is usually colder than air.
when space cooling is needed (e.g. summer) and warmer than air when space heating is needed (e.g. night time, winter). Of course, heat pumps can also use all kinds of waste heat, such as industrial and residential waste heat, or heat from sewage treatment.

In cold climates, their use has been limited to ground-source heat pumps as the outside air temperature is too low for using air-to-air heat pumps. However, more recent air-source heat pumps are able to supply heat even with outside air temperatures of -25°C, using injection circuits which bypass the evaporator and inject fluid into the compressor for cooling during compression or two-stage compression to increase fluid circulation volume. Freezing risks have been prevented by passing hot-leg fluid through the colder part of the heat exchanger in the outdoor units. The time needed for defrosting and from start-up to blow-off of heated air has also been shortened. These component technologies have significantly contributed to improving the space heating performance and efficiency of heat pumps. All these improvements have enabled the use of air-source heat pumps in cold climates for applications to space heating, floor heating, water heating and even road heating for snow melting.

In some cases, thermal storage systems are used to increase the efficiency of heat pumps and reduce peak power demand for buildings. These systems typically consist of a thermal storage tank where the heat produced overnight is stored and used during the day. Various thermal storage media have come into practical use. Chilled and hot water storage is used in thermal storage systems for heat pump air-conditioning systems. More recently, air-conditioning systems with ice-based, latent heat storage (and small-size storage tanks) have been developed. Also, air-conditioning systems with thermal storage based on the building body and no storage tank have come into practical use.

**PERFORMANCE AND COSTS**

Heat pumps can provide three to six units of useful thermal energy for each unit of energy consumed, whereas traditional combustion-based heating systems only provide less than one unit of thermal energy for each unit of energy consumed. Today’s best heat pumps can offer COP values between six and seven and a high reliability under a wide range of operating conditions. The heat pump's efficiency has increased substantially over the past years as a result of technical improvements and the use of inverters and control systems. Recently, the seasonal performance factor (SPF) (i.e. the ratio of heat delivered to the energy consumed over the season) of the most efficient, commercial heat pumps has reached the level of 6-7, although SPF varies considerably with the heat pump technology, heat source and operating conditions.

Ground-source heat pumps (GSHPs) can serve as effective systems for space cooling (summer) and heating (winter), as in most regions the ground temperature remains stable throughout the year (i.e. between 10-15°C). However, air-source heat pumps (ASHPs) are often the technology of choice for air-conditioning. The use of ASHPs is very cost-effective in regions where both space heating and cooling are required throughout the year. Most advanced devices can reach COP of higher than six.

**POTENTIAL AND BARRIERS**

Currently, space heating and cooling, together with hot-water supply, are estimated to account for roughly half of the global energy consumption in buildings. Most of this energy demand is met by combustion of fossil fuels with their related CO₂ emissions. Air-conditioning and cooling demand is growing, particularly in emerging economies. Heat pumps can reduce energy consumption and CO₂ emissions, as well as improve energy security. If combined with thermal storage, heat pumps can also reduce the
demand for peak power. It has been estimated that widespread use of heat pumps for space heating/cooling and water heating in the commercial sectors could reduce CO₂ emissions by 1.25 billion tonnes by 2050.

Major barriers to the widespread use of heat pumps include the insufficient recognition of benefits and the high investment costs. Defining international standards for heat pump efficiency, as well as labelling and providing incentives (e.g. subsidies, grants) for heat pump use, could help overcome these barriers. The use of heat pumps would be greatly encouraged if the thermal energy they captured were recognised worldwide as a renewable energy source. As for performance and costs, current R&D activities are expected to increase efficiency by 40-60 per cent for heating services and by 30-50 per cent for cooling services, and to reduce costs by 30–40 per cent and 5–20 per cent, respectively, by 2050.

Heat pumps are considered as a renewable energy technology in the European Union (EU), where they are expected to account for between 5 per cent and 20 per cent of the EU’s renewable energy target for 2020. Several other countries (e.g. the United States, the United Kingdom, Australia and Japan) grant tax reductions, subsidies or other benefits to facilitate the use of heat pumps. In many other countries however, heat pumps are not considered as renewable technologies and receive no incentives or subsidies. In addition, because significant differences exist in national standards and regulations to measure heat pump performance, their contribution to the penetration of renewable energy is not well captured in today’s energy statistics. To support heat pump deployment, national standards should be harmonised, consumers should be fully informed of the efficiency of heat pumps, and the investment costs of heat pumps
(compared to traditional combustion devices) should be reduced. Therefore, continued support to R&D and policy measures are essential to improve competitiveness and market penetration of heat pumps, thus exploiting their large potential to supply efficient and clean energy services.

APPLICATION

Common applications for heat pumps are air-conditioning, refrigeration and space heating in both residential and commercial buildings. Other applications include hot water supply in commercial buildings, cold storage warehouses and process heat and steam for industrial applications.

With capacities between 1kW and 10 MW, current heat pumps can provide heating and cooling to single houses or to entire districts. In industrial applications, they can be used at temperatures from below -100°C to above 100°C. ☀

Inputs from IEA-ETSAP and IRENA technology brief E-12 – 2013
India Trade Promotion Organisation organised the 33rd edition of its popular annual event, the India International Trade Fair, at Pragati Maidan, New Delhi from 14 to 27 November, 2013, where the exhibition of the Ministry of New and Renewable Energy proved to be a crowd puller with hundreds visiting it on a daily basis.
India’s International Trade Fair is the largest integrated trade fair with business-to-business and business to consumer components. It presents a complete range of products from diverse sectors from major manufacturers to small and medium enterprises. It has a large participation of international exhibitors. It is one of the largest trade fairs in the world both in terms of exhibitors and visitors’ participation and has evolved its unique character as an iconic national event.

The Ministry of New and Renewable Energy’s (MNRE) stall put up at the International Trade Fair became a centre of attraction during the exhibition. The stall was used to disseminate information on new and commercially successful methods of generating renewable energy. Its allied benefit to the environment was also outlined. Live demonstrations were staged that generated a lot of interest among the young and the old, alike. Many asked about the locations and listing of Akshay Urja shops and outlets where appliances could be purchased. Relevant brochures and materials were handed over to interested persons. With a persistent yearly increase in development of renewable energy the interest in the sector was palpable. A lot of industries dealing with renewable energy also made their presence felt at the Trade Fair 2013. Over half a million people visited the MNRE Pavilion in India International Trade Fair. The display of various renewable energy systems and equipment were the major attraction for the people. Many people booked the solar water heater at the exhibition. Many dignitaries visited the MNRE Pavilion. The MNRE is the nodal agency in the country on matters related to renewable energy and has incorporated the latter as an essential component of India’s energy policies.

MNRE
CHANGE IN MINDSET MAKES CHANDIGARH A MODEL SOLAR CITY

A Conference titled ‘Promoting Rooftop Solar PV Systems’ held on 23rd December 2013 at CII, Chandigarh, aimed to bring together all key stakeholders to deliberate on how to create a power surplus environment for a sustainable future.

A adoption of latest solar technologies, indigenous production of hi-tech solar photovoltaic (PV) panels and more efficient solar equipment, and most importantly, its acceptance by citizens, institutes and industry by aggressive promotion campaigns is the key to make Chandigarh a model solar city”, highlighted HE Mr Shivraj V Patil, Governor, Punjab and Administrator, UT Chandigarh, while addressing the Conference on Promoting Rooftop Solar Photovoltaic Systems in India organized by the Chandigarh Renewable Energy, Science and Technology Promotion Society (CREST), Confederation of Indian Industry (CII), Ministry of New and Renewable Energy (MNRE), GoI, The Energy and Resources Institute (TERI) and Shakti Sustainable Energy Foundation (SSEF) at CII Northern region headquarters at Chandigarh, on 23rd December 2013.

He further said that “Chandigarh, which has been chosen as the Model Solar City by the Government of India has potential to reach the ambitious target of solar energy production in next few years. The industry can capitalise on this and earn huge profits, because this is the energy of the future, being un-polluting and absolutely free, once the capital investment is put in. Even residents can earn profits by supplying excess energy back to the grid, simply by putting up solar panels on their roof tops. What is imperative is the sound popularisation, promotion and large scale domestic production of the same to achieve benefits of ‘economies of scale’. As the prices fall, we won’t need to import the panels from other countries and save a lot of forex reserves as well. Even financial institutions and banks can be collaborated with to generate funds for the same.”
“We would provide income tax concessions and also plead with the Centre for incentives to those who invest in R&D and adopt innovative technologies in this field.” He exhorted that he does not agree with those who say that the whole world is going to face an energy crisis in future due to its fast growing demand. He said that he is sure that mankind will find answer to such demand through innovations. What is required are the efforts to convert it in useful forms.

The Conference aimed to bring together all key incentive issues. Also, the industry needs to improve its supply chain management and production techniques.”

He also informed that the Chandigarh Administration is planning to implement a sound and effective single-window system for solar projects and rooftop applications. “Now, to claim subsidy, residents do not have to visit the Government of India offices and it can be availed at CREST level”. He informed that besides installing grid tied rooftop SPV plants at various government offices/schools/colleges, the UT Administration has installed “rooftop SPV plants

stakeholders to create a power surplus sustainable future and also to pre-launch the web-based GIS tool being created by TERI especially for Chandigarh as a pilot project, which would calculate the estimated rooftop potential of any individual roof as well as that for the entire city. The residents can just click the link and check the rooftop SPV potential of their respective homes. This shall also provide data on solar radiation available throughout the year on the roof, expected capacity of SPV plant that can be installed and expected electricity generation for the year from that particular roof. The link is – www.regisindia.com. This shall be available free of cost to any person.

Mr K K Sharma, IAS, Advisor to Administrator, UT Chandigarh, said “Technical-scientific expertise and capital investments are needed to make Chandigarh a model solar city. We would take utmost care of the metering and of 2 kW capacity each at five government residential houses as demonstration project which shall be a trend setting example”.

Mr Santosh Kumar, Director, Science & Technology, Chandigarh & CEO, CREST informed that CREST is going to launch new scheme for residents of Chandigarh where they can install smaller capacity SPV plants of 1kW, 2 kW, 3 kW, 5 kW capacity etc., on their rooftop and can avail 30 per cent subsidy of MNRE at local CREST level itself. He also informed that the residents who already have an inverter and battery system can just retrofit their existing system with solar panel and charge controller to use solar energy by spending Rs. 25,000 only. “In order to achieve grid parity by 2015, we need to adopt sustainable power generation methods at large-scale and rooftop solar PV systems will be a new boon in this field,” he added.
Solar Thermal Award Function

A total of 28 awards were distributed in the function held on 17th December 2013 which included awards to state nodal agencies, beneficiaries and channel partners of the Ministry.

Minister of New and Renewable Energy (MNRE) Dr. Farooq Abdullah highlighted the need for greater propagation of solar water heating system on the occasion of the Award distribution function on Solar Thermal Systems in New Delhi on 17th December 2013. Dr. Farooq Abdullah said that solar water heating can save a tremendous amount of energy. He emphasized the need for having more number of sale and service professionals/entrepreneurs in this area so that people have access to renewable sources of energy. He exuded confidence that the target of generating 20,000 MW through the Jawaharlal Nehru National Solar Mission (JNNSM) by the year 2022 would be achieved.

A total of 28 awards were distributed which included awards to state nodal agencies (SNAs), beneficiaries and channel partners of the Ministry. The award for the first position among SNAs for the category of ‘Solar Water Heating Systems’ (SWHS) was given to Gujarat Energy Development Agency, Gandhinagar. The award for the first position among SNAs for the category of ‘Solar Water Heating Systems’ relating to percentage increase in installation was given to Ladakh Renewable Energy Development Agency, Ladakh. Best website on Solar Water Heating System Award was given to National Informatics Centre (NIC), Ministry of Communication and Information Technology. Best SNA for use of Dish Solar Cookers and the award for highest number of SWHS installations in special category states was given to Uttarakhand Renewable Energy Development Agency, Dehradun. Kargil Renewable Energy Development Agency (KREDA), Kargil-Ladakh (J&K) was awarded Best SNA for largest installation of domestic green houses for the purpose of growing vegetables in extreme climatic conditions for the year 2012-13.

Earlier, Dr. Farooq Abdullah also released two knowledge documents developed by the Ministry in partnership with
UNDP-GEF that includes success stories and video films on installations, fl ers on concentrating solar technologies (CST) and a compendium of such technologies available.

Till date, 7.37 million sq meters have been installed. The factors influencing SWHS growth are capital subsidy under JNNSM policy, United Nations Development Programme (UNDP) project, state/city level regulations, for mandatory use of SWHS in certain sector, primarily in domestic and institutional sector. State governments are required to bring out GO/regulation in this sector. State wise installation is as follows:

- Gujarat, Karnataka, Tamil Nadu, Andhra Pradesh, Maharashtra, Kerala – 80.5 per cent.
- Rajasthan, Madhya Pradesh, Chhatisgarh, Jharkhand, Odisha – 6.4 per cent.
- Haryana, Punjab, Uttar Pradesh, NCR, Bihar, West Bengal – 11.6 per cent
- Jammu & Kashmir, Himachal Pradesh, Uttarakhand – 1 per cent.
- NE region – 0.4 per cent.

Of all the installations approximately 87 per cent installations are in residential sector, 2 per cent in hotels, 1 per cent in hospitals and industries each, in others 9 per cent. One good example coming up is Malkapur Nagar Panchayat, Maharashtra where 6000 houses will have SWHS and solar PV in place in association with NABARD and MNRE.

Till date 28000 square meter CST systems have been installed at Shirdi Brahmakumaris Ashram, Mount Abu; Art of Living, Bangalore; Shanti Kunj, Haridwar; and Sringeri Matt, near Bangalore; apart from various universities and college hostels. For cooling and laundry applications CSTs have been provided at places like Civil Hospital, Thane near Mumbai; Cancer Hospital, Muni Sewa Ashram near Vadodara; ITC Maurya, Delhi; Mahindra & Mahindra, Pune; and Gajraj Cleaners, Ahmednagar, Maharashtra.

IREDA MARKS ROBUST PERFORMANCE

Indian Renewable Energy Development Agency Limited (IREDA), a Government of India Enterprise under Ministry of New and Renewable Energy (MNRE) is a unique financial, institution dedicated for financing renewable energy and energy efficiency projects. IREDA has been spearheading the development of renewable energy projects in the country which has one of the highest levels of renewable energy deployment in the world.

During the financial year 2012-13, IREDA posted robust performance with an all-time high Profit before Tax (PBT) at Rs. 250.58 crores registering a 20.40 per cent rise over the previous fiscal and recorded its profit after tax of Rs. 202.65 crores compared to Rs. 173.13 crores over the previous fiscal. Loan sanctions and disbursement during the year 2012-13 stood at Rs. 3747.36 crores and Rs. 2125.50 crores respectively which is an increase of 10.02 per cent in sanctions and 14.58 per cent in disbursement as compared to the last year. IREDA presented a cheque of Rs. 27.50 crores towards dividend for FY 2012-13 representing an increase of 10 per cent as compared to last year. The dividend cheque was presented by Shri Debashish Majumdar, (CMD, IREDA) to Dr. Farooq Abdullah, Hon’ble Union Minister for New and Renewable Energy in the presence of Shri Ratan P. Watal, Secretary, MNRE and other senior officials of MNRE and IREDA on 14th November 2013 at New Delhi.
WIND TURBINES IN EXTREME WEATHER CONDITIONS

Current design standards do not cover extreme weather conditions, such as hurricanes, cyclones and typhoons, leading to complications for designers and wind turbine manufacturers who build wind projects in cyclone-prone areas.

Current design standards for wind turbines take into account short term extreme wind events but prolonged wind conditions experienced in tropical storms are not covered. Therefore guidelines for wind turbines in extreme conditions have been developed. The fact that design standards do not cover extreme weather conditions, such as hurricanes, cyclones and typhoons, provides complications for designers and wind turbine manufacturers who build wind projects in cyclone-prone areas. Therefore, guidelines to access the wind condition and wind turbine and safety related aspects when exposed to conditions experienced during such extreme weather are extremely pertinent.

Continuing the work from an initial 2011 innovation project, this year’s effort (by DNV Clean technology Center, Singapore and DNV KEMA, Denmark) focused on the content and structure of the guidelines for wind turbines in extreme conditions. The project consists of:

◆ Developing the methodology of analysing tropical cyclones;
◆ Developing the recommended practice (RP) structure for wind turbines in extreme conditions;
◆ Gap analysis of missing sections in the RP
◆ Refining the probabilistic wind analysis methodology which uses historical hurricane track data in order to calculate the probability that a hurricane of a certain category would affect the site.

A comparison between current design load cases in the IEC standard is also reviewed, to identify if it is applicable to the wind conditions experienced in a tropical storm event.

This project develops the framework and content for the RP. A good understanding on the gap in present practices and standards is required. Further research is required to develop this into a recommended practice that would allow developers, owners to evaluate the risk of having the project in a tropical cyclone-prone region.

Manufacturers and designers would also be able to take into consideration such extreme wind conditions when designing a wind farm located in the vicinity of such events.

The methodology for performing a probabilistic typhoon analysis uses the best track data from met offices worldwide. Comparisons of the current guidelines and standards are made and gaps identified between the design codes and extreme events. The creation of new design load cases is envisaged for future research.

In addition, identification of additional components that would reduce the impact from such extreme events, e.g. having a backup generator in place for turbines to ensure that yaw motion is possible in the event of grid disruption; and, using a pin-locked mechanical fixture, compared to a brake disc may be preferred due to potential wear and tear of using a brake disc; etc.

Benefits

◆ Better understanding of wind characteristics involved during tropical storms
◆ Able to help client understand the risk of having the wind farm near to these typhoon/cyclone-prone regions
◆ Development of a recommended practice in analysing wind turbines in extreme conditions
◆ Display thought leadership in the wind industry.

Inputs from: dnvgl.com
NEW STYLE TURBINE TO HARVEST WIND ENERGY

With blades of initially just one metre, the Wind Harvester has the potential for both commercial and domestic use.

The Wind Harvester, a small, more efficient turbine, is being developed by Heath Evdemon, founder of Wind Power Innovations Ltd, with the help of Future Factory, the Nottingham Trent University's sustainable design project.

The Wind Harvester would be able to make power from low and high wind speeds, unlike current turbines. Most traditional three-blade turbines generate energy from wind speeds between about 30mph to 50mph. A large scale fully working model is expected to be installed in the Derbyshire Peak District (where and when). A new way of generating wind energy which could see smaller, more efficient turbines on the landscape is being developed by a Derbyshire inventor.

With blades of initially just one metre, the Wind Harvester has potential for both commercial and domestic use. Traditional wind turbines typically have three blades which rotate around a horizontal hub at the top of a steel tower. Most generate maximum output at an approximate wind speed of 30mph and shut down to prevent storm damage at 50mph or above, causing reduced efficiency of some turbines. The new Wind Harvester is based on reciprocating motion that uses horizontal aerofoils similar to those used on aeroplanes. It is virtually noise-free and can generate electricity at a low speed, which may result in less opposition to new installations. It will also be operational at higher wind speeds than current wind turbines.

It can be made in any size up to approximately 15 metres across and only needs to be approximately half a metre off the ground in prominent positions such as hills and hillsides, rock outcrops, and on domestic, farm and industrial buildings and structures. All sizes can be broken down into handleable pieces so installation will not require the use of heavy machinery, which is particularly relevant to environmentally sensitive areas.

Inputs from ntu.ac.uk (Nottingham Trent University)
GREEN PRODUCTS

**DuraTrack™ HZLA solar tracker**

Up to 25 per cent more power from existing PV systems by using the DuraTrack™ HZLA - claims its manufacturer. This single-axis tracker uses a single drive and motor to move all modules from East to West, following the sun from sunrise to sunset to maximize power production.

**FLEXIBLE SYSTEM**

The multiple DuraTrack HZLA trackers laid out in long or short rows to fit the property's shape and the HZLA's design reduces shading when adding additional trackers to increase system size.

**FAST AND EASY TO INSTALL**

The manufacturers assert that a universal mounting system accommodates almost any type of module and DuraTrack™ high-speed mounting clamps make installation fast. The DuraTrack HZLA requires only commonly available materials for its foundation and columns.

**STURDY AND RELIABLE**

The company also claims that the DuraTrack HZLA is built of galvanized steel and anodized aluminium components to last longer. It adds that the DuraTrack HZLA is rated to 90mph wind loading and has been proven to stand up to high winds and harsh environments while providing maximum efficiency. The company also highlights that it is low maintenance as the dry-slide bearings require no lubrication.

*Source - RenewableEnergyWorld.com*

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**SOLAR AIR CONDITIONER**

This hybrid solar air conditioner is designed for low cost, easy installation and fast payback. The solar air conditioning technology requires no batteries, no inverter, no controller - just plug in the solar panels and start saving up to more than 80 per cent on daytime cooling or heating costs. During the day it runs primarily on solar power and only uses small amounts of power from the utility company as needed. Hybrid operation eliminates the need for batteries and allows 24 hour per day use of the system. The system primarily uses solar power, adding normal AC power.

For home or office use, this system can cool an area with 80 per cent or more of the energy coming from sunlight. In addition to cooling, the GEI-HY-12 H/C solar heat pump can provide solar powered heating, operating all the way down to an outside ambient temperature of 5 degrees F. The GEI-HY-12 H/C solar air conditioner needs no batteries, and only need two or three PV panels to obtain huge savings. During the day, when air conditioning is needed the most, you can operate this unit with very little draw on your utility meter. At night, one can continue to save due to the >SEER 19 rating on this unit. And because it is a ductless system, it allows 100 per cent of heating or cooling to be delivered to where it is needed without the loss that occurs in a ducted system. However, this is not an “off-grid” unit; 220V utility power is required.

*Source : www.geinnovations.net*
CHILDREN’S CORNER

WORDWORMS

Hidden amidst of maze of letters are terms that pertain to Renewable Energy. See if you can find all of them. Best of Luck.

B I O M A S S S A I N A A L O
S A B C D O F G H I K L E N
G B D B D L F G F I S L D N
E C B I D A F G U I H L M S
O D M O D R E N E W A B L E
T E E D D L F G L I Y L M N
H F T I D A L G C I U L O E
E G H E D M F H E D R O M R
R H A S D P F G L I J L E G
M I N E D E S A L G A E M Y
A L E L D E F G H I K L C M
L A P H O T O V O L T A I C

Answers:
This is one of very few books which addresses the issue of renewable energy from the point of view of landowners, farmers and rural land managers – those people who must make important decisions about how, where and when to install renewable energy sources on their land and the business implications of the decisions they make. The third edition of Renewable Energy in the Countryside contains a new chapter on biogas, up-to-date discussions on the implications of the Renewable Heat Initiative and new opportunities for solar energy and ground source heat in the context of farms and country houses.
In India


28-30 January 2014 4th International Conference on Solid Waste Management and Exhibition on Municipal Services, Clean technology, Place: Hyderabad, Andhra Pradesh, Organiser: Govt. of Andhra Pradesh, Department of Municipal Administration and Urban Development, Contact: Dr. B. Janardhan Reddy - 91 40 23302150, Website: www.iswmaw.com

21-23 February 2014 International Conference on Renewable Energy (ICRE 2014), Place: Pune, India, Organiser: SAISE South Asia Institute of Science and Engineering, Contact person: Mr. Zeke Zhou, Email: icre@saise.org, Tel:+86-27-86666663, Website: www.saise.org/icre2014

In Other Countries

14-15 January, 2014 4th Annual Electric Energy Storage Conference, Place: San Diego, CA, United States of America, Organiser: MARCUS EVANS, Contact person: Tyler Kelch, 312-540-3000 ext. 6680 Email: Tylerke@marcusevansch.com, Website: www.marcusevans-conferences-northamerican.com

19-20 February, 2014 3rd International Conference on Clean and Green Energy - ICCGE 2014, Place: Singapore, Organiser: International association of chemical, biological, environment engineering scientists (CBEES), Contact person: Ms. Sophia Du, +86-28-86528465 E-mail: iccge@cbees.org, Website: www.iccge.org

27-28 February, 2014 4th Annual Smart Grids Smart Cities Forum, Place: Warsaw, Poland, Organiser: Fleming Europe, Contact: Martin Makara + 421 257 272 143, Website: www.energy.flemingeurope.com

4-5 March, 2014 Solar Energy Africa 2014, Place: Nairobi, Kenya, Organiser: Solar Media, Contact: Sue Bradshaw, sbradshaw@solarmedia.co.uk, Website: www.africa.solarenergyevents.com

5-7 March, 2014 10th Energy Efficiency and Renewable Energy Congress and Exhibition for South-East Europe, Place: Sofia, Bulgaria, Organiser: Via Expo, Contact person: Maya Kristeva, +359 (32) 960 011, 966 813, Website: www.via-expo.com
# RENEWABLE ENERGY AT A GLANCE

Cumulative deployment of various renewable energy systems/devices in the country as on 31.12.2013

<table>
<thead>
<tr>
<th></th>
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</tr>
</thead>
<tbody>
<tr>
<td><strong>I. POWER FROM RENEWABLES</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>A. GRID-INTERACTIVE POWER (CAPACITIES IN MW)</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Wind Power</td>
<td>2500</td>
<td>99.30</td>
<td>1096.50</td>
<td>20149.50</td>
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<tr>
<td>Small Hydro Power</td>
<td>300</td>
<td>31.55</td>
<td>130.90</td>
<td>3763.15</td>
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<tr>
<td>Biomass Power</td>
<td>105</td>
<td>6.00</td>
<td>21.00</td>
<td>1284.60</td>
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<tr>
<td>Bagasse Cogeneration</td>
<td>300</td>
<td>40.40</td>
<td>175.45</td>
<td>2512.88</td>
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<tr>
<td>Waste to Power–Urban–Industrial</td>
<td>20</td>
<td>2.40</td>
<td>3.00</td>
<td>99.08</td>
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<tr>
<td>Solar Power</td>
<td>1100</td>
<td>129.09</td>
<td>495.13</td>
<td>2180.00</td>
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<tr>
<td>Total</td>
<td>4325</td>
<td>308.74</td>
<td>1921.98</td>
<td>29989.21</td>
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<tr>
<td><strong>B. OFF-GRID/CAPTIVE POWER (CAPACITIES IN MW(eq))</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Wind Power–Urban Industrial</td>
<td>10.00</td>
<td>2.50</td>
<td>4.06</td>
<td>119.63</td>
</tr>
<tr>
<td>Biomass (non–bagasse) Cogeneration</td>
<td>80.00</td>
<td>2.10</td>
<td>38.54</td>
<td>509.69</td>
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<tr>
<td>Biomass Gasifiers–Rural</td>
<td>1.00</td>
<td>0.064</td>
<td>0.35</td>
<td>17.05</td>
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<tr>
<td>–Industrial</td>
<td>9.00</td>
<td>0.250</td>
<td>2.88</td>
<td>141.67</td>
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<tr>
<td>Aero-Generators/ Hybrid systems</td>
<td>1.00</td>
<td>–</td>
<td>0.04</td>
<td>2.15</td>
</tr>
<tr>
<td>SPV Systems (&gt;1kW)</td>
<td>40.00</td>
<td>2.52</td>
<td>19.70</td>
<td>144.38</td>
</tr>
<tr>
<td>Water mills/micro hydel</td>
<td>500 Nos.</td>
<td>–</td>
<td>–</td>
<td>10.18 (2547 nos)</td>
</tr>
<tr>
<td>Bio-gas based energy system</td>
<td>2.00</td>
<td>2.00</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td>Total</td>
<td>145.00</td>
<td>7.434</td>
<td>67.23</td>
<td>944.75</td>
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<tr>
<td><strong>III. OTHER RENEWABLE ENERGY SYSTEMS</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Family Biogas Plants (No. in lakhs)</td>
<td>1.10</td>
<td>0.40</td>
<td>0.50</td>
<td>47.10</td>
</tr>
<tr>
<td>Solar Water Heating–Coll. Areas (Million m²)</td>
<td>0.60</td>
<td>0.10</td>
<td>0.47</td>
<td>7.47</td>
</tr>
</tbody>
</table>
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- Subsidy up to 30% of cost available from Government. Higher subsidy for special category including N-E states. Loans at 5% also available from selected banks
- Useful for homes, hotels, hospitals, guest houses, industries & other establishments requiring hot water
- For installation & to avail subsidy / soft loan contact our State Nodal Agencies in state capitals/ approved manufacturers/ Channel partners/ Banks/FIs participating in Scheme. Details available at our website: www.mnre.gov.in. Click at Solar Water Heater on home page or call Helpline No. 1800 233 4477 (Monday to Friday: 9.30 am to 6.30 pm, Saturday 9.30 am to 1.30 pm)
- Please check quality and price before you buy. Wide range of products available. Guidelines on quality and selections for a system also available at website.

Issued by:
Government of India
MINISTRY OF NEW & RENEWABLE ENERGY
B-14, CGO Complex, Lodi Road, New Delhi-110003
Helpline No. 1800 233 4477

www.mnre.gov.in