



सत्यमेव जयते

Ministry of New and
Renewable Energy
Government of India

Volume 10 • Issue 4 & 5 • February–April 2017

Renewable Energy Akshay Uria

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green by reducing the carbon foot print

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can meet a significant amount of your steam requirement for
community cooking & process heat applications



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Scheffler Dishes



Parabolic Trough Concentrators



Arun Dish

SALIENT FEATURES

- Can provide steam/hot oil/ pressurized water at 90-350 C
- Integrated with conventional boiler provides trouble free operations during non-sunshine hours. Systems with heat storage also available
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Renewable Energy Akshay Urja

SPECIAL REPORT



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Cover Image: Biogas upgradation by vacuum swing adsorption: biogas purification plant at M/s Sabar Dairy

B Velmurugan, Mehul Patel, and **Lalit P Patel** highlight the potential for waste to energy through a case study of M/s Sabar Dairy, which has been utilizing natural gas for its thermal applications in day to day milk-processing operations.



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Cover Image: Demand assessment for mini grids in villages of Uttar Pradesh

Onkar Nath says that in order to accelerate access to energy, especially in rural areas, efforts are being made to develop capacity in renewable energy sources, such as solar energy, biomass-based electricity, small hydro, wind energy, etc., in UP.



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Cover Image: Solar surface pump installed at Kawardha. This shows the success of solar pumpsets in India in states, such as Gujarat and Chhattisgarh.

मुझे दिसम्बर 2016 अंक पढ़ने का सौभाग्य मिला। सर्वप्रथम मैं आपको एवम् समस्त संपादकीय दल को धन्यवाद प्रेषित करना चाहता हूँ। भारत के प्रथम बायो सीएनजी संयंत्र के बारे में अच्छी जानकारी प्राप्त हुई। यह पढ़कर वाकई अच्छा लगा कि इस कार्य से जुड़े अनुसंधानकर्ताओं का लक्ष्य भारत की चारों दिशाओं में एग्रीगैस की नवाचारी प्रथाओं को आगे बढ़ाना और ईंधन का अधिक से अधिक प्रतिस्थापन सुनिश्चित करना है। झुगियों और ग्रामीण क्षेत्रों में रोशनी के लिए माइक्रो सोलर डोम को भी प्रोत्साहित किया जाना चाहिए क्योंकि यह एक अल्प लागत और ऊर्जा दक्ष युक्ति है, जो सूर्य की रोशनी की मदद से बिजली की आपूर्ति के अभाव को कम करती है।

विपिन पुरोहित

कानपुर, उत्तर प्रदेश

I really liked reading the October 2016 issue of your esteemed magazine. The Article on 'Next generation solar cells' is very informative. It gives details of the future scope of improvements as a potential source of alternative energy. All the articles in this issue are good. I request you to publish the National and International Forthcoming Events well in advance, so that we are able to attend the same. Kindly do the needful. Thanking you in anticipation.

Er Anant B Tamhane

Engineer Consultant Renewable Energy
Nagpur, Maharashtra

अक्षय ऊर्जा के दिसम्बर 2016 अंक में प्रकाशित श्री सी जे वेणुगोपाल का साक्षात्कार काफी ज्ञानवर्धक है। इससे उड़ीसा में गत वर्षों में नवीकरणीय ऊर्जा के क्षेत्र में हुए कार्यों के विषय में अच्छी जानकारी मिली। यह प्रसन्नता की बात है कि नवीन और नवीकरणीय ऊर्जा मंत्रालय ने प्रधानमंत्री श्री नरेन्द्र मोदी के स्वच्छ एवं हरित ऊर्जा के स्वप्न को साकार करने के लिए कई

महत्वपूर्ण कदम उठाए हैं। उत्तराखण्ड में सूर्यमित्र कौशल विकास कार्यक्रम भी महत्वपूर्ण है ताकि उद्यमशीलता कौशलों एवं आत्मनिर्भरता के साथ स्थानीय युवाओं को सशक्त बनाया जा सके।

राधामोहन उनियाल,

पौढ़ी गढ़वाल, उत्तराखण्ड

I read the December 2016 issue of *Akshay Urja* magazine. The article on conversion of biomass to ethanol is very interesting. The results provided by the authors demonstrated that most of the surplus rice straw, which is wasted currently, could serve as a source of renewable energy generation in the form of ethanol and methane-rich biogas. The article on the timeline and future of solar cells (year-wise innovations and developments) gives good information on solar cells. It would be pertinent to say that PV/solar technology shows no signs of slowing down. There is a huge opportunity for technological advancement in nanotechnology-based thin-film solar cell modules. Improvements and innovations are needed for further market scale-up.

Preeti R Sanyal

Darjeeling, West Bengal

दिसम्बर 2016 अंक में प्रकाशित लेख

‘माराकेश, मोरक्को, कॉप की कार्रवाई’ पढ़कर इस बात का आभास हुआ कि कॉप 22 जैसे महत्वपूर्ण अंतरराष्ट्रीय सम्मेलनों के आयोजन से विश्व, जलवायु परिवर्तन के मुद्दे पर संयुक्त रूप से एकमत एवं एकजुट हो सकता है। इसी अंक में प्रकाशित लेख ‘इथेनॉल के लिए बायोमास का रूपांतरण’ भी पढ़ने में अच्छा लगा। लेखक कहते हैं कि वर्तमान परिणामों में प्रदर्शित हुआ है कि अधिकांश अतिरिक्त चावल की भूसी, जो बर्बाद की जाती थी, इससे इथेनॉल और मीथेन से

भरपूर बायोगैस के रूप में ऊर्जा उत्पादन का एक अच्छा स्रोत मिल सकता है।

अजय कुमार गहलोत,

फरीदाबाद, दिल्ली एनसीआर

The Cover Story 'Vibrant Winds Blowing Across India' published in the December 2016 issue of *Akshay Urja* highlights the new developments in the wind energy sector in the country. It is heartening to note that wind power penetration in the overall electrical energy mix is increasing with each installation of wind turbine. I also read in the highlights of another article 'A New Dawn in Renewable Energy Sector in India' that India has attained 4th position in global wind power installed capacity. The 'Surya Mitra' mobile app is also a very nice initiative by the Ministry (NISE). All the articles and news items published in this issue are quite informative not only for people working in the energy sector, but also for the general readers who want to know about developments in renewable energy in the country.

Ashish M Raghuveer

Bengaluru, Karnataka



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

Editor, Akshay Urja



From the Editor's Desk

Dear Readers,

I am delighted to share with you that The Government has approved the enhancement of capacity from 20,000 MW to 40,000 MW of the Scheme for Development of Solar Parks and Ultra Mega Solar Power Projects. The enhanced capacity would ensure setting up of at least 50 solar parks each with a capacity of 500 MW and above in various parts of the country. This capacity enhancement of solar parks is due to the success of the implementation of the earlier capacity of 20,000 MW solar parks. The cost of the solar electricity generation has reached to the level of Rs 3.30 per kWh and now it seems that the days are not far away when the grid parity of solar power will be achieved.

Significantly, Mobile App for Solar Rooftop Systems: 'ARUN—Atal Rooftop Solar User Navigator' was launched by Shri Rajeev Kapoor, Secretary, MNRE, on the occasion of the National Review Meeting of RE Sector with the State Governments on January 24, 2017 in New Delhi. The app gives basic knowledge about the installation of solar rooftop in your house/premises. It is a brief guide on how to install the solar rooftop system. Also, it will give an estimate of installation based on different parameters, such as capacity or budget. I am sure that this new app launched by the Ministry would be very helpful for all the stakeholders.

The current issue presents an article on solar cables and connectors. Wiring for solar panels is a very critical component of solar PV technology and cable management is one of the most important aspects of the safety and longevity of nearly every PV system. This is primarily due to the extensive use of exposed cables used in the DC PV array. Since the equipment is installed outdoors on

rooftops and in open fields, the electrical conductors must be rated for sunlight resistance and be supported and secured properly. We have also presented another article on the various applications of geothermal energy while highlighting its prospects in India. While there are some obvious advantages and disadvantages, geothermal energy has the potential to play a significant role in moving India towards a cleaner, more sustainable energy system.

The present issue also focusses on a case study in which we inform you that the Uttarakhand Renewable Energy Development Agency (UREDA) in cooperation with GIZ, India, has developed and implemented a pilot project based on an innovative approach, where a cluster of improved watermills addressed a specific demand for energy for livelihood activities and is owned and operated by a self-help group within the local community. The article presents an overview of the pilot project and recommendation to replicate this model across other districts in Uttarakhand.

I am sure that all the articles and information in the present issue will be useful reading material and you will find it informative and interesting as well. Please do not forget to share your views and suggestions.

Happy reading!

ARUN K TRIPATHI
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RENEWABLE ENERGY NEWS

Solar Park Targets Enhanced to 40,000 MW

The Government of India has approved the enhancement of capacity from 20,000 MW to 40,000 MW of the Scheme for Development of Solar Parks and Ultra Mega Solar Power Projects. The enhanced capacity would ensure setting up of at least 50 solar parks each with a capacity of 500 MW and above in various parts of the country. This capacity enhancement of solar parks is due to the success of the implementation of the earlier capacity of 20,000 MW solar parks.

Smaller parks in Himalayan and other hilly States where contiguous land may be difficult to acquire in view of the difficult terrain, will also be considered under the scheme. The capacity of the solar park scheme has been enhanced after considering the demand for additional solar parks from the States. The Solar Parks and Ultra Mega Solar Power Projects will be set up by 2019–20 with Central Government financial support of ₹8,100 crore. The total capacity when operational will generate 64 billion units of electricity per year which will lead to abatement of around 55 million tonnes of CO₂ per year over its life-cycle. It would also contribute to long-term energy security of the country and promote ecologically sustainable growth by reduction in carbon emissions and carbon footprint, as well as generate large direct and indirect employment opportunities in solar and allied industries, such as glass, metals, heavy industrial equipment, etc. The solar parks will also provide productive use of abundant uncultivable lands which in turn facilitate development of the surrounding areas. ■

Source: <http://pib.nic.in>

Budget 2017 Brings Lower Indirect Levies for Clean Energy Equipment

The Budget has given a boost to renewable energy, announcing another 20,000 MW of solar park development in phase II and a slew of duty reductions on components for fuel cell-based power generating and biogas systems, as well as wind energy equipment. Giving a boost to clean energy programme, the Union Finance Minister Shri Arun Jaitley proposed massive cuts in excise and customs duties on materials used in solar and wind plants, and also announced the second phase of solar park development for 20 GW capacity. Besides, the minister also proposed to feed about 7,000 stations with solar power in the medium term saying that a beginning has already been made in 300 stations and work will be taken up for 2,000 railway stations as part of 1,000 MW solar mission.

Commenting on the budget proposals about renewable energy, Minister of State (IC) for Power, Coal, New & Renewable Energy, and Mines, Shri Piyush Goyal, said that his ministry would soon start auction for another 20 GW of solar parks in the country as announced in the Budget.

The Finance Minister has proposed zero basic customs duty (BCD) on solar tempered glass for use in manufacture of solar cells/panels/modules. At present, BCD on those is 5 per cent. Similarly, he proposed to reduce countervailing duty (CVD) on parts/raw materials for manufacturing of solar tempered glass for use in solar photovoltaic cells/



modules, solar power generating equipment or systems, flat plate solar collector, solar photovoltaic module, and panel for water pumping and other applications, to 6 per cent from the existing 12.5 per cent. The Budget has also proposed to reduce excise duty on these materials to 6 per cent from the existing 12.5 per cent.

It is also proposed to reduce the BCD, CVD, and SAD (Special Additional Duty) of 24 per cent on resin and catalyst for manufacturing of cast components for Wind Operated Energy Generators to 5 per cent. However, it is proposed to levy 6 per cent excise duty on solar tempered glass for use in solar photovoltaic cells/modules, solar power generating equipment or systems, flat plate solar collector, solar photovoltaic module and panel for water pumping and other applications. At present, there is no excise duty on these materials. ■

Source: <http://timesofindia.indiatimes.com/>

₹600 Crore Allocated for 'Grid Connected Rooftop and Small Solar Power Plants Programme'

An amount of ₹600 crore has been allocated for the projects under 'Grid Connected Rooftop and Small Solar power Plants Programme' and ₹508.84 crore has been released till January 31, 2017. This was stated by Shri Piyush Goyal, Minister of State (IC) for Power, Coal, New & Renewable Energy and Mines in a written reply to a question in Lok Sabha.

The Ministry of New and Renewable Energy (MNRE) has been promoting 'Grid Connected Rooftop and Small Solar Power Plants Programme' with a Central Financial Assistance (CFA) of

up to 30 per cent of benchmark cost in General category States and up to 70 per cent in Special Category States, North Eastern States, Lakshadweep, and Andaman & Nicobar Islands. Residential, Institutional, and Social sector are covered under this CFA pattern. For Government Sector, achievement linked incentive up to ₹18,750/kWp in General Category States and ₹45,000/kWp in Special Category States, North Eastern States, and Andaman & Nicobar Islands and Lakshadweep is available under the Programme. ■

Source: <http://pib.nic.in/>



Powerlooms will Get Subsidy for Shift to Solar Mode

The Government has approved a new scheme to provide financial assistance in the form of capital subsidy to small powerloom units for



installation of solar photovoltaic (SPV) plants. The scheme aims to alleviate the problem of power cuts faced by the decentralized powerloom units in the country. The funds requirement for the three years (2017–18, 2018–19, and 2019–2020) would be 19.95 crore covering 480 powerloom units. The subsidy is expected to make power cost economical for the looms and make the units self-sufficient on the power front while the government can supply grid power to other industries. ■

<http://energy.economictimes.indiatimes.com>

Engineering Students in Kolkata Create Device for 24x7 Solar Power

While battery manufacturers and solar power companies are struggling to develop batteries that would be cheap, smaller in size, and can store power for days, an engineering college in Kolkata has devised a combo of solar-based generation and power storage system that can supply power perpetually 24 hours a day all through the year at a fraction of conventional battery cost. It is scalable to any size and is suited for any hilly area as well as multi-storeyed buildings. A 100 kW pilot project is already being

planned in the hills of the eastern states of India, while its smaller version, producing 100 W of power 24x7, is now running in Kolkata on a four-storeyed building. "The system is hugely scalable. It can be set up on a building that can generate 100 W or more throughout the day to even a few megawatts at fraction of battery costs," said Shri S P Gon Choudhury, Chairman of Renewable Energy College in Kolkata.

The system consists of a solar pump—basically solar modules that would generate power during day and run a water pump. It also consists of two water tanks at two different

elevations. The upper tanks would release water at half the speed at which it receives water from the lower pump. The falling water would rotate a turbine—an equipment that generates electricity when rotated by an external force—falling stream of water from the elevated tank in this case. During day, water from the lower tank would be pumped to the upper tank. A portion of this water also flows down simultaneously into the lower tank generating power. The rest of the water in the elevated tank keeps flowing down during night, thus producing power the entire day. ■

Source: <http://energy.economictimes.indiatimes.com/>



Haryana Signs MoU for Setting up of 100 MW Solar Power Projects

The Haryana Government has signed a Memorandum of Understanding (MOU) with a leading company Prestige Ocean Holding and Investments Limited for the setting up of 100 MW solar power projects in the State with an investment of ₹500 crore.

Haryana Principal Secretary, New and Renewable Energy Department, Shri Ankur Gupta signed the agreement on behalf of the Haryana Government while Managing Director, Danny Cheng signed the agreement on behalf of Prestige Ocean Holding and Investments Limited. Speaking on this occasion, Danny Cheng said that in the first phase, 100 MW power plant would be set up in the State which would also generate employment opportunities for about 400–500 youth.

He said that the work for setting up of project would be completed within 15 months after the allotment of land for the same. In the second phase, the company has a plan to start the manufacturing of solar panel, solar fan, and other solar equipments for which there would be a requirement of 1,600 acres of land. The Haryana Government had announced its Solar Power Policy-2016 in early 2016. The policy aims at creating conducive atmosphere for the investors to invest in the state in the solar energy sector and envisaged to add 4,000 MW of solar power by 2022. 📌

Source: <http://www.dailypioneer.com/>



Hon'ble President of India Inaugurates Solar Power Project in Rashtrapati Bhawan

The Hon'ble President of India Shri Pranab Mukherjee has inaugurated the first phase of a solar power project in the President's Estate that would generate 670 kW electricity for the sprawling premises. Under the project, seven rooftop solar panels have been installed with an investment of ₹2.23 crore on separate buildings in the President's Estate in a record time period of four months. "This is the future order which we are establishing today. It is a pleasant occasion for me to be the part of this initiative aimed at generating solar power," Mukherjee said. "We must conserve energy so that the needy get their share of power. Whenever there is need for development, energy is required and if a section does not get energy, it remains backward. Electricity must be conserved and utilized in proportion of the requirement so that it could also be provided to the needy." "India has signed Paris Climate agreement to limit the use of fossil fuels and carbon emission. Replacing fossil fuels with renewable energy is the need of the hour. We have enough quantity of solar energy which must be utilized. Renewable energy is good for our climate as it reduces carbon footprints. This will make the President's Estate more energy efficient." Mukherjee said. The solar panels have been installed on the roof of seven buildings which



include market area, sewage treatment plant, museum, Dr Rajendra Prasad Sarvodaya Vidyalaya, motor garage, and cultural centre. Around nine lakh unit of electricity would be generated from this green project. There is a system which enables 24/7 monitoring of the quantity of electricity generated from the solar panels. 📌

Source: <http://indianexpress.com/>

₹300 Crore Invested in Andhra Pradesh for Renewable Energy

Gamesa India, a renewable energy company, has inaugurated its Greenfield integrated manufacturing facility at Nellore, Andhra Pradesh. The company invested around ₹300 crore in the facility. The plant was inaugurated by Chief Minister of Andhra Pradesh Shri N Chandrababu Naidu. This is Gamesa's largest facility in India and forms a part of Gamesa's 100 million euro investment plan for India as announced in 2014.



The plant's phase-1 work, which included setting up of the integrated blade manufacturing facility for the G114-2.0 MW wind turbine, was completed in a record time of six months. Phase 2, which is stipulated to conclude in mid-2017 is underway, will see the manufacturing of turbine blades, generator, and other component assemblies for wind turbines and solar inverters. An integrated plant, the new manufacturing facility will spawn the growth of several ancillary industries in the state. Currently, the plant employs close to 500 personnel and will employ about 1,000 people in the next three years, said the company. "With the inauguration of the Nellore facility, one of the largest for the company in the world, Gamesa India will be integrated even more strongly to cater to the growing energy demands of the country. Achieving this milestone will ensure further expansion of clean energy footprint in India," said Jose Antonio Cortajarena, chief corporate-general secretary, Gamesa. ■

Source: <http://www.business-standard.com/>

Solar Power Lights up Indian Warship

For the first time in the country, solar panels have been installed on an Indian warship. The survey class vessel INS Sarvekshak, attached with the southern naval command, has been fitted with 18 sheets of solar panels atop its hangar. "It took about six months to put the entire system in place. We are now using solar energy for lights and a couple of air conditioners," said Captain Rajesh Bargoti, commanding officer of the ship. The 300-W panels generate about 5.4 kW power.

Bargoti said one of the challenges faced by the project was that marine

environments were not suitable for normal solar panels, as saline and humid surroundings would damage it. "Also, the wind speed can affect the panels, which may get uprooted while at sea. So, we had to look at flexible panels that had anti-rust properties, were marine compatible, could withstand high wind speeds, perform on flat installations and had very low weight," he explained.

"We have 10 batteries which are used for storage. So, we have been using only solar power for the purpose of lighting during sail. When we are anchored, we use power supplied



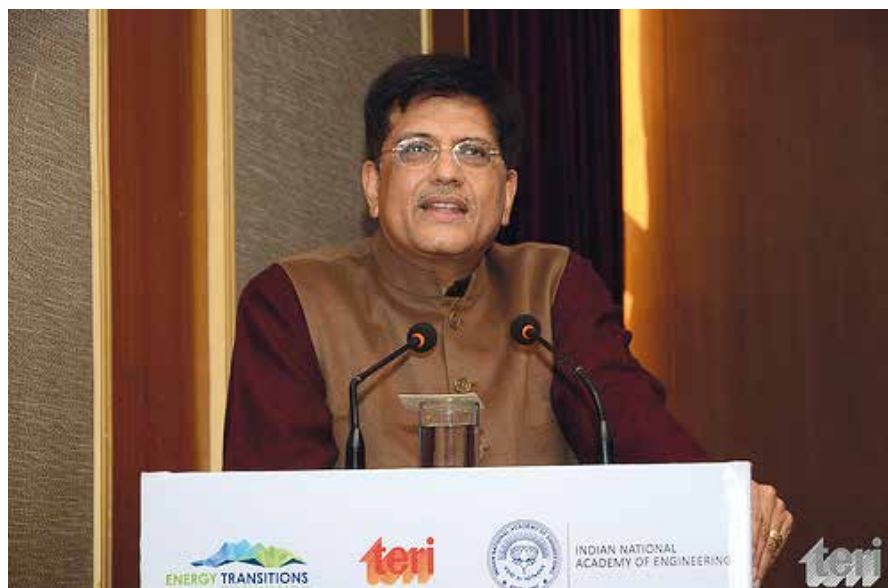
by the state electricity board and not diesel," said electrical engineer Commander Sreejith Thampi. ■

Source: <http://timesofindia.indiatimes.com/>



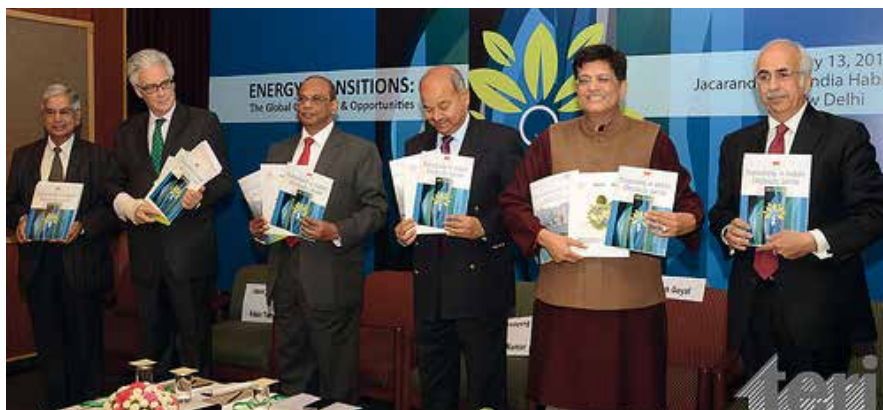
Conference on 'Energy Transitions—The Global Challenges & Opportunities' organized by TERI

The Energy and Resources Institute (TERI) unveiled the findings of its study report 'Transitions in the Indian Energy Sector—Macro Level Analysis of Demand and Supply Side Options' on January 13, 2017. This report was released alongside two others—one by the Electricity Transitions Commission (ETC), and the other by the Indian National Academy of Engineering (INAE). The reports were released by Shri Piyush Goyal, Minister of State (I/C) for Power, Coal, New and Renewable Energy and Mines, Government of India, as part of a day-long conference organized by TERI on Energy Transitions. The TERI report indicates that current installed capacity and the capacity under construction would be able to meet demand till about 2026, keeping India power sufficient. The report estimates that no new investments are likely to be made in coal-based power generation in the years prior to that. The TERI report also estimates that beyond 2023–24, new power generation capacity could be all renewables, based on cost competitiveness of renewables as well as the ability of the grid to absorb large amounts of renewable energy together with battery-based balancing power. Speaking at the event, Shri Piyush Goyal, said, "Universal access to electricity is one of the primary



aims of the Government, and meeting demand is a major facet of this initiative. We see India becoming the energy capital of the world. India is also committed to lowering the emissions intensity of its development in line with our INDCs towards the Paris Agreement. We are looking at several initiatives towards making solar energy price competitive to coal." Speaking on the occasion, Dr Ajay Mathur, Director General, TERI, said "The target to achieve the United Nations Framework Convention on Climate Change (UNFCCC) commitments presents tremendous opportunity to put India at the forefront of economies transitioning towards low carbon growth. This includes improving electricity access, clean technology development, manufacturing, and

job creation. Our report shows that the cost of renewable electricity and its storage is on a steady decline and could stabilize at around ₹5 per KWh. This would enable India to move decisively towards renewables for future generation. What this, means is that India has a ten-year window where no new investments are likely to be done in coal, gas, or nuclear energy generation. The decarbonization of power generation is also an opportunity to move other carbon-based sectors like transport to electricity, thus multiplying the benefits of clean energy generation." TERI's demand scenario suggests that the current installed capacity and the capacity under construction and after taking into account retirements, would be able to meet the demand till about 2026 or so. This suggests that there would be no new coal-based capacity investment that would be approved till about for years prior to that. Between 2014 and 2024, India has a 10-year window. If in this 10-year window, the price of solar and battery reaches the ₹5/ unit mark, all new capacity additions would be in renewables. In case, this price goal would be achieved, or nearly achieved, by 2023–24, if appropriate infrastructure to absorb large amounts of renewable energy, together with battery-based balancing power, is in place. ■



US Solar Smashes Records with 95 Per Cent Growth

The United States solar market nearly doubled in 2016, topping out at 14,625 MW of new solar installed. According to the latest report from GreenTech Media and the Solar Electric Industry Association (SEIA), the US is now home to more than 1.3 million solar PV installations with a capacity of over 40 GW. That's enough to power 8.3 million households—which would light up every home in New York City.

Even at a \$22.8 billion valuation, the American solar sector is relatively small—but it is also strong. Solar's average annual growth over the past decade has been 68 per cent and the industry fuels an economic engine that employs more than 260,000 Americans across 9,000 solar businesses. Although top solar states still lead by a landslide in total capacity installed, they have paved the way for new markets with a record of 22 states that have added more than 100 MW of capacity in 2016. Not only is solar generation more evenly spread across the country, new installations are outpacing all other sources of electricity. For the first time ever, solar ranked as the number one source of new electric generating capacity in the US and accounted for 39 per cent of new capacity additions across all fuel types. 🇺🇸

Source: <https://www.terrasmart.com/u-s-solar-smi-preview/>



Lightweight Rotor Blades Developed for Offshore Wind Turbines

Offshore wind turbines are becoming ever larger, and the transportation, installation, disassembly, and disposal of their gigantic rotor blades are presenting operators with new challenges. Fraunhofer researchers have partnered with industry experts to develop highly durable thermoplastic foams and composites that make the blades lighter and recyclable. Thanks to their special properties, the new materials are also suitable for other lightweight structures, for instance in the automotive sector. The trend towards ever larger offshore wind farms continues unabated. Wind turbines with rotor blades measuring up to 80 m in length and a rotor diameter of over 160 m are designed to maximize energy yields. Since the length of the blades is limited by their weight, it is essential to develop lightweight systems with high material strength. The lower weight makes the wind turbines easier to assemble and disassemble, and also improves their stability at sea. 🇩🇪

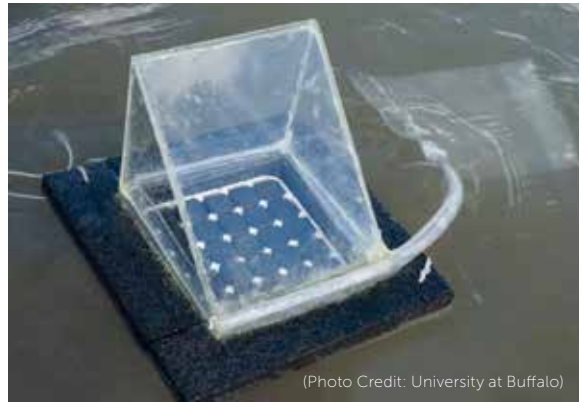
Source: www.sciencedaily.com



Academics Build Ultimate Solar-Powered Water Purifier

Academics at the University at Buffalo School of Engineering and Applied Sciences have added a third element—carbon-dipped paper—that could turn into a highly efficient and inexpensive way to turn saltwater and contaminated water into potable water for personal use. The idea, which could help address global drinking water shortages, especially in developing areas and regions affected by natural disasters, has been described in a study published online today in the journal *Global Challenges*.

"Using extremely low-cost materials, we have been able to create a system that makes near maximum use of the solar energy during evaporation. At the same time, we are minimizing the amount of heat loss during this process," says lead researcher Qiaoqiang Gan, PhD, associate professor of electrical engineering in the University at Buffalo School of Engineering and Applied Sciences. To conduct the research, the team built a small-scale solar still. The device, which they call a 'solar vapour generator', cleans or desalinates water by using the heat converted from sunlight. Here's how it works: The sun evaporates the water. During this process, salt, bacteria or other unwanted elements are left behind as the liquid moves into a gaseous state. The water vapour then cools and returns to a liquid state, where it is collected in a separate container without the salt or contaminants. Based upon test results, researchers believe the still is capable of producing 3–10 litres of water per day, which is an improvement over most commercial solar stills of similar size that produce 1–5 litres per day. 🇺🇸



(Photo Credit: University at Buffalo)

Source: www.sciencedaily.com

Germany Gets One-Third of Electricity from Renewables in 2016

In another shining example of renewable energy leadership, in 2016, Germany used more renewable electricity than ever before, receiving 32 per cent of the gross amount of electricity consumed in the country from sun, wind, and other renewable sources.

The Centre for Solar Energy and Hydrogen Research Baden-Württemberg (ZSW) and the German Association of Energy and Water Industries (BDEW) arrived at this figure in an initial estimate in late 2016. If the projections are correct, more than 191 billion kWh of electricity will have been generated from renewables in 2016. This would mark an increase from the previous year during which the country consumed slightly more than 187 billion kWh, which is 31.5 per cent of the gross amount of electricity consumed that year. The federal government's energy targets call for renewables' share in gross electricity consumption to arrive at 35 per cent by 2020 and the country is clearly on track to achieve that goal.

Stefan Kapferer, Chairman of BDEW's General Executive Management Board said that while the growing share of renewables in the mix is positive, the country still needs conventional sources of power to back up the ongoing conversion of the country's energy supply. He also stated that the grid expansion is necessary. 🇩🇪

Source: <http://www.renewableenergyworld.com/>



Solar Energy Powers Pacemakers

The first real-life study to provide data on the potential of powering medical implants with solar cells has been done by some Swiss researchers. The notion of using solar cells placed under the skin to continuously recharge implanted electronic medical devices is a viable one. Swiss researchers have done the math and found that a 3.6 sq. cm solar cell is all that is needed to generate enough power during winter and summer to power a typical pacemaker. The study is the first to provide real-life data about the potential of using solar cells to power devices, such as pacemakers and deep brain stimulators. According to lead author Lukas Bereuter of Bern University Hospital and the University of Bern in Switzerland, wearing power-generating solar cells under the skin will save patients the discomfort of having to continuously undergo procedures to change the batteries of such life-saving devices. The findings are set out in Springer's journal *Annals of Biomedical Engineering*.

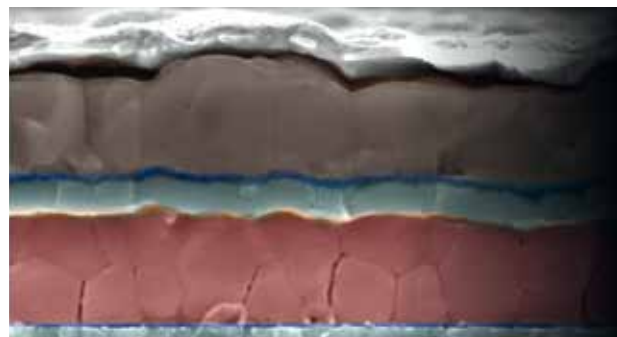
Various research groups have recently put forward prototypes of small electronic solar cells that can be carried under the skin and can be used to recharge medical devices. The solar cells convert the light from the sun that penetrates the skin surface into energy. To investigate the real-life feasibility of such rechargeable energy generators, Bereuter and his colleagues developed specially designed solar measurement devices that can measure the output power being generated. The cells were only 3.6 sq cm in size, making them small enough to be implanted if needed. For the test, each of the 10 devices was covered by optical filters to simulate how properties of the skin would influence how well the sun penetrates the skin. The tiny cells were always found to generate much more than the 5–10 microwatts of power that a typical cardiac pacemaker uses. The participant with the lowest power output still obtained 12 microwatts on average. 📌

Source: www.sciencedaily.com



High-Efficiency Solar Cells Created

Researchers from Stanford and Oxford using tin and other abundant elements have created novel forms of perovskite solar cells—a photovoltaic crystalline material that is thinner, more flexible and easier to manufacture than silicon crystals. "Perovskite semiconductors have shown great promise for making high-efficiency solar cells at low cost," said study co-author Michael McGehee, a professor of materials science and engineering at Stanford. "We have designed a robust, all-perovskite device that converts sunlight into electricity with an efficiency of 20.3 per cent, a rate comparable to silicon solar cells on the market today." The new device consists of two perovskite solar cells stacked in tandem. Each cell is printed on glass, but the same technology could be used to print the cells on plastic.



Previous studies showed that adding a layer of perovskite can improve the efficiency of silicon solar cells. But a tandem device consisting of two all-perovskite cells would be cheaper and less energy-intensive to build, the authors said. A typical perovskite cell harvests photons from the visible part of the solar spectrum. Higher-energy photons can cause electrons in the perovskite crystal to jump across an 'energy gap' and create an electric current. A solar cell with a small energy gap can absorb most photons but produces a very low voltage. A cell with a larger energy gap generates a higher voltage, but lower-energy photons pass right through it.

An efficient tandem device would consist of two ideally matched cells, said co-lead author Giles Eperon, an Oxford postdoctoral scholar currently at the University of Washington. "The cell with the larger energy gap would absorb higher-energy photons and generate an additional voltage," Eperon said. The smaller gap has proven to be the bigger challenge for scientists. Working together, Eperon and Leijtens used a unique combination of tin, lead, cesium, iodine, and organic materials to create an efficient cell with a small energy gap. The successful result was a tandem device consisting of two perovskite cells with a combined efficiency of 20.3 per cent. 📌

Source: www.sciencedaily.com

NATIONAL REVIEW OF RE SECTOR



The Ministry of New and Renewable Energy (MNRE) organized a two-day National Review Meeting with the State Government officials of Renewable Energy sector on January 23–24, 2017. Mobile App for Solar Rooftop Systems: ‘ARUN—Atal Rooftop Solar User Navigator’ and Information Guide on Rooftop Systems were also launched on the occasion of the National Review Meeting of the RE Sector with the State Governments.

Speaking at the review meeting, Shri Rajeev Kapoor, Secretary, MNRE emphasized on the need to comply with Renewable Purchase Obligations (RPOs) and facilitate the renewable energy installations through conducive policies and timely payments for RE power purchased. He also urged upon the States to see the

RE power in the backdrop of India’s commitment of raising 40 per cent of electric installed capacity from non-fossil fuel by 2030 under intended nationally determined contributions (INDCs). It was observed that in general the compliance of RPOs needs to be ensured. The Secretary urged upon the States to formulate and modify their policies and prepare a conducive policy regime for RE.

Shri Rajeev Kapoor gave away awards in Off-grid Solar PV Programme in 12 categories namely Solar Lantern, Solar Home Lighting Systems, Solar Power Packs, Solar Street Light, Solar Power Plant, Solar Pumps (Irrigation), Solar Mini/Micro Grid, Solar Pumps (Drinking), Bank Scheme—Solar Home Systems, Bank Scheme—Solar Pumps, Cold Storage and R O Systems. Secretary,

MNRE also presented the Annual Day Awards of Association of Renewable Energy Agencies of States (AREAS) to various State Nodal Agencies for best performance in different sectors of renewable energy during 2015–16.

The progress of each State was reviewed, the next financial year plans were discussed, and the issues raised by the States were deliberated upon in detail and efforts were made to find their solutions in this review meeting. Presentations were made by the senior officers of the Ministry on each Programme and the State-wise issues were flagged.

State Power/Energy Secretaries in charge of Renewable Energy, Heads of State Nodal Agencies, and other concerned senior officials of States attended the Review Meeting. Senior officers of MNRE, CERC, NTPC, IREDA,

SECI, NISE, NIWE, NIBE, etc., also participated in the meeting.

⚡ Mobile App for Solar Rooftop—'ARUN' Launched

Mobile App for Solar Rooftop Systems: 'ARUN—Atal Rooftop Solar User Navigator' was launched by Shri Rajeev Kapoor, Secretary, MNRE, on the occasion of the National Review Meeting of RE Sector with the State Governments on January 24, 2017 at India Habitat Centre, New Delhi. The function was attended by all State Power Principal Secretaries/ Secretaries, Heads of all State Nodal Agencies, PSUs, Channel Partners, MNRE officials, etc.

The Government of India has fixed an ambitious target of 40,000MW from rooftop solar by 2022. In order to achieve this target MNRE has undertaken activities, such as promotion of solar power, training, empanelment of agencies, sanction of projects, monitoring of the project, subsidy disbursement, etc. To manage and monitor the installation of solar rooftop system an online portal called SPIN has been designed and developed by the National Informatics Centre (NIC), MNRE. This portal can be accessed by: www.solarrooftop.gov.in. Around 1,200 agencies were empanelled online by MNRE using this portal. The data related to the installations have already started to enter in SPIN. Based on the coordinates of installation,



➤ Shri Rajeev Kapoor, Secretary, MNRE, launching the 'ARUN' app

geo-tagging has also been done with the help of ISRO. As of now, around 1,500 plus users are using this portal.

In today's fast paced world, phones are not just used for calling, or sending text messages, etc., but with smartphones we can schedule our complete day, check emails, make conference calls, connect using social network, and perform a host of other activities. Hence, the proposal of a mobile app for promoting and installation of solar rooftop power system came to NIC. NIC has designed and developed a simple but informative and useful application for the layman as well as the developers of solar power. Initially android version of the app has been developed. The app has been named 'ARUN—Atal Rooftop solar User Navigator' and it has the following features:

- **Basics:** Basic knowledge about the installation of solar rooftop in your house/ premise.
- **Guidelines:** Brief guide for how to install the solar rooftop system.
- **Rooftop Solar Calculator:** It will give an estimate of installation based on different parameters, such as capacity or budget.
- **How to install:** Here you are submitting the interest request to MNRE and the MNRE-approved agencies will contact you for further help.

- **Schemes and Policies:** Here you can view the policies and schemes of the state of your choice.
- **List of SNAs and Agencies:** You can view the MNRE-approved agencies of the state of your choice.
- **FAQs:** Frequently Asked Questions clear almost all doubts about solar rooftop installation.
- **Feedback:** You can send your request/feedback to MNRE.

ARUN was designed and developed by National Informatics Centre, Ministry of New and Renewable Energy by Shri Saji K Abraham, TD NIC under the leadership of Shri Deep Bansal, TD & HOD Renewable Energy Informatics Division guided by Shri G K Gaur, DDG and HOG, NIC.

The app is deployed in Google Play stores and can be downloaded free of cost from the following link: <https://play.google.com/store/apps/details?id=nicmnre.nicpvapplication&hl=en>

It is a simple mobile app which is very easy to handle and understand. It is very useful for understanding the basics about solar rooftop and the methods of installation. The app provides a clear picture regarding the different schemes and policies, and is frequently updated. **AU**

BIOGAS UPGRADATION BY VACUUM SWING ADSORPTION

Exploring a Clean Energy Reserve

B Velmurugan, Mehul Patel, and Lalit P Patel highlight the potential for waste to energy through a case study of **M/s Sabar Dairy**, which has been utilizing natural gas for its thermal applications in its day-to-day milk-processing operations. Among these upgrading technologies, a suitable site-specific technology working at low pressure, called 'vacuum swing adsorption' (VSA) has been identified for installation at M/s Sabar Dairy.

There is a rapid growth in use of renewable energy globally, especially biogas. Biogas is produced in anaerobic conditions, that is, in the absence of oxygen by fermentation of organic substrates, including manure, sewerage, household waste, industrial wastewater, etc. Biogas mainly contains methane and carbon dioxide and traces of hydrogen sulphide, ammonia, hydrogen, and moisture. Biogas calorific value is around 21 MJ/m³, which contains methane and can be used as cooking fuel in domestic kitchen or industrial canteen. If biogas is to be used as a substitute to natural gas, it needs to be cleaned and upgraded to the quality equivalent of methane in pipeline. One of the hot

topics in bioenergy industries is the upgradation technology of biogas to biomethane due to rise in price of oil and natural gas. The biogas cleaning and upgradation process increases the calorific value and removes the undesirable gases, such as hydrogen sulphide, carbon dioxide, and moisture, which will be more harmful to the system to be utilized.

Sabarkantha District Co-operative Milk Producers' Union Limited (Sabar Dairy), Himmatnagar, Gujarat, has been utilizing natural gas for its thermal applications in its day-to-day milk-processing operations. M/s Sabar Dairy processes around 20 lakh litres of milk per day and the raw effluent generated from the milk-processing plant is treated in its effluent treatment

plant. Equalized effluent containing chemical oxygen demand (COD) of 5,000–10,000 mg/L (depending upon the season and product processed) is pumped into a high-rate anaerobic reactor, that is, an up-flow anaerobic sludge blanket reactor to produce biogas and subsequently 70–80 per cent COD has been reduced due to anaerobic treatment. Since the biogas produced have the potential to replace a part of its natural gas utilization in boilers and canteen for cooking after upgradation and also reduce its cost of expenditure on natural gas, M/s Sabar Dairy sought help from M/s Gujarat Knowledge Application and Facilitation Centre (A centre of excellence by CII, Government of Gujarat and Gujarat

NRE), Ahmedabad, for implementing a suitable biogas upgradation technology. As a technical network partner to Gujarat Knowledge Application and Facilitation Centre, Sardar Patel Renewable Energy Research Institute (SPRERI), Vallabh Vidyanagar, Gujarat, has been approached for technical guidance to erect and commission a biogas purification plant at M/s Sabar Dairy.

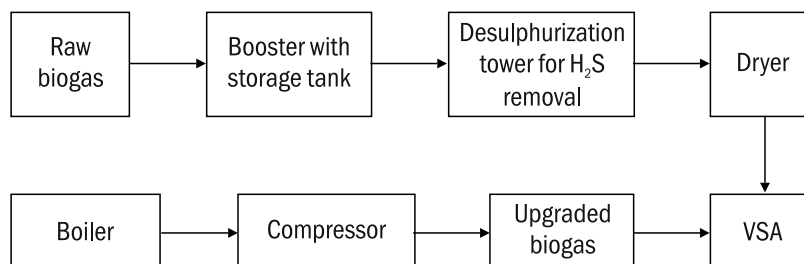
⚡ Necessity for Upgradation of Biogas

Around 100 m³/h of biogas with methane (CH₄), 60–65 per cent; carbon dioxide (CO₂), 30–35 per cent; and hydrogen sulphide (H₂S), 2000–2500 ppm was produced from high rate anaerobic digester at M/s Sabar Dairy. As a value addition and to reduce greenhouse gas emissions, the biogas produced has been upgraded to biomethane (equivalent to natural gas) and is being utilized in the existing boiler and canteen as a substitute fuel to natural gas. Removal of CO₂ from biogas enhances the calorific value closer to the range of natural gas, which is nothing but CH₄, that is, natural gas. There are various options available to upgrade biogas by removing carbon dioxide, such as adsorption, absorption, cryogenic, membrane, etc. Among these upgrading technologies, a suitable site-specific technology working at low pressure, namely 'vacuum swing adsorption' (VSA) has been identified for installation at M/s Sabar Dairy. The main advantage of the VSA process is that adsorption of carbon dioxide takes place at low pressure and reduces higher compression requirement of biogas feeding and desorption at vacuum, which completely evacuates the carbon dioxide from the adsorbents and quicker regeneration for the next cycle of operation. Hence, setting up of a biogas purification plant has helped M/s Sabar Dairy to replace the natural gas utilization in their existing boilers or canteen for cooking

without any change in their existing infrastructure.

⚡ The Process

Cleaning and upgradation of biogas is very important to get a natural gas equivalent fuel. Cleaning of biogas involves removal of hydrogen sulphide, water vapour, and upgradation for complete removal of carbon dioxide, which enhances calorific value of biogas nearer to natural gas. A 100 m³/h low-pressure VSA technology has been deployed for purification of biogas at Sabar Dairy. Schematic arrangement of VSA-based biogas purification plant has been shown in Figure 1.



⚡ Figure 1: Schematic arrangement of biogas purification plant

The biogas produced from raw dairy effluent is stored in a biogas storage tank. A blower boosts the biogas up to 0.7 bar pressure from the storage tank and passes through the desulphurization unit, where most of H₂S present in the biogas is removed. Iron oxide is used as the packing material in H₂S scrubber. After passing through the H₂S scrubber, the gases are cooled in a chilling unit to remove the moisture present in the gas. If H₂S is not removed prior to the adsorption process, it will lead to poisoning of the composite bed of adsorbents, and with moisture it forms a corrosive acidic solution in the downstream utilization systems. Hence, cleaning of H₂S and water vapour are very much essential during the biogas purification process. The limits of H₂S tolerance in biogas utilization equipment have been given in Table 1.

Table 1: Hydrogen sulphide tolerance limits in biogas utilization equipment

Utilization	H ₂ S tolerance limit (ppm)
Upgraded biogas	<4
Kitchen stoves	<10
IC Engines	<50–500
Boiler	<1,000
Turbines	<10,000

After cleaning, the biogas is passed through twin towers packed with composite bed of molecular sieves by low-pressure VSA process to separate CH₄ from CO₂. Adsorption of CO₂ on the molecular sieves leads to the CH₄

removal from the top of the tower and by vacuum, leading to evacuation of CO₂. The advantage of twin tower is when one tower performs adsorption, the other one is used for regeneration and the process becomes cyclic and continuous supply of biomethane of natural gas equivalent fuel is collected in a surge vessel and in biomethane storage tank. Then with the help of a compressor, it is sent through pipelines to existing boiler or canteen for cooking purpose.

⚡ Operational Experiences

The performance of VSA-based biogas purification plant has been monitored, since it has become operational from February 2015 to till date, and it has been working without any major maintenance problem.



Picture 1: Pictorial view of VSA-based biogas purification plant

A pictorial view of VSA-based biogas purification plant has been shown in Picture 1. The composition of biogas before and after purification using VSA system has been shown in Table 2.

Table 2: Composition of biogas before and after purification

Parameter	Before purification	After purification
CH ₄ (%)	60–66	90–94
CO ₂ (%)	30–35	4–5
H ₂ S (ppm)	2,000–2,500	1–2

The total amount of purified biogas with 90 per cent methane content for the period of 16 months, that is, from February 2015 to May 2016 has been completely utilized in their existing boiler replacing the same quantity of

natural gas obtained from government sources.

Economics

Due to seasonal variations and depending on the products processed, COD of the effluent varied in a vast range from 5,000 to 10,000 mg/L and that leads to the effect of change in biogas production. On an average, only 23 per cent utilization of the biogas purification plant has been achieved till May 2016 from installation due to varying biogas production and intermediate breakdown in feeding pump to the anaerobic digester. Total purified biogas, that is, natural gas equivalent during the period February 2015 to May 2016 was 2,79,226 m³ and

the total electrical energy consumed was 2,15,188 kWh. Natural gas was purchased at the rate of ₹30/m³, which corresponds to a total savings of ₹8,376,780, by replacing it with the natural gas equivalent purified biogas. The energy requirement and cost of purified biogas per m³ were 0.77 kWh and ₹5.78, respectively. Cost economics of a 100 m³/h VSA-based biogas purification plant installed and commissioned at M/s Sabar Dairy has been shown in Table 3. If the capacity of the VSA-based biogas purification plant was fully utilized, the energy requirement and cost of purified biogas per m³ will be 0.34 kWh and ₹2.53, respectively. Simple payback period for the purification plant with

and without government incentive of 30 per cent of the plant cost will be 2 and 2.8 months, respectively.

Table 3: Economics of a 100 m³/h VSA-based biogas purification plant

Basic parameters	
Number of working days	330
Installation cost of the biogas purification plant (₹)	3,682,450
Biogas inlet flow (330 days @ 66.6% CH ₄) (m ³)	792,000
Total purified biogas (330 days @ 90% CH ₄) (m ³)	586,080
Life of the plant (years)	20
Annual cash outflow (A)	
Maintenance @ 3% of the total cost (₹)	110,474
Personnel (one skilled @ ₹300/d) (₹)	99,000
Electrical energy requirement (kWh)	198,000
Cost of electrical energy (@₹7.50/unit) (₹)	1,485,000
Total (₹) (A)	1,694,474
Annual cash inflow (B)	
Saving in natural gas @ ₹30/m ³	1,7582,400
Total (Rs.) (B)	17,582,400
Net cash flow (₹) {C=(B-A)}	15,887,926
Specific costs	
Energy requirement (kWh/m ³ purified biogas)	0.34
Energy requirement (kWh/ m ³ raw biogas)	0.25
Total cost of purified biogas (₹/m ³)	2.53
Payback period (months)	2.80

The cost and calorific value of 1 m³ of natural gas equivalent purified biogas can replace the following approximate values of fossil fuels, as shown in Table 4.

Table 4: Approximate replacement of fossil fuel with 1 m³ purified biogas

Fossil fuel	Quantity	
	In terms of cost	In terms of calorific value
Coal (imported) (kg)	1	1.30
Log wood (kg)	0.51	2.58
Wood pellets (kg)	0.25	2.20
Fuel oil (L)	0.13	0.98
Diesel oil (L)	0.05	1.20
Gasoline (L)	0.04	1.22
Natural gas (m ³)	0.08	1
LPG (kg)	0.05	0.79



▲ Sabarkantha District Co-operative Milk Producers' Union Limited, Sabar Dairy, Himmatnagar, Gujarat

Conclusion

Upgradation of biogas to biomethane (natural gas equivalent fuel) using VSA technology at a pressure closer to atmospheric pressure is not only a big advantage to use it as a clean source of energy but also more environment friendly compared to the usage of fossil fuels. The case study at M/s Sabar Dairy, Himmatnagar, Gujarat, using VSA-based biogas purification plant for thermal applications has been in operation from February 2015. The plant has demonstrated potential of clean energy reserve available in the form of biomethane, which substitute the fossil fuels and enhance overall economics of milk-processing industries as well as the reduction of greenhouses emissions into the atmosphere. **AU**

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Managing Solar Cables and Connectors

For Safety and Longevity of PV System



Despite being a critical component, wiring for solar panels is rarely discussed. **Khyati Vyas** highlights that cable management is one of the most important aspects of the safety and longevity of nearly every photovoltaic (PV) system. This is primarily due to the extensive use of exposed cables used in the DC PV array. Since the equipment is installed outdoors on rooftops and in open fields, the electrical conductors must be rated for sunlight resistance and be supported and secured properly.

A significant amount of work goes into the complex process of designing and planning a photovoltaic (PV) power plant, whether on the rooftop of a building or ground-mounted on the field. This then translates into an efficient, working PV power plant in situ. With the rapid uptake of PV, it is also common to see homeowners who design and implement their own small PV rooftop projects. With so much already invested, it would be vexing if careless cable management after installation led to losses. And dangling, untidy cables are simply unaesthetic. Cables are subjected to thermal, mechanical, and external loads. Just like the rest of the system, cables need to last the stipulated 25 years or more. Being exposed to harsh environmental conditions like temperature fluctuations and direct ultraviolet (UV) rays can damage unprotected cables and in turn the wires in them that carry the power generated.

Applications

To connect the components of a solar energy system, you will need to use correct wire sizes to ensure low energy loss and to prevent overheating and possible damage or

even fire.

There are four components to connect together: the solar panels, the charge controller, the batteries, and the inverter. The charge controller is used to prevent the batteries from overloading; the wires that connect the panel to the charge controller should be correctly sized to minimize transmission power loss. Correspondingly, the further away the panels are, the larger the wire gauge should be. The inverter is used to convert the DC power collected by the panels into AC power, which is the most popular form of electricity accepted by appliances. These systems are typically outdoors, so any cable used for this type of application needs to be UV radiation resistant and suitable for wet locations. For solar tracking panels, the cables used need to be flexible as the panels will be moving along with the sun. Depending upon the system capacity cabling utility varies as follows:

- **Small-scale systems with string inverters:** A three-core AC cable is used for connection to the grid if a single-phase inverter is used, and a five-core cable is used for three-phase feed-in.
- Large-scale system wiring with central inverters.

- Larger power collector cables are used to interconnect from the generator box referred to as the Main DC and DC combiner to the central inverter. These cables must be shielded when over 50 m in length (IEC62548).

Significance of DC and AC Cables

DC cables are used predominantly in solar projects and hence, issues around their usage are still not understood very well unlike AC cables, which are used extensively across the power sector. Moreover, intense commercial pressure is forcing project developers and contractors to reduce capital cost resulting in the selection of inferior products and/or sub-optimal design.

DC Cable

DC cables connect modules to inverters and are further segmented into two types.

String DC cables

These cables are used to interconnect solar modules and to connect modules with string combiner boxes or an array combiner boxes. Cables for interconnecting modules come pre-connected with modules, whereas the cables required to interconnect strings and to connect with combiner boxes are procured separately. String DC cables carry current of only around 10 Ampere (A) and a small cross section (2.5 mm^2 to 10 mm^2) is sufficient for this purpose.

Main DC cables

These cables are used to connect array combiner boxes with inverters. These cables carry higher current of around 200–600 A in utility scale projects and require a larger cross section (95 mm^2 to 400 mm^2). DC cables, except for those pre-connected with modules, account for only around 2 per cent of solar project





cost, but can have a significant impact on the power output. Improper design and/or poor cable selection can lead to safety hazards, reduced power output, and other performance issues.

Experts believe that power output loss in DC cables can be as high as 15 per cent but it is time consuming and arduous to empirically isolate and quantify the role of DC cables in poor performance. Further, a higher voltage drop typically leads to heating up of cables and fire accidents. Power loss in DC cables is measured in terms of voltage drop from module to inverter. As current in the cables remains the same, voltage drop implies proportionate loss of power.

LT and HT Cables (AC Cables)

LT and HT cables are AC cables with a higher voltage rated capacity. These cables are used to connect inverters to transformer and transformer to the on-site substation. At present, cables of 1,000 V rating are typically used for this purpose but the trend is now shifting towards the use of 1,500 V cables. HT cables are used for power transmission at high voltage from

on-site substation to transmission grid substation. Depending on the project capacity, voltage rating of these cables can range from 11,000 V to 33,000 V. LT and HT cables are widely used in the power sector including both conventional and renewable energy power generation plants. However, DC cables are used primarily in solar projects.

Aluminium is widely used in AC cables, which have a life of over

reaches steady state with minimal thermal stress. Operation in a solar plant is discontinuous because of ever changing irradiation. Figure 1 shows the type of cables used in a solar PV plant.

Cable Specifications

Economically generating electricity from renewable sources requires a cabling system engineered to

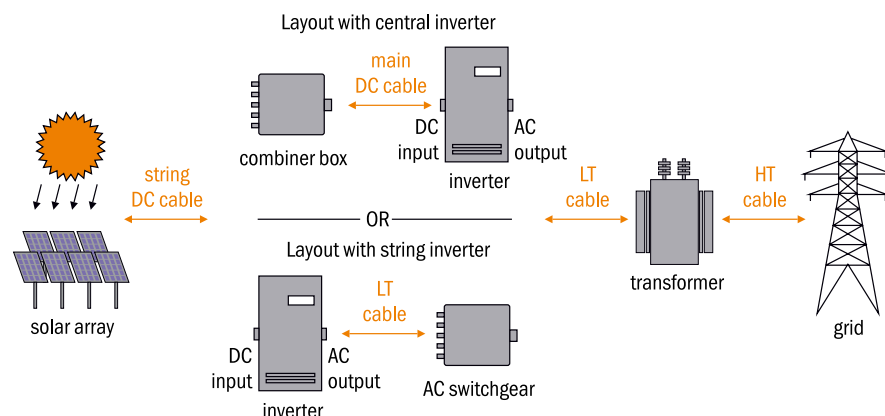


Figure 1: Type of cables used in Solar PV Plant

35 years and have been in wide operation throughout the world. In AC cables, flow of current is usually continuous, whereby the cable

optimize efficiency and minimize line losses. This allows more of the generated power to reach substations where it is transmitted to the grid. To optimize efficiency, cables used at the point of solar power generation offer a higher voltage range of up to 2,000 V versus the standard 600 V rating for conventional applications. Medium-voltage cables used between transformers and substations are being re-engineered to provide better efficiency over the life of the cable through cooler operation and lower line loss.

Solar cables, which are UV and weather resistant and can be used within a large temperature range, are laid outside. Single-core cables with a maximum permissible DC voltage of 1.8 kV and a temperature range from -40°C to $+90^{\circ}\text{C}$ are the norm here. A metal mesh encasing the cables improves shielding and overvoltage protection, and their insulation must not only be able to withstand thermal but also mechanical loads. The



cross-section of the cables should be proportioned such that losses incurred in nominal operation do not exceed 1 per cent. String cables usually have a cross-section of 4–6 mm².

Cables used in solar generation must be designed to withstand long-term exposure to sunlight. To maintain long-term performance and reliability, solar cables have been developed to resistant UV, ozone, and water absorption, as well as provide excellent flexibility for sub-zero conditions and deformation resistance during prolonged exposure at high temperatures. Given the often-extreme installation environments for solar power systems, coupled with the need to save time and ensure reliability, pre-connectorized cable solutions have been developed. Ideal for utility-scale generation systems, these solutions enable fast, easy connections, simplifying installation while removing the inconsistencies associated with field termination. Along those same lines, DC feeder cables for connecting combiner boxes to inverters are now offered as all-in-one metal-clad cables that increase reliability and eliminate the need to install conduit. PV cables are also being engineered in a full array of colours to easily identify source, output, and inverter circuits without the need for time-consuming marking tape or tagging cables.

⚡ Connecting Technology

There was a need to develop connection technology rapidly over the last few years, as inadequate contacting can cause electric arcs. Secure connections are required that will conduct current fault-free for as long as 20 years. The contacts must also show permanently low contact resistance. Since many plug connectors are required in order to cable a PV plant, every single connection should cause as little loss as possible, so that losses do not accumulate. Given the precious nature



of the solar power acquired from the PV plant, as little energy as possible should be lost.

Screw terminals and spring clamp connectors (e.g. in the module junction boxes and for connection to the inverter) are gradually being replaced by special, shock-proof plug connectors, which simplify connection between modules and string cables.

Crimp connection (crimping) has proven itself to be a safe alternative for attaching connectors and bushes to the cables. It is used both in the work carried out by fitters on the roof and in the production of preassembled cables in the factory.

An alternative plug connector design has been developed to allow the connection to be fixed in place without the need for special tools: in this instance, the stripped conductor is fed through the cable gland in the spring-loaded connector. Subsequently, the spring leg is pushed down by thumb until it locks into place. The locked cable gland thus secures the connection permanently.

Plug connectors and sockets with welded cables are also available in the market. Such connections cannot, however, be used during installation work on the roof, but only during

production in the factory.

Another development is preassembled circular connection systems for the AC range. These are intended to reduce the high levels of installation work required when several inverters are used within one plant. Owing to the sharp increase in copper prices, aluminium has recently gained significance as an electrical conductor. It is possible to save around 50 per cent by using aluminium cables, particularly for underground cables at low- and medium-voltage levels. However, their poor conductivity means that they are thicker than copper cables. Careful attention must be paid to the default breakaway torque of their screw connections, as, in comparison to copper, aluminium tends to creep under roofs which are very heavy. If the screw connections are too tight, the cable loosens over time, possibly resulting in an electric arc, not to mention the associated risk of fire and all the consequential damage.

⚡ Standards for Plug Connectors

Since PV modules generally come equipped with preassembled plug connectors, several modules can



easily be connected to form a string. Connecting these strings to the inverter, on the other hand, is not always straightforward. A variety of different cable connectors are available in the market, and as yet no standards have been established for these interconnection systems. Plug connectors from different manufacturers are usually either completely incompatible or they fail to provide a connection that will remain permanently snug. If the connector fits too tightly, this can cause the insulating plastic parts to break. A loose fit, on the other hand, poses the risk of creating high-contact resistance. This leads to yield losses and the areas around the connection heating up, even causing an electric arc and the connector to melt. When connecting a plug with a socket from a different manufacturer, a cross-over connection is created, which can generally only be proved to be reliable if complex, expensive tests are performed. In addition to measuring the contact resistance and determining the connection strength, accelerating aging tests and weather exposure tests must also be carried out. Such tests will make it clear whether or not the different materials are compatible. This concerns both

the metals used to manufacture the contacts and the plastic materials employed. There are currently no cross-over connections which have been tested in accordance with DIN EN 50521 VDE 0126- 3:2009-10: 'Connectors for photovoltaic systems; safety requirements and tests' and approved by both manufacturers (socket manufacturer A combined with plug manufacturer B or socket manufacturer B combined with plug manufacturer A). A standard for photovoltaic plug connectors, which should be as international and uniform as possible and is similar to that for domestic Schuko plugs, is desirable and necessary to ensure reliable connections between products from different manufacturers. If such a standard were to be introduced, manufacturers would be in a position to offer reciprocal warranties for specific cross-over connections.

Market Demand

Despite the promising growth of solar power and related cable developments aimed at ensuring its economic viability, this emerging market is not without challenge. Codes and standards are struggling to keep pace with new technologies

and applications, while a relatively new contractor base is in need of continuous on-going training to stay one step ahead of evolving installation practices. As such, the industry has seen a variety of cable designs and practices, many of which may not necessarily support long-term solar needs. Application-specific cables and contractor certification are paramount to ensuring the economic viability of solar power systems. Cable manufacturers are challenged with balancing up-front costs with long-term reliability while continually meeting evolving requirements and trends, from developing cables for new micro inverter technology where DC power is converted to AC at the panel, to meeting more stringent fire ratings, test methods, UL and CSA standards, National Electric Code requirements, and global standards for halogen-free, fire-retardant, and low-corrosive gas emissions. To meet these advancing trends and standards, develop application-specific cables, and ensure the performance and reliability to support the long-term needs of solar applications, manufacturers must be committed to solar energy with significant investment in R&D efforts and a strong presence in the market through continued participation with standards bodies, utility regulators, and renewable developers. Consumer demand for distributed solar energy systems is rapidly growing, and small-to medium-scale solar photovoltaic (PV) systems are turning up in any location with available space and abundance of sunlight—from rooftops and parking lots, to brown fields and highways. No matter what the size of the system, all PV applications require high-quality cabling that provides excellent mechanical properties and superior sunlight resistance for outdoor installations, flame-resistance for added safety, and flexibility for easy handling. **AU**

Contributed by Er. Khyati Vyas, BE, MTech, Chemtrols Solar Pvt Ltd, Mumbai, India.





Demand Assessment for Mini Grids in Villages of Uttar Pradesh

Onkar Nath says that in order to accelerate access to energy, especially in rural areas, efforts are being made to develop capacity in renewable energy sources, such as solar energy, biomass-based electricity, small hydro, wind energy, etc., in Uttar Pradesh. He presents a demand assessment for villages in the state as the Government of Uttar Pradesh through its nodal agency UPNEDA is making constant efforts to facilitate generation of green and clean energy for the people of the state.





Uttar Pradesh (UP) is one of the largest states in India by area and it is also among the largest states in India in terms of economy, with the state gross domestic product (GDP) of ₹708,000 crore, with the key economic activities based on agriculture and service industries. Despite this, several inequalities exist within the state, with a large proportion of the population, especially in rural areas still lacking access to basic infrastructure services, such as electricity or clean cooking solutions. But, now efforts are being made to develop capacity in renewable energy sources, such as solar energy, biomass-based electricity, small hydro, wind energy, etc., in the state in order to accelerate access to energy, especially in rural areas. The Government of Uttar Pradesh through its nodal agency Uttar Pradesh New and Renewable Energy Development Agency (UPNEDA) is making untiring effort to facilitate generation of green and clean energy for the people of the state.

⚡ Demand Assessment Survey

Under this context, GIZ in cooperation with its state partner UPNEDA has conducted a demand assessment survey in the districts of Kanpur Nagar and Banda. The exercise was carried out under the context of developing a private sector model for attracting large-scale participation of private players for the promotion of mini grids in the state of Uttar Pradesh, India. Five key elements were proposed under the private sector model. These elements are:

- Selection of villages on a cluster-based approach in order to provide economies of scale;
- A reduction in the pre-investments costs towards demand assessment, system sizing, site selection, etc.;
- A reduction in the costs of financial closure through pre-established financial structures/linkages;

- A reduction in the risk of demand uptake through efforts to encourage productive end uses of electricity;
- A reduction in the policy and regulatory risk through appropriate mitigation structures.

The findings of the demand assessment was intended to serve as a base for establishing solar mini-grid pilot projects, which would further be helpful in demonstrating the proof-of-concept for a viable business model of distributed generation in the state of Uttar Pradesh.

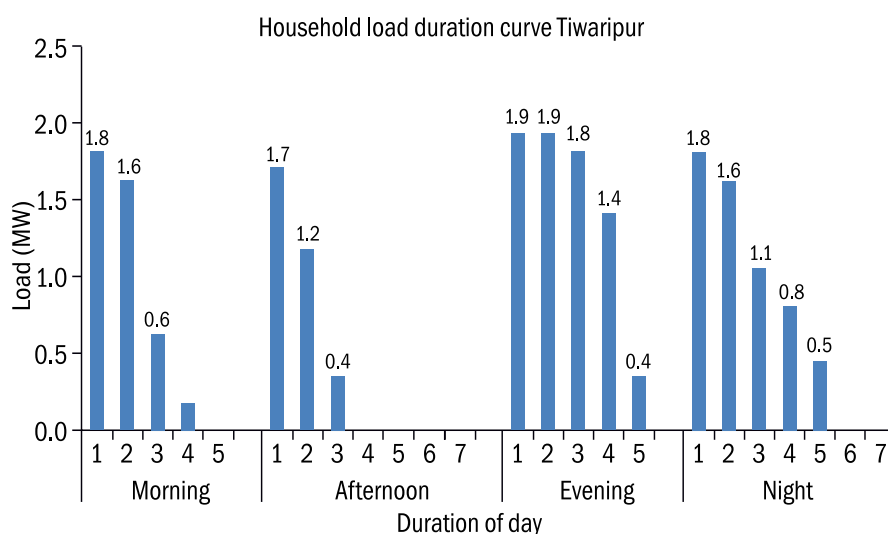
⚡ Data Collection

Fifty un-electrified or de-electrified villages were identified for demand assessment survey in each of the districts (Kanpur Nagar and Banda). A primary survey was carried out to estimate the load demand for three target segments, that is, households, irrigation loads, and commercial/ productive loads. This primary survey

survey covered detailed information related to demographic, socio-economic, and prevailing energy usage.

⚡ Findings

Inter alia, the household surveys captured key information, such as electricity requirement in various intervals of time, preference for electrification options, and income and expenditure patterns. Using these data, load duration curves and load profile curves have been generated for all the villages in the two districts. The average HH energy demand for all villages in Kanpur Nagar and Banda were calculated (65.44 kWh/day and 62.6 kWh/day respectively). Some samples of household load profile, productive load profile, and irrigation load profile have been illustrated in Figure 1. All the load curves generated are found to have peaks in the morning and evening, which is typical



⚡ **Figure 1:** Household load duration curve Tiwaripur

adopted a mix-design approach with both qualitative and quantitative aspects. The quantitative data was captured through household surveys (100 per cent household's survey in a village combined with 10 per cent of the household's survey in the remaining 49 villages) and surveys of commercial and irrigation loads. The

of village load curves. Similar load curves have also been generated for the productive loads using the time of operation provided by their owners in the survey response (Figure 2). With regards to irrigation load curves, the average load on a per-day basis is estimated using the time and duration of operation of irrigation pumps for

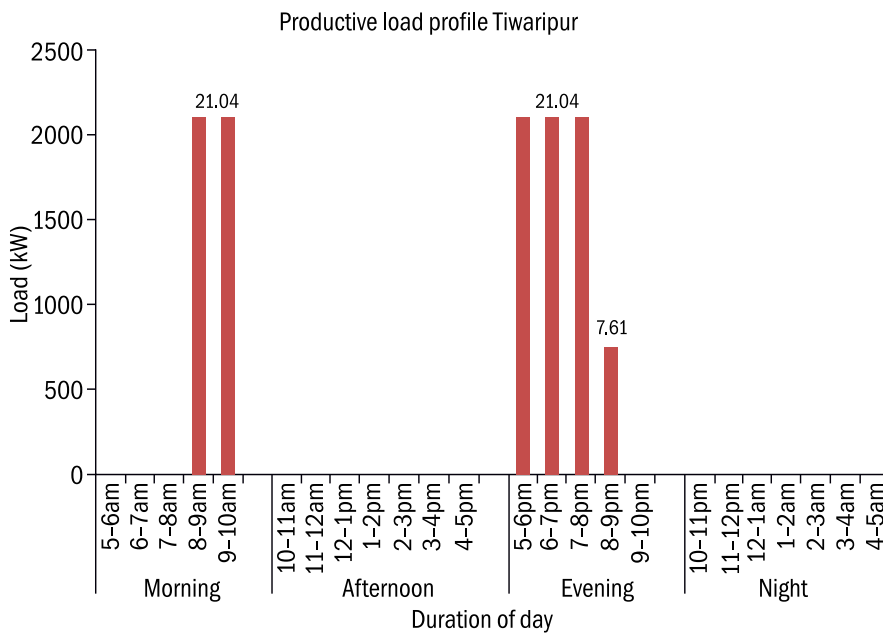


Figure 2: Productive load profile Tiwaripur



Access to energy in rural areas

various cropping seasons. In most of the villages of Kanpur Nagar and Banda, *Kharif* and *Rabi* crops are cultivated and in some cases *Zaid* crops are also cultivated that result in uniform loads throughout the year (Figure 3). On comparing the preferred options for electrification with the economic status it was observed that irrespective of the card-holding category (such as 'below poverty line', 'above poverty line' etc.,) or income level, options B and C (Table 1) were the preferred choice of majority of households in both Kanpur Nagar and Banda. Table 1 illustrates different options that were used during survey.

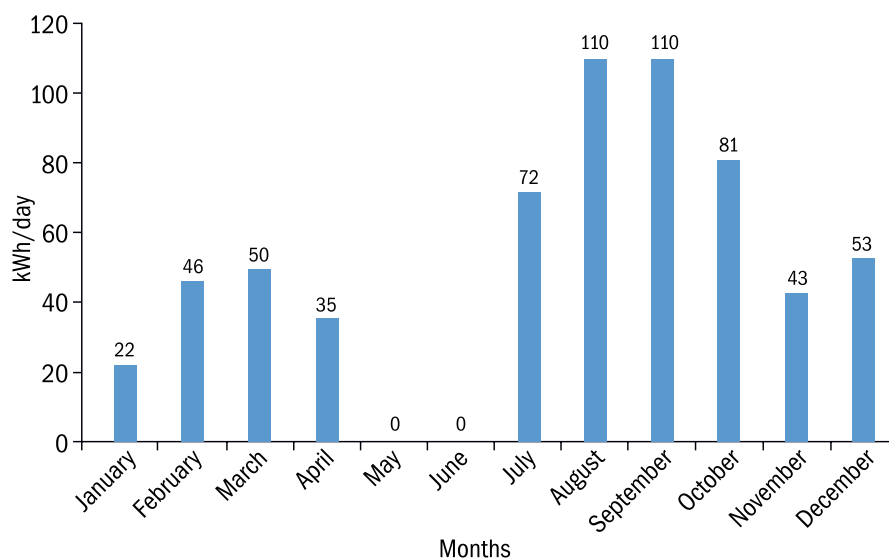


Figure 3: Irrigation load analysis (Maniyapur)

Table 1: Various options that were used during the survey

Options	Description
A	1 light bulb (1.5W) for 4 hrs per day + 1 mobile phone charger for 2 hrs
B	2 light bulbs (1x1.5W and 1x3W) for 4 hrs per day + and 1 mobile phone charger for 2 hrs
C	2 light bulbs (1x1.5W and 1x3W) for 4 hrs per day + 1 mobile phone charger for 2 hrs per day + 1 radio for 6 hrs
D	2 light bulbs (1x1.5W and 1x3W) for 4 hrs per day + 1 mobile phone charger for 2 hrs per day + 1 TV (80W) for 2hrs
E	2 light bulbs (1x1.5W and 1x3W) for 4 hrs per day + 1 mobile phone charger for 2 hrs per day + 1 fan (50W for 4 hrs)
F	2 light bulbs (1x1.5W and 1x3W) for 4 hrs per day + 1 mobile phone charger for 2 hrs per day and other loads

The findings inferred that the maximum demand was for running household appliances, irrigation pumps followed by mills and fodder cutting machines. It was also interesting to know that some of the households have latent demand in

the form of coolers, refrigerators or even washing machines despite being un-electrified or de-electrified. As of now, these machines are powered by diesel-based generator or lying idle.

The data gathered through this detailed survey can play an important role for optimum design of the solar based mini-grid systems.

Promotion of Productive Uses of Energy

With regards to reduction in the risk of demand uptake, a local agency was engaged to promote productive uses of energy in selected village of the district of Kanpur Nagar.

The engaged agency promoted productive uses of energy through Focus Group Discussions (FGDs) and SHGs/Cooperative meetings. The focus was to create awareness among people about advantages of switching to electricity for running equipment (irrigation pumps, rice huller, flour mills, oil expeller, fodder cutting machines, etc.,) over diesel. The awareness also included doing cost-benefit analysis and explaining to people in a non-technical way.

Financial Linkages

With regards to reduction in the costs of financial closure through pre-established financial structures/linkages, a combination of equity, debt, and grant (subsidy, if available) has been proposed. Recently, KfW Development Bank and the Indian Renewable Energy Development Agency Ltd. (IREDA) signed a line of credit for €20 million to be utilized for 'access to energy' by financing renewable energy projects in India. It is expected that to an extent the issue of access to finance would be addressed.

Regulatory Risks

With regards to mitigating regulatory risks through policy interventions, the Government of Uttar Pradesh has recently adopted a mini grid policy for electrification of un-electrified area through the participation of private players in the state. It is expected that the policy will mitigate some of the regulatory risks perceived by the private players and will encourage large-scale participation of private players in order to promote mini grids for electrification in the state. Moreover, the Ministry of New and Renewable Energy (MNRE) has issued a draft national policy for mini and micro grids. The policy aims to create up to 500 MW capacity in the private sector in the next five years. **AU**

Contributed by Mr Onkar Nath, Technical Expert, GIZ India, Jor Bagh, New Delhi, India. Email: onkar.nath@giz.de



Data collection



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Geothermal Energy in India

Potential and Prospects

Dr S S Verma discusses the various applications of geothermal energy while highlighting its prospects in India. While there are pros and cons of this form of renewable energy, geothermal energy has the potential to play a significant role in moving any particular region towards a cleaner, more sustainable energy system. It is one of the few renewable energy technologies that can supply continuous, base-load power.



respective of its form, we always depend on energy—whether it is general or electricity in particular—in order to accomplish our daily routines. With lives revolving more around seeking comfort and as less natural ways of accommodation mark the shift away from a sustainable way of life, the demand for energy in almost all its forms other than industrial purposes, for compulsory lighting, heating, and cooling, is growing exponentially. Scientists say that the sources of energy that are needed to power the modern conveniences are running dangerously low. We could run out of oil in as little as 40 years and out of natural gas soon after that. These fossil fuels have been percolating beneath the earth for hundreds of millions of years, and once they are gone, they are going to take millions of more years to replenish. Not only are we running out of fossil fuels, but they are adding to our environmental woes by releasing nasty byproducts that increase pollution and contribute to global warming.

Quest for New Sources of Energy: Geothermal Energy

Scientists are running a race against time to find cleaner, more efficient, and renewable sources of energy. One potential source that we have barely tapped is right underneath our feet. Deep inside the earth lies hot water and steam that can be used to heat our homes and businesses, and generate electricity cleanly and efficiently. This is called geothermal energy which is derived from the Greek words 'geo' meaning 'earth' and 'therme' meaning 'heat'. Geothermal energy is the heat stored in the earth's crust. Resources of geothermal energy range from the hot, shallow ground water to hot rock found a few miles beneath the earth's surface, and even deeper to the extremely high temperatures of

molten rock called magma. Most of the time magma stays beneath the surface, heating the surrounding water trapped within those rocks. Sometimes that water escapes through cracks in the earth to form pools of hot water (hot springs) or bursts of steam (geysers). The rest of the heated water remains in pools under the earth's surface called geothermal reservoirs. Deep geothermal wells, a mile or more deep, can tap reservoirs of steam or very hot water that can be used to generate electricity.

People began harnessing geothermal energy thousands of years before they had the technology to dig down into geothermal reservoirs. The ancient Romans used hot springs to heat their homes, bathe, and cook. In 1892, the first modern district heating system was developed in Boise, Idaho. It used water piped from hot springs to heat buildings. The first geothermal energy plant was built in Larderello, Italy, in 1904. The global geothermal power generation is at 13.3 GW in January 2016 and, if the current trend continues, is projected to increase to 18.4 GW by 2021, and to 32 GW by 2030. As of 2015, the top five leading countries in the geothermal power generation are USA (3,450 MW), Philippines (1,870 MW), Indonesia (1,340 MW), Mexico (1,017 MW), and New Zealand (1,005 MW). The total installed capacity, reported in 2014, for geothermal direct utilization worldwide is around 70.3 GW and the leading countries with the largest capacity of geothermal direct utilization are China, Sweden, USA, Turkey, Iceland, Japan, Hungary, Italy, and New Zealand. Iceland is one of the biggest users of geothermal energy—virtually the entire city of Reykjavik is heated with water which is pumped from hot springs and geothermal wells. Some cities—like Klamath Falls, Oregon—even pump hot water underneath their roads and sidewalks in the winter to melt snow and ice. This is competitive with

some fossil fuel facilities, but one must keep in mind the associated benefits relating to drastic reduction of pollution. Generation costs depend on ownership arrangements, financing, transmission, the quality of the resource, and the size of the project. Geothermal plants are relatively capital-intensive (₹ 30 cr per MW worldwide cost), with low variable costs, and no fuel costs. Usually financing is structured so that the project pays back its capital costs in the first five years, delivering power at 5–10¢/kWh.

Applications of Geothermal Energy

Space/District Heating

In areas where hot springs or geothermal reservoirs are near the earth's surface, hot water can be channelized directly to heat homes or office buildings. Geothermal water is pumped through a heat exchanger, which transfers the heat from the water into the building's heating system. The used water is injected back down a well into the reservoir to be reheated and used again. A few feet under the ground, the soil or water remain at a constant of 50 to 60 degrees Fahrenheit (10–15 degrees Celsius) all year round. In this method, geothermal heat pumps use a system of buried pipes linked to a heat exchanger and ductwork into buildings. In winter, the relatively warm earth transfers heat into the buildings and in summer, the buildings transfer heat to the ground or use some of it to heat water. These heat pumps perform the dual function of serving as both air conditioners and providing heating systems. It is indeed remarkable that a bit of warmth can be used to heat or cool homes and offices.

Agriculture, Mushroom Culture, and Aquaculture

In temperate and colder climates,



greatly improved plant and fish growth can be achieved by heating soils in greenhouses or fish ponds using geothermal heat.

Power Generation

Hot water and steam from the underground can be channelized through underground wells and used to generate electricity in a power plant. With over 13,000 MW of installed capacity, geothermal electric power generation is a well-proven technology that has been especially successful in countries and islands that have a high reliance on imported fossil fuels. There are three types of geothermal power plants in use today, these are:

- i. **Dry Steam Plants** use geothermal steam directly. Dry steam power plants use very hot ($>235^{\circ}\text{C}$) steam and little water from the geothermal reservoir. The steam goes directly through a pipe to a turbine to spin a generator that produces electricity. This type of geothermal power plant is the oldest.
- ii. **Flash Steam Plants** use high pressure hot water to produce steam when the pressure is

reduced. Flash steam power plants use hot water ($>182^{\circ}\text{C}$) from the geothermal reservoir. When water is pumped to the generator, it is released from the pressure of the deep reservoir. The sudden drop in pressure causes some of the water to vaporize to steam, which spins a turbine to generate electricity. Both dry steam and flash steam power plants emit small amounts of carbon dioxide, nitric oxide, and sulphur, but generally 50 times less than traditional fossil-fuel power plants. Hot water not flashed into steam is returned to the geothermal reservoir through injection wells.

- iii. **Binary Cycle Plants** use moderate-temperature water ($107\text{--}182^{\circ}\text{C}$) from the geothermal reservoir. In binary systems, hot geothermal fluids are passed through one side of a heat exchanger to heat a working fluid in a separate adjacent pipe. The working fluid, usually an organic compound with a low boiling point, such as isobutane or isopentane, is vapourized and passed through a turbine to generate electricity. An ammonia-water working fluid using system

boosts geothermal plant efficiency by 20–40 per cent and reduces plant construction costs by 20–30 per cent, thereby lowering the cost of geothermal power generation.

Geo-thermal Energy in India

Prospects of Geothermal Energy in India

India has a huge potential to become a leading contributor in generating eco-friendly and cost-effective geothermal power. Around 6.5 per cent of electricity generation in the world would be done with the help of geothermal energy and India would have to play a bigger role in the coming years in this direction. But in India, the power generation through geothermal resources is still in its nascent stages. The Geological Survey of India (GSI) has identified about 340 geothermal hot springs in the country. Most of them are in the low to medium temperature range, that is, from $50\text{--}150^{\circ}\text{C}$ which is suitable for direct heat applications and power generation through the binary-cycle method. These springs are grouped into seven geothermal provinces, that is, the

Himalayan (Puga, Chhumathang), Sohana belt in Haryana, Cambay Graben basin, Son-Narmada-Tapi (SONATA) lineament belt, West Coast, Godavari basin, and Mahanadi basin. Some of the prominent geothermal resources include the Puga valley and Chhumathang in Jammu and Kashmir, Manikaran in Himachal Pradesh, Ratnagiri in Maharashtra, and Tapovan in Uttarakhand. A new location of geothermal power energy has also been found in Tattapani in Chhattisgarh. In addition, Gujarat is set to tap geothermal electricity through resources which are available in Cambay between the rivers Narmada and Tapi. For harnessing geothermal energy in the country, the Ministry of New and Renewable Energy (MNRE) has been supporting research and development (R&D) on exploration activities and resource assessment during the last 25 years. This includes formation of expert groups, working group, core group, and committees in addition to providing financial support for such projects and for resource assessment. MNRE is targeting for the deployment of geothermal capacity of 1,000 MW in the initial phase till 2022. Resource assessment is being planned in 2016–17 for the public domain.

The objective of the programme is to assess the potential of geothermal resources in the country and to harness these resources in two distinct categories discussed below.

Power production

The Government of India and the Ministry of New and Renewable Energy (MNRE) have begun contemplating a major initiative in research, development, demonstration, and deployment (RDD&D) of geothermal technology for harnessing the geothermal energy in the country for the period of 2015–17. Geothermal electricity generation is site and technology specific and India falls in the Low Geothermal Potential Region with

low- or medium- heat enthalpy. The government is planning to encourage the demonstration of projects at the first stage in order to assess the technical viability of the project before going to the commercial models. Various resource assessments carried out by GSI, UNDP, and NGRI under the aegis of CEA, UNDP, and MNRE established the potential 10,600 MWth /1,000MWe spread over 340 hot springs across seven geothermal provinces/11 states. The average rough capital cost on not exceeding the basis stands at 30 Cr per MW (Rs 12 per kWh). As per the international reports, a 1 MW geothermal power plant generates about 8.3 million units (MU) per MW per annum compared to solar 1.6 MU per MW, wind 1.9 MU per MW, and hydro 3.9 MU per MW.

Ground source heat pumps (GSHPs)/ Geo-exchange pumps

Ground Source Heat Pumps (GSHPs) use the earth's relatively constant temperature between 16–24°C at a depth of 20 feet to provide heating, cooling, and hot water for homes and commercial buildings. GSHPs harvest heat absorbed at the earth's surface from solar energy. The temperature in the ground below 6 metres (20 ft) is roughly equal to the mean annual air temperature at that latitude at the surface. It uses the earth as a heat source (during winter) or as a heat sink (during summer). GSHP's is effective in all kind of climate zones or can be deployed anywhere in India on a 24x7 basis. This technology is being used worldwide since the last 50 years. According to the reports published in the World Geothermal Congress in 2010, up to the year 2013, the installed capacity of GSHP in the world is 52.7 GWt. More than 3 million GSHP units of capacity 7 kW to 35 kW (24,000 to 120,000 Btu/h) installed worldwide in 43 countries. The leading countries using this technology are USA, Sweden,

Germany, Switzerland, Canada, Japan, and China. The Government of India, Ministry of New and Renewable Energy (MNRE) contemplate initiatives in RDD&D of geothermal technology specifically for the purpose of cooling, drying, space heating, greenhouse cultivation, industrial processes, cold storage, poultry and fish farming, mushroom farming, horticulture, etc. MNRE considers GSHP as a part of utility/HVAC system of the structure/premises (existing as well as under construction), therefore, the Ministry has recently exempted the drilling of geothermal bores/ wells from any separate permissions required as earth is only used as a source or sink. Permissions that have already been acquired for the structure, building, or industrial plan from the concerned administrative or engineering authority serve as the necessary clearance for the drilling of geothermal bores or wells. MNRE is also working in collaboration with BEE on increasing the efficiency by more than 50 per cent of conventional HVAC system by retrofitting or replacing the cooling towers (air cooled) by the Energy Star qualified Geothermal Heat Pumps.

Indian Organizations Working in Geothermal Energy

- Central Electricity Authority
- Geological Survey of India
- Indian Institute of Technology, Mumbai
- Regional Research Laboratory, Jammu
- National Geophysical Research Institute, Hyderabad
- Oil and Natural Gas Corporation, Dehradun.

Ongoing Projects in India

- Magneto-telluric investigations in Tattapani geothermal area in Madhya Pradesh



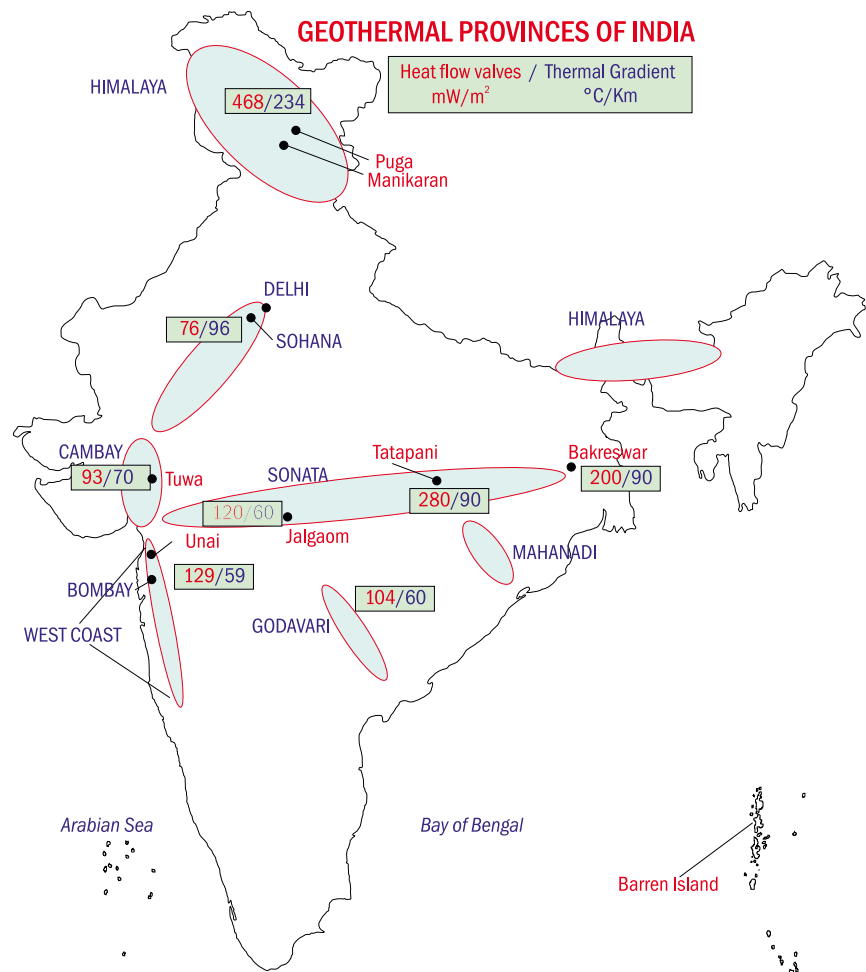
- Magneto-telluric investigations in Puga geothermal area in Ladakh region, Jammu & Kashmir.

⚡ Geothermal Energy—Pros and Cons

Technically speaking, geothermal energy is a renewable source of energy that can produce energy as long as the Earth exists. Geothermal energy is a type of energy that can truly make it easy for companies to get what they need without using a lot of fossil fuels in the process. Let us now list some of the most important pros and cons that are related to using geothermal energy.

⚡ Pros of Geothermal Energy

- **Renewable:** Geothermal energy is extracted from the earth's core and will be available as long as the earth exists. It is, therefore, renewable and can be used for roughly another 4–5 billion years. While fossil fuels have an expiry date, renewable sources like geothermal energy is not going to expire anytime soon.
- **Environment friendly:** Geothermal energy is green in all aspects of its production and use. It is actually known for having the least impact of any power source. When it comes to the process of developing and making it, geothermal power is practically completely emission free. There is zero carbon used when it comes to the production of this type of power. Also, the whole procedure can clean out sulphur that may have been discharged from the other processes.
- **No fuel needed:** No fuel is used during the production and use of the energy. Furthermore, because there is no mining or transportation related to the process—which means that there are no trucks emitting fumes and gas—the atmosphere remains unaffected.
- **Abundant supply:** With geothermal energy, there are no shortages or other sorts of problems that



▲ Geothermal provinces of India

sometimes occur with other types of power. They are not subject to the same issues as solar or wind power, which means that we will not face a shortage on account of weather-related problems. Essentially, this means that there is a limitless supply of this kind of energy. It is also intrinsically basic and dependable, so we do not have to worry about it being more of a hassle than its actual worth.

- **Significant savings:** There has been a tremendous increase in the number of homeowners who want to utilize geothermal energy for heating and cooling purposes. The result is that less energy is used for heating homes and offices which results in significant savings for home owners. It might prove

expensive initially but 30–60 per cent savings on heating and 25–50 per cent savings on cooling can cover that cost within few years. A geothermal heat pump can help to save enough money in energy costs.

- **Smallest land footprint:** Geothermal energy extracts heat from hot water; the steam from hot water move the turbines that produce electricity. To extract this energy, substantial amount of piping is required to be laid underground. But, thanks to new innovation in the field of technology, geothermal energy has the smallest land footprint of any major energy source in the world. The costs are very competitive. As of now, geothermal energy has proved to be quite cost aggressive

in a few areas where it is being produced. In order to accurately gauge how much of an impact it has had, we should observe its proceedings closely in the areas where it has been implemented.

⚡ Cons of Geothermal Energy

- **Suitable to a particular region:** Everything that deals with geothermal power seems to be really far away from practically everything that is in and around the area. Prime destinations are exceptionally zone specific, hence one cannot find geothermal power outside of those areas. Also, the prime destinations are frequently kept at a distance from urban areas, which means that they are virtually useless when it comes to cities as such.
- **High initial costs:** For those residential owners who are thinking of using geothermal energy, high upfront costs is something that turns out to be a huge distraction. For an average-sized home, installation of geothermal heat pumps costs between Rs 7–8 lakhs that can pay off itself in another 5–10 years down the line through significant cost savings.
- **Cost of powering the pump:** Geothermal heat pumps still needs a power source that can run it. The pumps need electricity to run that can transfer energy from the earth's core to homes.
- **Surface instability:** Geothermal has become infamous for causing earthquakes as setting up of geothermal power plants can alter the land's structure. A process called hydraulic fracturing is an integral part for building a large scale and efficient geothermal system power plants that can trigger earthquakes.
- **Environmental concerns:** There are some environmental concerns like water use is one of the big concerns, because geothermal



power uses a lot of water in its processes as such. There are also a number of different compounds that go into the air, water, and ground as a result of the process, including sulphur dioxide and silica discharges, both of which can harm the environment.

- **High temperatures needed:** The process is not exactly an easy one to be executed as boring into warmed rock is extremely troublesome.
- **May run out of steam:** If the heat in place is not taken care of properly, it can cause a meltdown or other issues where the energy is not properly distributed or used.

⚡ The Future of Geothermal Energy

Geothermal energy has the potential to play a significant role in moving any particular region towards a cleaner, more sustainable energy system. It is one of the few renewable energy technologies that can supply continuous, base-load power. Additionally, unlike coal and nuclear plants, binary geothermal plants can be used as a flexible source of energy to balance the variable supply of renewable resources, such as wind and solar energy. Binary plants have the capability to ramp production up and down multiple times each day, from 100 per cent of nominal power down to a minimum of 10 per cent. The costs for electricity from geothermal facilities are also

becoming increasingly competitive with conventional energy resources. There is a bright future for the direct use of geothermal resources as a heating source for homes and businesses in any location. However, in order to tap into the full potential of geothermal energy, two emerging technologies require further development: Enhanced Geothermal Systems (EGS) and co-production of geothermal electricity in oil and gas wells. Geothermal energy is generally regarded as environmental friendly, sustainable, and reliable, and this makes geothermal energy a must in some places, but heavy upfront costs stop us from realizing the full potential. It can also be manufactured underground. The extent of influence which geothermal power will have on our energy systems in the future depends on technological advancements, energy prices, and politics (subsidies on energy). When it comes to green energy, geothermal energy is one of the first types that is being explored. As time goes on, new innovations that are being engineered will make its use more simple. These innovations are guaranteed to be able to use lower temperatures in future iterations of the technology as well.

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Upgradation of Watermills

The Uttarakhand Renewable Energy Development Agency (UREDA) in cooperation with GLZ, India has developed and implemented a pilot project based on an innovative approach, where a cluster of improved watermills addressed a specific demand for energy for livelihood activities (processing, packaging and marketing ground flour and spices) and is owned and operated by a self-help group within the local community. This article presents an overview of the pilot project and recommendation to replicate this model across other districts in Uttarakhand.

In Uttarakhand, watermills (*Gharats*) have traditionally been the lifeline of rural communities and used to provide mechanical power, primarily for grinding food grains. However, as access to these remote rural communities improved (improvements in road infrastructure as well as penetration of the electricity grid), the traditional watermills were being gradually replaced by diesel and electric mills. Efforts have been made to improve the efficiency of the watermills and make them more competitive. The Government of India through its nodal ministry (MNRE) introduced a nation-wide scheme in 2002–03 that offered a significant

subsidy for such upgradation of watermills. Despite the subsidy available under this scheme, the demand for such upgradation of watermills has not been very high.

Based on the prevailing scenario, a preliminary study was undertaken, covering a sample survey of 100 watermillers, to assess the current status of the Improved Watermills Programme in Uttarakhand. The key findings are as follows:

- The improved watermill has a significantly higher processing capacity as compared to the local demand;
- Due to lack of appropriate forward and backward linkages to service

potential demand beyond the local market, the watermills do not generate adequate revenues for the watermillers;

- In particular, the survey indicated that although there are examples of watermillers earning as high as ₹15,000 per month, the median value is less than ₹1,000 per month;
- The study also highlighted the need for appropriate linkages to banks for financing end-use appliances as well as working capital requirements.

Approach

With the aim to develop a business case for watermills, UREDA together

Some Quick Facts about Watermills

- Around 15,499 traditional watermills have been found in existence in a survey conducted by UREDA.
- Traditional watermills work at 10–15 per cent efficiency whereas upgraded watermills work at about 45–50 per cent efficiency.
- The output of watermill can be increased up to 300 per cent after improvement.
- Improved watermill can also generate electricity up to 5 kW.
- Small Scale Industry Department, Government of India, has declared Watermill (*gharat*) as Small Scale Industry and State Government has exempted watermill parts and products from Value Added Tax (VAT)

training on operation and maintenance of improved watermills.

» **SHG capacity building:**

The members of the Swaraj Group were imparted the required training on products manufacturing, working principles of SHG group management and strengthening, and books and accounts maintaining.

with GIZ, India, designed and implemented a pilot project based on an innovative and holistic approach, where a cluster of improved watermills addressed a specific demand for energy for livelihood activities that were owned and operated by the Self Help Group (SHG) within the local communities.

⚡ Pilot Project in Uttarkashi, Uttarakhand

- **Group formation and mapping of local demand:** UREDA in cooperation with GIZ did a detailed assessment to identify an appropriate demand, which can be catered by utilizing the energy

available from a cluster of improved watermills. A local agency was engaged for the formation of a cluster of watermills and an SHG. The SHG was called the Swaraj Group. Five watermills in a cluster-based approach were upgraded depending upon feasibility of mechanical or electro-mechanical upgradation and also in line with the required demand to process grains, spices, and cattle feed (Figure 1).

- **Capacity Building:** Two levels of capacity building were carried out (Picture 1):
 - » **Technology capacity building:** The members of the Swaraj Group were imparted required

- **The Group as an enterprise:** With a focus on sustainable intervention, the initiative business model was introduced within the Group. Business plan was developed for the Group which started emerging as an enterprise. To have legal recognition, the Group has obtained certifications from Directorate of Industries as a micro enterprise, FSSAI, PAN, VAT/TIN, etc., from relevant departments.
- **Market linkages:** Required market linkages were established for the Group in the markets of Dehradun and Delhi (Picture 2). However, more efforts are required in establishing market linkages since the products are competing with other premium products in the markets. Also, the Group is participating in different national-/ regional-level fairs to promote the products.
- **Access to finance:** There are major barriers for any business model, especially business models that depend on traditional practices. The Swaraj Group had to pass different obstacles as they needed to sell the new concept of enterprise. With an aim to enable local financial infrastructure, Uttarakhand Gramin Bank was approached for financial linkages.
- The Swaraj Group was able to mobilize loan as a working capital from Uttarakhand Gramin Bank. The working capital is being used to buy raw materials from the local communities and expand business.



⚡ **Picture 1:** Capacity building

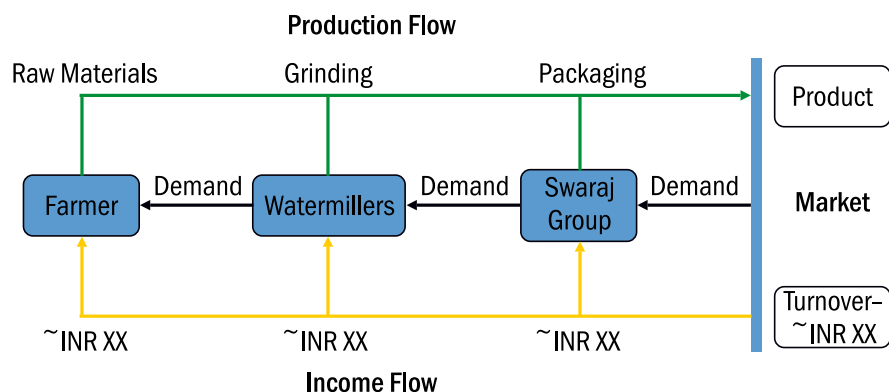
About the Swaraj Group

Total no. of members in the group: 12

Total no. of watermillers: 5

Total no. of women: 6

Working Model of the Swaraj Group



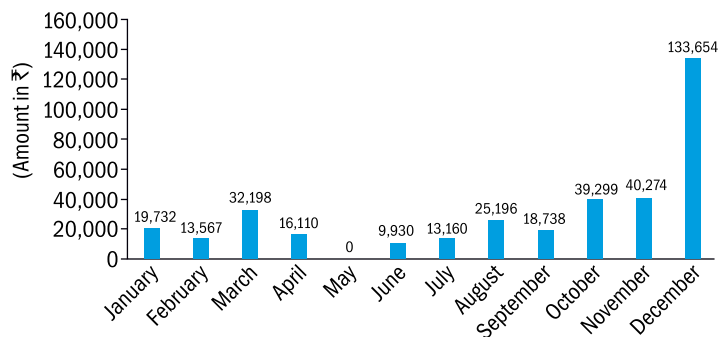
 **Figure 1:** Working model of the Swaraj Group


Value Proposition of the Products

- The products are made from clean sources of energy.
- The products are made from locally available raw materials in the region.
- The nutritious value of products processed from watermills is considered superior in quality and taste.

Outputs

- Evidence from the operation of the Group shows increased usage



 **Figure 2:** Month-wise turnover of the group in year 2016; Total: ₹361,858

Note: In the month of May, water to run watermills was diverted for agricultural purposes and, therefore, no business took place. The depicted graph is only illustrative in nature and actual sales figure/graph may vary.

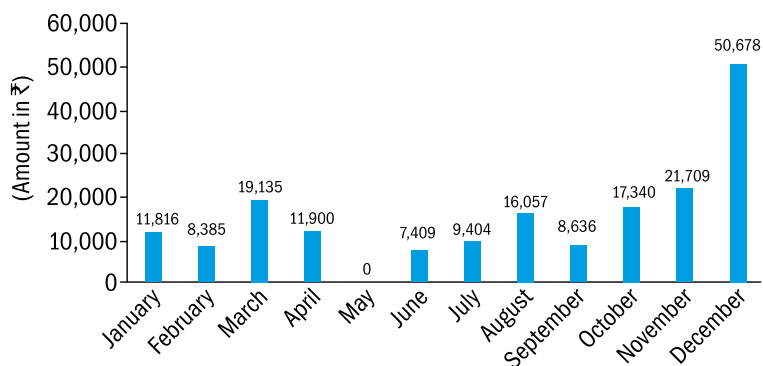
of watermills due to increase in demand for processing grains which is resulting in an increased income of the watermill owners (Figure 2).

- Another interesting aspect observed during the pilot was that the pilot work not only helped in

the revival of watermills but also encouraged local communities/ farmers to increase the productivity of traditional crops, such as millets, buckwheat, etc., which are being grown in a limited quantity due to various reasons. The farmers are getting fair price for their produce without intervention of middlemen (Figure 3).

Direct Impacts

- Increased uses of watermills resulted in increase in income of the watermill owners.
- Members of the Group, especially women got livelihood opportunities and, additional income.
- Additional revenue to local farmers by way of supplying raw materials.
- Endorsement by government



 **Figure 3:** Raw material cost: Farmers' revenue 2016

Note: In the month of May, water to run watermills was diverted for agricultural purposes and therefore, no business took place. The depicted graph is only illustrative in nature and actual sales figure/graph may vary.

officials about the adopted approach and potential to replicate it in other parts of the state.

- Reduction of greenhouse gas (GHG) emissions by way of avoiding energy generated from diesel/electric based mills to grind grains/spices (Picture 3).

Potential Impacts

- Potential to climate change mitigation activities, such as easing the burden of the use of fossils fuels (diesel) and also reducing the burden on use of electricity for grain-milling activities.



❖ **Picture 2:** Market linkages were established for the group

- Potential to contribute positively on environmental issues because it works on clean sources of energy.
- Potential to address social issues by way of increasing employment to locals including women (Picture 5).
- Potential to reduce GHG emissions linked to agricultural post-harvest processing.
- Locally processed agricultural products are less expensive and, therefore, more affordable for the poor population, increasing food security and helping to reduce poverty and hunger.
- Potential to reduce workload of women for agro-processing.

⚡ Recommendations

Based on the execution of pilot on the adopted approach, the following recommendations have been suggested in order to strengthen the ongoing improved watermill programme.

⚡ Institutional aspect

- Engagement of local agencies, which can be allotted a cluster for upgradation of watermills and also



❖ **Picture 3:** Reduction of greenhouse gas (GHG) emissions by way of avoiding energy generated from diesel/electric based mills to grind grains/spices

linking with any business group.

The local agencies will have a stake in overall functioning of the group in order to minimize the traditional approach of local agencies to work on a project mode, that is, for a limited time period.

- Existing institutional structures for delivery and servicing of improved watermills need to be strengthened. Further, there is a need to allocate resources towards periodic renovation and maintenance of such watermills.

⚡ Business aspect

- When promoting improved watermills (IWMs), the emphasis should be on identifying appropriate demand for such energy for productive end uses/livelihood activities. The Improved Watermill Programme should also, therefore, allocate some resources towards identifying and establishing such demand linkages.

⚡ Technology side

- The focus of the Improved Watermill Programme should be

predominantly for mechanical power output, given that the grid penetration levels and the availability of the electricity from the grid are high in Uttarakhand.

- The electrical output option should be made available only in the case of remote locations where the grid has not reached. In order to address this, the quantum of subsidy should be linked to the power output, whether mechanical or electrical, thereby reducing the incentive to choose the electro-mechanical option, which currently attracts a higher subsidy.

Disclaimer: The views, opinions, findings, and conclusions or recommendation expressed in this paper are strictly those of the authors. They do not necessarily reflect the views of UREDA and GIZ. UREDA and GIZ take no responsibility for any errors or omissions in, or for the correctness of, the information contained in the paper. For more information, readers are encouraged to directly contact the author of this paper. **AU**

Article Courtesy of UREDA and GIZ, India.

Solar Thermal in Leh and Kargil

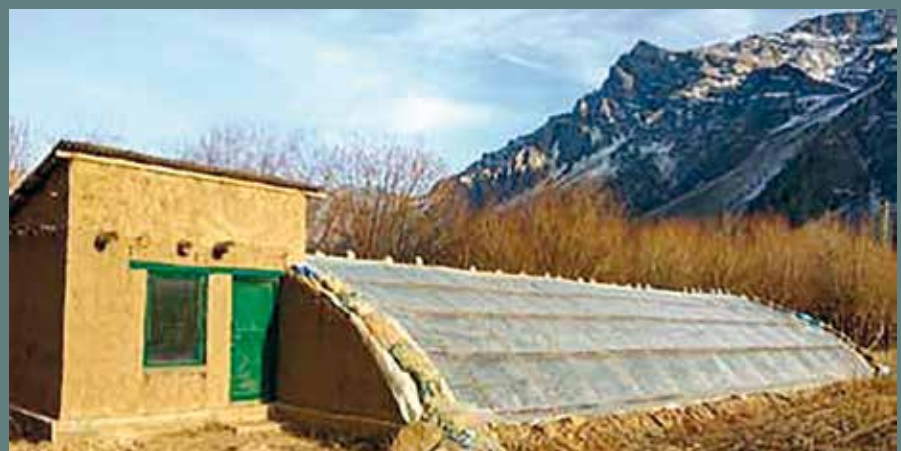
The Ladakh Region of Jammu and Kashmir, with its extreme environment, faces enormous energy adversities throughout the year which become even more acute during the winter months. The 'Ladakh Renewable Energy Initiative' scheme of the Ministry of New and Renewable Energy (MNRE) has been launched especially to accelerate widespread use of solar thermal systems for heating, cooking, and steam generating applications. The implementing agencies are Kargil Renewable Energy Development Agency (KREDA) in Kargil and Ladakh Renewable Energy Development Agency (LREDA) in Leh District of Jammu and Kashmir.



Installation of domestic and commercial solar water heating systems (SWHs) by KREDA in Kargil region

The Remarkable Achievements

Till November 2016, KREDA has installed 6,700 solar water heating systems (SWHs) covering an area of 9,000 sq. m collector area for individual households, government institutions, and commercial units in the Kargil region. There is a growing awareness and demand for SWH systems in the region. LREDA has installed 2,150 units of dish-type solar cookers; 20,384 sq. m of solar water heaters; 750 numbers of commercial green houses; 2,500 domestic green houses; and 5 units of solar steam cooking system CST-based having 320 sq. m area.



Installation of domestic type 'green house' in Kargil region

Solar Green House

Kargil has a natural advantage of receiving plenty of sunshine in the winter months. Based on this, KREDA as per MNRE guidelines, introduced green house in the district. This technique is indigenous using locally available materials. The 'green house' is designed to maximize the solar absorption in the day and to minimize the heat loss at night.



Jamyang School, Leh-Ladakh (installation) and (kitchen)

Solar Steam Cooking System in Leh

MNRE has sanctioned nine steam cooking systems, each with an aperture area of 64 m². It was found that five out of these nine systems having collector area of 320 sq. m. were successfully completed and handed over to the beneficiary. **AU**

Gujarat Solar Water Pumpsets

The Benefits and Advantages

In Gujarat, the power consumption for agriculture pumpsets is more than 20 per cent of the total consumption, which increases year by year, because the distribution companies (DISCOMs) are releasing approximately 1 lakh connections per year.

The issues faced by the DISCOMs with regard to release of agriculture connections are as follows:

- The power tariff to the agriculture category is subsidized and the subsidy burden is increasing due to the increase in conventional power costs.
- There are a large number of agriculture pumpsets using diesel, where there is no electricity connection.
- Due to large geographical area, huge infrastructure, that is, length of the HT line and transformer centre is required to cater power supply to agriculture.
- A huge waiting list of more than 3.70 lakh applications for agriculture connections.

In view of the above, to reduce burden of subsidy on the State Government, and to save huge expenditure on infrastructure, such as HT line, transformer, etc., and with a view to promote renewable energy, the State Government has implemented Scheme of Solar Water Pumpsets for



agricultural pumpsets to be installed at various locations of DISCOMs from the financial year (FY) 2014–15. The Ministry of New and Renewable Energy (MNRE) is also providing Central Finance Assistance, i.e., ₹32,400 per HP for AC Pump and ₹40,500 per HP for DC Pump under Solar Water Pumping System.

For the implementation of the Scheme, the State Government had approved budgetary provision of ₹50 crore, ₹60 crore, and ₹125.50 crore for FY 2014–15, FY 2015–16, and FY 2016–17, respectively.

⚡ Beneficiaries Criteria for Availing the Benefit of the Scheme

Registered, FQ paid, and FQ under payment for conventional agriculture connection beneficiaries can switch over their applications for solar water pumpsets. Farmers who have not applied for conventional agriculture connection can also register their applications for Solar Water Pump scheme. Scheduled caste farmer/tribal farmer is required to pay ₹1,000 per HP only and all other category farmers have to pay ₹5,000 per HP only for setting up the solar pumpsets as a onetime payment. **AU**

Clean Light for Children to Study

Million Solar Urja Lamp (SoUL) Programme

India has one of the youngest populations in the world, with 350 million children less than 14 years of age making school education essential for future of the country. However, 221 million people residing in India are still without electricity access and many more with poor quality of supply (IEA, 2015). Many young school-going students either do not have access to alternate clean light source or suffer from erratic electricity supply, both of which affect their study during evening hours. Alongside 'Right to Education', it is desirable to provide 'Right to Clean Light' and hence there is a need for a countrywide, self-sustainable solar lamp programme.

One million Solar Urja Lamps (SoULs) were distributed during 2014–16 in four Indian states of Madhya Pradesh, Maharashtra, Rajasthan, and Odisha, covering 23 districts, 97 blocks, and more than 10,900 villages. There are 54 assembly and distribution centres and 350 SRCs in operation, with training provided to 1,409 local people. While



implementing, 7,35,000 lamps were distributed in just 9 months between July 2014 to March 2015, while the remaining 2,65,000 lamps in 4.5 months from November 2015 to March 2016. With 77 per cent tribal blocks (as defined by the Ministry of Tribal Affairs) and 83 per cent educationally backward blocks (as defined by the Ministry of Human Resource and Development) amongst its intervention blocks, MSP focussed on reaching the most marginalized population. The impact analysis of the MSP revealed that SoULs have replaced one kerosene wick lamp in beneficiary households, thus contributing to saving kerosene consumed for lighting. Besides, its usage for study purpose, it was an aid in various other domestic and livelihood activities.

The objective of the SoUL programme developed and executed by IIT Bombay is to provide clean light for study purpose to each and every child in the country, in the fastest possible way and in the most cost-effective manner.

Benefit and Impact of the Project

Being the central coordinating agency, expertise of IIT Bombay in solar technology, operations management, and socio-economic impact analysis were integrated in the MSP. Assembly-cum-distribution centres were established at the block level (a unit of intervention), in premises of nine partnering NGOs.

Locals from intervention blocks were hired and trained to assemble high-quality solar study lamps, campaign, and distribute lamps to the target beneficiaries (i.e., school students enrolled between classes 5 to 12), thereby encouraging local employment, entrepreneurial skills, affordable power, upliftment of weaker sections of the society and by contributing to the cause of 'Right to Education'. **AU**

Bio-CNG

A Suitable Choice for Green Transportation

Dr Shailey Singhal and **Dr Madhu Sharma** highlight that although introduction and usage of Bio-CNG as transportation fuel has been in usage since a few years, there is a need to create awareness even among the urban society to maximize the use of biogas for various purposes including transportation.

Compressed natural gas (CNG) is an important transportation fuel obtained by compressing natural gas to the pressure above 3,100 pounds per square inch. CNG is used as a substitute to gasoline, diesel, and LPG. Use of CNG is promoted worldwide as it is a clean fuel and CNG vehicles show an average reduction in ozone forming emissions to around 80 per cent as compared to gasoline vehicles. CNG has several advantages over conventional fuels, viz., petrol and diesel. It causes lesser corrosion and wear to the body of engine; it is environmentally benign due to lower emissions of carbon and particulate matter per equivalent distance travelled; and being lighter than air, it is safer in case there is a spill. Owing to its advantages, the use of CNG is increasing worldwide in the present scenario. This increase is even more expected when the governments of various nations including India have put a step forward for decreasing the use of diesel particularly for vehicular use due to environmental concerns. In some countries, the respective governments have decided to keep the prices of CNG lower than gasoline to promote its use as transportation

fuel. But the question arises: till when can we obtain CNG from natural gas? In the current scenario, the total global consumption of natural gas is 199 trillion cubic ft per year against the production of 98 trillion cubic ft per year. This gap of 21 per cent is even going to increase to around 54 per cent by 2040. In order to bridge this gap, it is desirable to find some alternative source for CNG to be obtained in a sustainable manner.

If looked at wisely, biogas is a potential candidate and a suitable choice to convert it into bio-CNG. Raw biogas comprises approximately 50–65 per cent methane with 30–40 per cent carbon dioxide and the rest are impurities of hydrogen sulfide, water, and other trace elements. Removing carbon dioxide and hydrogen sulfide by suitable techniques, biogas can be upgraded to bio-CNG.



▲ Biogas converted to Bio-CNG at IIT-Delhi



From a chemical perspective, there is no difference between biogas and natural gas; they both mainly consist of methane. The big difference lies in the way of their generation. Natural gas is a fossil fuel requiring millions of years to materialize, whereas biogas can be produced from what traditionally is considered to be waste in no more than 14 days. This also indicates that biogas is 100 per cent renewable, whereas natural gas is being depleted. The biogas ecocycle starts when waste is being produced. This can be organic waste from households collected at landfills and wastewater treatment plants or agricultural byproducts. The important benefits of Bio-CNG as transportation fuel include significant savings over gasoline and diesel: it is only 25–50 per cent of current gas/diesel cost; and utilizing a local, green, renewable fuel source—leads to upto 90 per cent greenhouse gas (GHG) reductions.

⚡ **Bio-CNG as a Transportation Fuel**

The introduction and usage of Bio-CNG as transportation fuel is not very new for the scientists and the world, but there is a need to create awareness even among the urban society to maximize the use of biogas for various purposes including transportation. The use of natural gas was initiated in the Po River Valley of Italy in the 1930s, followed by New Zealand in the 1980s. It is interesting to mention that in New Zealand, 10 per cent of the nation's cars were converted to natural gas as a fuel. India, Australia, Argentina, and Germany also have considerable use of natural gas-powered buses in their public transportation fleets. For vehicle use, biogas has to be upgraded to correspond to high-quality natural gas. The vehicle does not know whether it is running on natural gas or cleaned biogas, so from an end-use point of view high calorific natural gas and cleaned biogas are equivalent (on



⚡ Public transport bus operated on Bio-CNG

the condition that the biogas does not contain contaminants). Various technologies are available nowadays in the market for upgrading biogas to Bio-CNG and can be well used for the purpose. Primary targets for Bio-CNG vehicles include heavy-duty freight trucks, transit buses/shuttle buses/school buses, medium-duty delivery, and commercial service trucks. Public transport is the basis of sustainable urban transportation systems. Biogas-driven buses help improve urban air quality. Compared to diesel and petrol, biogas reduces local emissions substantially. Extended use of biogas for city buses lowers emissions, improves inner city air quality, limits the impact from traffic on climate change, and strengthens the role of public transport. The implementation of biogas buses is a driver for more regional production of biogas and thereby creating new jobs in the area of renewable fuels and contributing to the total economy of the nation. Policymakers of a country have to play major role in making the future fuelled by an increasing amount of upgraded biogas, especially in the transportation sector in order to achieve sustainable development.

⚡ **Some Successful Initiatives using Bio-CNG**

- IIT-Delhi is converting biogas to Bio-CNG using water scrubbing technique and is supplying it to the CNG refilling stations. They have an automatic plant of 20 Nm³/hr capacity for biogas production, which is purified for the removal of carbon dioxide and hydrogen sulphide to convert into Bio-CNG.
- The Kaira District Co-operative Milk Producers Union Limited, popularly known as Amul Dairy, has become the first in India's food industry to start a fully automated bio-CNG generation and bottling plant to utilize energy from its plant's waste. For every litre of milk that is processed at the dairy, one litre water (two million litres a day) is used for chemical cleaning of plant and machinery. This water has residual milk solids which generates 2,500 cubic m of methane per day with 60–65 per cent purity. This biogas from digesters is collected in a double membrane raw biogas balloon with a capacity of 1,000 cubic m and it is transferred for

purification to convert it to bio-CNG with more than 93 per cent of methane content.

⚡ Bio-CNG at Amul Dairy, Kaira, Vadodara

- The \$16.9-billion Mahindra Group's vehicles at Mahindra World City, near Chennai, is powered by Bio-CNG generated at a plant on its premises, which was inaugurated by Shri Piyush Goyal, Minister of State (IC)—Power, Coal, New and Renewable Energy and Mines. The plant involved an investment of ₹1.6 crore and is a joint CSR initiative between Mahindra Research Valley (MRV) and Mahindra World City Developers Limited (MWCDL). This plant converts 8 tonnes of food and kitchen waste generated every day at the MWC into 1,000 cubic m of raw biogas. Further, the raw biogas yields 400 kg per day of purified CNG-grade fuel which is equivalent to a 200 kW power plant. As a by-product, four tonnes of organic fertilizer will be produced per day.
- The country's first public bus running on human and animal waste is going to be introduced in



↗ Bio-CNG vehicle at IIT-Delhi

Kolkata by the end of March 2017. The bus will travel a distance of 17.5 km between Ultadanga and Garia. Shri Jyoti Prakash Das, Chairman & Managing Director of Phoenix India

Research and Development Group, an alternative energy company told that the bus fare has also been brought down to ₹1 only which is normally ₹12 at this route. It is planned to ply 12 such buses on 12 different routes in the city soon. Increasing number of users of biogas as transportation fuel indicates the enhanced awareness about this very promising source of renewable energy among the general public and also the policymakers. It is a fact that despite including biogas in the daily life, India is lagging behind as compared to the developed countries, but let us look forward to the day when substituting conventional energy by renewable energy makes India really proud of the achievement. **AU**

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↗ Bio-CNG at Amul Dairy, Kaira, Vadodara

A Low-Cost Improved Wood Cookstove Design

Billions of people in rural sector use wood cookstoves to cook their meals. Traditional stoves create harmful kitchen pollution. According to a report by the World Health Organization (WHO), over 4 million people in the world die prematurely from illness attributable to the household air pollution from cooking with solid fuels. Low thermal efficiency of these stoves also consume large amount of wood and takes much more time for cooking. Currently, improved wood cookstoves are yet not available at an affordable price. Considering the present need, an improved but low-cost wood fuel cookstove is presently designed and fabricated. Wood sticks are used as fuel in this stove. During test, measured thermal efficiency is found to be 24.7 per cent. Smoke emission is also reduced. Power output rating of the present prototype is 2.8 kW per hour.

⚡ The Present Design

The stove consists of a kiln burnt top open cylindrical mud jar and a both-end-open M S cylinder. The mud jar acts as an outer cylindrical enclosure of the double-walled stove. The metallic cylinder is placed concentrically inside the mud jar which functioned as combustion chamber of the stove. An annular metal plate at the top of the combustion chamber encloses the annular gap in between the combustion chamber top and top of the mud jar. A rectangular opening is cut in the mud jar near the bottom, both for fuel feed and primary air entry. The combustion chamber has also a rectangular opening at its bottom and horizontally divided by an M S rod at mid position of the opening. Firewood sticks are placed inclined inside the combustion chamber through the upper half of the rectangular opening. One end of wood sticks is supported on M S rod and the other end is supported on the bottom of the mud jar

surrounded by combustion chamber wall. Primary air is entered into the combustion chamber through a rectangular passage below the wood sticks holding the M S rod. A series of circumferential holes are provided near the bottom of mud jar for entry of secondary air into annular passage formed in between the combustion chamber and mud jar. Combustion chamber is also provided with secondary air holes throughout its circumference located just above the fuel feed cum primary air opening passage. Secondary air stream is preheated, which passes through the annular passage in between combustion chamber wall and mud jar



⚡ Photograph of the mud jar and metallic combustion chamber



⚡ Photograph of the stove in assembled position



⚡ Photograph of the burning stove with wood sticks

and then entered into the combustion chamber to complete combustion in smokeless condition.

⚡ Specifications of the Stove

- Outer diameter of mud jar: 30 cm
- Inside diameter of mud jar: 27.5 cm
- Total height of mud jar: 25 cm
- Inner height of mud jar: 20 cm
- Inner cross-sectional area of mud jar: 593.65 sq. cm
- Dimension of fuel feed opening cum primary air entry passage in mud jar: 15 cm x 12cm
- Diameter of secondary air entry ports provided in mud jar: 2.5 cm
- No. of ports: 15 nos.
- Distance from centre of ports to inside bottom of jar: 2 cm
- Diameter of combustion chamber: 21.5 cm
- Cross-sectional area of combustion chamber: 362.86 sq. cm
- Height of the combustion chamber including pot stands: 22.5 cm
- Height of pot stands from top of the stove: 2.5 cm
- Dimensions of fuel feed opening cum primary air entry passage in combustion chamber: 13.5 cm x 10.6 cm
- Diameter of fuel rest rod: 0.6 cm
- Available area for fuel feed in fuel feed opening cum primary air entry passage: 13.5 cm x 5cm
- Available area for primary air entry in fuel feed opening cum primary air entry passage: 13.5 cm x 5cm
- Diameter of secondary air entry ports in combustion chamber: 2.5 cm
- No. of ports: 13 nos.
- Distance from top of the fuel feed opening to centre of ports: 2.5 cm
- Total area of secondary air entry ports: 63.78 sq. cm.
- Area of annular secondary air passage in between mud jar and combustion chamber: 230.79 sq. cm
- Percentage of annular secondary air

passage area with respect to area of combustion chamber: 63.6 per cent.

⚡ Material

Outer cylindrical mud jar: Kiln burnt potter's clay

Combustion chamber: 18 gauge M S sheet

Pot stands: 6 mm M S strips.

⚡ Merits of Newly Designed Stove

- High thermal efficiency with reduced rate of smoke emission
- Simple design
- Low cost.



⚡ Photograph of the weigh machine used in test



⚡ Photograph of the stirrer assembly for thermal efficiency test



⚡ Photograph of the stove under thermal efficiency test

Thermal efficiency test of the stove was done as per I S specification CIS 1315 Z (Part 1) 1991.

⚡ Result of Thermal Efficiency Test

- Mass of wood consumed with full power during an hour: 2.4 kg
 - Burning capacity of stove per hour: 9,744.67 kcal
 - Measured thermal efficiency: 24.7 per cent
 - Power output per hour: 2.8 kW.
- The stove finds use and application in rural areas both for domestic and community cooking purposes according to the size of the stove.

Cost of prototype fabrication:

₹450 only. **AU**

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Building Integrated Photovoltaic Modules

Building-integrated photovoltaics (BIPV) are photovoltaic materials that are used to replace conventional building materials in parts of the building envelope, such as the roof, skylights, or facades. They are increasingly being incorporated into the construction of new buildings as a principal or ancillary source of electrical power, although existing buildings may be retrofitted with similar technology. The advantage of integrated photovoltaics over more common non-integrated systems is that the initial cost can be offset by reducing the amount spent on building materials and labour that

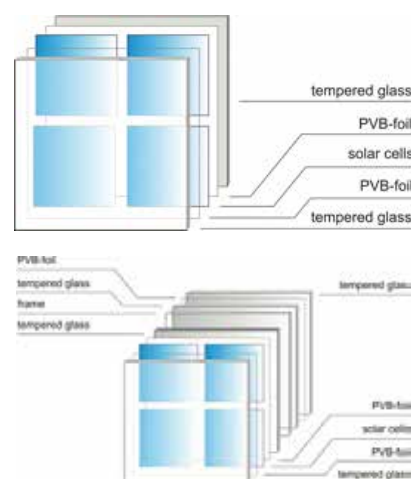
would normally be used to construct the part of the building that the BIPV modules replace. These advantages make BIPV one of the fastest growing segments of the photovoltaic industry.

A BIPV module concept in India has been installed at Gandhinagar in Gujarat. Actually, it is a solar PV module only but with a different feature for its kind. Normally, solar modules are either placed on the rooftop, on streetlight pole, or mounted on the ground for large scale projects and many other applications.

BIPV modules are placed on the 'used to replace' conventional building materials in parts of the *building envelope*, such as the roof, skylights, or facades. BIPV as the name suggests are solar modules that integrate into the building, walls, windows, roofs, etc. These integrate very well into the building structures and thus give a more elegant look to the construction. These are especially designed materials with ancillary source of electrical power. Both new construction as well as older ones can use this technology. The advantages of using BIPV modules are as follows:

- Aesthetically pleasing
- Saves building materials and labour costs
- Can be used on weaker building structures and roofs where solar panels cannot be installed
- Can be used on structures, such as facades and skylights where solar panels cannot be installed.

As roof-integrated transparent modules, usually glass-glass laminates without frame are used. For special roof types, curved roof plastic laminates are used. Crystalline cells are the most common solution—transparency rate is defined by distance between solar cells (as larger the distance the larger the



Construction of transparent solar modules (glass to glass). Single glazing (left) and thermal insulating glazing (right) laminated with PVB foil

transparency rate of transparent modules). For roof integrated glazing's, use of laminated safety insulating glass modules is obligatory due to safety issues.

Significantly, BIPV systems generate electricity and allow for the entry of natural light and also provide heat insulation to the building. The PV panels are integrated aesthetically into the architecture of the building. **AU**

Source: Neety Euro Asia Solar Energy (<http://www.nease.in/>)



Stakeholders' Workshop for Large Scale Commercial Biogas Plants

Indian Biogas Association organized a one day's Stakeholders' Workshop for Large Scale Commercial Biogas Plants on January 19, 2017 in Gurugram, Delhi-NCR, India. This workshop was supported by the Ministry of New and Renewable Energy (MNRE) and German Biogas Association (Fachverband Biogas e V).

The objective of this workshop was to promote large-scale commercial biogas plants by analysing and resolving the challenges impeding the potential growth of this segment. By bringing all relevant stakeholders and government on a single platform may give this industry a new direction for a sustainable success with commercial viability. The workshop was mainly divided into three sections—Technical session, Financial session, and Policy session, which addressed major hurdles prevalent in the growth of large scale biogas plants.

The workshop had participation from different facets of the Biogas



technology across India. Many companies, policymakers, state nodal agencies, consultants, manufacturers, technology providers, and investors attended the workshop. During discussions, participants of the workshop identified the gaps between desired and existing scenario and discussed solutions to plug in the

gaps. Major challenges were noted and they were prioritized by the anonymous voting of participants at the end of the sessions.

MNRE has already taken a note of the outcomes of the workshop and the Indian Biogas Association shall also draft a report based on the discussions. **AU**

WANT TO BE A WRITER ON RENEWABLE ENERGY ?

IF YES, HERE'S THE OPPORTUNITY!

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

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

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Learn to Make a SOLAR STILL

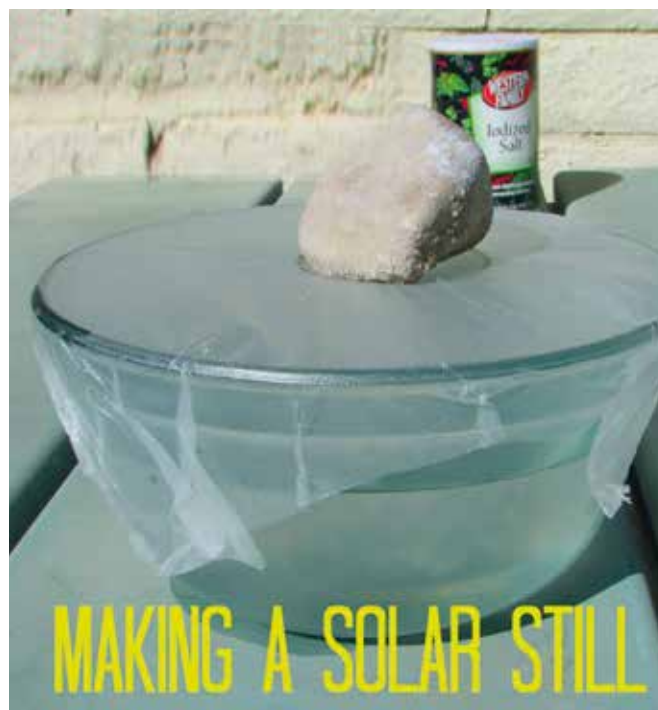
Dear Children,

A solar still distills water, using the heat of the Sun to evaporate, cool then collects the water. There are many types of solar still, including large scale concentrated solar stills, and condensation traps (better known as moisture traps amongst survivalists). In a solar still, impure water is contained outside the collector, where it is evaporated by sunlight shining through clear plastic or glass. The pure water vapour condenses on the cool inside surface and drips down, where it is collected and removed.

Distillation replicates the way rainfall occurs. The sun's energy heats water to the point of evaporation. As the water evaporates, water vapour rises, condensing into water again as it cools and can then be collected. This process leaves behind impurities, such as salts and heavy metals, and eliminates microbiological organisms. The end result is pure distilled water.

You can easily make a solar still by following the steps below.

- The best thing about this renewable energy activity is that it would be useful to know how to do in nature if you had no fresh water to drink or in an emergency situation. A solar still is an easy way to distill water, using the heat of the sun to create evaporation from salt water or any impure water and turning it into fresh water, leaving the salt behind.
- Here, we will make a simpler version of a solar still with a glass bowl, a small glass jar, and plastic wrap.





- Fill a bowl with water and mix a few tablespoons of salt until it dissolves in the water. Put a glass jar in the centre of the bowl, and push it down. You do not want to get any of the salt water into the jar, so make sure the water is not too full in the bowl.



- Cover it all with a plastic wrap and seal it tight. Put a rock in the centre to weight it down and allow the water to fall into the jar. Place it outside in the warm sun for a few hours. What happens is that the water evaporates and collects on the plastic wrap. Then with the rock in the centre it causes the water to run down towards the jar and pool in the jar.
- If you let it work for several hours, there will be a small amount of water in the jar. Taste it, and the water will not taste salty, but fresh. **AU**

Source: <http://teachbesideme.com/simple-science-making-solar-still/>



The Indian Navy is the naval branch of the Indian Armed Forces. It plays a major role in protecting and safeguarding the nation.



Yes, we are all proud of the Indian Navy and all our armed forces.

Do you know that for the first time in the country, solar panels have been installed on an Indian warship. INS Sarvekshak has been fitted with 18 sheets of solar panels atop its hangar. The 300-W panels generate about 1.5 kWh electricity per day.



Oh, it is a wonderful initiative of solar power lighting an Indian Warship. We hope it is beneficial for meeting its energy requirements.

Eurostat Statistics Explained | <http://ec.europa.eu/>

Eurostat Statistics Explained is your guide to European statistics. Statistics Explained is an official Eurostat website presenting statistical topics in an easily understandable way. Together, the articles make up an encyclopedia of European statistics for everyone, completed by a statistical glossary clarifying all terms used and by numerous links to further information and the latest data and metadata, a portal for occasional and regular users. To find the information one needs, one has to select a theme from the menu given below or use the coloured boxes on the right. The search function (alt-f) can also be used. **AU**

Building-Integrated Solar Energy Systems

Robert E Parkin; CRC Press, 548 pages

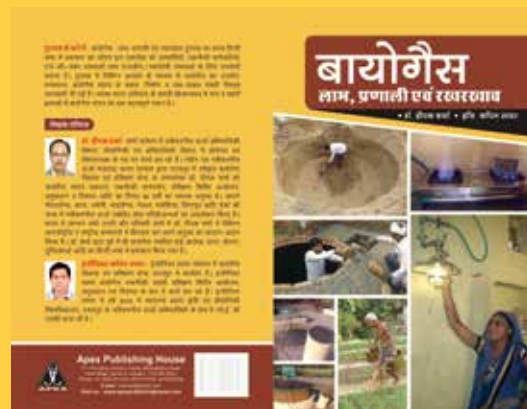
This book presents techniques for building and optimizing structures with integrated solar energy systems. It describes active solar systems such as photovoltaics and parabolic concentrators as well as passive solar systems and covers optimal materials to use, daylighting, shading, solar blinds, rock and water energy storage and more. It discusses the best ways to site a solar structure considering exposure, elevation, slope, clearance, wind protection, etc. The book includes numerous full-colour figures and more than 100 MATLAB® files. **AU**



Hindi Text Book on Biogas

Dr Deepak Sharma and Er. Kapil K Samar Apex Publishing House, Udaipur

This book presents a knowledge base to biologists, academicians, farmers, and agricultural scientists, who will gain in terms of understanding the basic concepts and applications of biogas technology. The book is written in user-friendly Hindi language and the content is arranged in such a systematic



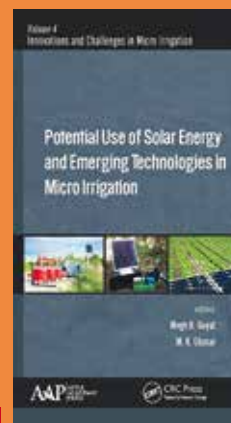
manner that makes its application very simple and easy to understand. It is conveniently arranged by application including waste generation, biogas, bio-manure, and Government scheme. This book also consists of frequently asked questions (FAQs), all supposed to be commonly asked by entrepreneurs, farmers, and new technocrats on biogas technology. The book is a perfect first-stop reference for any scientist, engineer, technical staff, or student looking for information on biomethanation technology. **AU**

Potential Use of Solar Energy and Emerging Technologies in Micro Irrigation

Megh R Goyal, Manoj K Ghosal; Apple Academic Press, 360 pages

This new book, the fourth volume in the Innovations and Challenges in Micro Irrigation book series, examines the potential of solar energy and other emerging energy technologies in micro irrigation to create sustainable energy sources. The authors discuss a variety of innovative micro irrigation system designs, with a special focus on solar energy and photovoltaic (PV) energy. The book:

- Examines several new and innovative design systems for micro irrigation
- Reviews a portable solar photovoltaic powered pumping system for micro irrigation system in vegetable cultivation
- Discusses a new concept of measured irrigation (MI), which is a low-pressure micro-irrigation system that controls the application rate to each plant
- Reviews the performance of a solar greenhouse for water saving and sustainable farming
- Considers nutrient management through drip fertigation to improve yield and quality of crops. **AU**



2017 SUSTAINABLE ENERGY IN AMERICA FACTBOOK

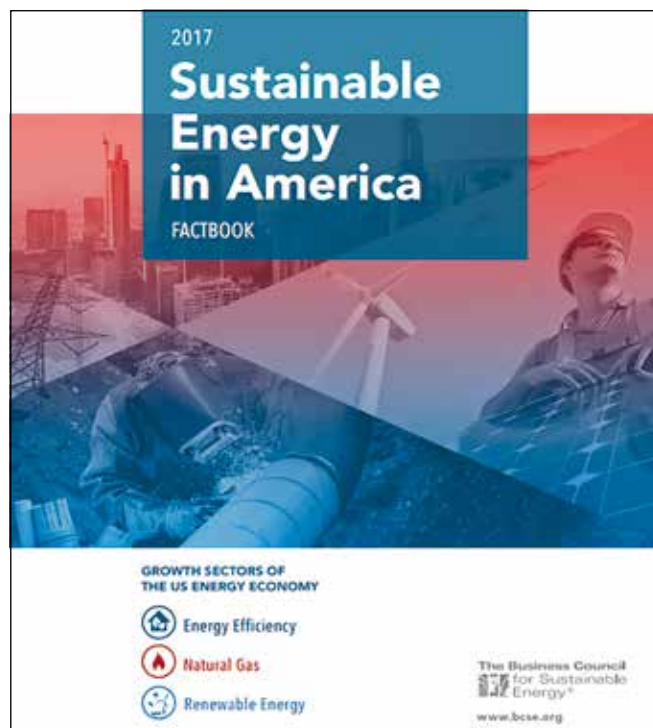
The 2017 edition of the Sustainable Energy in America Factbook—produced for the Business Council for Sustainable Energy by Bloomberg New Energy Finance, provides up-to-date, accurate market information about the broad range of industries—energy efficiency, natural gas, and renewable energy—that are contributing to the country’s move towards cleaner energy production and more efficient energy usage. The 2017 Sustainable Energy in America Factbook marks the fifth year that BCSE and BNEF have collaborated to document the transformation of the US energy system and the growing contributions of sustainable energy technologies.

In the past five years, these contributions have been significant, including:

- The addition of 76 GW of renewable energy generating capacity, and 39 GW of natural gas-fired capacity. Renewables (inclusive of large hydro) and natural gas now meet half of US power demand, up from only 38 per cent in 2011.
- A 10 per cent improvement in US energy productivity, meaning the US economy is using 10 per cent less energy to power each unit of growth.
- A 4 per cent drop in average retail electricity prices in real terms. In New York, Texas, and Florida, prices have fallen over 10 per cent in that time.
- A 12 per cent jump in total gas production, and a 79 per cent surge in shale gas extraction since 2011.
- A 12 per cent improvement in vehicle fuel economy, propelled by federal fuel efficiency standards.

The 2017 Factbook provides an update through the end of 2016, highlighting a number of key developments that occurred as the long-term transformation of US energy continues to unfold. The rapid pace of renewable energy deployment accelerated, consumption and export of domestic natural gas hit record levels, and the economy grew more energy efficient than ever.

Utilities ramped up investments in electric and natural gas transmission, helping create a more reliable energy system. In the face of all this change, the people of the USA are enjoying lower energy bills and are directing less of their household income to energy spending than at any other time on record. The Sustainable Energy in America Factbook provides a detailed look at the state of US energy



and the role that a range of new technologies are playing in reshaping the industry. TheFactbook is researched and produced by Bloomberg New Energy Finance and commissioned by the Business Council for Sustainable Energy. As always, the goal is to offer simple, accurate benchmarks on the status and contributions of new sustainable energy technologies.

The authors also highlight that the book:

- Aims to augment existing, reputable sources of information on US energy
- Focusses on renewables, efficiency, and natural gas
- Fills important data gaps in certain areas (for example, investment flows by sector, contribution of distributed energy, etc.)
- Contains data through the end of 2016 wherever possible
- Employs Bloomberg New Energy Finance data in most cases, augmented by EIA, FERC, ACEEE, LBNL, and other sources where necessary
- Contains the latest information on new energy technology costs. **AU**

Source: <http://www.windpowerengineering.com/>

National

March 23–25, 2017 | Chennai, India

International Conference on Clean Energy and Combustion technologies for Sustainable Habitation

Website: <https://www.mypadnow.com/iccect2017>

April 06–07, 2017 | Chennai, India

International Conference on Sustainable Environment and Energy

Website: <http://10times.com/icsee-chennai>

April 07–08, 2017 | Hyderabad, India

RenewX

Website: <http://www.renewx.in/>

April 25–27, 2017 | New Delhi, India

Windenergy India 2017

Website: <http://www.windergy.in/>

May 10–12, 2017 | New Delhi, India

Smart Cities India Exhibition and Conference

Website: <http://www.smartcitiesindia.com/>

International

March 28–29, 2017 | Johannesburg, South Africa

Solar Show Africa and Power & Electricity World Africa 2017

Website: <http://www.terrapinn.com/>

April 04–05, 2017 | Hamburg, Germany

Hamburg Offshore Wind Conference

Website: <http://10times.com/offshore-wind-hamburg>

April 10–12, 2017 | Minneapolis, USA

International Biomass Conference & Expo

Website: <http://www.biomassconference.com/>

May 08–12, 2017 | Berlin, Germany

Energy Storage World Forum

Website: <http://www.energystorageforum.com/>

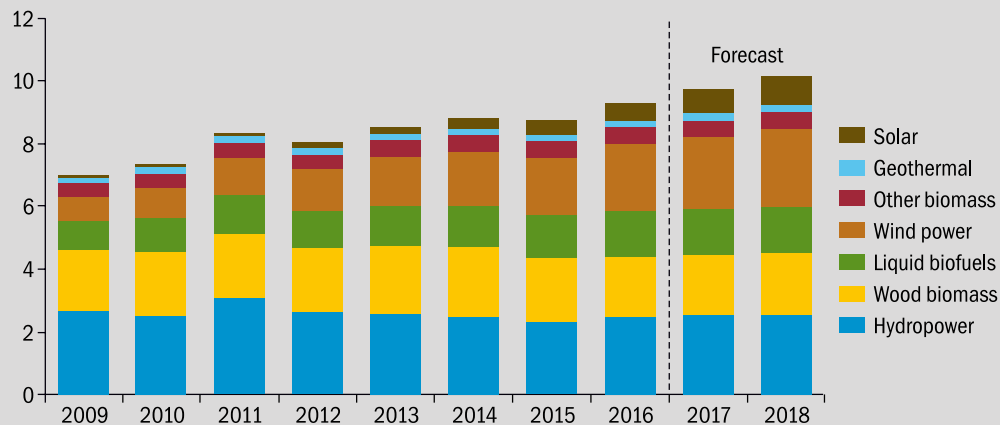
June 07–08, 2017 | Eveleigh, Australia

Renewable Cities Australia

Website: <http://10times.com/renewable-cities>

RENEWABLE ENERGY AT A GLANCE: GLOBAL

U.S. renewable energy supply
quadrillion British thermal units (Btu)

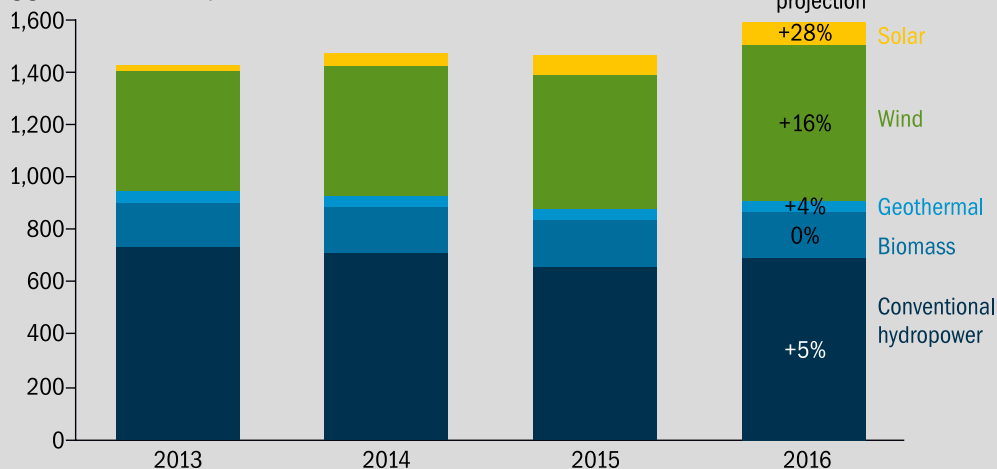


Note: Hydropower excludes pumped storage generation. Liquid biofuels include ethanol and biodiesel.
Other biomass includes municipal waste from biogenic sources, landfill gas and other non-wood waste

Source: Short-Term Energy Outlook, February 2017

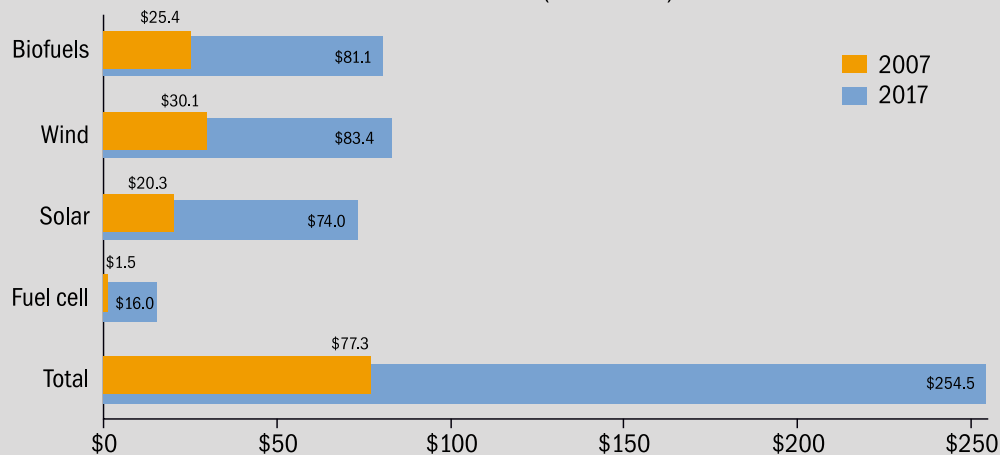
Electricity generation from utility-scale plants, 2013–16

giga watt hours per day



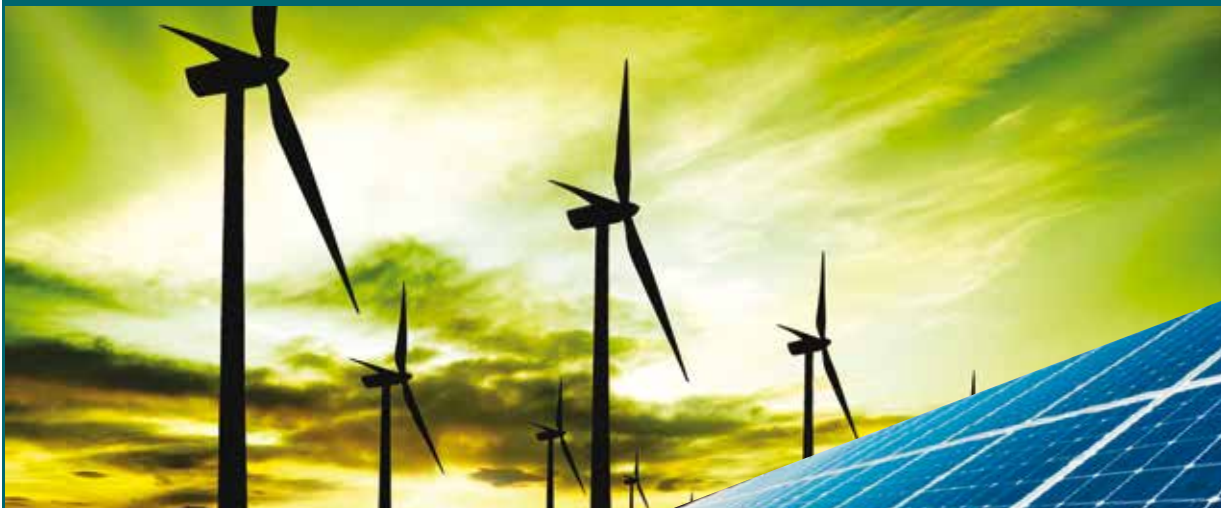
Source: www.eia.gov

Clean energy projected growth
2007–2017 (\$US Billions)



Source: commons.wikimedia.org

CALL FOR RENEWABLE PURCHASE OBLIGATION (RPO) COMPLIANCE THROUGH PURCHASE OF RENEWABLE ENERGY CERTIFICATES (RECs)



For the attention of Obligated Entities (Distribution Companies, Captive Power Consumers and Open Access Consumers) in India

- Renewable energy development is of strategic importance for India from the point of view of long-term energy supply security, decentralization of energy supply particularly for the benefit of the rural population, environmental benefits, sustainability and also reducing carbon footprints of the economy.
- **Electricity Act 2003 has made RPOs mandatory for Obligated Entities.**
- RPOs can be met either by purchasing electricity from renewable sources or by purchasing RECs.
- Non-compliance of RPOs attracts penalties under Section 142 of the Electricity Act.

Are you an Obligated Entity?

REC Regulation 2010 and court orders have mandated RPO Compliance

Comply RPO by purchasing RECs for the year 2016-17 before 31 March 2017 and avoid huge penalties.

REC trade takes place on last wednesday of every month on power Exchanges
For more details log on to
www.ixindia.com or www.pxil.com

For more information, refer to RPO regulation of the respective State Electricity Regulatory Commissions (SERCs)



Government of India

MINISTRY OF NEW AND RENEWABLE ENERGY

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