Renewable Energy
Akshay Urja

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The utilization of wind energy in India has been growing at a steady rate over the past few years. In this article, **J K Jethani** via detailed policy measures, commercial viability, and wind power infirmity management guidelines, traces the trajectory of wind energy in the country and the way forward.

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This article discusses about the successful implementation of the smart city programme in Surat and also highlights that TERI has been actively participating with the SMC in planning and execution of various projects for increased and improvised utilization of the city's solar potential.

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In this article, **Radhey Shyam Meena,** with **Dilip Nigam, S K Gupta, A S Parira,** and **Dr A K Tripathi** describe the critical success factors including development of solar parks in India and the related tariff trends.

मान्यवर, मुझे यह जानकर काफी खुशी हुई कि नवीन और नवीकरणीय ऊर्जा मंत्रालय, भारत सरकार द्वारा अक्षय ऊर्जा पत्रिका का विमोचन किया गया। मुझे भी यह पत्रिका उपायुक्त कार्यालय के माध्यम से प्राप्त हुई। पत्रिका पढ़ने उपरान्त पाया गया कि यह काफी ज्ञानवर्धक होने के साथ-साथ ऊर्जा से सम्बन्धित तथ्यों की जानकारी भी प्रदान करती है। इस पत्रिका में सौर ऊर्जा की नवीनतम तकनीक के बारे में भी जानकारी व विभिन्न विशेषज्ञों की टिप्पणी के बारे में भी जानकारी प्राप्त हुई।

मैने इलेक्ट्रिकल इंजीनियरिंग, चार वर्ष का डिप्लोमा किया हुआ है तथा जिला अम्बाला में सौर ऊर्जा के बारे में लोगो को जागरूक करता हूँ इस बारे में मुझे जिला प्रशासन द्वारा स्वतंत्रता दिवस समारोह, 2017 पर सम्मानित भी गया गया। अत: आपसे विनम्र प्रार्थना है कि आपके विभाग द्वारा अक्षय ऊर्जा पत्रिका मुझे भी मेरे पते पर भिजवाई जाये ताकि इस बारे में सरकार द्वारा उठाये गये कदम, नई तकनीक, नई नीतियों के बारे में जानकारी प्राप्त कर सकूं और लोगों को इस बारे में जागरुक कर सकूं, धन्यवाद सहित।

गुरशरण सिंह
अंबाला, हरियाणा

I liked the article on new forms of printed solar cells published in the June 2017 issue. Printable solar cells that are flexible and lightweight are the need of the hour. This technology will boost the use of solar energy. It is very promising and could bring great future for the use of solar power. All other articles, such as Micro-Mini Solar grids; PV plant; Energy Generator from Paddy straw are informative and useful. I would request you to publish articles on RE Net Metering in details, that is, regarding laws; permission of net metering from state government; tariff paid to grid connected consumers by the govt. etc.

Er Anant B Tamhane
Consulting Engineer Renewable Energy,
Nagpur, Maharashtra

अक्षय ऊर्जा के जून 2017 अंक में प्रकाशित सभी लेख एवं जानकारियां काफी उपयुक्त लगीं। नवीकरणीय ऊर्जा के क्षेत्र में भारत में हो रहे विकास के बारे में पढ़कर हमेशा अच्छा लगता है। हाल ही में राष्ट्रीय राजधानी क्षेत्र, दिल्ली में सभी लोगों को विषैले प्रदूषण की मार झेलनी पड़ी। लेकिन, मुझे पूरा विश्वास है कि यदि आने वाले वर्षों में हम सौर, पवन एवं अन्य नवीकरणीय ऊर्जा के स्रोतों का अधिकाधिक उपयोग करेंगे तो भविष्य में वायु प्रदूषण की समस्या से निजात पाया जा सकेगा।

अभिमन्यु ठाकुर,
नई दिल्ली

I am a regular reader of *Akshay Urja* magazine and I want to congratulate the Ministry (MNRE) and TERI to bring out such a wonderful publication on renewable energy since the last 12–13 years. As a reader, the journey has been fascinating so far as over the years, I have learnt a great deal about renewable energy from this publication. The article on energy generation from paddy straw is an excellent one indeed. The mechanized harvesting of paddy crop has led into open field burning of paddy straw. Burning of million tonnes of paddy straw releases large quantities of greenhouse gases (GHGs), which is very hazardous for the atmosphere. The case study on utilization of paddy straw for power generation through biomethane production route and bioethanol production on commercial scale and improved biomass cookstove on domestic scale is a very appropriate one keeping in mind the kind of air pollution the Delhi/NCR region is witnessing these days.

Dr M K Dutta
Noida, Uttar Pradesh

जून 2017 अंक में प्रकाशित सभी लेख काफी उपयोगी लगे। विशेष तौर पर, सौर वायु हीटर पर प्रकाशित प्रकरण अध्ययन मेरे लिए बहुत उपयोगी है। माइक्रो हाइड्रो पावर (ऊर्जा उत्पादन का वैकल्पिक तरीका) पर प्रकाशित लेख एक बढ़िया सफलता कथा को दर्शाता है। ''सौर कैबिनेट ड्रायर'' लेख भी बहुत ज्ञानवर्धक है। नवीकरणीय ऊर्जा पर महत्वपूर्ण लेख पढ़ने के लिए अक्षय ऊर्जा से बेहतर पत्रिका शायद ही कोई और हो सकती है। आपकी संपादकीय टीम को शुभकामनाएं।

लक्ष्मी नारायण आहूजा,
चण्डीगढ़

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*

सत्यमेव जयते
आनन्द कुमार
ANAND KUMAR

सचिव
भारत सरकार
नवीन और नवीकरणीय ऊर्जा मंत्रालय
SECRETARY
GOVERNMENT OF INDIA
MINISTRY OF NEW AND RENEWABLE ENERGY

Message

Renewable energy has already become a key component of the energy mix in the country and is set to play an increasingly important role. The Ministry has plans to scale up renewable energy deployment to reach a cumulative installed capacity of around 175 GW by 2022 that includes 100 GW solar power capacity. Renewable power excluding hydro above 25 MW installed capacity has already reached over 60 GW, contributing over 17 % of the country's electric installed capacity. For the period April-September 2017, renewable energy contributed over 9% in the electricity mix.

On the international cooperation front for the development and deployment of solar energy, 46 countries have already signed the International Solar Alliance (ISA) treaty, and many more are set to join. ISA has become a treaty-based international intergovernmental organization on December 6, 2017. The ISA initiative is the vision of the Hon'ble Prime Minister and India will continue support for the ISA to realize its objective.

Now, Multilateral Development Banks and other Financial Institutions have started supporting solar projects through low-cost finance. Research and technology institutions worldwide have started working in a big way to bring the cost of solar power and storage within the reach of all. Recently, we have also started tapping unconventional funds, as a five-year 'masala bond' was issued by the Indian Renewable Energy Development Agency (IREDA) and was listed on the London Stock Exchange, raising nearly $300 million (₹19.5 billion). This will help in building robust and transparent assurance frameworks around green bond investment. The money raised from green bonds will go towards financing renewable energy projects across India. This is another area where India is likely to tap resources for harnessing the full potential of renewable energy in the country.

Increased focus on renewable energy and on long-term plans have resulted in making renewable energy sector a very attractive investment destination. Targets coupled with ease-to-do-business offer businesses excellent opportunity for setting and scaling up industries, leapfrogging technologies, and creating volumes. Many steps are also being taken in the country to improve the contractual/counter-party risk framework that is critical to all investors. Emphasis is being laid on simple and predictable policy framework laid in the form of tariff policy and standardization of solar PPAs, etc., to reduce the investment risks. The second wind

Contd...

अक्षय ऊर्जा से देश विकास
गांव गांव बिजली, घर घर प्रकाश

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auction held in October 2017 has resulted in discovery of record low wind tariff. In order to accelerate the global efforts to promote the deployment of renewable energy, and bringing together the international investment community with key sectoral and policy stakeholders, the 2nd edition of the Global Renewable Energy Investors Meet & Expo (RE-INVEST) is scheduled for 19-21 April 2018.

Akshay Urja newsletter is instrumental for disseminating awareness about the Government of India's initiatives in renewables. Our efforts are towards making it more informative with an ever widening reach.

With best wishes.

[Anand Kumar]

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अक्षय ऊर्जा से देश विकास
सूरज एक रूप अनेक

From the Editor's Desk

Akshay Urja is a humble effort from us to chronicle the latest renewable energy initiatives and developments in the country. The renewable energy landscape in the country is truly going through a disruptive transformation. Every day, we are witnessing new knowledge buffeted by discontinuities in every direction. Over the period, surge towards larger share of renewables has taken a shape of mass movement. We perceive the Government of India's role as a facilitator for providing an environment through affirmative action by mandating to progressively increase the share of renewables.

Distinguished readers, we have been fortunate to have your unconditional support all along. We keenly look forward to your suggestions, inputs, and contributions for improving the quality and outreach of the magazine. We also encourage you to send us success stories and photographs depicting multi-dimensional use of renewables. We will be happy to include the selected ones in the forthcoming issues of the magazine with the name of the sender (in the form of a credit line) on the photograph.

With compliments and season's greetings!

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ISA BECOMES A TREATY-BASED INTERNATIONAL INTERGOVERNMENTAL ORGANIZATION

In terms of its Framework Agreement, with ratification by Guinea as the 15th country on November 6, 2017, the International Solar Alliance (ISA) has become a treaty-based international intergovernmental organization on December 6, 2017. The ISA, headquartered in India, has its Secretariat located in the campus of the National Institute of Solar Energy, Gwal Pahari, Gurugram, Haryana.

The ISA is an Indian initiative, jointly launched by the Prime Minister of India, Shri Narendra Modi and the President of France on November 30, 2015, in Paris, on the sidelines of COP-21. It aims at addressing obstacles to deployment at scale of solar energy through better harmonization and aggregation of demand from solar rich countries lying fully or partially between the Tropic of Cancer and Tropic of Capricorn. Presently, 46 countries have signed and 19 countries have ratified the Framework Agreement of ISA.

Signatory Countries (46)
Australia, Bangladesh, Benin, Brazil, Burkina Faso, Cambodia, Chile, Costa Rica, Democratic Republic of Congo, Comoros, Cote d'Ivoire, Djibouti, Cuba, Dominican Republic, Ethiopia, Equatorial Guiana, Fiji, France, Gabonese Republic, Ghana, Guinea, Guinea Bissau, India, Kiribati, Liberia, Madagascar, Malawi, Mali, Mauritius, Nauru, Niger, Nigeria, Peru, Rwanda, Senegal, Seychelles, Somalia, South Sudan, Sudan, Tanzania, Tonga, Togolese Republic, Tuvalu, UAE, Vanuatu, and Venezuela

Ratifying Countries (19)
India, France, Australia, Bangladesh, Comoros, Cuba, Fiji, Guinea, Ghana, Malawi, Mali, Mauritius, Nauru, Niger, Peru, Seychelles, Somalia, South Sudan, and Tuvalu

ISA Interim Secretariat has been operational as a de-facto organization since January 25, 2016. Three programmes—Scaling Solar Applications for Agriculture Use, Affordable Finance at Scale, and Scaling Solar Minigrids—have been launched.These programmes will help in achieving the overall goal of increasing solar energy deployment in the ISA member countries for achieving universal energy access and speeding up economic development. In addition to the existing three programmes, ISA has initiated plans to launch two more programmes: Scaling Solar Rooftops and Scaling Solar E-mobility and Storage.

Further, ISA has also been developing a Common Risk Mitigating Mechanism (CRMM) for de-risking and reducing the financial cost of solar projects in the ISA member countries. The instrument will help diversify and pool risks on mutual public resources and unlock significant investments. An international expert group has been working on the blue print of the mechanism and it will be rolled out by December 2018.

Another major initiative is establishment of Digital Infopedia which will serve as a platform to enable policy makers, Ministers and corporate leaders from ISA countries to interact, connect, communicate and collaborate with one another. The interactive platform was operationalized on May 18, 2017. Digital Infopedia will have three heads: (a) Member countries counter for investment opportunities; (b) at least 1,000 best practices on solar energy (audio/visual), and (c) Member countries of ISA and the ISA Secretariat audio and visual interaction.

Source: pib.nic.in

RENEWABLE ENERGY NEWS

SHRI R K SINGH TAKES OVER AS THE NEW MINISTER OF STATE (I/C) FOR POWER AND NEW & RENEWABLE ENERGY

Shri Raj Kumar Singh took over as the new Minister of State (I/C) for Power and New & Renewable Energy. Speaking to media after assuming his office, Shri Singh said that there is lot of dynamism in both the Power and Renewable Energy Ministries which will be continued. Shri Singh said, that he would meet all standards of performance set by his predecessor and new Railway Minister Shri Piyush Goyal in the Ministries of Power and Renewable Energy. The country is now energy surplus and the vision of the Ministries has been defined by his predecessor, Shri Singh added. He assured Shri Goyal that the good work started by him will be completed and the Prime Minister's vision will be realized.

Shri Goyal said that the officials in Ministries as well as in its PSUs want to cross limitless boundaries. The PSUs are very committed. Talking about Shri Singh, Shri Goyal said that he has always been concerned about providing electricity to all homes and under his leadership now the Power and New & Renewable Energy Ministries will achieve new benchmarks of performance and targets.

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

RAJ BHAVAN GETS GOA'S FIRST GRID-CONNECTED ROOFTOP SOLAR POWER PLANT

The state's first grid-connected 30 kW rooftop solar power plant was inaugurated at Raj Bhavan by the Governor of Goa, Smt Mridula Sinha. Grid connectivity ensures that surplus solar power generated by the plant is fed to the power grid, allowing the consumer to sell surplus solar power to the power grid in the long run. The 30 kW power plant was installed four years ago and connected to the electricity grid only on May 17 this year. The project was commissioned in 2013 under the special area demonstration project scheme of the Ministry of New and Renewable Energy.

The plant has a capacity of generating 30,000 units per year and is expected to bring down the power bills of the entire Raj Bhavan complex. Once the solar policy is finalized, the solar tariff rate for buying surplus solar power from consumers whose plants are connected to the grid would be fixed by the electricity department. Goa Energy Development Agency (GEDA), Public Works Department (PWD) works division IV, Mormugao Port Trust (MPT), and the National Institute of Technology (NIT) had recently connected their solar installations to the grid system in the state.

On the occasion, Smt Sinha spoke of a solar revolution and highlighted the importance of generating green renewable energy in the state, adding that collaboration with GEDA would encourage other parts of the state to replicate such green projects.

Source: https://timesofindia.indiatimes.com

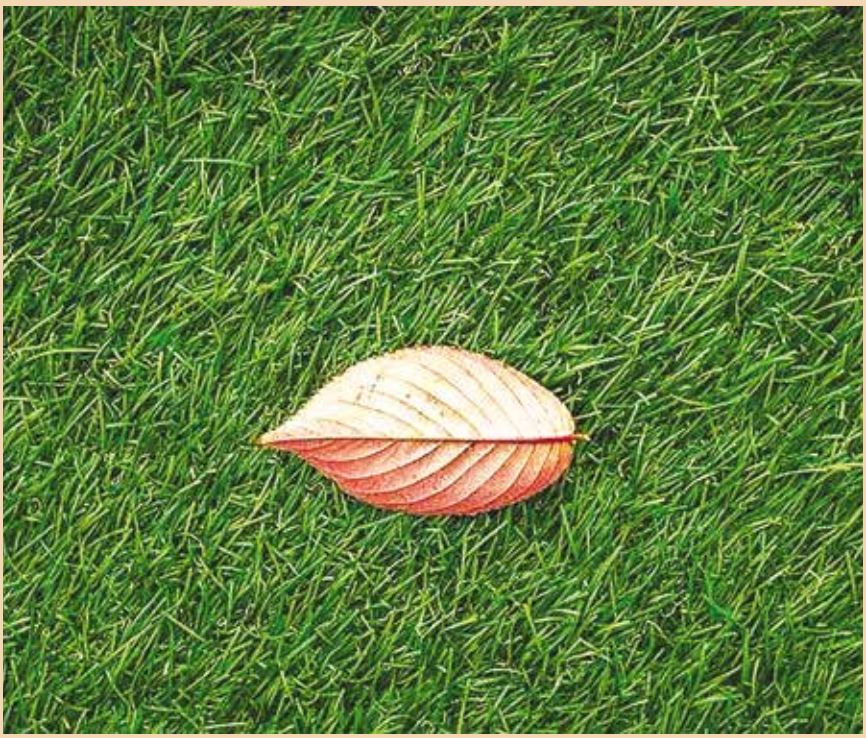
INDIAN SCIENTISTS DEVELOP LEAF THAT ABSORBS WATER, SUNLIGHT TO CREATE FUEL

Scientists have developed an artificial leaf that absorbs sunlight to generate hydrogen fuel from water, an advance that may provide clean energy for powering eco-friendly cars in the future.

The ultra-thin wireless device mimics plant leaves to produce energy using water and sunlight. "It is known that hydrogen generation from renewable resources will be the ultimate solution to our energy and environment problems," said Chinnakonda S Gopinath, a senior principal scientist at the Council of Scientific and Industrial Research (CSIR)—National Chemical Laboratory in Pune. "Hydrogen burning gives energy and water as a byproduct, underscoring its importance and relevance to the present day world. Though India basked in sunlight, not enough had been done to translate it into energy. This line of research is very relevant to our country. India is blessed with plenty of sunlight through the year that is not exploited significantly to produce energy or hydrogen," he said.

The device consists of semiconductors stacked in a manner to simulate the natural leaf system. When visible light strikes the semiconductors, electrons move in one direction, producing electric current. The current almost instantaneously splits water into hydrogen—which researchers believe is one of the cleanest forms of fuel as its main byproduct is water. In view of pressing energy and environmental issues, it was important to produce hydrogen from natural resources such as sunlight and water, Gopinath said. "In the present work, we have made an attempt to generate solar hydrogen. The preparation method reported is simple and practicable and hence there is a very good possibility of scaling it up," he said. The research, published in the Scientific Reports, an online, open-access journal from the publishers of Nature, states that the device of an area of 23 sq. cm could produce 6 litres of hydrogen fuel per hour. "When exposed to sunlight for 25 hours, the device retained its efficiency. The cell does not need any external voltage and performs better than existing solar cells," he said.

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



INDIA GETS LOWEST WIND TARIFF OF ₹2.64 PER kWH

The wind tariff in India touched lowest level of ₹2.64 per kWh in the second wind auction conducted by the Solar Energy Corporation of India (SECI) on behalf of the Ministry of New and Renewable Energy, Government of India. The tariff discovered is much lower than first wind auction concluded at ₹3.46 per kWh in February 2017. With

improving technology and reducing tariffs the Ministry is not only confident of achieving the target of 175 GW by 2022 but exceeding it.

Against the 1,000 MW capacity, SECI received 12 bids totalling to 2,892 MW capacity of which nine bids with a cumulative capacity of 2,142 MW were shortlisted for e-reverse auction. The five winners selected for total 1,000 MW capacity wind power projects include ReNew Power for 250 MW projects quoting ₹2.64/kWh, Orange Sironj for 200 MW projects quoting ₹2.64/kWh, Inox Wind for 250 MW projects quoting ₹2.65/kWh, Green Infra for 250 MW projects quoting ₹2.65/kWh and Adani Green for 50 MW projects quoting ₹2.65/kWh. These wind projects are to be commissioned within 18 months from the date of issue of Letter of Award by SECI to successful bidders. The power from these projects will be supplied to obligated entities for fulfillment of their non-solar RPO obligation at pooled price of capacity selected.

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

MNRE AND GIZ SIGN AGREEMENT TO IMPROVE FRAMEWORK CONDITIONS FOR GRID INTEGRATION OF RENEWABLE ENERGIES

The Ministry of New and Renewable Energy (MNRE), Government of India, and Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH India on behalf of the Government of the Federal Republic of Germany have signed an agreement on technical cooperation under the 'Indo-German Energy Programme—Green Energy Corridors (IGEN-GEC)'. The main objective of this programme component is to improve the sector framework and conditions for grid integration of renewable energies.

Speaking on the occasion, the then Minister of Power and New & Renewable Energy Shri Piyush Goyal said, "I am delighted that this relationship between GIZ and India will result in improved market mechanisms and regulations, help us train manpower, to ensure grid stability and integration of renewables into grid and ensure safer and secure grid and a grid which can take cyber challenges". Shri Goyal further added that Germany is a very reliable partner country and has been supporting India in achieving its goal for sustainable development through bilateral cooperation for almost six decades now.

Being committed to this objective, GIZ and MNRE will work on improving market mechanisms and regulations for integration of renewable energies; advancing technical and institutional conditions in specified target states, regions and on a national level; adding human capacities to handle systemic (strategic, managerial, financial, technical) renewable energies integration in an efficient and effective manner. It was added that India and Germany would further benefit each other in the journey towards sustainable development. There would be economic growth and a cleaner world with successful continuation of cooperation and fruitful exchange.

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

GREEN POWER: INDIA TO SURPASS EU

India's renewable energy expansion is set to overtake that of the European Union (EU) for the first time by 2022. The installed renewable energy generation capacity in the country would also double by then, says a report titled, *Renewables 2017*, released by the International Energy Agency. Solar photovoltaic (SPV) and wind together would represent 90% of India's capacity growth in the coming years as auctions have yielded some of the world's lowest prices for both the technologies, the report said. Boosted by a strong solar PV market, renewables accounted for almost two-thirds of the net new power capacity around the world last year, with almost 165 GW coming online. New SPV capacity grew by 50% globally last year, with China accounting for almost half of the expansion. For the first time, SPV additions rose faster than any other fuel, surpassing the net growth in coal. By 2022, global renewable electricity capacity should increase by 43%, the report said. By then, renewables will account for 30% of global power generation, up from 24% in 2016.

This year's renewable forecast is 12% higher than last year, thanks mostly to solar PV upward revisions in India and China. India, China, and the United States will account for two-thirds of global renewable expansion by 2022, the report said. Globally, auction price of solar PV energy has fallen to three cents (1.97) per unit. In India, Rajasthan signed deals at 2.44 per unit in May 2017 to produce 500 MW solar power. The wind energy tariff fell to 2.64 per unit in an auction conducted by Solar Energy Corporation of India in Gujarat.

Source: https://timesofindia.indiatimes.com

GREEN ENERGY TARIFFS WILL FALL FURTHER, HELP ACHIEVE TARGETS: SHRI ANAND KUMAR

Renewable energy tariffs that have already tumbled to a record low will fall further and help India achieve its ambitious targets for generating green electricity, Secretary, MNRE, Shri Anand Kumar said. "In the years to come, with the technology improving, we expect that the tariffs would go down further, both in solar and wind sector," Kumar told *The Economic Times*. "The ministry welcomes this trend of falling tariffs, which will provide a boost to the renewable energy sector in the country," he added.

"This is a boost to the renewable energy sector and it makes RE power affordable for the benefit of the common man. As more and more renewable energy would be generated, the issue of grid balancing will be automatically taken care of. Power from renewable sources will bring a household revolution in the country," Shri Anand Kumar said. Lowering the tariffs will help the country realize its goal of adding 175 GW renewable energy capacity by 2022, Kumar said, as there will be more takers for cheaper power. "I am confident that we will not only achieve this target, but will also exceed it," he said.

Source: http://economictimes.indiatimes.com/

POSTPONEMENT OF RE-INVEST

The Global RE-INVEST 2017, India-ISA Partnership; Renewable Energy Investors Meet and Expo initially proposed to be held from December 7–9, 2017 has been rescheduled to April 19–21, 2018, due to unavoidable reasons. The Ministry of New and Renewable Energy (MNRE) is grateful to all the speakers, panelists, delegates, manufacturers, developers, technology providers, research institutions, NGOs, and sponsors for their support to the event. The structure of the programme for RE-INVEST 2018 would remain same as was for RE-INVEST 2017. All the speakers who have confirmed their participation are being requested to reconfirm for the new dates. The delegates who have already registered need not register again.

IREDA'S GREEN 'MASALA BOND' RAISES $300 MN IN LONDON

A five-year 'masala bond' issued by the Indian Renewable Energy Development Agency (IREDA) was listed on the London Stock Exchange, raising nearly $300 million (19.5 billion), with a coupon of 7.125%. The green 'masala bond' on London Stock Exchange's International Securities Market is certified by Climate Bonds Initiative, an international, investor-focussed not-for-profit initiative that helps build robust and transparent assurance frameworks around green bond investment. The money raised from its green bond will go towards financing renewable energy projects across India. This is the fourth green bond by an Indian issuer to be issued on London Stock Exchange. Axis Bank and NTPC joined in 2016, raising the equivalent of $500 million and $300 million. In June, REC raised $450 million, the exchange said. Ten new green bonds have been listed on the London Stock Exchange in 2017 alone.

Shri K S Popli, chairman and managing director of IREDA, said: "The Green Masala Bond is a significant milestone for IREDA in this regard, as we embark on the next phase of renewable and sustainable energy led expansion. The overwhelming response to the issue is a testament to the confidence of global investors in IREDA and the Indian renewable sector in general."

IREDA's green bond is the latest in a long line of global firsts for London Stock Exchange Group, including numerous high profile Indian and green bond issuances on London Stock Exchange.

Source: http://www.hindustantimes.com

NEARLY 140 COUNTRIES COULD BE POWERED ENTIRELY BY WIND, SOLAR, AND WATER BY 2050

More than 70% of the countries in the world—including the UK, US, China and other major economies—could run entirely on energy created by wind, water, and solar by 2050, according to a roadmap developed by scientists. And they pointed out that doing so would not only mean the world would avoid dangerous global warming, but also prevent millions of premature deaths a year and create about 24 million more jobs than were lost.

One of the scientists said the social benefits of following their roadmap were so 'enormous' and essentially cost free that human society should "accelerate the transition to wind, water, and solar as fast as possible".

Rooftop solar panels and major solar power plants; offshore and onshore wind turbines; wave, hydroelectric and tidal schemes; and geothermal energy would also be used to replace fossil fuels to generate electricity, power vehicles and heat homes.

Source: http://www.independent.co.uk/

SOLAR-POWERED DEVICES MADE OF WOOD COULD HELP MITIGATE WATER SCARCITY CRISIS

Engineers at the University of Maryland's A James Clark School of Engineering have created a novel technological solution to the pressing global challenge of water scarcity by creating a suite of solar steam generation devices that are at once efficient, easily accessible, environmentally friendly, biodegradable, and extremely low cost. Inspired by the process by which water is carried through trees from roots to small pores on the underside of leaves, the UMD research team created several new ways in which water can be transported through wood, purifying it for safe use. Energy from the sun and a block of wood smaller than an adult's hand are the only components needed to heat water to its steaming point in these devices.

The global crisis of water scarcity is a pressing global challenge, and the situation is far worse in developing countries, where safe water is difficult to secure for 1 billion people. "Cost and manufacturing are key challenges in using the solar-steam technology for seawater desalination and for the first time, wood-based structures can potentially provide solutions," said Liangbing Hu, UMD associate professor of materials science and engineering and the leader of the projects. Hu is interested in scaling up these devices for commercial use, which includes designing ways to easily manufacture the devices and bring down their cost. The team is trying out a few twists on the basic idea of using a darkened surface on the wood to heat the water, then pulling it through the wood's natural porous structures.

Picture a bowl of unpurified water sitting in a sunny spot. On top of it floats a small block of wood about two inches by two inches. The side of the block facing up is darkened, to catch the sun's rays. As the sun heats the wood, the water below is drawn up through the wood's natural channels. The hot dark surface evaporates the water, which can be condensed and distilled off. The salt or other contaminants are too heavy to evaporate, so they stay below. One design, as published in the journal *Advanced Materials*, uses carbon nanotubes—tiny, naturally dark structures grown in a lab—to coat one side of the wood and heat the water inside. Another, described in the journal *Advanced Energy Materials*, uses metal nanoparticles to achieve the same results. Both of these designs are very efficient, but come with a higher cost to produce.

Source: https://www.sciencedaily.com

SCOTLAND GETS WORLD'S FIRST FLOATING WIND FARM

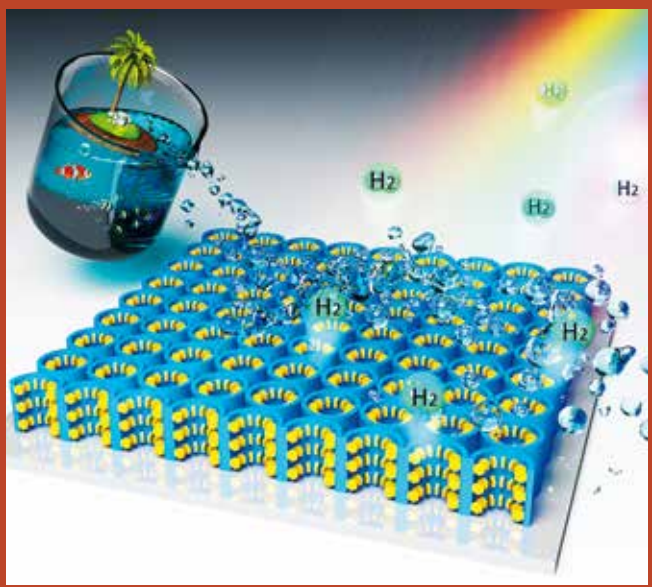
The world's first full-scale floating offshore wind farm has come up in the north-east coast of Scotland. Five wind turbines have been installed across the ocean, where they have started working off the coast. According to Statoil, the Norwegian state energy company behind the project, the technology enables wind power to be harvested in waters too deep for the current conventional bottom-standing turbines. Known as Hywind, the Peterhead wind farm will generate power for 20,000 homes. "This is a tech development project to ensure it's working in open sea conditions. It's a game-changer for floating wind power and we are sure it will help bring costs down," said Leif Delp, project director for Hywind.

Source: http://www.energynext.in/

NEW NANOMATERIAL CAN EXTRACT HYDROGEN FUEL FROM SEAWATER

It is possible to produce hydrogen to power fuel cells by extracting the gas from seawater, but the electricity required to do it makes the process costly. UCF researcher Yang Yang has come up with a new hybrid nanomaterial that harnesses solar energy and uses it to generate hydrogen from seawater more cheaply and efficiently than current materials. The breakthrough could someday lead to a new source of the clean-burning fuel, ease demand for fossil fuels and boost the economy of Florida, where sunshine and seawater are abundant.

It's done using a photocatalyst—a material that spurs a chemical reaction using energy from light. When he began his research, Yang focussed on using solar energy to extract hydrogen from purified water. It's a much more difficult task with seawater; the photocatalysts needed aren't durable enough to handle its biomass and corrosive salt.



As reported in the journal *Energy & Environmental Science*, Yang and his research team have developed a new catalyst that is able to not only harvest a much broader spectrum of light than other materials, but also stand up to the harsh conditions found in seawater. "We've opened a new window to splitting real water, not just purified water in a lab," Yang said. "This really works well in seawater."

Yang developed a method of fabricating a photocatalyst composed of a hybrid material. Tiny nanocavities were chemically etched onto the surface of an ultrathin film of titanium dioxide, the most common photocatalyst. Those nanocavity indentations were coated with nanoflakes of molybdenum disulphide, a two-dimensional material with the thickness of a single atom.

Typical catalysts are able to convert only a limited bandwidth of light to energy. With its new material, Yang's team is able to significantly boost the bandwidth of light that can be harvested. By controlling the density of sulphur vacancy within the nanoflakes, they can produce energy from ultraviolet-visible to near-infrared light wavelengths, making it at least twice as efficient as current photocatalysts.

"We can absorb much more solar energy from the light than the conventional material," Yang said. "Eventually, if it is commercialized, it would be good for Florida's economy. We have a lot of seawater around Florida and a lot of really good sunshine." In many situations, producing a chemical fuel from solar energy is a better solution than producing electricity from solar panels, he said. That electricity must be used or stored in batteries, which degrade, while hydrogen gas is easily stored and transported.

Source: https://phys.org

The Sun Reigns

The International Solar Alliance (ISA) came a complete circle at CoP23, Bonn, since its inception at CoP21 in Paris in 2015. The ISA, a treaty-based international intergovernmental organization of 121 prospective solar-rich Member Countries situated fully and partially between the Tropics, was co-founded by Hon'ble Prime Minister of India, Shri Narendra Modi and former President of France, H.E. Francois Hollande on the sidelines of the Paris Climate Talks. The ISA was ratified by 15 Member Countries into a legal entity on December 6, 2017.

As a precursor to the ratification, the ISA, in partnership with the Ministry of New and Renewable Energy (MNRE), Government of India and the Confederation of Indian Industry (CII) hosted a Curtain Raiser for the ISA Founding Ceremony at the India Pavilion at CoP23, Bonn, on November 13, 2017.

The event was graced by Secretary, MNRE, Shri Anand Kumar;

» Interim Director General, International Solar Alliance, Shri Upendra Tripathy, addressing the Curtain Raiser of the ISA Founding Ceremony

» Secretary, Ministry of New and Renewable Energy, Government of India, Shri Anand Kumar, addressing the Curtain Raiser of the ISA Founding Ceremony

Secretary, Ministry of Environment, Forest and Climate Change, Government of India, Shri C K Mishra; Special Envoy for the implementation of the ISA, Government of France, H E Ségolène Royal, and Interim Director General of the ISA, Shri Upendra Tripathy.

Speaking on the occasion, Shri Anand Kumar, hoped that, in the spirit of affirmative action, developed countries will earmark a percentage of Overseas Development Assistance (ODA) towards solar energy projects in developing countries. He suggested that Multilateral Development Banks and other financial institutions provide wholehearted support for solar projects through low cost finance, and research & technology institutions worldwide try their utmost to bring the cost of solar power and storage within the reach of all. He reaffirmed Indian Government's continued support for the ISA as a translation of the vision of Prime Minister Modi.

Shri Mishra underlined the need for integrating solar energy into sustainable development goals by arranging technologies, finance, and capacity building for solar projects and augmenting storage.

Ms Royal highlighted the five key points to accelerate global solar deployment: setting concrete goals, developing and leveraging common tools, enhancing projects, establishing decentralized PV solutions, and forging new partnerships that capitalize on complementary capabilities.

Shri Tripathy described the ISA's programmes on facilitating affordable finance for solar, scaling up solar applications for agriculture, and promoting solar mini-grids in Member Nations. The discussions covered the ISA's Common Risk Mitigation Mechanism (CRMM) project, aimed at de-risking investments into solar energy projects in developing countries, and a multinational panel on accelerating global solar deployment through the ISA.

at CoP23

» (from left to right) Shri Anand Kumar Secretary, Ministry of New and Renewable Energy, Government of India; H E Ségolène Royal, Special Envoy for the implementation of the ISA, Government of France; Shri C K Mishra, Secretary, Ministry of Environment, Forest and Climate Change, Government of India; and Shri Upendra Tripathy, Interim Director General, International Solar Alliance, at the Curtain Raiser of the ISA Founding Ceremony

A DEEP DIVE INTO INDIA'S 175 GW RE TARGET

The Confederation of Indian Industry (CII) partnered the Ministry of New and Renewable Energy (MNRE), Government of India to host a panel discussion on innovative financing and market evolution to achieve India's target to install 175 GW installed renewable energy capacity by 2022, on November 16, 2017 at the India Pavilion at CoP23, Bonn, Germany.

The 175 GW target includes 100 GW solar, 60 GW wind, 10 GW bio-energy and 5 GW small hydro power (SHP). Proactive policies and concerted effort between all stakeholders have led to the installation of over 60 GW already.

The discussions included policymakers, industry leaders, financiers and multilateral agencies, and covered a number of issues including the major challenges to achieve India's ambitious renewables target; ways to finance further generation as well as market development for large buyers as well as retail sales; easing offtake of the generated renewable power; creating a reliable distribution network to reach renewables into urban societies and rural communities, and driving transformative change through cleantech innovations.

The 175 GW target has been distributed between Indian states and Union Territories. To understand the policies and processes being employed by the states to achieve their individual targets, in 2016, NITI Aayog commission a study on 'India's Renewable Energy Capacity Addition Roadmap', with CII as the knowledge partner. The Executive Summary of the report, covering 9 states and based on interactions with state energy departments; electricity regulatory commissions; generation, transmission and distribution companies; grid operators; power planning agencies; industry, financiers, and multilateral agencies, was launched at the session. AU

Courtesy: Ms Shuva Raha, Deputy Director & Head – New Initiatives, Energy Confederation of Indian Industry (CII)

» A packed hall for the ISA Curtain Raiser

» Launch of NITI Aayog report on 'India's Renewable Energy Capacity Addition Roadmap', with CII as knowledge partner, at the MNRE-CII session on 'Market Evolution to Achieve 175 GW Renewables'

NEW GUIDELINES FOR TARIFF-BASED COMPETITIVE BIDDING PROCESS

To Reduce Risk, Enhance Transparency and Increase Affordability of Solar Power

The Ministry of New and Renewable Energy (MNRE), Government of India, has issued the new guidelines for tariff-based competitive bidding process for procurement of power from grid connected solar PV power projects on August 3, 2017. Here, **Sarvesh Devraj** discusses the objectives and the key reforms initiatives of these new guidelines.

According to one of the key objectives of Electricity Act, 2013 "Promotion of competition in the electricity in India" emphasizes on the reduction of electricity cost through the competitive procurement mechanism. The power purchase cost of electricity is the major cost ingredient for distribution likenesses, thus the overall cost of electricity enhances on consumer side. Hence, when India is taking tremendous lead in deploying renewable sources of energy, such as solar for meeting its current energy demands, the appropriate regulations/guidelines would be certainly instrumental in reducing cost of electricity from solar energy. The National Tariff Policy, 2016, has also stressed on purchasing power from the renewable energy sources. It stated that procurements of renewable power of specified capacities shall be done

through competitive bidding process. Keeping this in mind and making solar more affordable to consumers, the Ministry of New and Renewable Energy (MNRE), Government of India, issued the new guidelines on August 3, 2017, for tariff-based competitive bidding process for procurement of power from grid connected solar PV power projects.

These guidelines have been issued under the provisions of Section 63 of the Electricity Act, 2003, for long-term procurement of electricity by the 'procurers' [the distribution licensees, or the authorized representative(s), or an intermediary procurer] from grid-connected solar PV power projects ('projects'), having size of 5 MW and above, through competitive bidding.

OBJECTIVE

The new guidelines aim to provide more freedom to investors, flexibility, and transparency in solar PV generated electricity. The specific objectives of these guidelines are as follows:

Protection of consumer's interests

Chief objective of the guidelines would be to promote competitive procurement of electricity from solar PV power plants through distribution licensees. The competition in purchasing/selling of solar-based power will reduce the power purchase cost, hence the reduction in overall cost of procurement.

Bring transparency in procurement mechanism

The guidelines also focus on bringing more transparency and fairness in procurement process. In case of long-term power procurement within state or inter-state, the guidelines would provide a framework for an intermediary procurer for a trading.

Standardization and uniformity

To protect the interests of the investors by bringing more confidence and business, these guidelines aim to provide more stability and uniformity in process.

To ease the procurement process, minimizing the risk associated with the solar PV projects among stakeholders thereby encouraging investments, increased bankability of the solar projects, and profitability for the investors.

KEY REFORMS INITIATIVES

Various reforms initiatives such as *power purchase agreement* (*PPA*), repowering, bidding process, etc., have been directed in the announced guidelines. The detailed discussions on these key reforms are described here.

PPA reforms

The PPA period has been kept high because then in case of higher PPA it tends to give lower tariff. The PPA for the solar PV projects should not be less than 25 years from the scheduled date of commissioning. In any case, unilateral termination is not allowed and also there shall be no change in the PPA proposed.

In case of supplying less energy corresponding to the minimum capacity utilization factor (CUF) by the solar power generator will be subjected to pay penalty for the shortfall in energy supply below the signed CUF level. The amount of the penalty will be according to PPA, which has ensured the interests of procurers. On the other side, in case of availability of power that is more than the maximum CUF mentioned in PPA, the generators have rights to sell it to another entity, provided first right of refusal will vest with the Procurer(s).

Generation compensation

In a few conditions where the plants are ready to commission but some constraints, such as lack of power evacuation infrastructure, grid unavailability or eventuality of back-down have arisen due to off-take constraints, these should be minimized by providing some generation compensations. The new reforms on the generation compensation include off-take risk reduction process for the current running projects. Generation compensation provided for following off-take constraints are given in Table 1.

Table 1: Generation compensation for various off-take constraints

Off-take constraints type	Generation compensation
Grid unavailability	Compensation by way of procurement of excess generation/ outright compensation
Back-down	50% of [(average generation per hour during the month) x (number of back down hours during the month) x PPA tariff

Repowering

The new norms say that solar power generators will be free to re-power from time to time according to their suitability during the specified PPA duration. But there will be change for the procurer for buying electricity; it should be within the range of CUF, mentioned in the PPA. Any excess generation power generators are free to sell the power to anyone after the consent of current procurers.

Bid structure and process

Bid structure will be designed in the form of packages with minimum size of each package being 50 MW. Apart from this, smaller packages will be applicable only for the North-Eastern and special category states. Bidders have to bid for entire package. Bids have been allowed in both power (MW) and energy (kWh) terms. There are two ways of selecting bidding parameters for the procurers: tariff as bidding parameter and viability gap funding (VGF) as bidding parameters.

- *Tariff as bidding parameters:* In case of this, the bidding parameters will be the tariff quoted by the bidders. The procurers shall opt for—fixed tariff for 25 years (in ₹/kWh) and escalating

» Solar modules at rooftop, Chhattisgarh-1

tariff with pre-defined annual escalations (in ₹/kWh).

- *Viability gap funding (VGF) as bidding parameters:* It involves a mechanism wherein a predetermined tariff is offered to the solar power generator along with a financial assistance, to enable the solar power generator to supply power at this tariff.
- To make bidding process more effective and transparent, e-bidding has been stressed on.

PAYMENT SECURITY MECHANISM

The procurers have to ensure the regular payments to their respective power providers. There is formulation of proper payments security mechanism to avoid the risk of generators in case of delayed/ non-payments. The instruments like Letter of Credit (LC), payment security fund, and state guarantee will ensure generators interest. There are different clauses for the procurers based on their procurement process, that is, whether it is purchased directly from generators of through any intermediate procurers. Table 2 provides information about the payment security mechanism.

Table 2: Payment security mechanism

Scenarios	Security Instruments	Mechanism
Direct procurement by procurer from solar power generator	Letter of credit (LC)	Amount not less than 1 (one) month's average billing from the Project under consideration;
	Payment security fund	Payment for at least 2 (two) months' billing of all the Projects tied up with such fund.
	State government guarantee	Guarantee to cover at least 3 (three) months' average billing of the Projects.
Intermediary-procurer procures from the solar power generator and sells to the end Procurer	Payment security by intermediary procurer to the solar power generator	
	Letter of credit (LC)	An amount not less than 1 (one) month's average billing from the Project under consideration
	Payment security fund	Support payment of at least 2 (two) months' billing of all the Projects tied up with such fund.
	b) Payment security by end procurer to intermediary procurer	
	Letter of credit (LC)	An amount not less than 1 (one) month's average billing from the Project under consideration
	Payment security fund	Support payment of at least 2 (two) months' billing of all the Projects tied up with such fund
	State government guarantee	Guarantee to cover at least 3 (three) months' average billing of the Projects.

RATIONALIZATION OF PENALTIES

According to the commission schedule the project (less than 250 MW) should be commissioned within 13 months. In case failing to do so there is adequate penalty on solar power generators according to the PPA. There is always uncertainty between generators and procurers to take these penalties. Clarity on penalties certainly saves the risk involved with the investments. So penalties have been rationalized to reduce the overall cost to the generators while ensuring the scheme guidelines.

TERMINATION COMPENSATION

In case of termination of PPA and making projects more bankable, termination compensation has been introduced. These compensations will be securing the generators' and lenders' investments. Quantum and modality for termination compensation in case of both generator default and procurer default has been clearly defined.

SUMMARY

To summarize, new guidelines for tariff-based competitive bidding process for procurement of solar power will help enhance transparency and fairness in the procurement process, while protecting consumer interests through affordable power. These guidelines will also provide standardization and uniformity in processes and a risk-sharing framework between various stakeholders involved in the solar PV power procurement. This will help in reducing off-taker risk and thereby encourage investments, enhance bankability of the Projects and improve profitability for the investors. AU

Mr Sarvesh Devraj, Research Associate, Renewable Energy Technology Applications, Renewable Energy Technologies Division, TERI, New Delhi.

ESCALATION TO THE RENEWABLES IN INDIA

From Moderate to Exponential Growth

Up-scaling of the target for overall renewable energy capacity by more than five times to 175 GW by the year 2022, which includes 100 GW from solar, 60 GW from wind, 10 GW from bio-power, and 5 GW from small hydro-power, has energized the RE sector. **Pankaj Saxena** and **Rahul Rawat** highlight the major achievements in the solar and wind sectors during the last three years and the future for the sector.

A swift transformation has been observed in the renewable energy (RE) sector of India in the past three years in terms of both installed capacity and programme formulation/implementation. The growth has been further pushed up by the encouraging policy regime, precise incentives, and declining trend in the price of photovoltaic module. Every segment of RE, that is, solar, wind, biomass, small hydro, and bio-power, have been focussed in a mission mode to fulfil the objective of providing sustainable power to all households. The steps towards achieving the enhanced targets are in line, such as international cooperation, launch of new schemes, generation of trained work force, proper evacuation of power, and regulations for quality control. Apart from the fact that everyday new strides are being taken within the country in the RE sector, India is playing a pivotal role in the international arena as well. International Solar Alliance was launched as a special platform for mutual cooperation among 121 solar resource-rich countries lying fully or partially between Tropic of Cancer and Tropic of Capricorn at CoP21 in Paris on November 30, 2015, to develop and promote solar energy, with its headquarter in India. The scaling up of the targets for solar energy requires a skilled workforce for installation and maintenance of the systems. A programme was launched to provide training to 50,000 personnel in five years, of which more than 11,000 Suryamitras have been trained so far and about 8,400 Suryamitras trained in FY 2016/17.

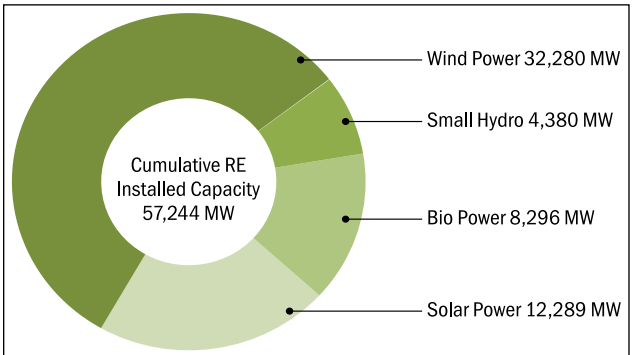
The growth of 115% has been achieved with capacity addition of 25,287 MW grid-connected renewable power during last three and a half years (2014/15 to 2016/17 and up to September 30, 2017), as compared to 11,746 MW installations during preceding three years (2011/12 to 2013/14). The cumulative installed capacity of grid-connected renewable power has reached 60,157 MW at the end of September 2017, which accounts for 18.26% of installed capacity from all resources. The 60,157 MW installed grid-connected renewable power capacity includes 32,700 MW from wind, 14,771 MW from solar, 4,380 MW from small hydro, and 8,295 MW from bio resources. The electricity generation by RE sources has also increased enormously from 61.78 BU (5.56% of total generation)

during 2014/15 to 81.86 BU (6.59% of total generation) during 2016/17. Green energy corridor of over 8,553 ckt-km (circuit kilometres) of transmission lines is being set up with ₹38,000 crore to facilitate smooth evacuation of renewable power from generation stations to load centres. Figures 1 to 3 summarize the major developments in the RE sector.The major achievements in the solar and wind sector made during the last three years (as on March 31, 2017) are summarized as under:

NATIONAL SOLAR MISSION

The National Solar Mission (NSM) was launched in 2010 with a target of deploying 20 GW of grid-connected solar power by 2022 and to reduce the cost of solar power generation in the country through: (i) long-term policy; (ii) large-scale deployment goals; (iii) aggressive R&D; and (iv) domestic production of critical raw materials, components, and products in order to achieve grid tariff parity by 2022. The foundation of the solar sector, in terms of policy, market, and R&D, laid by the NSM in the country over the period enables aggressive revision of the initial target of 20 GW to 100 GW by year 2022. The achievement of 363% has been made with capacity addition of 12,319 MW grid-connected solar power during last three and a half years (2014/15 to 2016/17 and up to 30.9.2017), as compared to 2,621 MW installations during preceding three years (2011/12 to 2013/14). The major milestones achieved during last three years are as follows:

- Biggest ever solar power capacity addition of 5,526 MW in 2016/17, which is 83% more than the last year's achievement of 3,019 MW.
- Seven national schemes launched to promote grid-connected solar power projects that cover the major sectors, that is, defence, railways, airports, ports, educational institutions, canal banks and canal tops, government, industry, private, residential sectors.
- Under solar park scheme, 34 solar parks in 21 states with aggregate capacity of 20,000 MW are sanctioned, of which 7,600 MW bided out and 70,000 acres land acquired. Encouraged with the success of solar park, the Government has approved another 20,000 MW capacity addition through solar parks. The levelized tariff reached to the lowest level of ₹3.30/kWh at Rewa Solar Park in Madhya Pradesh, which is approaching close to grid parity.



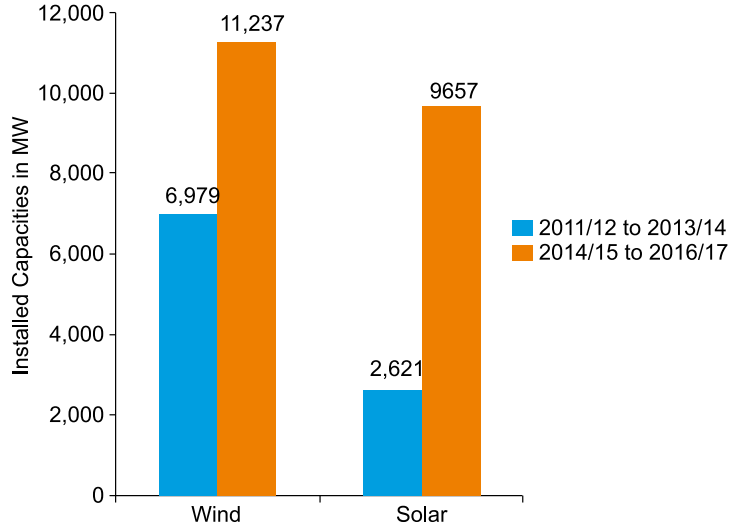
» **Figure 1:** Cumulative RE installed capacity 57,244 MW (till March 31, 2017)

- The Ministry launched the scheme in January 2015 to set up 1,000 MW of grid-connected solar photovoltaic (PV) power project by Central Public Sector Undertakings (CPSUs) and government organizations with viability gap funding (VGF). The Ministry of New and Renewable Energy (MNRE) had allocated 1,037.26 MW capacity to 16 CPSUs/ government organizations within the sanctioned funds of ₹1,000 crore for this scheme.
- A new scheme of ₹5,000 crore for grid-connected solar rooftop system was launched in June 2014 and capacity addition of 790 MW has been achieved as on Sept. 30, 2017. All states/union territories notified net-metering/feed-in-tariff to encourage solar rooftop plants. A dedicated portal, SPIN and a mobile app was launched for solar rooftops. A total sanction of $1,300 million has been received from World Bank, KfW, ADB, and NDB through which the SBI, PNB, Canara Bank, and IREDA will be in the position to fund at the rate of less than 10%. The world's largest 12.5 MWp solar rooftop system on single roof was installed at Dera Beas, Amritsar, Punjab.
- During the last 3.5 years, that is, 2014/15 to 2016/17 and up to 30.9.17, a total of 123,919 of solar water pumps were installed, which was a growth of 905% in solar water pumps compared to 12,319 solar pumps installed in the past 24 years since 1991 till 2013/14. So far, over 100,000 solar water pumps have been installed in the country.
- Over 203 concentrated solar thermal projects with 51,328 sq. m area equivalent to 34.2 MWe aggregate capacity have been commissioned and are expected to save 1.23 million litres of fuel oil and reduce 5,730 tonne of CO_2 per year.
- One million 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.

WIND POWER

A growth of 67% has been witnessed in the wind power sector power during last 3.5 years with capacity addition of 11,658 MW wind (2014/15 to 2016/17 and up to 30.9.17), as compared to 6,979 MW installations during preceding three years (2011/12 to 2013/14). There was the largest-ever wind power capacity addition of 5,502 MW in 2016/17, thereby exceeding the target by 37%. The cumulative wind power installed capacity has reached to 32,280 MW as on March 2017 against the enhanced target of 60 GW to be achieved by 2022.

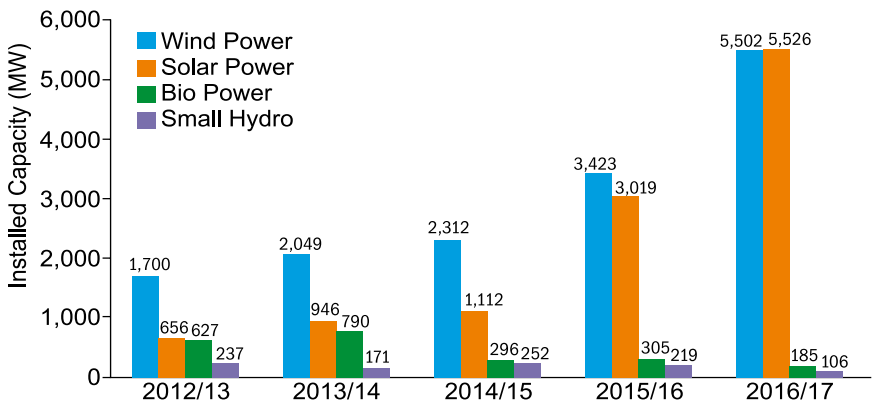
The targets for capacity addition could not be achieved for last two years, that is, FY2013/14 and FY2014/15 because



» **Figure 2:** Growth of RE (2011/14 vis-a-vis 2014/17)

both AD and GBI were discontinued from April 01, 2012. Though the GBI was restored in September 2013, the new government, in its first budget announced in July 2014, restored the AD benefit to wind energy sector giving much-needed boost to the sector. The major milestones achieved during last three years are as follows:

- India ranks fourth in the world after China, USA, and Germany.
- Wind power potential of the country was estimated to be 302 GW at 100 metre hub height.
- For the first time, lowest tariff of ₹3.46/kWh was determined through e-reverse auction for 1,000 MW wind power projects.
- A total of 21 manufacturers with 55 models up to 3 MW wind energy generator size have manufacturing capacity of 10,000 MW/annum.
- MNRE, in August 2016, released Policy for Repowering of Wind Power Projects with an objective to promote optimum utilization of wind energy resources by creating facilitative framework for repowering.
- The National Offshore Wind Energy Policy has been notified on October 6, 2015. The policy will provide a level playing field to all investors/beneficiaries, domestic and international.
- The National Institute of Wind Energy (NIWE), Chennai, took upon itself the task of forecasting and scheduling in Tamil Nadu. As a result, the state has evacuated over 11 BU of wind energy in 2016/17 as compared to the 7 BU in the previous year.
- A scheme was sanctioned to enable DISCOMs of the non-windy states to fulfil their non-solar renewable purchase obligation through purchase of wind power at a tariff determined by transparent bidding process. Under the scheme, 1,000 MW wind power projects are envisaged to be set-up in windy states. The scheme will be implemented by Solar Energy Corporation of India.
- For optimal and efficient utilization of transmission infrastructure and land, reducing the variability in renewable power generation and thus achieving better grid stability, draft Wind–Solar Hybrid Policy was issued in June 2016.



» **Figure 3:** Yearly progress of RE sectors during last 5 years

THE WAY FORWARD

The growth is expected to continue with the same pace as the MNRE aims to add about 14.5 GW of installed capacity during 2017/18 which includes 10 GW from solar PV, 4 GW from wind, and 0.5 GW from other sources in order to achieve generation target of 8.5% of the total electricity generation. Taking into the account the projected electricity generation from conventional sources by the Central Electricity Authority of India (CEA), about 114 BU of generation is estimated to be required from renewables for achieving target of 8.5%. However, there are several constraints being faced by RE sector that need to be addressed in a time bound manner. The implication of GST, centre–state coordination, timely completion of green energy corridor, RPO compliance, quality of PV modules, and robust monitoring mechanism of projects are some sectors that need to be focussed. AU

Shri Pankaj Saxena, Scientist 'F', MNRE, and Shri Rahul Rawat, Scientist 'B', MNRE, New Delhi.

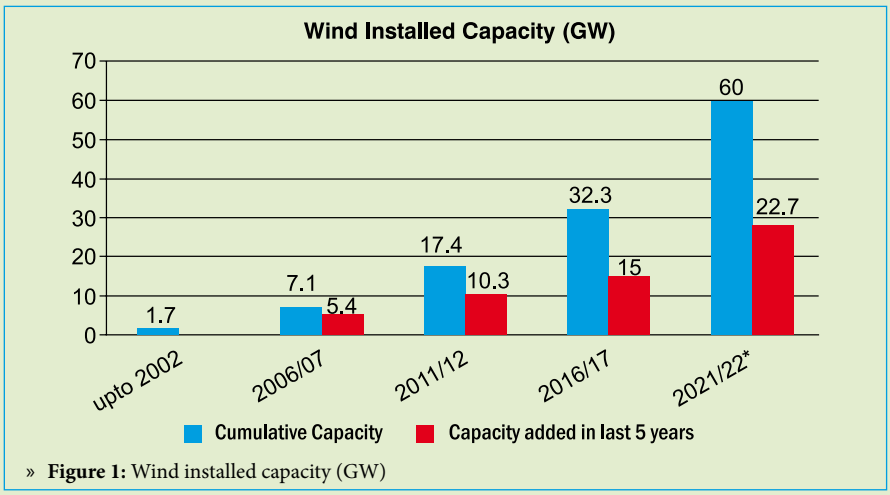
WIND POWER DEVELOPMENT IN INDIA

An Overview

The utilization of wind energy in India has been growing at a steady rate over the past few years. In this article, **J K Jethani** via detailed policy measures, commercial viability, and wind power infirmity management guidelines, traces the trajectory of wind energy in the country and the way forward.

» Orange DND Wind Power Pvt Ltd- 22.5 MW

The wind power development in the country was initiated in the early 1990s followed by the introduction of 100% accelerated depreciation benefit for wind projects in 1994. The present wind power installed capacity in the country is over 32.7 GW and wind energy constitutes around 55% of the total renewable capacity in the country.



» **Figure 1:** Wind installed capacity (GW)

As per the *Global Wind 2016 Report*, published by Global Wind Energy Council, at the end of 2016, globally India ranked fourth in terms of wind power installed capacity and the total wind power installed capacity at the end of 2016 was around 487 GW.

In spite of the sharp increase in wind power capacity in the country, only a fraction of the country's wind potential has been tapped till date. As per the recent assessment of National Institute of Wind Energy (NIWE), the potential for onshore wind at 100 m above ground level is over 302 GW.

The vast untapped wind power potential could be harnessed to meet India's policy goals, address energy security challenges, and achieve low carbon growth, in a cost effective manner.

In this endeavour, the Ministry of New and Renewable Energy (MNRE), Government of India, has adopted a multidimensional approach, aiming at large-scale commercialization of cost-effective generation of grid-quality wind power. The wind power programme includes comprehensive wind resource assessment programme, research and development, implementation of demonstration projects to create awareness, development of infrastructural capability, capacity to manufacture along with installation, operation and maintenance of wind turbines and conducive policy formulation.

WIND POTENTIAL

Wind energy is intermittent and highly site-specific and, therefore, an extensive Wind Resource Assessment Programme is essential for selecting the potential sites. Therefore, MNRE, Government of India, placed emphasis on Wind Resource Assessment since the beginning and today, India has an abundance of data, collected from over 800 wind monitoring stations installed all over India.

The recent assessment conducted by NIWE, with actual land availability estimation using NRSC Land Use Land Cover (LULC) data, indicates a gross wind power potential of about 302 GW @ 100 m in the country. Most of this potential exists in seven windy states. The state-wise wind power potential at 100 m height is described in Table 1.

Table 1: Wind power potential in India at 100 m above ground level

S. No.	State	Wind Power Potential at 100 m in GW
1	Andhra Pradesh	44.23
2	Gujarat	84.43
3	Karnataka	55.86
4	Madhya Pradesh	10.48
5	Maharashtra	45.39
6	Rajasthan	18.77
7	Tamil Nadu	33.80
	Total (7 windy States)	292.97
8	Other States	9.28
	All India Total	**302.25**

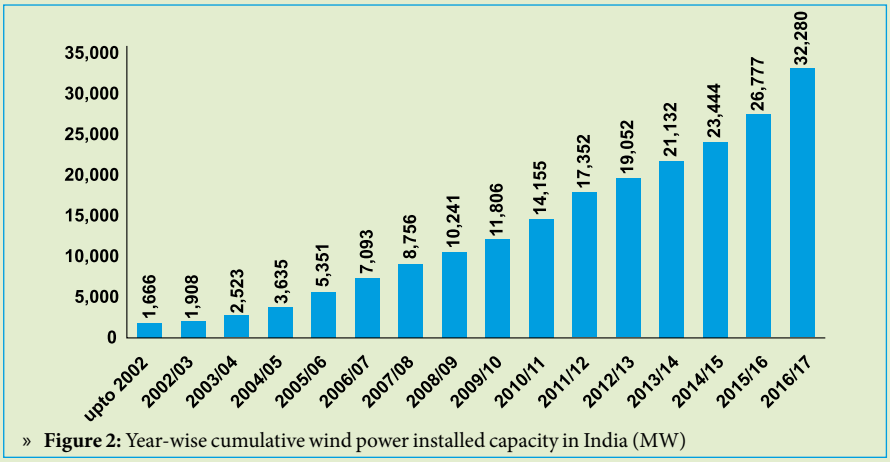
» 50.4 MW hybrid tower wind farm in Rajasthan

The online wind atlas is available on the NIWE website www.niwe.res.in.

COMMERCIAL DEVELOPMENT AND GENERATION

Technology development and manufacturing base

The wind electric generator technology has evolved very rapidly in the country. State-of-the-art technologies are now available for manufacture of wind turbines and all major global players in the field have made their presence in the country. The unit size of machines has gone up to 3.00 MW. Over 50 different models of wind turbines are being manufactured by more than 20 different companies in India, through (i) joint ventures under licensed production, (ii) subsidiaries of foreign companies, and (iii) Indian companies with their own technology. The current annual production capacity of domestic wind turbines is about 10,000 MW. The focus is to promote a technology suitable for low wind regimes of India. Wind turbines and wind turbine components are exported to the US, Australia, Europe, Brazil, and Asian countries. Due to a stronger domestic manufacturing sector, around 70%–80% indigenization has been achieved in the sector. Interestingly, the cost of Indian wind turbines is one of the lowest in the world.



» **Figure 2:** Year-wise cumulative wind power installed capacity in India (MW)

» 90.3 MW hybrid tower wind farm in Madhya Pradesh

Deployment

The annual growth picked up from the start of 2002. A total wind power capacity of around 32.3 GW was operational as on March 31, 2017. Year-wise cumulative wind power installed capacity is given in Figure 1. With an installed capacity of over 7.86 GW, Tamil Nadu is the leader in wind. During 2016/17, capacity of 5502 MW, the highest ever in a single year, was added. The state-wise wind power capacity added during 2016/17 and cumulative wind power capacity as on March 31, 2017, is described in Table 2.

Table 2: State-wise wind power capacity

S. No	State	Wind Power Capacity addition during FY 2017 (MW)	Cumulative Wind Power Installed Capacity operational at the end of FY 2017 (MW)
1	Andhra Pradesh	2,187.45	3,618.85
2	Gujarat	1,392.00	5,340.62
3	Karnataka	882.30	3,751.40
4	Kerala	8.00	51.50
5	Madhya Pradesh	356.70	2,497.79
6	Maharashtra	117.55	4,771.33
7	Rajasthan	287.70	4,281.72
8	Tamil Nadu	247.57	7,861.46
9	Telangana	23.10	100.80
10	Others	-	4.30
	Total	**5,502.37**	**32,279.77**

Generation

The Central Electricity Authority (CEA) has begun compiling the renewable energy generation data since 2014/15. The state-wise quantum of energy produced from wind energy during 2014/15, 2015/16, and 2016/17 is described in Table 3.

Table 3: The state-wise quantum of energy produced from wind energy during 2014/15, 2015/16, and 2016/17

Sl. No.	State	Wind Power Generation in MU		
		2014/15	2015/16	2016/17 (Tentative)
1	Andhra Pradesh	1,675.82	2,013.04	3,187.85
2	Gujarat	5,660.09	6,446.58	7,720.01
3	Karnataka	4,658.1	4,797.95	6,058.65
4	Kerala	58.4	51.45	72.59
5	Madhya Pradesh	592.25	1,558.43	3,256.38
6	Maharashtra	6,804.8	6,121.34	7,490.75
7	Rajasthan	4,171.63	4,767.36	5,764.12
8	Tamil Nadu	10,147.1	7,273.23	11,935.26
9	Telangana	0	0	211.93
	Total	**33,768.2**	**33,029.4**	**45,697.54**

The contribution of wind energy in the total renewable generation during 2014/15, 2015/16, and 2016/17 was 55%, 50%, and 56%, respectively.

GUIDELINES FOR SETTING UP WIND POWER PROJECTS

To bring about healthy and organized growth of the wind energy sector and achieve optimum generation of power in the most efficient and cost-effective manner, MNRE issued revised guidelines for wind power projects in 1996. These guidelines, relating to preparation of Detailed Project Reports (DPRs), micro-siting, selection of wind turbine equipment, operation & maintenance, performance evaluation, etc., have created and raised the level of awareness among the State Electricity Boards, State Nodal Agencies, manufacturers, developers, and investors about planned development and implementation of wind power projects. However, due to the advancement in wind turbine technology and requirement to comply to various standards and regulations issued by CERC, CEA, and other regulatory bodies, the need to issue comprehensive guidelines for development of onshore wind power projects in the country was felt. Accordingly, new guidelines for development of onshore wind power projects were issued on October 22, 2016, incorporating requirement of site feasibility, type and quality certified wind turbines, micro-siting criteria, compliance of grid regulations, real time monitoring, online registry and performance reporting, health and safety provisions, decommissioning plan, etc. The key provisions of the new guidelines are as follows:

- NIWE mast data to be made available online free of cost
- Wind site allocations to be developed within a maximum of four years

- Micro-siting shall be based on an optimized output rather a strict mandated minimum distance between wind turbines.
- Safe distance prescribed for public roads, railway tracks, highways, buildings, public institutions, and EHV (extra high voltage) lines.
- Wind turbines to comply with grid regulations. It shall be mandatory to install ABT (availability-based tariff) meter with telecommunication facility.
- Online registry will be created followed by mandatory reporting of monthly performance.
- Noise and shadow flicker to ensure health and safety of people working/ residing near the wind farm will be prescribed.

NEW INITIATIVES

The government, on its part, has been instrumental in promoting the wind energy sector in the country via a range of fiscal incentives and new schemes.

Amendment in Tariff Policy

Renewable Purchase Obligation (RPO) was introduced through the Electricity Act, 2003, mandating the obligated entities to procure a minimum percentage of their total energy procurement from renewables. The state regulators declared the requisite RPO level, ranging from 3% to 12%, for the year 2016/17. The amended Tariff Policy notified in January 2016 provides for purchase of renewable energy by different states in more or less the same proportion. The policy further provides for prescribing long-term growth trajectory of RPO by Ministry of Power, Government of India, in consultation with MNRE.The MoP has issued RPO trajectory up to 2019 notifying uniform RPOs across the country.

Since the wind power potential is concentrated in 7–8 windy states, to facilitate the inter-state transmission of (wind) power from one windy state to other states, the Tariff Policy provides for waiving of the interstate transmission charges and losses for inter-state sale of wind power.The Ministry of Power (MoP) on September 30, 2016, issued an order for waiver of ISTS charges and losses for wind and solar power subject to the following conditions:

I. The waiver is applicable for wind power projects commissioned till March 31, 2019, and for 25 years from the date of commissioning of the projects. Further, the waiver is available for projects having power purchase agreements (PPAs) with discoms for compliance of RPO.

II. For solar, the waiver was valid up to June 30, 2017, as per CERC regulations.

III. The waiver is only applicable for solar and wind projects awarded through a competitive bidding process.

Forecasting and Scheduling

At this juncture, it is important to note that the infirm nature of wind power, attributed to both natural wind fluctuations as well as man-made designs of wind turbine, poses a challenge for grid security and stability. The issue, however, could be addressed through proper forecasting and scheduling of wind power.

The CERC has already notified a mechanism for scheduling and forecasting in case of inter-state transmission of solar and wind power. The states of Gujarat, Tamil Nadu, Madhya Pradesh, and Odisha, have already notified draft regulations for intra-state transmission of wind and solar power and the states of Andhra Pradesh, Chhattisgarh, Jharkhand, Karnataka, and Rajasthan have already finalized these regulations. NIWE, Chennai, has undertaken the forecasting and scheduling exercise in Tamil Nadu which has resulted in better management of transmission system for evacuation of wind power in the state and during 2016/17, over 12 BU of wind power was evacuated compared to around 7 BU earlier. Similar initiatives have been carried out in Rajasthan and Gujarat as well. For proper forecasting and scheduling, it is necessary to put in place a metering and communication infrastructure at all pooling stations for real time generation of data.

Green Energy Corridors

The maximum wind power potential is concentrated in 7–8 wind resource-rich states wherefrom wind power is evacuated from the resource rich to the off-taker states. This requires strengthening of transmission in intra-state as well as inter-state transmission infrastructure.

The Green Energy Corridors Project, instrumental in identification of transmission requirement for renewable power capacity addition during the Twelfth Five Year Plan period, is currently under implementation. Intra-state transmission infrastructure projects of total cost over ₹10,000 crore, in eight states, have already been approved and the central government is providing 40% of the project cost as grant from National Clean Energy Fund and another 40% of the project cost is available as soft loan through the German Bank KfW.

Repowering Policy

Most of the wind turbines installed up to the year 2000 are of capacity below 500 kW and are at present located at sites replete with high wind energy potential. It is estimated that over 3,000 MW capacity installations are produced by wind turbines of 500 kW capacity or below. In order to optimally utilize the wind energy resources, repowering is imperative. The main features of the repowering policy are enumerated as follows:

- As part of the policy, wind turbine generators of capacity 1 MW and below will be eligible for repowering.
- IREDA will provide an additional interest rate rebate of 0.25% for repowering projects.
- Benefits available to the new wind projects, that is, accelerated depreciation or GBI as per applicable conditions will also be available.
- In case augmentation of transmission system from pooling station onwards is required, the same would be carried out by the respective state transmission utility.
- Additional generation could either be purchased by discoms at feed-in-tariff applicable in the state at the time of

commissioning of the repowering project or allowed for third party sale.

Draft Wind–Solar Hybrid Policy

Research has revealed the complementary nature of solar and wind power and how hybridization of the two technologies will aid in minimizing the variability, apart from optimally utilizing the infrastructure, including land and transmission system. Accordingly, with the objective of providing a framework for promotion of large grid connected wind-solar PV system for optimal and efficient utilization of transmission infrastructure and land, reducing the variability in renewable power generation, and achieving better grid stability, MNRE issued the draft Wind–Solar Hybrid Policy.

The goal of the policy, currently pending approval, is to achieve wind–solar hybrid capacity of 10 GW by 2022 and to encourage new technologies, methods, and way-outs involving combined operation of wind and solar PV plants. The states of Andhra Pradesh and Gujarat also issued draft hybrid policies.

Wind Bidding Scheme

Out of 302 GW wind power potential in the country, over 297 GW is concentrated in the eight windy states in the country. To enable discoms of non-windy states to fulfill their non-solar RPO obligation through purchase of wind power at a tariff determined by transparent bidding process, a scheme for setting up of 1,000 MW Inter-State Transmission System (ISTS) connected Wind Power Projects was sanctioned by MNRE on June 14, 2016. PTC India Ltd was selected as trading company to sign PPAs with successful bidders and back-to-back power sale agreements (PSAs) with state utilities/bulk consumers under the Scheme. Solar Energy Corporation of India (SECI), the implementing agency of the Scheme, issued tender document on October 28, 2016, and e-reverse auction was conducted on February 23, 2017. The first wind bid was concluded at record low wind tariff of ₹3.46 per kWh of wind energy. The SECI issued letter of allocation (LoA) to the selected five bidders on April 5, 2017, and the projects under the Scheme are likely to be commissioned by September 2018. The wind tariff in India touched the lowest level of ₹2.64 per kWh in the second wind auction (1,000 MW) conducted by SECI on October 4, 2017. Wind bidding guidelines under Section 63 of Electricity Act, 2003, are likely to be issued by the Ministry of Power, which will enable the states to bid for wind power projects.

» 90.3 MW hybrid tower wind farm in Madhya Pradesh

» 119.7 MW wind farm in Ellutla, Andhra Pradesh

SMALL WIND ENERGY SYSTEMS

Besides, MNRE is also promoting a scheme on 'Small Wind Energy and Hybrid systems (SWES)', wherein both the wind and solar energy are effectively utilized for power generation by installing a hybrid system consisting of both aero-generator/small wind turbine and solar photovoltaic technologies. Under the scheme, CFA @₹1.00 lakh per kw is provided to the community users for installation of small wind and solar hybrid system. So far, a total of around 3,155 kW small wind energy systems have been installed in 23 States/UTs. The Scheme was operational till 31.3.17. An evaluation of the scheme was undertaken and it is proposed to redesign the scheme to increase its coverage.

» 119.7 MW wind farm in Ellutla, Andhra Pradesh

DEVELOPMENT OF OFFSHORE WIND ENERGY

India has vast coastline of 7,600 km and considering the development of offshore wind energy in the Indian Exclusive Economic Zone (EEZ), the National Offshore Wind Energy Policy was approved and notified in October 2015. MNRE has been authorized as the nodal ministry for use of offshore areas within the EEZ of the country and NIWE has been authorized as the nodal agency for development of offshore wind energy as well as to carry out allocation of offshore wind energy blocks, coordination, and allied functions with related ministries and agencies. Initial studies carried out by NIWE indicate offshore wind energy potential on the coasts of Gujarat and Tamil Nadu. For assessment of offshore wind power potential, a LiDAR (Light Detection and Ranging) has been installed at an identified offshore site near Gujarat.

The Ministry of New and Renewable Energy, Government of India, placed emphasis on Wind Resource Assessment since the beginning and today, India has an abundance of data, collected from over 800 wind monitoring stations installed all over India.

ISSUES AND FUTURE PERSPECTIVE

Two major promotional incentives curtailed—accelerated depreciation is reduced from 80% to 40% and GBI not extended after March 31, 2017. There are apprehensions that cost of wind power will increase due to GST, which will be in force from July 2017.

With successful auction of wind power, all the wind capacity is likely to be added through the bidding route. The establishment of projects, through bidding process, around 21 months' time is required (3 months for bidding process and 18 months for completion of projects). Bidding has begun recently and therefore no wind project being established through bidding process will be commissioned during the current year, this will affect achievement of targets. The government has set a target of achieving 60,000 MW by 2022 which means a capacity addition of around 30,000 MW in the next 5 years (annual capacity addition of 6,000 MW). To achieve this ambitious target, conducive policy framework and long-term RPO trajectory prescribed by MoP is required to be adopted by the states. The government has already taken positive steps by waiving inter-state transmission charges and losses for inter-state sale of wind power, which will facilitate non-windy states to fulfill their RPO requirement by buying wind power from windy states. To further accelerate the process, bidding has already been introduced in order to discover a suitable price discovery mechanism for interstate sale of wind power. The focus area will be on repowering and wind–solar hybrid projects that will require formulation of promotional programmes and schemes for demonstration. AU

Shri J K Jethani, Director, MNRE, Government of India, New Delhi.

SURAT
INDIA'S LEADING 'SMART–SOLAR CITY'

With the objective of promoting the cities that provide core infrastructure and give a decent quality of life to its citizens, a clean and sustainable environment, and application of 'smart' solutions; the Government of India launched the 'Smart Cities Mission' in 2015. In this article, **Alekhya Datta**, **Abhinav Jain, Jinesh Patel, and K H Khatwani** discuss about the successful implementation of the smart city programme in Surat city of Gujarat and also highlight that TERI has been actively participating with the Surat Municipal Corporation (SMC) in planning and execution of various projects for increased and improvised utilization of the city's solar potential.

In its 'Intended Nationally Determined Contribution' (INDC) to the United Nations Framework Convention on Climate Change (UNFCCC), post the 21st Conference of Parties (COP21) held in Paris in 2015; India declared a voluntary goal of reducing the emissions intensity of its GDP by 33–35%, over 2005 levels, by 2030, despite having no binding mitigation obligations as per the Convention. A slew of policy measures were launched to achieve this goal. The National Solar Mission (NSM) received a thrust with the achievable target being increased from 20 GW to 100 GW of installed solar capacity by the year 2022. The target is intended to be met through 40 GW of rooftop solar projects and 60 GW of large- and medium-scale grid-connected projects.

Moreover, with a vision to reduce the Green House Gas (GHG) emissions and to propel the nation towards 'energy sufficiency', a list of 60 solar cities was issued by the Ministry of New and Renewable Energy (MNRE), under the Government of India's 'Development of Solar Cities' programme which is designed to support/encourage urban local bodies to prepare a roadmap to guide their cities in becoming 'renewable energy cities' or 'solar cities'. Likewise, with the objective of promoting the cities that provide core infrastructure and give a decent quality of life to its citizens, a clean and sustainable environment, and application of 'smart' solutions; the Government of India launched the 'Smart Cities Mission' in 2015. Under the mission, the Ministry of Urban Development (MoUD) identified total 100 smart cities distributed amongst various states of the country. As per the smart city guidelines, issued by the Government of India, at least 10% of the smart city's energy requirement should be met by solar power. The city of Surat, in the state of Gujarat, is amongst one of the few cities in India which have bagged the prestigious spot in both the aforementioned lists of model Indian cities issued respectively by MNRE and MoUD.

Consequently, the Surat Municipal Corporation (SMC) has been pro-actively taking measures to meet the expectations in the field of renewable energy. Surat Municipal Corporation is a local self-government body which came into being under the Bombay Provincial Municipal Act, 1949. It carries out all the obligatory functions and discretionary functions entrusted by the BPMC Act, 1949.

At the root of Surat city's success story lies the Gujarat Government's strong will for development and a concrete and systematic plan of action for achieving the Surat city's goals and expectations related to solar power. Initially, the SMC signed a MoU with the Solar Energy Corporation of India (SECI), in order to facilitate the implementation of solar rooftop scheme in Surat city. The SMC planned its roadmap to success in consultation with various stakeholders such as the DISCOMs, State Nodal Agencies, Chief Electrical Inspector, Project Developers, Banks, etc. Moreover, the SMC sought the project management consultancy services of The Energy and Resources Institute (TERI),New Delhi, for carrying out feasibility studies and monitoring the implementation of various solar and energy efficiency projects in the city. As estimated by TERI, the rooftop potential of 11,924 MW is found to be

distributed amongst various smart cities of the country; of which nearly 418 MW (~3.5%) exists in the city of Surat. The SMC has taken numerous initiatives in order to harness this substantial solar resource available in the city. TERI has been actively participating with SMC in planning and execution of various projects for increased and improvised utilization of the city's solar potential.

The 'Solar Revolution' under SMC was kick started by the launch of Solar Rooftop program on the September 22, 2016; which is now also celebrated as the "Solar Equinox Day: A Mega Event on Rooftop Solar Energy for Surat Smart City". It was on this occasion that the "#SuratSolar" brand was launched under which the "SuratSolar" website ("http://suratsolar.suratmunicipal.gov.in/") and mobile application ("https://play.google.com/store/apps/details?id=in.smc.suratsolar&hl=en") were introduced for ease of outreach to the common man, in order to create awareness and encouragement for installing Grid Connected Rooftop (GCRT) system. The website and mobile app act as a 'single window portal' for information dissemination, and for consolidation of interest/applications received for solar rooftop installation. Handouts and pamphlets are also distributed, every year, on the 'Solar Equinox Day' to promote widespread utilization of solar power. The rooftop solar programme has received great support from the regional political and public figures. The Hon'ble Mayor – Surat City appointed a team of 200 'Solar Friends' for spreading awareness regarding GCRT systems. This resulted in organization of various workshops on 'Advantages of GCRT systems and Net Metering' for the common public. Effective mass publicity was also carried out through various means, such as National/Regional Newspapers, Social Media (e.g. Facebook (@SuratSolar), Twitter [@RooftopSolarSMC] etc.), FM Radio, public hoardings, and standees, etc. Video messages to adopt rooftop solar were also propagated in 22 Indian languages by 22 brand ambassadors consisting of various social figures, such as MPs, MLAs, etc.

Looking at the city's pro-active and fast paced progress in deployment of GCRT systems, the Gujarat Energy Development Authority (GEDA) declared the SMC as the nodal agency for receiving all the applications regarding installation of GCRT in Surat city, which are then forwarded to GEDA in Gandhinagar. Unlike Surat, residents of all other cities in Gujarat need to directly approach GEDA in Gandhinagar in order to seek approval for installation of solar power plants. In addition to the subsidy of ₹20,700 per kWp offered by MNRE, GEDA also provides a subsidy of ₹10,000 kWp with a maximum limit of ₹20,000 per consumer. Moreover, as per the state regulations, earlier, the solar power plants having installed capacities only up to 50% of the sanctioned load were permitted within premises of all categories. However, in order to promote the deployment of GCRT systems, the Government of Gujarat has waved off this cap on installed capacities and have permitted the installation of solar plants with capacities up to 100% of the sanctioned load, for all the premises under 'residential' category. Deployment of electric vehicles is also under progress in various cities of Gujarat, to promote which the Government of Gujarat is providing subsidy of ₹10,000 only to the students studying in classes 9–12 for purchasing electric (battery operated) two-wheelers; in addition to the subsidy of ₹7,500–29,000 offered by the Central Government for battery-operated two-wheelers under its flagship programme entitled, 'Faster Adoption and Manufacturing of (Hybrid &) Electric Vehicles' (FAME). Under the FAME scheme, the Central Government also offers subsidy of ₹11,000–61,000 for

» Home page of the #SuratSolar Website

» #SuratSolar Mobile App as viewed in Google Play Store

» Various GCRT installations in Surat City

three-wheelers, ₹76,000–138,000 for passenger cars, and ₹102,000–187,000 for light-commercial vehicles.

All these efforts for the implementation of rooftop solar programme led to unprecedented outcomes. Surat city successfully achieved a massive GCRT installed capacity of 3.6 MWp over various government buildings under the SMC; consultancy services for which were provided by TERI. More than 3,600 applications have been received for cumulative installation of more than 15 MWp; including both residential and non-residential consumers. Of this, more than 800 installations (approx. 5 MWp) have been completed till date.

But, the goals and aspirations of this throbbing city of approx. 4,466,826 individuals do not end here. The city is also in the process of converting nearly 208 schools under SMC into Model Green Schools under the 'Green Campus Scheme' of MNRE, by combining GCRT and energy-efficiency (EE) measures. These schools were individually surveyed by the experts' team from TERI and a cumulative potential of nearly 3.4 MWp had been estimated. Various other 'Smart and Innovative Projects' in the pipeline include: demonstration of electric vehicles (EVs) and EV-charging points, installation of GCRTs on shelters for the city's Bus Rapid Transit Service (BRTS),

» Launching of guidebooks and pamphlets for awareness on rooftop solar photovoltaic systems

» Inauguration of SMC's 3.6 MW GCRT Project by the Hon'ble Chief Minister of Gujarat, Shri Vijay Rupani

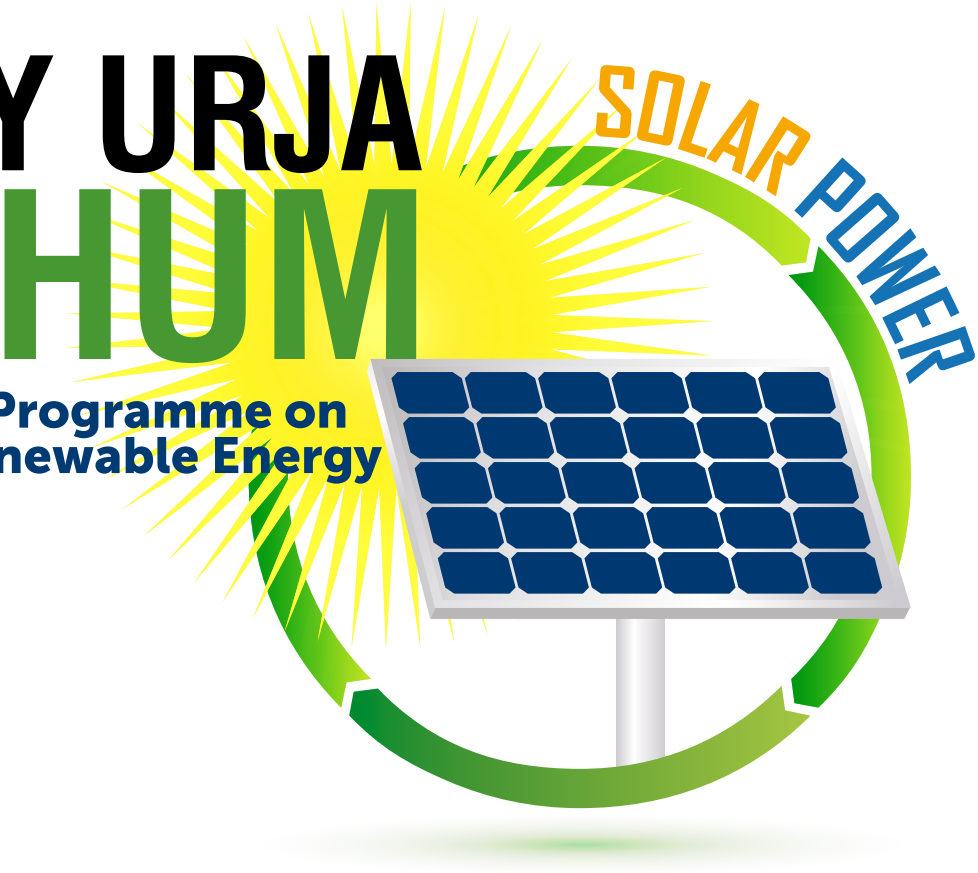
installation of floating PV at suitable water bodies in the city, etc. TERI has been an active partner of SMC in all these projects. Scope of EVs for three-wheelers and SMC owned vehicles in the city is being currently assessed by TERI; while as per the pre-feasibility study conducted by TERI, each BRTS shelter in Surat is estimated to have available rooftop potential of around 6.3 kWp. Also, the scope of installation of 100 kWp of grid connected floating-PV at the 'Gopi Talao' Lake in Surat is being investigated by TERI. The city is also in the process of establishing a centralized system for monitoring the power generation and consumption patterns of all the solar power plants under SMC. Museums/ Eco-Parks/Renewable Energy Knowledge Centres have also been proposed to create widespread and sustained awareness regarding energy and environment amongst the common man. Till date, the Surat city has achieved total energy conservation of 75.8 GWh/Annum (34%) by deploying GCRT measures alone and 95.4 GWh/Annum (43.4%) was conserved by simultaneous deployment of GCRT and EE – Measures.

Thus, the Surat City is indeed emerging as one of the leading 'Solar Smart Cities' in India and is a legend in the making, which will act like a light house for all the aspiring smart cities of the country. AU

Mr Alekhya Datta, Fellow and Mr Abhinav Jain, Associate Fellow & Area Convenor, Electricity & Fuels Division, TERI, New Delhi; Mr Jinesh Patel, Assistant Engineer and Mr K H Khatwani, Addl. City Engineer, Surat Municipal Corporation.

AKSHAY URJA AUR HUM

Radio-Sponsored Programme on Applications of Renewable Energy



The Ministry of New and Renewable Energy (MNRE) had started 'Akshay Urja Aur Hum', a Radio Sponsored Programme (RSP) from September 16, 2016, on every Friday and Tuesday. The concluding episode (104th episode) was aired on All India Radio on September 12, 2017. The programme covered various areas of renewable energy in Hindi and in 19 regional languages, that is, Assamese, Bengali, Gujarati, Konkani, Kannada, Kashmiri, Khasi, Malayalam, Manipuri, Tamil, Marathi, Mizo, Nagamese, Nepali, Oriya, Punjabi, Telegu, Urdu, and Garo. The RSP was broadcast from 37 Vividh Bharati Stations, 20 FM Rainbow Stations, 4 FM Gold Stations, and 33 Primary Channels/Local Radio Stations of All India Radio.

RESPONSES/SLOGANS FROM LISTENERS

MNRE received some very good and interesting responses from its listeners throughout India. Some of the listeners have also sent very appropriate slogans regarding the need of harnessing various forms of renewable energy in the country. Here, we are presenting some of the very remarkable and creative responses or slogans that MNRE had received. AU

Courtesy: Shri Nimai Ghatak, MNRE

I heard the Episode on 'Solar Roof Top Systems for Government Buildings' and shared it with my college principal. She appreciated it by penning the following slogan in Hindi:

"Desh ko viksit banana hai,
Solar panel ab har sarkari
aawas mein lagana hai"

Ms Radhika Bhalla
<rads9642@gmail.com>

I really like listening to 'Akshay Urja aur Hum' programme on radio. It is very informative for everybody. My slogan is:

"Surya, Jal, Vayu aur
Biomass,
Anant Akshay Urja hai
ab hamare paas"

Ms Farha, Mumbai
<farhanaz1311@gmail.com>

In the new India that we all have envisioned, solar energy is our magic formula towards development and prosperity. My slogan is:

"Saurya Urja:
Naye Bharat ki nayi pasand"

Mr Kalyan Verma, Noida
<npti.kalyanverma.2012@gmail.com>

पवन ऊर्जा से
विद्युत उत्पादन,
प्रदूषण मुक्ति का
उत्कृष्ट साधन

Ms Manju Shrivastav, Noida
<manju20srivas@gmail.com>

पवन ऊर्जा का
करे उपयोग,
प्रदुषण हटाने में
करे सहयोग।

Dr Sandhya Kashyap, Delhi
<kashyapsandhya08@gmail.com>

I listened to your informative and educative programme. I would like to thank the Ministry for broadcasting such good programmes for the masses. I am hereby sending you a slogan:

"Sab milkar karo Akshay Urja
ki jai jaikaar,
Khul gaye vikas ke dwaar,
chhayi Roshni ki bahaar"

Mr Vikas Sharma, Delhi
<vkas9776@gmail.com>

"Saur urja se
ghar-ghar ujiyaara,
bhag gaya dar kar
andhiyaara"

Mr Manoj Roy, Kolkata
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अनन्य धरा और
मानवता के हित में,
हम आज लें यह संकल्प,
पर्यावरण संरक्षण करेंगे
लगाकर वृक्ष,
अपनाकर अक्षय ऊर्जा
जैसे विकल्प।

Ms Jyotsana Choubey
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I am a regular and keen listener of your radio programme 'Akshay Urja aur Hum'. I have learnt a great deal from this programme, such as information on solar energy, solar water heater, solar pump, solar cooker, etc. So, I hope in future too this informative programme will continue to enlighten all of us on renewable energy.

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GREEN JOBS IN RENEWABLE ENERGY

Sectoral Scope and Employment Structure

Green jobs are employments that contribute to preservation and conservation of the environment, be they in traditional sectors, such as manufacturing and construction, or in new, emerging green sectors such as renewable energy (RE) and energy efficiency. Here, **Bhawna Tyagi** discusses potential and scope of the generation of green jobs in the RE sector in India and also highlights that in the light of recent events in the climate change sphere, it becomes crucial to evaluate new opportunities and sustainable green jobs that can be generated by transition to RE.

With growing recognition and importance of climate change, both developed and developing countries are taking various initiatives towards achieving carbon free world. These initiatives are also being taken both at an international and national level, such as formation of United Nations Framework Convention on Climate Change (UNFCCC), Kyoto Protocol, shift in focus of National policies towards renewable sources of energy, among others. While taken to combat climate change, these have also resulted in generation of co-benefits in terms of employment generation and reduction in carbon emissions.

The concept of green jobs was first recognized after the publication of report by United Nations Environment Programme (UNEP) and International Labour Organization (ILO) on "Green jobs: Towards decent work in a sustainable, low-carbon world" in 2008.

The report broadly defines green jobs

as "work in agricultural, manufacturing, research and development (R&D), administrative, and service activities that contribute substantially to preserving or restoring environmental quality. Specifically, but not exclusively, this includes jobs that help to protect ecosystems and biodiversity; reduce energy, materials, and water consumption through high efficiency strategies; de-carbonize the economy; and minimize or altogether avoid generation of all forms of waste and pollution". (*Source*: UNEP, 2008)

GREEN JOBS IN THE RE SECTOR

One such sector in which green jobs are generated is renewable energy (RE). There has been an increase in investment in the sectors, directly or indirectly, for generation of green jobs. There even has been a change in the patterns of investment flows, which cater to areas beginning from RE generation up to energy efficiency projects, both at the household and industrial level. Globally, RE sector has employed, directly and indirectly, 9.8 million people in 2016 (*Source*: IRENA, 2017). Among renewables, the most consistent increase in jobs has been observed in the solar photovoltaic (PV) and wind sector with more than doubling of number since 2012. Indian government has also realized the importance of renewable energy and has even set up to achieve a target of 175 GW by 2022. However, initiatives to tackle the issue of climate change, such as, shifting towards renewable energy from conventional sources, will have implications on employment in the conventional sectors. For instance, there have been job losses in the fossil fuel sectors, due to increasing automation in extraction, overcapacity, industry consolidation, regional shifts, etc. Further pressure has been added following enhancing focus on climate change and rise in use of renewable energy.

As we move towards an economy which promotes RE and green economy, some jobs will be substituted, eliminated, or just transformed to greener profiles. Thus, in the light of recent events towards climate change, it becomes crucial to evaluate new opportunities and sustainable green jobs that can be generated by transition to RE. In addition to that, it needs to be seen how these can compensate for decline in employment in the conventional sectors which affects the lives of millions of individuals.

APPROACH

Green jobs in RE sector have been analysed by various studies for different countries including China, the US, South Korea, European Union, etc. Various methodologies have been devised for estimating direct and indirect employment. For the former, employment factor approach is used, whereas for the latter, multiplier analysis, supply chain analysis, and input–output analysis. However, input–output models are the most widely employed methodology for assessing green jobs and have been used by various studies in countries, such as South Africa, Mauritius, China, the US, South Korea, etc. Using the multi-regional input–output model, Markandya et al. (2016) estimated that 530,000 jobs were generated from structural change in the EU energy sector itself, of which one-third was due to trans-boundary effects within the EU.

In case of India, various papers have discussed the concept of green jobs, however detailed estimation of green jobs in case of RE is limited. Several studies have relied primarily on secondary estimates given in the reports by MNRE and IRENA. Studies have estimated current and future job potential primarily by employing employment factor approach, stakeholder consultations, primary surveys of companies, literature reviews, and discussions with sector experts.

SECTOR AND SCOPE

The RE sector includes biomass gasifiers, wind, hydro (large and small), waste-to-energy systems, co-generation and solar (PV, lanterns, and water heaters), etc. However, employment potential has been analysed mainly for two sectors—solar (mainly PV) and wind sector—with a focus on grid-based technology. This is mainly due to data limitations as there is no RE industry directory which provides firm size, type of employment, and other comparable data in this sector.

Only a few studies have made an attempt to provide employment estimate in sectors other than solar and wind. However, only CEEW and NRDC have tried to capture employment generation in off-grid solar projects.

Stage/Phase-wise estimation

Along with the growth in RE sector, there has been a potential for creating new jobs along the supply chain, starting from manufacturing to operation and maintenance (Figure 1). Among them, there are other intermediary activities that span the whole lifecycle of the projects, such as consulting, financing, education and training, and research and development. Thus, stage-wise estimation of employment generation is crucial to study the impact of RE on employment. However, estimates are present mainly for two stages: construction and commissioning, and operation and maintenance. Detailed

» **Figure 1:** Value chain in renewable energy sector

stage-wise assessment has been presented majorly in studies conducted by CEEW and NRDC covering four stages—business development, design and pre-construction, construction and commissioning, and operations and maintenance. Employment estimates in other sectors of RE value chain, such as manufacturing, banking, financial services, etc., were insufficient due to data limitation. A recent study conducted by CEEW and NRDC in 2017 attempted to estimate employment generation in an upstream sector but mainly restricted to manufacturing of equipment. Their analysis revealed that majority of employment is generated during construction and commissioning stage.

Size of the project

It has been observed that there is an inverse relationship between employment generation in the RE sector, mainly solar and wind, and the size of the project. This highlights the concept of economies of scale. Smaller projects up to 5 MW in size may provide the most employment opportunities per megawatt. This is also highlighted in another study by 'Bridge to India' conducted in 2014 that small rooftop creates maximum number of jobs (0.32 million) in comparison to large rooftop systems (0.22 million), utility scale projects (71,000) and ultra-mega projects (63,000). Presently, it is difficult to conclude with certainty about this inverse relationship because of unavailability of per project employment estimates in the sector.

EMPLOYMENT STRUCTURE

Evidence regarding the impact of RE on the creation of employment opportunities exists, but is not disaggregated into different categories such as direct and indirect employment, full time and part time job, skilled and unskilled, etc.

Estimation of direct/indirect employment

There are three types of employments which are generated in RE sector, viz. direct, indirect, and induced. Direct jobs are generated in design, development, management, construction/ installation, and maintenance phase of the project; indirect jobs are associated with manufacturing of equipment and material used for facility, supply chain, banking, and financial sectors; and lastly, induced employment are the ones created due to spending of earnings by person directly and indirectly employed by the projects.

Direct and indirect employment for RE sector was estimated to generate 60,500 jobs in wind sector, 120,900 in solar PV, 35,000 in liquid biofuels, 13,800 in solar heating/cooling, 58,000 in solid biomass, 85,000 in biogas, 12,000 in small hydro, and in large hydro 0.23 million jobs in 2017. RE sector has already generated employment more than what MNRE and CII predicted for 2020, that is, approximately 14 lakhs jobs (Source: MNRE and CII, 2010). However, a recent study by IREDA, Deloitte, and INAE estimated that 1,116,400 trained personnel will be required by 2022 to achieve a solar target of 100 GW.

Among other sectors, solar PV has created more jobs per unit of energy. Within the solar sector, rooftop solar projects create maximum number of job years per MW, that is, 24.72 FTE per MW while ground-mounted solar projects create 3.45 FTE per MW. In case of wind projects 1.27 FTE per MW is created and in solar module manufacturing 2.6 indirect FTE per MW will be generated.

Estimation of Full time Job Equivalents (FTE)

In case of renewables, all jobs are not created throughout the lifetime of the projects. Short-term jobs are created in the business development, design and pre-construction and construction phase whereas long-term ones are created for operation and maintenance till the lifespan of the project. Thus, it becomes crucial to evaluate full-time equivalents (FTE) generated in the renewable energy sector.

CEEW and NRDC evaluated that in the solar sector, approximately 1 million FTE jobs will be generated by 2022

to achieve the target of 100 GW grid connected capacity. They analysed the potential under different combinations of rooftop projects, large-scale projects and solar parks based on MNRE's target of achieving the 100 GW goal. If rooftop solar is prioritized, then FTE employment generation will be highest in this sector as it is highly labour intensive and thereby, creating a potential 1.3 million jobs by 2022. In the wind sector, 183,500 FTE jobs (excluding manufacturing) will be generated to achieve the 60 GW target by 2022. CEEW and NRDC have also evaluated FTE employment generation in three existing projects (Table 1). In case of wind sector, approximately 5.15 FTE jobs are generated per megawatt. In case of solar PV, approximately 9 FTE and in solar rooftop PV 33.9 FTE jobs are generated in grid and off-grid sector, respectively.

Table 1: Estimates for FTE job creation for specific project given by CEEW and NRDC studies

Sector	Project	MW	FTE during first year	FTE in post-commissioning Phase	Grid/ off-grid
Wind	GAMESA-RENEW Project, Jath Maharashtra	85	438	102.5 (20)	Grid
Solar PV	Kiran Project, Rajasthan	20	180.8	44.5 (25)	Grid
Solar rooftop PV	Hero Motorcorp, Haryana	0.08	2.71	0.549	Off-grid

Source: CEEW and NRDC (2014)

Skilled and unskilled employment

As solar sector is more labour intensive than wind sector, hence it generates more employment. Within solar, rooftop projects require higher skill set of workers because expertise is needed to install PV panels on rooftop than ground mounted projects. In solar rooftop, 72% employment generation is for skilled workers. Among various segments of value chain, majority of unskilled jobs are generated in construction and installation phase. In case of business development phase, majority of jobs generated are of skilled nature.

The 20 MW solar plant in Rajasthan by Kiran Energy generated a total of 180.8 FTE jobs (primarily for highly skilled personnel and construction workers) (*Source*: CEEW and NRDC, 2015). However, none of the studies have clearly defined skilled and unskilled employment in their studies. Further, the quality

of jobs generated in renewable energy sector has not been assessed by any of the studies.

GENDER DISPARITY AND SPATIAL DISTRIBUTION

Generally, it has been witnessed that female participation in workforce is low due to hindrance by legal/social factors such as the need to provide protection and facilities like crèche, maternity leaves, among others. Thus, it becomes crucial to analyse how far RE sector has contributed in addressing these hindrances. Due to data limitations, the employment potential with respect to gender in RE sector has not been analysed by any of the studies. With respect to spatial distribution, there is only one study by CEEW and NRDC that has analysed geographical distribution of employment generation potential in case of solar and wind sector. The study argued that jobs in solar sector will be well distributed throughout the country while jobs in wind sector will be concentrated mainly in coastal areas of states, such as Maharashtra, Andhra Pradesh, Telangana, Tamil Nadu, Karnataka, etc.

THE WAY FORWARD

The evidence regarding the impact of RE on employment generation is limited. This is primarily due to data limitations as there is no RE industry directory which provides detailed information about firm size, type of employment (skilled/unskilled, direct/indirect, etc.) and other comparable data in this sector. Unlike developed countries, in India, companies do not report employment generated in press releases for RE sector.

Due to dearth of data on jobs which have been created, most of the estimates were derived from stakeholder discussions. However, detailed estimation has not been carried out in case of India to arrive at estimates of green jobs creation in RE sector. Input–output models are the most widely employed methodology for assessing green jobs as it offers an analytical framework to calculate direct, indirect, and even induced employment. However, no input–output models have been developed for India to estimate employment in the RE sector. Furthermore, limited attention has been given to the types of skills and employment opportunities that can be created along the supply chain of RE development.

Comparison of estimates for job creation across studies is difficult due to difference in capacity estimates, location, time period, methodology, and different grouping of technology. Some studies have given estimates of employment generation which includes both direct and indirect employment. Also, some studies have estimated employment for all the stages (except upstream sector) while others, either have not specified the stages or have estimated for construction and operation and maintenance phase only. Most of the studies have focussed only on solar and wind sector. Therefore, it is difficult to arrive at realistic estimate about the number of green jobs generated and their potential in RE sector in India.

Thus, there exists information gap which needs to be addressed to analyse the actual net benefits emanating from shifting to RE in India. Employment generation numbers can encourage broad political and public support for stronger renewable energy financing and policies. AU

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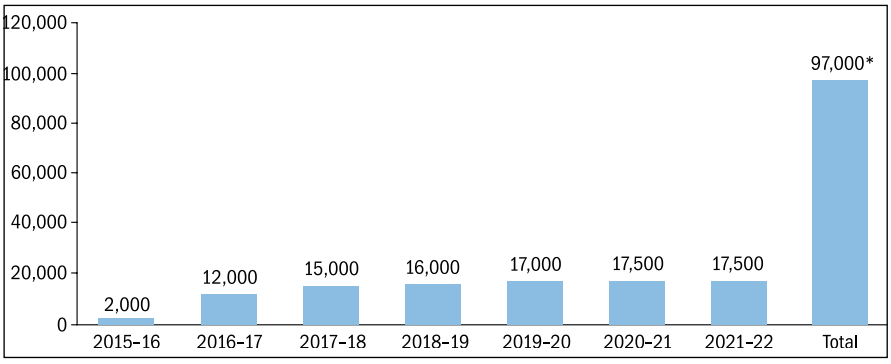
SUCCESS STORY OF SOLAR PARKS IN INDIA

Vis-à-vis Beginning of a New Era of Solar Tariff

Renewable energy has been an important component of India's energy planning process for quite some time, especially since India seeks to make significant contributions towards climate change mitigation and emerge as a responsible global powerhouse. Solar energy has rapidly emerged as a reliable, affordable, and clean solution for meeting India's fast-growing energy demand and supply power to all. Thus, it is crucial for India to promote large-scale mega solar projects, like solar parks, in order to promote ecologically sustainable growth and to meet the challenges of climate change, with technology and investment flow from around the globe, as one of the national goals. In this article, **Radhey Shyam Meena,** with **Dilip Nigam, S K Gupta, A S Parira, and Dr A K Tripathi** describe the critical success factors including development of solar parks in India and the related tariff trends.

The National Solar Mission (NSM) was launched in 2010 as a major initiative of the Government of India with active participation from states to promote ecologically sustainable growth while addressing India's energy security challenges. It will also constitute a major contribution by India to the global effort to meet the challenges of climate change. The mission targets include deployment of 20,000 MW of grid-connected solar power by 2022 to be achieved in three phases which include 2,000 MW of off-grid solar applications including 20 million solar lights by 2022 and 20 million sq. m. solar thermal collector area. The first phase (up to

2013) focussed on promoting scale-up in grid-connected solar capacity addition of 300 MW through a scheme of bundling with thermal power. In the second phase (2013–17) capacity addition of 3,000 MW under the Central scheme was envisaged through various schemes. In the third phase (2017–22), the target up to year 2022 of 20,000 MW or more was to be decided dependent on the experiences and learning of the first two phases. Further, on June 17, 2015, The Government of India revised the NSM target of grid connected solar power projects from 20,000 MW by year 2022 to 100,000 MW by year 2022. The government has planned to achieve the target of 100 GW by setting up distributed rooftop solar projects and medium & large scale solar projects; the year-wise break-up of capacity has been shown in Figure 1.



*3,743 MW commissioned up to 2014/15

» **Figure 1:** Year-wise target of solar capacity by 2022

MAJOR SCHEMES OF THE CENTRAL GOVERNMENT

The government of India has launched several schemes to achieve the target of 100 GW. The details of major central schemes are as given in Table 1.

Table 1: Details of schemes for promotion of solar energy

S.No.	Scheme/Programmes
(A)	Grid Connected
1	Scheme for setting up of over 300 MW of Grid connected solar PV projects by Defence establishments and para military forces
2	Scheme for development of Solar parks and Ultra Mega Solar power projects of 40,000 MW
3	750 MW VGF scheme under JNNSMM Phase II Batch I
4	2,000 MW VGF scheme of NSM Phase II Batch III
5	5,000 MW VGF Scheme Batch IV Phase II
6	Setting up of 1000 MW of Grid connected solar PV Power project by CPSUs, Government organizations
7	15,000 MW grid connected solar PV power plants through NTPC
8	Grid connected rooftop and small solar plants of 4,200 MW
9	Development of 100 MW Grid connected solar PV power plants on canal banks and tops
(B)	Off Grid
1	Capital subsidy scheme for providing basic lighting needs through solar charging stations (with lanterns) to be implemented in 100 villages in each of 60 LWE affected districts
2	Off grid & Decentralized solar application scheme in 2nd phase of JNNSM-Solar cooker programme
3	Capital subsidy scheme for installation of solar thermal systems
4	Solar water heating
5	Solar air heating
6	Solar steam generation/ pressurized hot water/air systems
7	Solar thermal refrigeration/cooling
8	Solar Thermal Power Park (including hybrid with Solar PV)
10	Installation of 10,000 nos. of solar photovoltaic water pumping systems for irrigation purpose implemented through NABARD

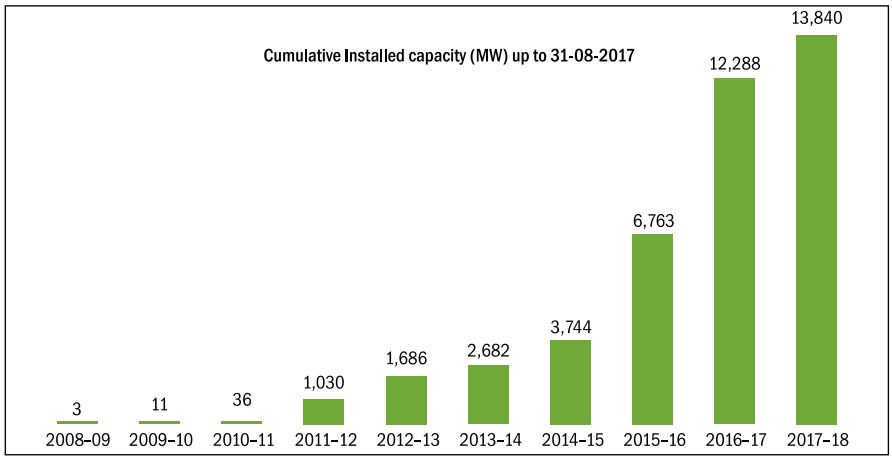
THE MARKET FOR SOLAR ENERGY

The investment in renewable energy sector in India for the years 2013, 2014, and 2015 was US$ 6.6, 8.3, and 10.2 billion, respectively, with foreign direct investment increasing from $ 4.14 billion in 2013/14 to $7.76 billion in 2015/16. This shows that the Indian solar market is in its growing stage. Details of solar power installed capacity and cumulative

» Solar Park in Kerala

capacity addition in India during the last three years and the current year are given in Figure 2.

The total cumulative was increased from 3 MW in the financial year 2008/09 to 13,840 MW in 2017/18 as shown in Figure 2.

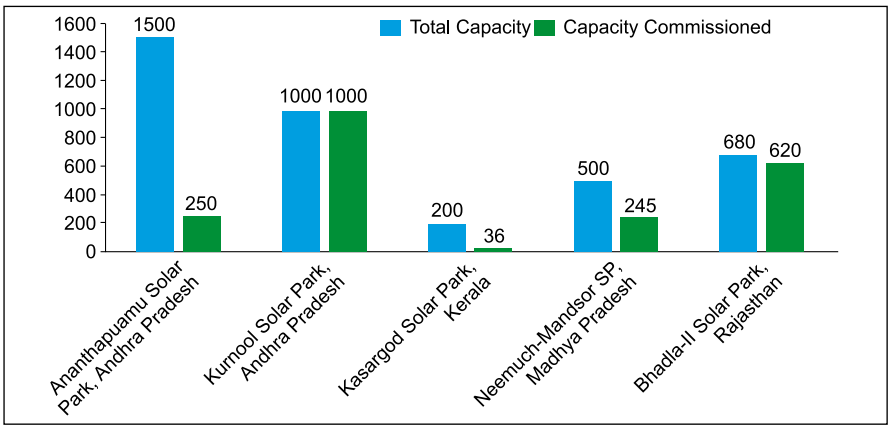


» **Figure 2:** Year-wise cumulative capacity commissioned till August 31, 2017 (in MW)

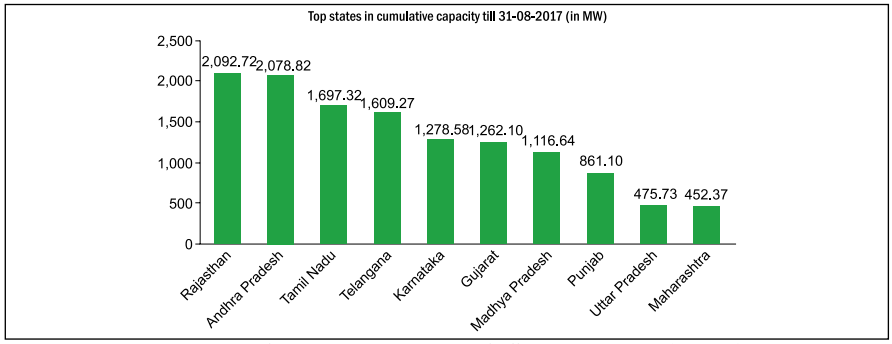
The progress of solar installation in the country was increased rapidly due to various factors, Rajasthan with the cumulative capacity of 2,092 MW stands at number one position in the country. Andhra Pradesh which was earlier at the first position during the March, 2017 now stands at the second position in India with a cumulative capacity of 2,078 MW.

THE CURRENT STATUS OF SOLAR PARK DEVELOPMENT IN INDIA

The Ministry of New and Renewable Energy (MNRE), Government of India, is already implementing a scheme for development of solar parks which was launched in December 2014. The capacity of the solar park scheme has been enhanced in February 2017 from 20,000 MW to 40,000 MW after considering the demand for additional solar parks from the states. All the solar parks are targeted for completion by 2019/20. As on August 2017, 36 solar parks in 21 states with an aggregate capacity around 21,000 MW have been approved which are at various stages of development. Solar projects of aggregate capacity 2,151 MW have already been commissioned in 5 Solar Parks up to August 31, 2017 as shown in Figure 4.



» **Figure 4:** Solar projects commissioned inside the five solar parks up to August 31, 2017



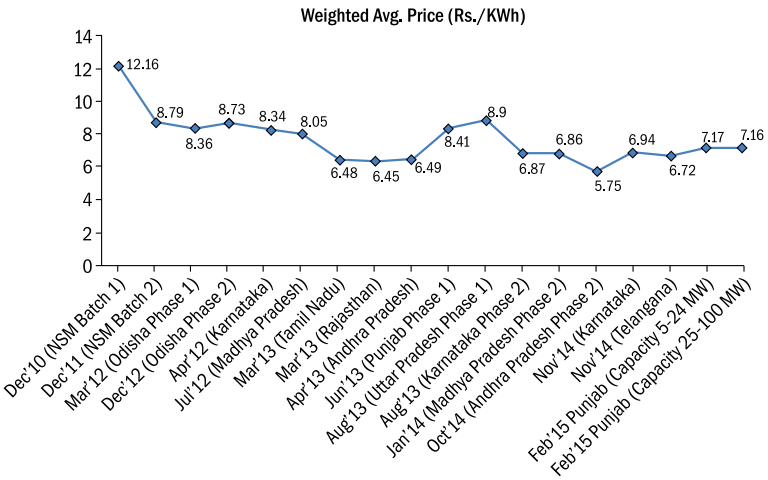
» **Figure 3:** Top 10 states in solar capacity commissioned till August 31, 2017 (in MW)

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 CO_2 per year over its life cycle. It would also contribute to the long-term energy security of the country and promote ecologically sustainable growth by a 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.

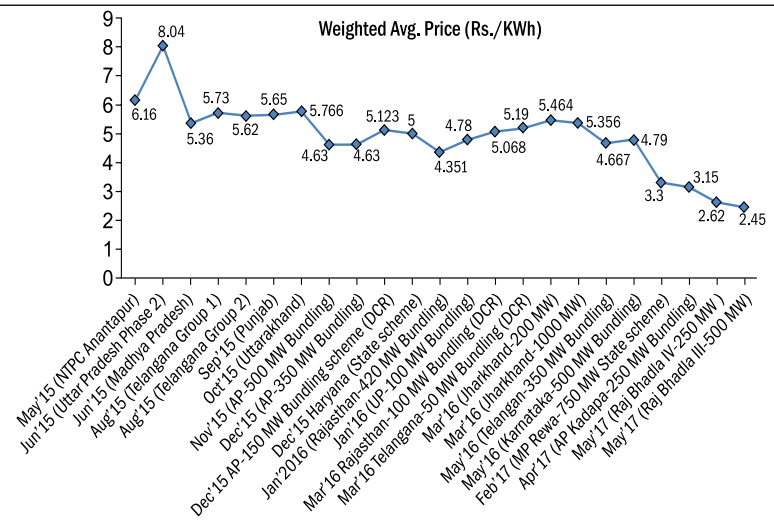
THE RECENT DOWNWARD TRENDS IN SOLAR TARIFF

Since renewable energies are considered to be the new outlet for dealing with energy shortage and environmental pollution, renewable energy industries have expanded rapidly in the recent years. Renewable energy policies can significantly contribute to the expansion of domestic industrial activities in sustainable energy.

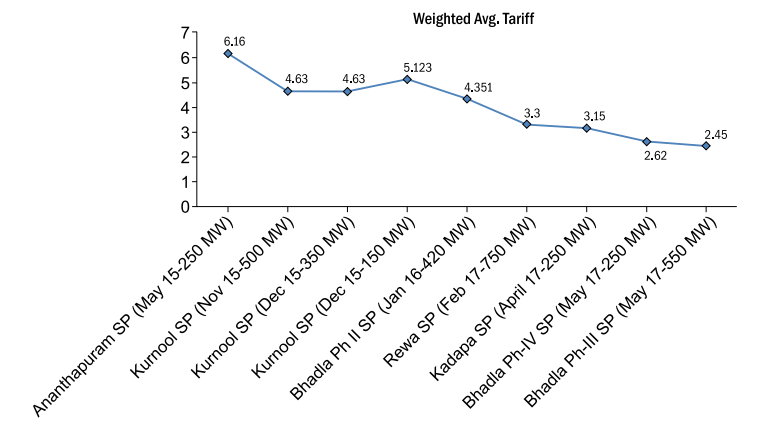
Tariff is a major factor for the development of solar projects in any country. Calculation of tariff depends on various factors that include location, solar irradiance in the State, availability of conducive State policy for solar, availability of land, the cost of financing and business environment, willingness of DISCOMS to purchase the solar power, power evacuation infrastructure, etc. Tariff in Indian solar market changed regularly as shown in Figures 5 (a) and 5



» **Figure 5(a):** Weighted avg tariff (₹/kWh) from 2010 to February 2015



» **Figure 5(b):** Weighted avg tariff (₹/kWh) from May 2015 to May 2017



» **Figure 6:** Weighted avg tariff (₹/kWh) in solar parks

(b) that the weighted average tariff varies from ₹12.16 per unit to ₹2.45 per unit.

The recent downward trends in solar tariff may be attributed to the factors, such as economies of scale, assured availability of land, and power evacuation systems under the solar parks.

It is clear from Figure 6 that tariff of solar has continuously decreased from ₹6.16/kWh to ₹2.45/kWh in solar parks which states that by using better tools for solar projects and by enhancing the interest of bidder, solar tariff in India may reduce less than the tariff of Bhadla Phase III Solar Park project.

SOME REMARKABLE CASE STUDIES

Rewa Solar Park in Madhya Pradesh (750 MW)

The Rewa Solar Park was developed by Rewa Ultra Mega Solar Limited (RUMSL); a Joint Venture Company (JVC) of SECI and MPUVNL. In a recent bid for 750 MW Solar Power Project at Rewa Solar Park in Madhya Pradesh, a levelized tariff of ₹3.30/kWh was achieved, the tariff so discovered would depend inter alia on the cost of long-term debt and prices of solar modules. Further, the tariff of Rewa project has been lower on account of effective mitigation of risks under the PPAs, bankability, and robust project preparation process. The tariff of Rewa Project is not unviable; rather it is low on account of its better project structure, bankability, balanced risk allocation, pre-identified available land, the readiness of internal and external evaluation structure, and a soft loan from the World Bank.

The projects (three units each of 250 MW) were awarded to the three successful bidders.

The tariff of ₹2.97, ₹2.974, and ₹2.979 per kWh discovered for the three 250 MW units each of Rewa project is the first-year tariff with 5 paise per year increase for 15 years. The levelized tariff for 25 years of Rewa Solar Park projects would be around ₹3.30/kWh.

Kadapa Solar Park in Andhra Pradesh (1,000 MW)

The Kadapa Solar Park in Andhra Pradesh (1,000 MW) developed by Andhra Pradesh Solar Power Corporation Pvt. Ltd. (APSPCL); a JVC of SECI, APGENCO, and NREDCAP have also set a new record after the success of Rewa Solar Park. Solairedirect emerged as the lowest bidder with a tariff ₹3.15 a unit, a new low, for the 250 MW capacity. The

winning bid at the Kadapa Solar Park being set up by NTPC is the levelized tariff for 25 years with no escalation. This is lower than the lowest bid received for the 750 MW Rewa Solar Park. The reason is the falling prices of solar panels. Another reason for the aggressive bidding is the number of solar power projects offered by states is declining.

Bhadla Phase IV Solar Park in Rajasthan (500 MW)

The Bhadla Phase IV Solar Park in Rajasthan (500 MW) was developed by Adani Renewable Energy Park Rajasthan Limited (AREPRL): a JVC of Adani Renewable and State Government of Rajasthan. In bidding process of Bhadla IV, SECI has been invited the bids for 250 MW. In reverse auction Phelan Energy Group and Avaada Power at a tariff of ₹2.62 per unit won the contracts for 100 MW each. SBG Cleantech won the rest 50 MW at ₹2.63.

Bhadla Phase III Solar Park in Rajasthan (1,000 MW)

The Bhadla Phase III Solar Park in Rajasthan (1,000 MW) was developed by Surya Urja Rajasthan Ltd: a JVC of Surya Urja and State Government of Rajasthan. In bidding process of Bhadla III, SECI invited the bids for 500 MW and set up a new era of the solar tariff with the new lowest in Indian solar sector beating the previous record of ₹2.62 per unit. In reverse auction, ACME at a tariff of ₹2.44 per unit won the contracts for 200 MW. SBG won the rest 300 MW at ₹2.46. It helps in the vision of clean affordable power for all at very low prices.

Pavagada Solar Park in Karnataka (2,000 MW)

The Pavagada Solar Park in Karnataka (2,000 MW) was developed by the Karnataka Solar Power Development Corporation Ltd (KSPDCL); a JVC of KREDL and SECI, which is also one of the first projects of its kind in the world. Here, 200 MW grid connected solar photovoltaic power projects along with large scale with 15 min battery energy storage facility is to be set by SECI.

» Kurnool Solar Park

Kurnool Solar Park in Andhra Pradesh (1,000)

The Kurnool Solar Park (1,000 MW) was developed by Andhra Pradesh Solar Power Corporation Pvt. Ltd. (APSPCL); a JVC of SECI, APGENCO, and NREDCAP. Solar Park set up in Gani and Sakunala village of Orval Madal in Kurnool District of Andhra Pradesh had been commissioned and is operational since March, 2017. Around 240 MU of clean energy is generated from this park till end of May resulting in savings of 2.1 lakh tonnes of CO_2 emissions.

With commissioning of 1,000 MW capacity at single location, Kurnool Solar Park has emerged as the world's largest solar park after 850 MW Longyangxia Dam Solar Park, China which was commissioned in 2016.

The government is promoting solar energy through fiscal and promotional incentives, such as capital subsidy, tax holiday on the earnings for 10 years, generation-based incentive, accelerated depreciation, viability gap funding (VGF), financing solar rooftop systems as part of home loan, concessional custom duty, exemption from excise duty, preferential tariff for power generation from renewables, and foreign direct investment up to 100 per cent under the automatic route, etc.

Challenges and the Way Forward

Solar irradiance in the State, availability of conducive State policy for solar, availability of land, the cost of financing and business environment, such as the willingness of DISCOMs to purchase the solar power, payment security, power evacuation infrastructure, etc., are the challenges envisaged. In India, one of the biggest challenges faced is land allotment. Then, there is the revenue department, the issue of private land conversion, all these are time-consuming and challenges. The other challenges are matching the timelines between the development of solar parks including power evacuation arrangements of central transmission utility (CTU) or state transmission utilities (STU) and setting up of solar projects.

However, with active involvement and making concerted efforts in consultation with State Governments and different stakeholders these challenges are getting easier to deal with. Overall, the solar parks project has been very positive and the response from developers has been encouraging. As a result, energy storage, hybrid project, and large grid connected wind–solar PV system in India for optimal and efficient utilization of transmission infrastructure and land; there has been reduction of the variability in renewable power generation and thus achieving better grid stability and improved power quality projects initiated. AU

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» 1.5 MW rooftop plant

GRID-CONNECTED SOLAR PV PLANTS AT AMU

Helping India's Climate Change Pledge

Dr Mohammad Rihan

highlights that as an important part of the initiative by the Indian Government of installation of 100 GW of solar power by 2022, the Aligarh Muslim University (AMU) has installed grid-connected solar PV plants in the campus with total capacity of 4.5 MW. This article describes the background, cost–benefit analysis of these solar plants, the impact on environment, and the future scope.

India is at a complex stage with respect to the energy scenario. The demand for energy is increasing rapidly. It is expected that India will contribute the maximum amount of addition to the energy requirement in the world in the next 25 years. On the other hand, it is committed through various international agreements for reducing the carbon emissions significantly.

In 2015, the United Nations Framework Convention on Climate Change (UNFCCC) was held in Paris. During the convention the 196 nations that are part of the UNFCCC approved the Paris Agreement, which aims to limit global temperature rise to 2 °C, and to make best efforts to keep it to 1.5 degrees.

India's pledge in the agreement offers a comprehensive approach to curb the adverse impacts of climate change. An important part of the pledge is that the country will reduce the carbon emissions intensity of its GDP by 33 to 35 per cent by 2030 from 2005 levels. Moreover, the commitment is to achieve about 40 per cent cumulative electric power installed capacity from non-fossil-fuel energy resources by 2030.

Satisfying this pledge requires pursuing installation of alternate energy sources aggressively. The Indian climate is particularly suitable for utilization of solar photovoltaic (PV) power. The Government of India has set up a target of installation of 100 GW of solar power by 2022.

Academic institutions can play an important role in this mission because they function mostly during daytime, which makes them ideally suited for harnessing the available solar power and the availability of technical competence. The Aligarh Muslim University (AMU) in recent years has been pursuing this path towards energy conservation and reduction in reliance on conventional sources of electricity aggressively. It has been a priority area for the university.

As an important part of this initiative, the university has installed 4.5 MW capacity grid-connected solar PV plant in the campus. This article describes the background, cost–benefit analysis of these plants, the impact on environment, and the future scope in the following sections.

ELECTRICITY CONSUMPTION SCENARIO AT AMU

The Aligarh Muslim University (AMU) at Aligarh, Uttar Pradesh, is one of the oldest central universities in the country. It was established in 1920 and over the years it has grown into a huge

institute in terms of both geographical area and the number of students. At present, the University has more than 150 departments of study. The AMU is primarily a residential university with more than 10,000 students residing in different halls of residences. Due to its vast nature, the electricity consumption of the University is very high. The sanctioned load of the main campus at Aligarh is 8.5 MVA. The campus is fed by a dedicated feeder of 132 kV through a 33 kV substation in the campus. Electricity is an essential requirement for the growth of an institution; accordingly the consumption is high and it is increasing with expansion in the campus.

The campus is free from load shedding and the tariff structure is governed by the Rate Schedule HV-1 of UP State Electricity Regulatory Commission for public institutions being fed by a single point supply at 33 kV.

The present annual electricity consumption of the university is around 2.6 crore units of electricity which is a huge burden on the university's budget as well as a major concern from the environment point of view also. An exponential increase in the electricity bill was recorded and observed in the last 5 years.

The exponential increase in the electricity bill presented a grave challenge for the university as most of the non plan grant from the UGC is utilized in paying the bills leaving very little margin for other development work. Moreover, the regular revision of tariff made it difficult for the university. Infrastructure development is an integral part for the growth of an institution. A very well equipped Trauma Centre has been established by the ministry in the campus. Three large new halls of residences for students are also under construction. These developments will further increase the electricity consumption.

» 1.5 MW rooftop plant

» 1.5 MW rooftop plant

All these developments led the university administration to explore the possibility of installation of grid-connected solar PV power plants in the campus. Pursuing in this direction, the university has successfully installed 4.5 MW capacity grid-connected solar PV plant in the campus. The installation includes a 3 MW solar farm installed on an unutilized barren land on the outskirts of the campus. Remaining 1.5 MW capacity plant is distributed across 16 rooftops in the campus. This plant has been installed in RESCO mode under the SECI/CPWD scheme of the Government of India. Details of these two plants and their cost–benefit analysis is presented in the following sections.

3-MW GRID-CONNECTED SOLAR FARM

The university has installed a 3-MW ground-mounted, solar power plant on an unutilized barren land outside the main campus. Before initiating the installation, simulation studies were performed to decide the optimal capacity of the plant. Based on the simulation studies, the plant is expected to generate about 45 lakh units of electricity per year with a payback period of about 6 years.

The plant was commissioned on

June 10, 2017, and it generated 236,541 units of electricity (kWh) in the month of June. During the month of July, the total number of units generated by the plant is 253,605 despite heavy rains and disruption to the transmission line due to storm for about seven days in the month. The electricity generated by the plant is being fed to the university network via a transmission line installed from the solar plant to the 33kV dedicated substation of the university situated at a distance of about 2.5 km from the solar farm. The maximum generation for any day till now has been 15,587 units which has crossed even the most optimistic estimates. Considering the present per unit rate of electricity in the campus, the savings from the plant for the month of June 2017 was approximately ₹21.62 lakh while for the month of July 2017, the approximate saving was ₹23.18 lakh. It is a major step towards making the university a green campus, and it will also relieve the state power grid from a significant share of load during day time.

The units generated in the month of June and July 2017 along with savings; financial as well as savings in equivalent CO_2 emissions is given in Table 1.

Table 1: Benefits of 3-MW solar power plant

Month	Units Generated	Financial Savings (Approx.)	Equivalent Carbon Emissions Savings (Approx.)
June 2017	236,541	₹21.62 lakh	205,790 kg
July 2017	253,605	₹23.18 lakh	220,636 kg

The plant has been installed for a total cost of about ₹20.60 crore including construction of boundary wall around the plant, operation and maintenance, and security for ten years. The total life of a solar power plant is 25 years. With the performance shown in the first two months, it is expected that the investment will be recovered in about 5–6 years at the present rate of electricity. If the rate of electricity is increased, which usually happens every alternate year, then the return on investment period will further reduce.

At present, the power generated from the solar plant is being utilized only for captive consumption of the university. However, the university would like to feed the power generated from the plant into the State Power Grid on Net-Metering basis. For this purpose, an application has been submitted for required modifications in the Rooftop Solar PV Grid Interactive Systems Gross/Net Metering Regulations, 2015, of Uttar Pradesh Electricity Regulatory Commission (UPERC), notified on March 20, 2015.

1.5-MW ROOFTOP SOLAR PV PLANT

Another solar power plant of 1.5 MW capacity has been installed in the campus under a scheme of the Government of India. The plant has been installed and maintained by a developer identified by the Solar Energy Corporation of India Limited (SECI) (A Government of India Enterprise). Under this scheme, the University has not invested any amount and provided the rooftops of 16 buildings only.

The university is purchasing electricity from the developer at a rate which is about 33% less than the present grid electricity rate and moreover this rate will remain fixed for the next 25 years irrespective of the increase in the grid rate. The plant has been operational since April 2017. The number of units generated in each month and approximate savings is given in Table 2.

Table 2: Benefits of 3-MW solar power plant

Month	Units Generated	Financial Savings (Approx.)	Equivalent Carbon Emissions Savings (Approx.)
April 2017	134,872	₹4.23 lakh	117,338 kg
May 2017	172,968	₹5.43 lakh	150,482 kg
June 2017	146,373	₹4.60 lakh	127,344 kg
July 2017	126,600	₹3.98 lakh	110,142 kg

» AMU main entrance

Again it may be noted that savings will further increase every time there is a hike in the grid electricity rate.

The total 4.5 (3 and 1.5) MW capacity makes it one of the largest non-commercial installations of renewable energy in the country and definitely the largest in any academic institution in the country. The two plants together are generating about 20,000 units of electricity on a clear day. This has resulted in considerable savings but also contributing significantly in the national mission on environment protection by major reduction in carbon emissions.

THE WAY FORWARD

Availability of such a large grid-connected installation in the university provides a very good opportunity for carrying

» 3 MW ground mounted plant

out research and development projects addressing various issues of large grid-connected solar power plants. The plants can also be utilized for imparting training to Engineers of DISCOMS and Entrepreneurs, etc., which is an important part of the National Solar Mission. Organizations, such as the Ministry of New and Renewable Energy (MNRE), National Institute of Solar Energy (NISE), Uttar Pradesh Power Corporation Limited, and India Smart Grid Forum are taking keen interest in these plants for different training, research, and development activities. Some of the important areas of future development are as follows:

- *Performance evaluation of large grid-connected solar PV plants in North India:* A research project may be carried out to evaluate the performance of these solar power plants for one complete year. It will be helpful for other such plants to be commissioned especially in North India.
- *Training centre on solar power:* The two solar PV plants installed at AMU provides a very good opportunity for producing trained manpower in order to promote the solar power. The AMU campus is ideally suited for such a training centre in the country because apart from MW scale grid-connected solar plants in the campus it has a renowned Electrical Engineering Department with a very well established lab on solar power and it has a centre for renewable energy also sanctioned by the Ministry. Moreover, the infrastructure required for training programmes, such as classrooms, computing facilities, guest houses etc., are also available. In response to the call issued by NISE, the university has already submitted a formal application in this regard.
- *Promotion of solar power in universities:* The experience gained and lessons learned can be utilized for promoting installation of solar power; especially in other academic institutions in the country. Many other academic institutions are now trying to replicate this experiment in their campuses and the university is extending all possible cooperation in this regard.
- *Research project on monitoring of grid-connected solar PV:* Monitoring and control of active distribution networks with large grid-connected solar plants is an important area of concern. The set-up at AMU may be utilized for research work in this area. It can be a major contribution to the National Smart Grid Mission also. AU

» 3 MW ground mounted plant

Dr Mohammad Rihan is working as Associate Professor in the Department of Electrical Engineering and as Member Incharge, Electricity Department, Aligarh Muslim University. He has been the Incharge of the Solar Power Projects Completed at AMU. His research interests are in the field of Smart Grid, Grid Integration of Renewables, and Synchrophasors measurement in Smart Grid. He is a Senior Member of IEEE.

Power Minister chairs the 4th Foundation Day Celebrations of National Institute of Solar Energy, Gurugram

» Dr Arun Kumar Tripathi, Director General, NISE, presiding over the 4th Foundation Day Celebrations of National Institute of Solar Energy, Gurugram

» Shri Raj Kumar Singh, Minister of State for Power and New & Renewable Energy presented with a set of four books on Solar Energy published by NISE.

Union Minister of State (IC) for Power and New & Renewable Energy, Shri Raj Kumar Singh, presided over the 4th Foundation Day celebrations of National Institute of Solar Energy (NISE), at its campus in Gurugram, Haryana, on October 27, 2017.

"NISE should aim to establish itself as the World's leading institute in the field of solar energy through its world class R&D, testing and certification, and training to emerge as a 'Centre of Excellence'. NISE should strive further and set up regional centres for research and development in solar energy", said Shri Raj Kumar Singh, while addressing scientists, research staff, and other guests on the occasion.

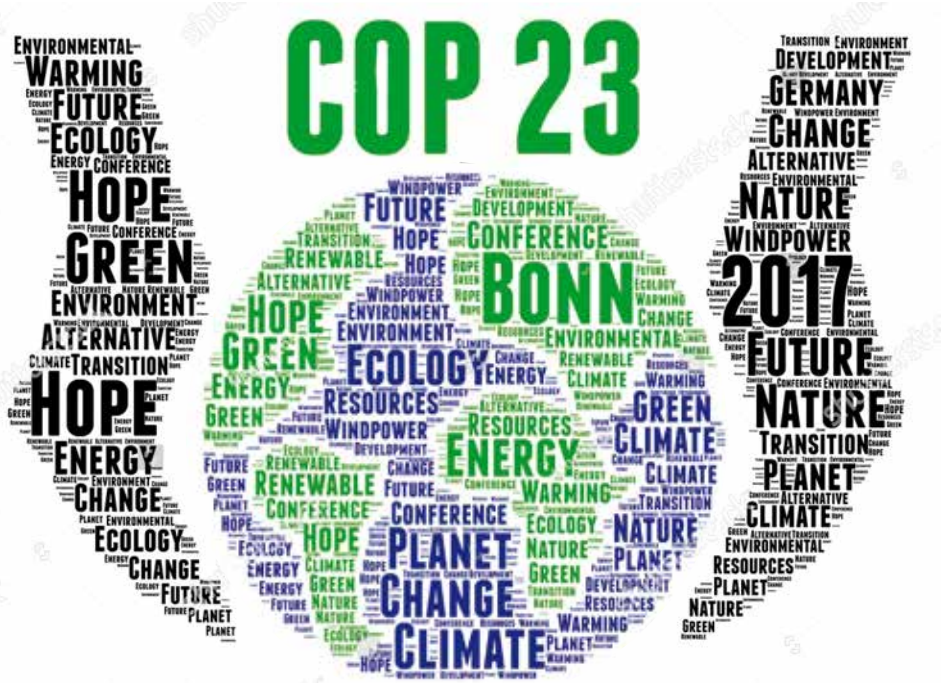
"There is no dearth of funds for R&D activities", the Minister added, while complimenting on the number of innovative prototype projects developed at NISE. He said that NISE should work quickly and patent some of the products and encouraged scientists to work out strategies for public–private collaborations to reach end-users. The Minister also launched the Automation System for Customer Service Cell for Testing Facilities at NISE. The Minister was also presented with a set of four books on solar energy published by NISE.

The Minister was particularly impressed with the solar powered RO water dispensing ATM, and the solar powered milk chilling unit. He urged upon NISE to work with central and state agriculture ministries, along with National Dairy Development Board to take up demonstration projects of the solar technologies developed at NISE.

The Minister also gave away awards to school children from Gurugram who won prizes for various competitions on solar energy, organized by NISE and conducted by Delhi Public School, Gurugram, held in the month of October 2017. AU

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

MNRE ORGANIZES PANEL DISCUSSION ON 'INNOVATIVE FINANCING AND MARKET EVOLUTION TO ACHIEVE 175 GW RENEWABLES BY 2022' AT COP 23



MNRE, Government of India, in partnership with the Confederation of Indian Industry (CII), organised a panel discussion on 'Innovative Financing and Market Evolution to achieve 175 GW renewables by 2022' on November 16, 2017, at the India Pavilion at the Conference of Parties (CoP) 23, Bonn, Germany.

Reaffirming India's resolution to go ahead with the set agenda with determination and clarity, Shri C K Mishra, Secretary, Ministry of Environment, Forest and Climate Change, Government of India, said that India has been pursuing its goals of setting up renewable energy capacities and changing its energy mix, and will continue to do so to provide equitable sustainable development. Giving examples of how the question is no longer about availability of finances but that of cheap finances Shri K S Popli, CMD, Indian Renewable Energy Development Agency Limited (IREDA) said that the markets have matured and one indicator of that is seen in how the bond markets have progressed.

Dr Ajay Mathur, DG, The Energy and Resources Institute (TERI) stressed upon the need to push for higher research in storage technology which could compliment the infirm renewable power. There is an imminent need to look at bringing down storage costs, he added. AU

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

SHRI R K SINGH INAUGURATES WORKSHOP ON 'WASTE TO ENERGY'

Union Minister of State (IC) for Power and New and Renewable Energy, Shri R K Singh has emphasized the need for setting up more waste management plants around the country. Shri Singh said this while inaugurating a Workshop on Waste to Energy—'Swachchata Se Swachh Urja' on September 26, 2017, in New Delhi. The workshop was organized by the Ministry of New and Renewable Energy, Government of India, as a part of 'Swachchata Hi Sewa' campaign.

Addressing the gathering, Shri Singh added that there is a huge amount of waste generated in a country such as India and said that there is an urgent need to convert the waste into energy. Citing the example of the Timarpur Okhla Waste Management Company Private Limited, the Minister called for setting up more such plants. A framework will be worked on for energy thus generated by these plants and subsequently rates fixed for them, the Minister added. Shri R K Singh also pointed out the need for change in the habits of the people to ensure effective waste collection and segregation. He said the citizens should be educated on effective waste management so that it would be easier for the industries to process the waste. He also added that effective waste management will help in creating a cleaner and greener India.

In his address, Shri Anand Kumar, Secretary, Ministry of New and Renewable Energy, Government of India, said that the Ministry's focus is on energy generation from urban, industrial, and agricultural waste/residues, municipal solid wastes, vegetable and other market wastes, slaughterhouse waste, and industrial wastes and effluents. These initiatives, he said, not only support generation of energy from the waste but also help in reducing pollution. It will also address the issue of burning of paddy straw by producing bio-CNG.

In his address the Secretary said, that since the inception of 'Swachh Bharat Mission' in 2014, the Ministry has already supported around 180 projects mainly based on production of bio-CNG/ biogas for various energy applications in industries and transport sector.

The three major waste-to-energy projects of 52 MW, based on Municipal Solid Waste (MSW) have already been installed and running successfully in Okhla, Ghazipur, and Narela-Bawana in Delhi, which help in converting solid waste to electricity. In addition, under 'Swachh Bharat Mission', about 40 projects with installed capacity of 344 MW supported by the Ministry of Housing and Urban Affairs, Government of India, are under various stages of commissioning.

The workshop deliberated upon how to utilize waste for generation of energy through various proven technologies and established business models to scale up the programme in close association with all stakeholders including corporate houses.

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

Green QUIZ

1. **Which among the following is most energy efficient?**
   (a) Incandescent bulb (b) Fluorescent tube light
   (c) Compact fluorescent lamp (d) All of the above

2. **In India and elsewhere, biomass can be obtained from**
   (a) Groundnut shells (b) Sugarcane bagasse
   (c) Rice husk (d) All of the above

3. **Solar cells are simple photovoltaic devices that convert solar energy directly into electricity and are manufactured from the second-most abundant element in the earth's crust. Name it.**
   (a) Bauxite (b) Silicon
   (c) Calcium (d) Strontium

4. **Biogas is a methane-rich gas formed by fermentation of animal dung, human sewage and crop residue. The advantage(s) of biogas is/are:**
   (a) A clean and smokeless fuel (b) Slurry left behind is used as fish feed
   (c) High potential in rural India (d) All of the above

5. **Which is the most common non-commercial biological fuel in a large number of developing countries?**
   (a) Animal dung (b) Crop residue
   (c) Coal (d) Fuelwood

6. **Hydro power, which is derived from water is one of the earliest sources of energy in the country. The first mini hydel plant was set up in 1897 at the following place.**
   (a) Shimla (b) Dehra Doon
   (c) Kulu (d) Darjeeling

7. **Wind energy is the kinetic energy associated with atmospheric air.It has been used for centuries for the following operation.**
   (a) Grinding grain (b) Generating electricity
   (c) Running cars (d) None of the above

8. **Large amounts of solar energy is stored in the oceans and seas. The process of harnessing this energy is called**
   (a) OTEC (ocean thermal energy conversion)
   (b) OTC (ocean thermal conversion)
   (c) OSTEC (ocean and sea thermal energy conversion)
   (d) None of the above

9. **This energy is the heat generated by natural process within the earth. The main energy sources are the hot rocks, magma, geysers, and hot-springs.** This form of energy is known as
   (a) Solar energy (b) Geothermal energy
   (c) Ocean thermal (d) All of the above

10. **Following is the most widely discussed impact of climate change:**
    (a) Increase in average sea level (b) Deforestation
    (c) Soil erosion (d) None of the above

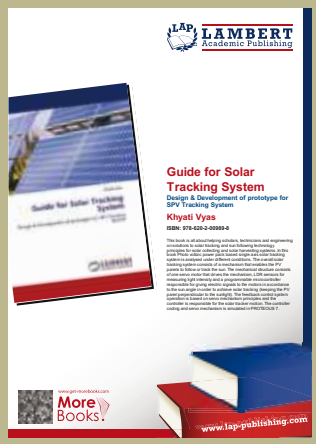
Answers
1. (c), 2. (d), 3. (b), 4. (d), 5. (d), 6. (d), 7. (b), 8. (a), 9. (b), 10. (a),

Source: http://edugreen.teri.res.in/

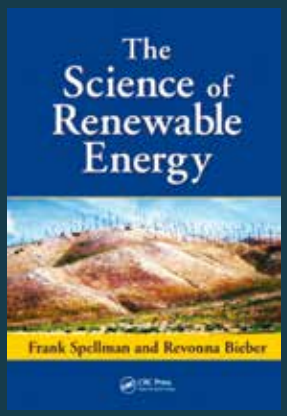
Illustrations by Vijay Nipane

Guide for Solar Tracking System

Khyati Vyas; Lambert Academic Publishing, 100 pages



This book is all about helping scholars, technicians, and engineering students on solutions to solar tracking and sun following technology principles for solar collecting and solar harvesting systems. In this book, photovoltaic power pack based single axis solar tracking system is analysed under different conditions. The overall solar tracking system consists of a mechanism that enables the PV panels to follow or track the sun. The mechanical structure consists of one servo motor that drives the mechanism, LDR sensors for measuring light intensity and a programmable microcontroller responsible for giving electric signals to the motors in accordance to the sun angle in order to achieve solar tracking (keeping the PV panel perpendicular to the sunlight). The feedback control system operation is based on servo mechanism principles and the controller is responsible for the solar tracker motion. The controller coding and servo mechanism is simulated in PROTEOUS 7. AU



The Science of Renewable Energy

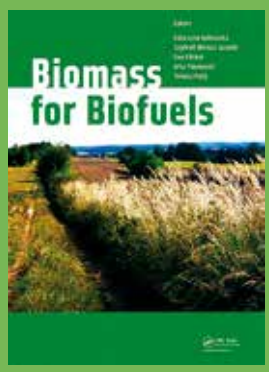
Frank R Spellman and Revonna M Bieber; CRC Press, 339 pages

The Science of Renewable Energy presents a no-nonsense discussion of the importance of renewable energy, while adhering to scientific principles, models, and observations. The text includes in-depth discussions of emerging technologies, including biomass and fuel cells, and major sources of renewable energy, such as ocean, hydro, solar, and wind energy.

To provide a fundamental understanding of the basic concepts of renewable energy, the book also offers an extensive discussion on the basics of electricity, since it is applied to and produced from all forms of renewable energy. While emphasizing the technical aspects and practical applications of renewable sources, the text also covers the economic, social, and policy implications of large-scale implementation. The main focus of the book is on methods of obtaining energy from self-replenishing natural processes while limiting pollution of the atmosphere, water, and soil, as this is a critical pathway for the future. Exploring the subject from a scientific perspective highlights the need for renewable energy and helps to evaluate the task at hand. The book is written for a wide range of readers, including students of diverse backgrounds and individuals in the energy industries, and presents the material in a user-friendly manner. Even individuals can have an impact on the quest to develop renewable energy sources. The concepts and guidelines described provide critical scientific rationale for pursuing clean and efficient energy sources as well as the knowledge needed to understand the complex issues involved. Woven with real-life situations, the text presents both the advantages and challenges of the different types of renewable energy. AU

Biomass for Biofuels

Katarzyna Bulkowska, Zygmunt Mariusz Gusiatin, Ewa Klimiuk, Artur Pawlowski, and Tomasz Pokoj; CRC Press, 188 pages



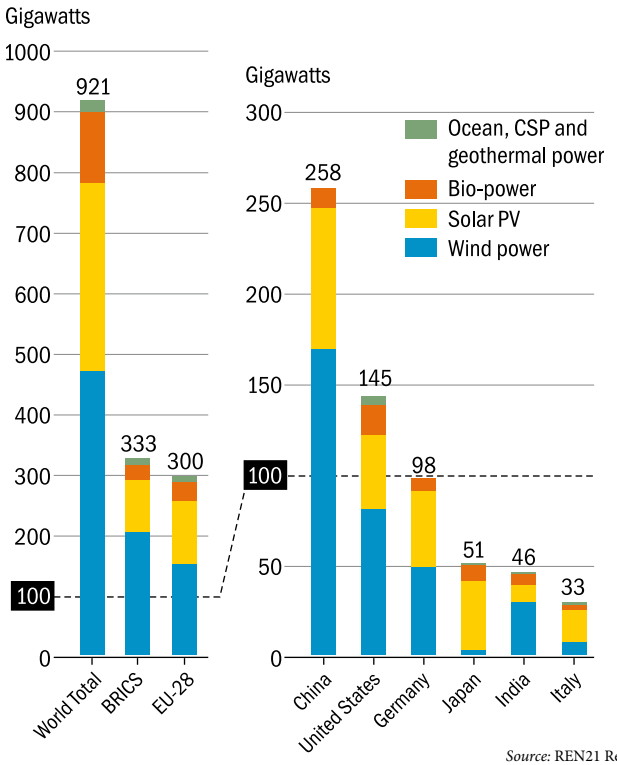
Biomass for Biofuels presents technological aspects of biomass conversion into advanced biofuels. Also discussed are the influence of growing biofuels markets on the natural environment and social relations as well as economic aspects of acquisition of biomass and its processing into biofuels. In addition, biomass characteristics are presented. A definition is provided, and its chemical composition and properties detailed. The focus is on lignocellulosic biomass, whose complex structure is a limiting factor for biofuels production via biological processes. For that reason, mechanical, chemical, and physicochemical methods that enable an increased availability for the microorganisms used for biomass conversion to biofuels are discussed. AU


NATIONAL
January 18–19, 2018 | New Delhi, India
India Rooftop Solar Congress (IRSC)
Website: http://www.solarquarter.com/indiarooftopsolarcongress/
February 8–10, 2018 | Gwalior, India
International Conference of Environmental Research
Website: http://icer18.jerad.org/
February 12–13, 2018 | New Delhi, India
India Energy Access Summit
Website: https://www.theclimategroup.org/event/india-energy-access-summit
February 15–17, 2018 | New Delhi, India
World Sustainable Development Summit (WSDS) 2018
Website: http://wsds.teriin.org/
February 23–25, 2018 | Lucknow, India
All India Solar Summit
Website: http://www.aiss.org.in/

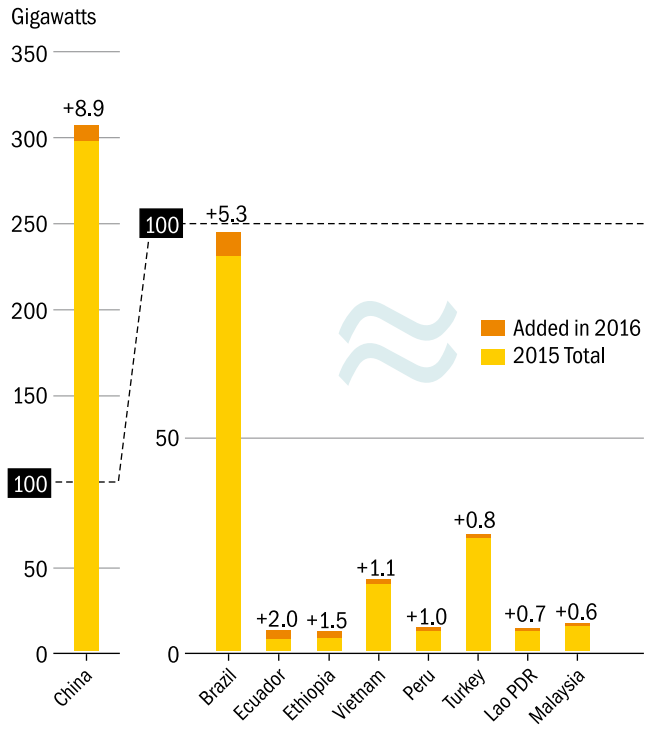

INTERNATIONAL
January 15–18, 2018 | Abu Dhabi, UAE
WFES Solar Expo
Website: https://www.solarexpo.ae
January 17–19, 2018 | San Diego, USA
10th AEE Solar Dealer Conference
Website: http://aeesolar.com/aee-solar-dealer-conference/
January 22–24, 2018 | Hong Kong
The Global Off-Grid Solar Forum & Expo
Website: https://10times.com/tgogsfe
January 28–February 2, 2018 | Ventura, USA
Renewable Energy: Solar Fuels (Gordon Research Conference)
Website: https://www.grc.org/renewable-energy-solar-fuels-conference/2018/
February 27–28, 2018 | London, UK
Energy Storage Summit
Website: http://storage.solarenergyevents.com/

RENEWABLE ENERGY AT A GLANCE: GLOBAL

Renewable Power Capacities in World, BRICS, EU-28 and Top 6 Countries, 2016



Hydropower Capacity and Additions, Top 9 Countries for Capacity Added, 2016



Source: REN21 Renewables 2017 Global Status Report

Jobs in Renewable Energy

Source: IRENA