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Ministry of New and Renewable Energy
Government of India

Renewable Energy Akshay Urja

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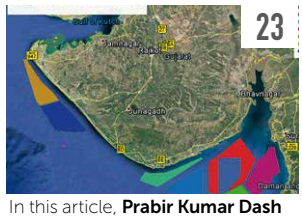
In this article, **Radhey Shyam Meena, Dilip Nigam, Anindya S Parira**, and **Sunil Kr Gupta** have done a comprehensive analysis on these aspects and also provide the current status of solar parks in India.



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In this article, **Prabir Kumar Dash** discusses India's efforts towards offshore wind through a robust programme based on sound resource assessment.

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Ashwin Gambhir and **Shantanu Dixit** say that the availability of the electricity grid in every village coupled with the national feeder separation programme makes Maharashtra's solar feeder programme and KUSUM's decentralized ground-mounted grid solar power plant programme quite feasible across India.

Akshay Urja (bilingual) is widely circulated to all stakeholders of renewable energy. We invite advertisements (in colour) from interested organizations, manufacturers, institutions, etc. The advertisement tariffs are as follows:

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WANT TO BE A WRITER ON RENEWABLE ENERGY ?

If yes, here's the opportunity!

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

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

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SECRETARY
GOVERNMENT OF INDIA
MINISTRY OF NEW AND RENEWABLE ENERGY

MESSAGE

The British Petroleum in its Annual Energy Outlook 2019 has predicted that renewable energy will become the dominant global source of power generation by 2040. IEA's Annual Energy Outlook 2018 has predicted that the convergence of cheaper renewable energy technologies, digital applications and the rising role of electricity is a crucial vector for change. The report also predicted that the world is witnessing a major shift in energy demand with demand growing fastest in India.

In India growth of renewables deployment is higher than the growth in energy demand. With over 78 GW installed renewable power capacity, 27 GW under installation and 38 GW under bid, India is well on the way to exceed 175 GW target by the year 2022. Our efforts are towards achieving the targets cost competitively without compromising on quality. On 7 May 2019 we convened a Chintan Bhaitak where views and suggestions from industry and other stakeholders were invited. Such interactions provide us insights for fine-tuning policies and programmes for addressing the emerging challenges.

We have proposed to organize the third edition of RE-INVEST (Renewable Energy Investors' Meet and Expo) from 30 October and 2 November 2019. Over the period, RE-INVEST has metamorphosed into a vital platform for bringing together renewable energy professionals, businesses, investors, financing institutions, academia, research communities and industry leaders to discuss, deliberate, and brainstorm on new financing approaches to scale up renewable energy deployment in the country. RE-INVEST website has now become functional.

Akshay Urja has been presenting Government of India's policies and activities in renewables space, and also keeping readers abreast of the latest developments. We look forward to your feedback for improving the quality and outreach of the newsletter.

With best wishes.

[Anand Kumar]

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From the Editor's Desk

Dear Readers,

This *Akshay Urja* issue is unique in many ways. The Secretary, MNRE, has kindly granted an interview that succinctly explains the present stage of renewables, priorities, and outlook for the next decade. The article on Renewable Park scheme lucidly states the salient features and is reflective of India's plan to optimally harness the renewable energy potential in the country. Prabir has aptly covered India's efforts towards offshore wind through a robust programme based on sound resource assessment.

Solar agricultural feeders have the potential to transform the electricity utilization pattern for agricultural purposes and generate additional income for farmers. Ashwin and Shantanu, from Prayas, have examined the Maharashtra policy, and true to Prayas' reputation, have drawn forward looking conclusions.

Renewables have progressively started touching common man's life in many ways. Renewables are not an exotic option any more, but are clearly the fulcrum for sustainable energy transition. Our efforts will prove that given the will, no target is difficult to achieve.

P C Maithani

RENEWABLE ENERGY NEWS

CABINET APPROVES COOPERATION AGREEMENT WITH FOCUS ON OFFSHORE WIND ENERGY

The Union Cabinet, chaired by the Prime Minister Shri Narendra Modi, has given its approval for a Cooperation Agreement between Ministry of New and Renewable Energy of India and Ministry for Energy, Utilities and Climate of the Kingdom of Denmark on strategic sector cooperation in the field of renewable energy with a focus on offshore wind energy and a Letter of Intent to establish an Indo-Danish Centre of Excellence for renewable energy in India. The Agreement was signed in March 2019 in New Delhi. The objective of the Cooperation Agreement is to promote cooperation between the two countries in the field of renewable energy with special focus on off-shore wind. The areas of cooperation would include technical capacity building for management of off-shore wind projects, measures to develop and sustain a highly efficient wind industry, onshore as well as offshore; measures to 'ensure high quality of wind turbines, components, and certification requirements; forecasting and scheduling of off-shore wind. The Indo-Danish Centre of Excellence in Integrated Renewable Power would work on renewable energy resource assessments with focus on onshore and offshore wind; hybridization of wind, solar, hydro, and storage technologies; testing and R&D; and skill development/capacity building. The signing of the documents will help in strengthening bilateral cooperation between the two countries.

Source: http://pib.nic.in

GOVERMENT INCENTIVIZES STATES UNDER SOLAR PARK SCHEME 2.0

The Centre has introduced a financial incentive for states and tweaked its policy to address two major issues plaguing solar park developers — shortage of land and lack of transmission facility. States will earn ₹0.02 for every unit of power produced at the solar parks, irrespective of where it is supplied, according to a letter to the principal secretaries of all states from the Ministry of New and Renewable Energy. The letter is also addressed to the managing director of the Solar Energy Corporation of India (SECI) and solar park developers. This is expected to ease the problem of acquiring revenue or private land for projects auctioned by SECI, nodal agency for conducting wind and solar auctions. The amendment to the policy is significant especially for Gujarat where the developers are in a fix. Gujarat is highly favoured for producing renewable energy because of its geographical location. The state has been going slow on leasing land to projects auctioned by central agencies but continuing to allocate land for projects auctioned by its own agency. The fiscal incentive of ₹0.02 per unit will have to be borne by the developer, according to the letter, but it will be allowed to add it to the tariff while bidding at auctions. Connectivity hurdles have lately delayed commissioning green power projects. The ministry said the onus of external transmission from solar parks will be on SECI and the cost of transmission facilities will be drawn from the Central Financial Assistance it provides for setting up the parks. "Internal infrastructure of the renewable energy park like internal power evacuation system, road, water, levelling of land, fencing, telecommunication and other facilities would be done by the developer at its own cost," said the letter. SECI also plans to set up a payment security fund (PSF), a risk mitigation mechanism to ensure regular payment of dues even if discoms drawing power delay payments citing funds crunch.

Source: economictimes.indiatimes.com

SOLAR POWER ACCOUNTS FOR 50% CAPACITY ADDITION IN 2018

Solar power for the first time in India made over 50% power capacity addition in 2018 although GST, safeguard duty, and land and transmission issues took a toll on large-scale power installation to whose effect the overall Indian solar market was down 15.5% in FY18, according to Mercom India Research's newly published report. The Indian solar market installed 8,263 MW in FY18 compared to 9,782 MW in FY17. But rooftop solar had a good year, growing 66% year-on-year (YoY). Of the total installed capacity in 2018, large-scale projects accounted for 6,608 MW, which was 23% lower than the capacity added in 2017. Rooftop installations came to 1,665 MW in 2018. Total power capacity additions from all sources was 16.3 GW in 2018, of which renewable energy accounted for nearly 70% of installations, with solar representing 50.7% of new capacity and wind with 14%. Coal accounted for 27.5% of the new capacity added. Mercom officials felt that a steady shift towards solar will continue to be seen as prices continue to drop. This is going to be the new normal as coal plants continue to shutter. In the fourth quarter of 2018, solar installations came to 1,638 MW, up 3% quarter-to-quarter from the 1,589 MW installed during the third quarter of 2018. But this was 52% lower y-o-y compared to the 2,491 MW installed in the fourth quarter of 2017. Rooftop installations in 2018 totalled 1,655 MW, a 66% growth y-o-y taking cumulative rooftop solar installations to 3,260 MW. In terms of annual growth, rooftop solar continues to be a bright spot, as commercial and industrial entities see it as a viable way to combat higher power tariffs.

Source: www.financialexpress.com

AKAL UNIVERSITY SWITCHES ON PUNJAB'S LARGEST SOLAR ENERGY PROJECT IN RURAL INSTITUTION

Managing Director of the Solar Energy Corporation of India (SECI), Shri Jatindra Nath Swain, inaugurated the 1.2 MWp solar power project at Akal University in Bathinda on April 6, 2019. In his address, Mr Swain said that this solar project, which is the largest for any rural educational institution, displays the forward thinking of an educational organization like Kalgidhar Society. This project would generate more than 80% of power requirements of the Akal University and 13 Akal Academies. This project has been built at a total cost of ₹5.2 crore, out of which the government has provided a total subsidy of around ₹1.7 crore. Mr Swain further said that SECI has made a great progress for the vision of 100 GW by 2022. He said "Solar power generation is a measure of sustainability and I am happy to see that Kalgidhar Society is harnessing the sun for making education system more sustainable. Along with solar, we also need to pay attention towards water conservation and rainwater harvesting to tackle the problem of climate change." This solar power plant project will reduce 35,000 metric tonnes of carbon emissions over 25 years. The carbon reduction impact of the project during its life time is equivalent to planting of 82,000 trees which will add to conservation of energy and environment, said Dr Gurmail Singh, Vice Chancellor, Akal University. The Kalgidhar Society has so far set up a total of 59 solar power plants in its Akal Academies in the region, in order to meet its energy demand from clean fuel.

Source: http://indianpowersector.com/

GAIL, BHEL SIGN PACT FOR DEVELOPMENT OF SOLAR POWER PROJECTS

State-owned gas utility GAIL India Ltd has signed an agreement with Bharat Heavy Electricals Ltd (BHEL) for cooperation in the development of solar power projects. "GAIL shall be the project developer and BHEL shall act as an engineering, procurement, construction, and project management contractor," the company said in a statement. BHEL shall also provide operation and maintenance services during the initial period upon becoming successful bidder. This development will help both the companies to leverage their competitive strengths to build a substantial portfolio in solar power projects. The memorandum of understanding aims at building a closer strategic partnership between the two Maharatna PSUs for jointly pursuing commercial solar power projects through participation in tariff/ Viability Gap Funding (VGF)-based competitive bidding process.

GAIL is India's biggest natural gas company with diversified interests across the value chain of trading, transmission, LPG production and transmission, LNG re-gasification, petrochemicals and city gas. It owns and operates a network of around 11,400 km of high-pressure trunk pipelines. It is working concurrently on multiple pipeline projects, aggregating over 5,400 km at an investment of about ₹24,000 crore, to operate over 16,000 km by 2021. GAIL commands 75% market share in gas transmission and has a gas trading share of over 50% in India. GAIL is also expanding its presence in renewable energy like solar and wind. It has India's second-largest rooftop solar PV power plant at its petrochemical complex at Pata, Uttar Pradesh. BHEL is one of the few companies in the world, and only company in India, having the capability to manufacture the entire range of power plant equipment. It has also been in the field of design, engineering, manufacturing, installation, and commissioning of solar power plants over three decades and has a portfolio of more than 700 MW.

Source: www.livemint.com

DMRC GETS 27 MW POWER FROM REWA PROJECT

Delhi Metro trains will now also run on solar power as the Delhi Metro Rail Corporation (DMRC) has received 27 MW power from the Madhya Pradesh-based Rewa Solar Power Project. This will also be the first time when the DMRC will be receiving power from an 'offsite source'. "Till now, solar power generated by roof-top solar plants installed in DMRC premises were utilised for auxiliary requirements such as lighting and air conditioning of stations, depots. But, now solar power coming from Rewa would also be used for operation of trains," a senior official of the DMRC said. He said, an agreement on offsite sourcing of power for the DMRC was signed in 2017. Marking the beginning of this 'new arrangement', DMRC's Managing Director Mangu Singh travelled in a metro train powered by solar energy along with other officials from the JLN Stadium station to Central Secretariat station on the Violet Line. Chairperson, Rewa Ultra Mega Solar, Manu Srivastava, and Director General, International Solar Alliance, Upendra Tripathi, were also present.

"The power received from Rewa will be utilised for the operational as well as auxiliary requirements of the Delhi Metro," the DMRC said. On an average about 345 million units (MU) of power will be received from Rewa in a calendar year. Besides the power received from Rewa, the Delhi Metro generates about 28 MW of solar power through a number of rooftop solar power projects which have been installed at stations, residential colonies and depots. The Rewa Ultra Mega Solar is a solar power plant in Madhya Pradesh's Rewa district. It has a total capacity of 750 MW and is one of the largest single-site solar power plants in the world.

Source: energy.economictimes.indiatimes.com

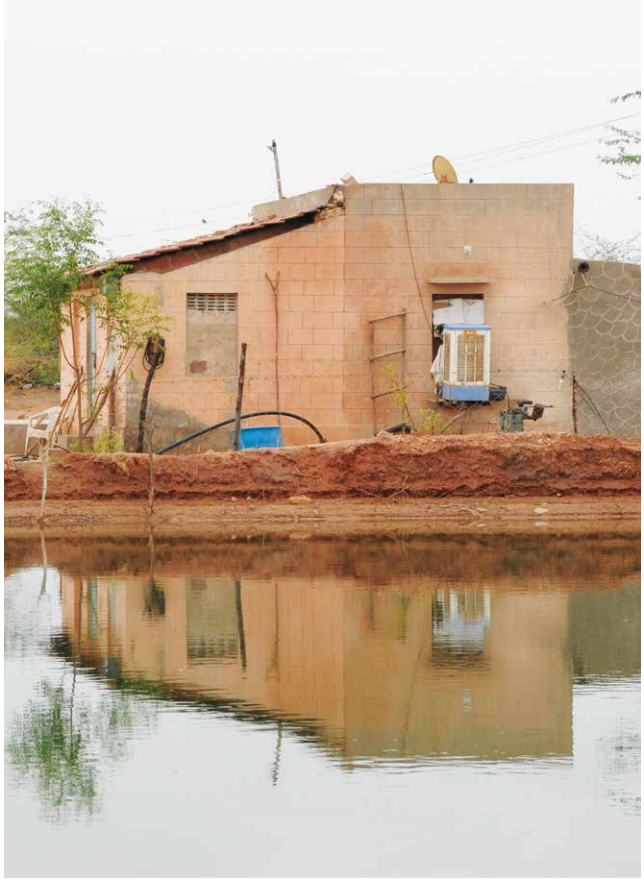
UP VILLAGE BECOMES RENEWABLE ENERGY MODEL

A village in Uttar Pradesh's Amroha district has presented itself as a model for renewable energy usage with complete dependence on solar power for all its needs. The solar-powered village in Chakanwala Panchayat named 'Mandironwala Bhuddi' has no electricity poles but is completely lit up using solar power. Solar panels have been installed at every house in the village as part of government's scheme. Shri Kanwar Singh Tanwar, the MP for Amroha said, "This area was surrounded by the Ganges and we thought of utilizing the power of the river. We have installed solar panels all across the area to make the lives of people easy. We will soon start working on the project pertaining to road connectivity."

A couple of villagers also talked about how solar power has helped to bring brightness into their area. Imarti, a village resident said, "This is very beneficial to us as we can do our household chores easily in the solar light." She also said that she expects that government would work towards road connectivity and development of the village. Another woman Ramshri said, "The solar lights have come last year. Before that, all the children were living in dark. Now we need a road and bridge to get better connectivity for our village."

Village resident Khacheru Singh said, "The life has changed a lot after the solar power was brought to the village. The facility was introduced in the village by local MP." The children of the village can be seen using the solar-powered lights to study in groups during night hours. Solar panels have been installed at every house in the village as part of government's scheme.

Source: energy.economictimes.indiatimes.com



MNRE ANNOUNCES DRAFT OF QUALITY CONTROL ORDER FOR SOLAR THERMAL SYSTEMS

To address and ensure quality of solar components across India's solar power ecosystem, the Ministry of New and Renewable Energy (MNRE) has floated a draft quality control order for Solar Thermal Systems. The Standardization specifics are in accordance with the Bureau of Indian Standards (BIS) guidelines.

The ministry has already announced the quality control order for Solar Photo Voltaic (SPV) Systems. According to the draft order, a manufacturer or seller of solar thermal systems will now have to register with BIS to obtain a Standard Mark. The order has also prohibited storage, sale, import or distribution of solar thermal systems by manufacturers or by any person on behalf of a manufacturer which does not bear the Standard Mark. However, the manufacturers of solar thermal systems meant for exports are exempted from the requirement of applying for a Standard Mark from BIS. This means that the outbound products may or may not adhere to the specifications. The Order is scheduled to come into force a year after its publication in the Official Gazette. The order adds, that solar thermal systems which do not conform to the specified standard will have to be deformed beyond use and disposed of as scrap by the domestic manufacturer or by the representative of an overseas manufacturer. In order to ensure compliance of the guidelines, MNRE can seek information along with sample of goods from the manufacturers on the systems any time. The ministry can also inspect the systems at any point in time. In cases of contravention, the ministry can also search and seize goods. In cases where the solar thermal systems are of varying size and rating, the goods will be grouped and granted series approval.

Source: www.saurenergy.com

DNV GL LAUNCHES DIGITAL PLATFORM FOR RENEWABLE PPAs

Energy advisory and certification body DNV GL has launched a new digital platform for renewable energy power purchase agreements. Instatrust is a global digital marketplace designed to be a one-stop-shop to connect corporations committed to buying clean energy with suppliers of wind and solar energy. On the web-based platform, recommended best practices will be screened and assets compared for a more transparent global renewable power purchase market.

The application will also provide a catalogue of best practices, guidelines, and standardized contracts helping to share lessons learned within the sector. Solar PV and wind combined will grow 85-fold by 2050 compared to 2016, representing about 28% of the world's primary energy supply. Combined with the drastic reduction in costs as well as a growing demand for corporate sustainability among investors and consumers, renewables have become an attractive possibility for corporations to implement that goal. We see that commitment from large corporations to buy renewable power will speed up the energy transition. The global power purchasing market is growing fast with regional characteristics and specific requirements and said Instatrust will match sellers and buyers in a trusted environment, thus helping speed up the adoption of wind and solar. Instatrust offers support to sellers in identifying and reaching out to active off-takers in the market; support to potential corporate renewable energy off-takers in issuing tenders and screening projects based on DNV GL's scoring methodology; and benchmarking projects in a quick and easy way to help energy buyers accelerate the procurement process with confidence. Caroline Brun Ellefsen, Global Head of Instatrust, said the corporate PPA market "needs to significantly scale up to avoid being a bottleneck in financing and building renewables. This growth in corporate PPAs will require an efficient and transparent market where stakeholders understand and mitigate emerging risks."

She said that having analysed over 65 GW of operational wind projects and supported more than 6,000 solar projects worldwide, DNV-GL Energy has "unparalleled insights into the evolving energy sector. Based on our experience, Instratrust is an advancement of our profound technical expertise, leveraging digital innovation to help both renewable energy buyers and sellers to facilitate renewable energy procurement for corporate companies."

Source: www.renewableenergyworld.com

RENEWABLE ENERGY NOW ACCOUNTS FOR A THIRD OF GLOBAL POWER CAPACITY

The decade-long trend of strong growth in renewable energy capacity continued in 2018 with global additions of 171 GW, according to new data released by the International Renewable Energy Agency (IRENA) on April 2, 2019. The annual increase of 7.9% was bolstered by new additions from solar and wind energy, which accounted for 84% of the growth. A third of global power capacity is now based on renewable energy.

IRENA's annual *Renewable Capacity Statistics 2019*, the most comprehensive, up-to-date and accessible figures on renewable energy capacity indicates growth in all regions of the world, although at varying speeds. While Asia accounted for 61% of total new renewable energy installations and grew installed renewables capacity by 11.4%, growth was fastest in Oceania that witnessed a 17.7% rise in 2018. Africa's 8.4% growth put it in third place just behind Asia. Nearly two-thirds of all new power generation capacity added in 2018 was from renewables, led by emerging and developing economies. IRENA's analysis also compared the growth in generation capacity of renewables versus non-renewable energy, mainly fossil-fuels and nuclear. While non-renewable generation capacity has decreased in Europe, North America, and Oceania by about 85 GW since 2010, it has increased in both Asia and the Middle East over the same period. Since 2000, non-renewable generation capacity has expanded by about 115 GW per year (on average), with no discernible trend upwards or downwards.

Source: www.irena.org

IN CONVERSATION WITH SHRI ANAND KUMAR, SECRETARY, MNRE

Renewables are playing a central role in augmenting grid power, providing energy access, reducing consumption of fossil fuels, and helping India pursue low carbon pathway. **Shri Anand Kumar**, Secretary, Ministry of New and Renewable Energy, Government of India, tells *Akshay Urja* in an exclusive interview.

How do you define the role of renewables in achieving an energy transition in India?

Renewables are part of India's vision not only to bring clean and affordable energy within the reach of all but also achieve social equity and address sustainability concerns. Harnessing these sources has already put India on energy transition path with cleaner environment, energy independence, and a stronger economy. India has ensured that the best policies are implemented for accelerating deployment, spurring innovative businesses and meeting the climate change mitigation goals.

Are we on track to meet the target of 175 GW of renewable energy capacity by 2022?

With over 78 GW installed renewable power capacity, 65 GW at different stages of fruition, India is well on the way to achieving the target. Since 2014, solar power capacity has grown over 11 times and wind power capacity increased by 1.7 times. Now, India has the fifth largest renewable power installed capacity in the world. However, this target is just the beginning, and by no means a ceiling of the ambition. We have worked systemically for putting in place facilitative policies and programmes for achieving the goal. Let me emphasize that our efforts are towards achieving the targets at the most competitive rates and we did not make any compromise either on quality of programme or its cost competitiveness. By the year 2022, the renewable power share in the overall electric installed capacity is expected to reach 37 per cent. If large hydro is included, the share of non-fossil fuel electric installed capacity in the electricity mix would be around 48 per cent.

How is the Ministry addressing the ever emerging policy challenges in the renewables space?

The need for enacting policies to support renewable energy is generally attributed to a variety of barriers and/or conditions.

The first barrier is higher initial capital costs even though lower operating costs make renewable energy cost-competitive on a life-cycle basis. Second, renewables are inherently intermittent and does not receive full credit for value of its power. Third, renewable energy projects have typically higher transaction costs, including costs for resource assessment, cost in developing project proposals, costs in assembling financing packages and also for negotiating power-purchase contracts. Fourth, investors rarely include positive environmental externalities of renewables in the bottom line used to make decisions. These apart, valuation of renewables from environment point of view and renewables being location specific (distributive in nature) require a special dispensation from regulatory angle.
In this context, the policy landscape for renewable energy deployment is ever evolving in response to felt needs. We have focused on "Ease to do business" and have brought out several diverse innovative policies. Waiver of inter-state transmission charges for sale of solar and wind power; Renewable Purchase Obligation trajectory that sets renewable energy targets for the States; catalysing initial deployment by providing Generation-Based Incentive; permitting Foreign Direct Investment up to 100 per cent under the automatic route; and Accelerated Depreciation and standards for deployment of Solar PV systems have been instrumental in creating robust pan-India renewable energy development.

How do you justify cancellation of the bids for solar and wind power in the recent past?

In a situation where the discovered tariff is higher than expected, cancellation of auctions become evident. The caps put in the reverse bidding process are based on the cogent principles that take into account all possible input costs. Such an action has been vindicated by the fact that the price discovered in the subsequent bids was lower than before.

How is the Ministry ensuring smooth availability of funds for renewable energy projects?

Over the period, India has become a favourable investment destination for renewables. A variety of investors finance renewable energy projects in India. India's financing landscape is largely represented through mixture of equity and non-recourse debt as private sector dominates in renewable energy financing. The very liberal foreign investment policy allows the foreign investors to enter into joint ventures with an Indian partner for financial and/or technical collaboration and for setting up of renewable energy-based power generation projects. Development banks such as IREDA, continue to represent a key source of funds for renewables, particularly in project finance. Venture Capital and Private Equity investments are also growing. Our present efforts are towards exploring international funding, and developing a suitable mechanism for risk mitigation. The major areas for action include tapping pension or sovereign funds; reducing cost of the foreign debt by reducing the currency hedging cost; de-risking the investment by putting in place robust Payment Security Mechanism; and also persuading bilateral and multilateral banks for earmarking a percentage of loan portfolio for renewables.

What are the Ministry's plans to increase use of renewables in the farm sector?

We have been making concerted efforts for de-dieselization of the farm sector and also increasing the farm income. Our plans for the next four years envisage around 2.75 million solar pumps and on a pilot basis 1 GW decentralized solar power plants on uncultivable lands of farmers.

What according to you are the major technological challenges and how do you plan to address them?

Creating an ecosystem for developing renewable energy technologies indigenously and facilitating domestic manufacturing, handling intermittency of renewable power; improving forecasting technology; creating an efficient and resilient renewable power transmission infrastructure; and developing storage technologies are the challenges and we have been making focussed efforts in their direction. Strategic research towards renewables includes improving performance and affordability of technologies; next generation photovoltaic, and energy storage technologies are high on the agenda. Coordinated research is being undertaken through R&D institutions, industry, and universities. We are exploring both domestic efforts and international experiences in these areas.

What is the outlook for the renewable energy sector?

The National Electricity Plan 2018 has estimated renewable power capacity of 275 GW by 2027. There are other estimates suggesting that by the year 2030, an electric installed capacity of 860 GW with solar and wind power contributing about 500 GW would be needed. These will necessitate a significant departure from business as usual and would entail a new paradigm with support mechanisms, facilitative policies, and access to new technologies and investment. We have been systematically working in all these areas. Mainstreaming of renewables in India's energy supply is part of India's 2030 vision and we are also committed to the global objective of realizing sustainable development and combating climate change.

3RD GLOBAL RE-INVEST 2019

Establishing India's Competitiveness in Global Renewable Energy Arena

The building blocks for the Indian renewable energy growth are now well in place, and it is time for the country to pole-vault to the next frontier of its journey.

The 3rd Global RE-INVEST 2019, will establish India's competitiveness in the global renewable energy arena. 3rd Global RE-INVEST is scheduled from 30th October to 2nd November, 2019 at India Expo Mart, Greater Noida, National Capital Territory of Delhi, India, and is being organized by the Ministry of New and Renewable Energy, Government of India, in partnership with the Confederation of Indian Industry. This will coincide with the Second Assembly of International Solar Alliance (ISA) and both these two events are likely to be inaugurated by the Hon'ble Prime Minister of India.

Themes revolving around future-oriented policy-making; scaling up and modernizing supporting infrastructure such as the grid and metering mechanisms; creating competences for high-tech, high-volume manufacturing, developing a skilled, adaptable workforce, and adopting the latest technologies including IoT, Software as a Service (SaaS), AI and robotics, will establish India as the most favourable destination for renewable energy in the world.

The details on RE-INVEST is available on <www.re-invest.in>, which is a dynamic website outlining not only the details of the conference and exhibition but also tracking the latest development in the sector. The 3rd RE-INVEST is expected to be attended by over 75 International Ministerial delegations, more than 1000 global industry leaders and 50,000 delegates. This platform will provide the connect and opportunity to showcase and share policies, achievements, strengths, and the plans for partnerships, through a strong and robust interactive format.

India was amongst the earliest nations to explore the potential of renewable energy, starting in the 1970s, driven by the urgency to ensure energy security in the wake of global 'oil-shocks'.

This will be a build up to the 2nd Global RE-INVEST India-ISA Partnership Conference & Expo, held in October 2018 which celebrated the major milestones of India's renewable energy programme and introduced new focus areas such as battery storage, offshore wind, commercial biofuels, solar rooftop, innovative financing, nextgen technologies, corporate RE buying, RE startups, and so on. It also took global centre-stage by hosting the First General Assembly of the ISA and the 2nd Renewable Energy Ministerial Meet of the Indian Ocean Rim Association (IORA).

However, India's RE story truly began in earnest in 2015. The Government, led by Hon'ble Prime Minister, announced the ambitious target of 175 GW of installed RE capacity by 2022, thus launching the world's largest RE expansion programme. RE-INVEST 2015, the 1st Global Conference & Expo, was held in February 2015 in New Delhi, to announce the 175 GW target to the international policy, business and investment community, and lay the roadmap for implementation.

The last 4 years saw investments worth US$ 42 billion come into India's RE sector and capacity double to 76 GW, driven by proactive policies, strong investor sentiment, cohesive public and private sector participation, sharp decrease in costs, and support from the states.

Besides enhancing national energy security through expansion and diversification of the fuel mix, renewables are now powering India's quest for sustainable economic growth and ensuring that development is aligned with its clean energy commitments. India becomes largest renewable energy auctions market in the world and the second-largest destination attracting clean energy investments

Successfully navigating this transition phase, as the world looks at disruptive innovations and sustainable solutions, will establish India as the new global RE hub is a question that will be answered at the 3rd Global RE-INVEST 2019.

Article Courtesy: Ms Sreya Majumder, Deputy Director and Lead Policy-Energy, Confederation of Indian Industry.

NEW HORIZONS COVERED BY MNRE

RE Round-Up for 2018–19

In this article, **N B Raju** highlights the new horizons achieved by the Ministry of New and Renewable Energy (MNRE) in 2018–19 as he presents an RE round up for the year.

The year 2018–19 was phenomenal in the manner in which India marched ahead in the pursuit of achieving its renewable energy targets.

RE ROUND-UP 2018–19

The year 2018–19 saw India progressing quite well towards fulfilling its renewable energy targets as the country attained global 4th and 5th positions in wind and solar power installed capacities, respectively. India is now at 5th global position for overall installed renewable energy capacity. As on March 31, 2019, India's renewable power installed capacity has already reached over 78 GW. Solar energy capacity has increased manifolds from 2.63 GW in 2014 to 28.18 GW by March 31, 2019. The wind energy capacity also increased considerably from 21 GW in 2014 to 35.62 GW by the end of 2018–19 (Table 1).

Table 1: Ministry of New & Renewable Energy

Source wise Grid Interactive Installed Power Capacity during last five years (in MW)											
Sector	**As on 31.03.2014**	**Achievement during 2014-15**	**As on 31.03.2015**	**Achievement during 2015-16**	**As on 31.03.2016**	**Achievement during 2016-17**	**As on 31.03.2017**	**Achievement during 2017-18**	**As on 31.03.2018**	**Achievement during 2018-19**	**As on 31.03.2019**
Wind Power	21042.58	2311.78	23354.36	3423.05	26777.41	5502.37	32279.78	1865.23	34145.00	1480.97	35625.97
Solar Power	2631.93	1112.08	3744.01	3018.9	6762.91	5526	12288.91	9362.64	21651.55	6529.20	28180.66
Small Hydro Power	3803.68	251.61	4055.29	218.6	4273.89	105.90	4379.79	105.95	4485.74	107.35	4593.15
Bio-Power	8041.63	355.72	8397.35	364.09	8761.44	187.65	8949.09	552.82	9501.91	414.70	9916.61
Total	**35519.82**	**4031.19**	**39551.01**	**7024.64**	**46575.65**	**11321.92**	**57897.57**	**11886.64**	**69784.20**	**8532.22**	**78316.39**

Projects worth 46.75 GW capacity have been bid out/under installation. The Government has declared the trajectory of bidding 60 GW capacity of solar energy and 20 GW capacity of wind energy till March 31, 2020. This has given assurance to the renewable energy developers and investors community about long-term commitment and planning of the Government in the RE sector encouraging them to make risk-free investments in the country.

LOWEST EVER SOLAR TARIFFS REGISTERED IN INDIA IN 2018

India registered the lowest ever solar tariff of ₹2.44 per unit in reverse auctions carried out by Solar Energy Corporation of India (SECI) in May 2017, for 200 MW and again in July 2018, for 600 MW. The tariff for grid-connected solar power projects is determined through competitive bidding process involving reverse e-auction. This has helped in bringing down the tariff significantly. The lowest solar tariff discovered as on date is ₹2.44/kWh in July 2018 in ISTS-based bidding of solar projects in India. The solar tariff has come down from around ₹18/kWh in 2010 to ₹2.44/kWh in 2018 due to various factors like economies of scale, assured availability of land and power evacuation systems, etc.

RPO TRAJECTORY FROM 2019–20 TO 2021–22

On June 14, 2018, the Ministry of Power notified the long-term renewable purchase obligation (RPO) trajectory from 2019–20 to 2021–22. The year-wise RPO levels are as under:

Long-term RPO trajectory	2019–20	2020–21	2021–22
Non-solar	10.25%	10.25%	10.50%
Solar	7.25%	8.75%	10.50%
Total	**17.50%**	**19.00%**	**21.00%**

The government issued guidelines for procurement of solar and wind power through tariff- based competitive bidding process involving reverse e-auction. It also issued order on waiving the Inter State Transmission Systems charges and losses for inter-state sale of solar and wind power for projects to be commissioned by March 2022. Standards for deployment of solar photovoltaic systems/devices were also notified.

The Government has revised the target of Grid Connected Solar Power Projects from 20 GW by the year 2021–22 to 40 GW by the year 2021–22 under the National Solar Mission. As on March 2019, 42 solar parks with cumulative capacity of 23,449 MW have been approved in 17 States. Over 100,000 lakh acres of land has been identified for various solar parks out of which over 75,000 acres have been acquired. Solar projects of aggregate capacity 4,195 MW have been commissioned inside various solar parks. The Ministry is also taking up projects for new emerging technologies such as floating solar power.

Cabinet approves launch of Kisan Urja Suraksha evam Utthaan Mahabhiyan (KUSUM)

A major development in the solar energy

sector in India happened in February 2019 when the Cabinet Committee on Economic Affairs approved the launch of Kisan Urja Suraksha evam Utthaan Mahabhiyan (KUSUM) with the objective of providing financial and water security to farmers. The proposed scheme consists of three components:

1. Component-A: 10,000 MW of Decentralized Ground Mounted Grid Connected Renewable Power Plants
2. Component-B: Installation of 17.50 lakh standalone Solar Powered Agriculture Pumps
3. Component-C: Solarization of 10 lakh Grid-connected Solar Powered Agriculture Pumps

All three components combined, the scheme aims to add a solar capacity of 25,750 MW by 2022. The total central financial support provided under the scheme would be ₹34,422 crore. The Component-A and Component-C will be implemented on pilot mode for 1,000 MW capacity and one lakh grid connected agriculture pumps respectively and thereafter, will be scaled-up on success of pilot run. Component-B will be implemented in full-fledged manner. For more information, please visit <http://pib.nic.in/PressReleaseIframePage.aspx?PRID=1565274>.

The Green Energy Corridor project continued under implementation in 2018–19. The project includes approx. 9,400 ckm transmission lines and Substations of total capacity of approx. 19,000 MVA to be completed by March 2020. The purpose is to evacuate approx. 20 GW of large-scale renewable power and improvement of the grid in the implementing States. Projects worth ₹6,766 crore have been awarded and approx. ₹1,400 crore have been disbursed to the States.

INDIA'S ACHIEVEMENTS IN WIND ENERGY SECTOR IN 2018–19

During the year, 1.48 GW wind power projects were commissioned with a cumulative achievement of 35.62 GW as on March 31, 2019. Around 9.4 GW capacity is under implementation or have been tendered out. The Government has issued 'Guidelines for Tariff Based Competitive Bidding Process for Procurement of Power from Grid Connected Wind Power Projects', vide Resolution notified on 8 December 2017, with an objective to provide a framework for procurement of wind power through a transparent process of bidding.

National Wind–Solar Hybrid Policy

The National Wind–Solar Hybrid Policy was issued in May 2018. The main objective of the policy is to provide a framework for promotion of large grid connected wind–solar PV hybrid system for optimal and efficient utilization of wind and solar resources, transmission infrastructure, and land. The wind–solar PV hybrid systems will help in reducing the variability in renewable power generation and achieving better grid stability. The Policy provides for

procurement of power from a hybrid project on tariff-based transparent bidding process for which Government entities were invited to bid. The Policy also permits use of battery storage in the hybrid project for optimizing the output and further reduce the variability. It mandates the regulatory authorities to formulate necessary standards and regulations for wind–solar hybrid systems.

Other Highlights of the Wind Energy Sector in India in 2018–19

A bid for setting up of first 1,200 MW Greenfield wind–solar hybrid project was floated by SECI. The National Offshore wind energy policy was notified in October 2015 with an objective to develop the offshore wind energy in the Indian Exclusive Economic Zone (EEZ) along the Indian coastline. Initial studies carried out by NIWE indicate offshore wind energy potential off the coasts of Gujarat and Tamil Nadu. LiDAR was commissioned on the monopile platform in November 2017 at Gulf of Khambhat, off Gujarat coast for wind resource assessment. NIWE floated Expression of Interest (EoI) for establishment of 1 GW offshore wind farm in Gulf of Khambhat region off Gujarat coast. National targets for offshore wind capacity additions of 5 GW by 2022 and 30 GW by 2030 were declared. All the major global players in this field have their presence in the country. Over 24 different models of wind turbines are being manufactured by more than 12 different companies in India. Wind turbines and components are being exported to the US, Australia, Europe, Brazil, and other Asian countries. Around 70%–80% indigenization has been achieved with strong domestic manufacturing in the wind sector.

OFF-GRID RENEWABLES

The Ministry is implementing off-grid and decentralized renewables programme for meeting energy demand for cooking, lighting, motive power, space heating, hot water generation, etc. The Ministry also supports deployment of decentralized

solar applications, such as solar lanterns, solar street lights, solar home lights, solar pumps, etc., in the country. As on March 2019, over 40 lakh no. of lanterns and lamps and over 2 lakh solar pumps have been installed in the country.

MNRE ANNOUNCES DRAFT OF QUALITY CONTROL ORDER FOR SOLAR THERMAL SYSTEMS

The MNRE has brought out draft quality control order for solar thermal systems (STS) for stakeholder comments. According to the draft order, a manufacturer or seller of solar thermal systems will now have to register with BIS to obtain a Standard Mark. The order prohibits storage, sale, import or distribution of solar thermal systems by manufacturers or by any person on behalf of a manufacturer which does not bear the Standard Mark.

EMPLOYMENT GENERATION THROUGH RENEWABLE ENERGY

During 2018–19, skill development programmes were conducted and monitored by MNRE's institutions such as NIWE and NISE. The feedback reveals that around 70% of the trained youths got decent employment opportunities in India and abroad.

CONCLUSION

India is now at the cusp of transition towards a renewable energy-based energy economy. Every passing year is giving India new experiences and lessons. The MNRE is continuously refining policies and programmes to address the emerging challenges. The Hon'ble Finance Minister in his Interim Budget Speech has indeed vindicated the Ministry's conviction and defined renewable energy as one of the major area of action for achieving energy security by the year 2030.

Shri N B Raju, Director I&PA, MNRE, New Delhi, India.

INDIA MOVES FROM SOLAR PARKS TO RENEWABLE ENERGY PARKS

A Comprehensive Analysis

India's progress from solar parks to renewable energy parks is an innovative step to reduce the effect of critical elements for sustainable growth. In this article, **Radhey Shyam Meena, Dilip Nigam**, **Anindya S Parira**, and **Sunil Kr Gupta** have done a comprehensive analysis on these aspects and also provide the current status of solar parks in India.

The concept of solar parks has emerged as a powerful tool for the rapid development of solar power projects under the National Solar Mission (NSM) of India. Assured availability of land and transmission infrastructure are the major benefits of a solar park. 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 solar park. The Solar Park Scheme aims to provide a huge impetus to solar energy generation by acting as a flagship demonstration facility to encourage project developers and investors, prompting additional projects of similar nature, triggering economies of scale for cost-reductions, technical improvements, and achieving large-scale reductions in greenhouse gas (GHG) emissions. It enables States to bring in significant investment from project developers, meet the solar renewable purchase obligation (RPO) mandate and provide employment opportunities to the local population.

With this background, the scheme for the development of Solar Parks and Ultra-Mega Solar Projects was introduced in December 2014 by the Ministry of New & Renewable Energy (MNRE), Government of India. It was planned to set up at least 25 solar parks, each with a capacity of 500 MW and above, thereby targeting around 20,000 MW of solar power installed capacity; in a span of 5 years commencing from 2014–15. Smaller parks are also allowed in Himalayan region and other hilly States where contiguous land is difficult to acquire in view of difficult terrain and in States where there is acute shortage of non-agricultural land.

To meet the demand for more solar parks from States, the capacity of the solar park scheme was enhanced from 20,000 MW to 40,000 MW in March 2017 with the aim to set up at least 50 solar parks by 2019–20. However, the time for solar parks has been extended from 2019–20 to 2021–22 as the availability of clear land and power evacuation are the two most critical elements for successful achievement of the target.

MODE FOR SELECTION OF SPPDs

Initially, there are 4 modes for selection of the Solar Power Park Developers (SPPDs). However, in order to bring more transparency, in selection of private entrepreneurs, CPSUs, such as SECI, NTPC, etc., the existing selection mode has been modified and some new modes have been introduced for the development of solar parks.

Mode-1	The State designated nodal agency or a State Government Public Sector Undertaking (PSU) or a Special Purpose Vehicle (SPV) of the State Government
Mode-2	A Joint Venture Company of State designated nodal agency and Solar Energy Corporation of India Ltd (SECI)
Mode-3	The State designates SECI as the nodal agency
Mode-4	Private entrepreneurs with equity participation from the State Government or its agencies based on open transparence bidding process
Mode-5	By Central Public Sector Undertakings (CPSUs), such as SECI, NTPC etc., in own or leased land
Mode-6	Private entrepreneurs without any Central Financial Assistance from MNRE
Mode-7	Solar Energy Corporation of India (SECI) acts as the Solar Power Park Developer (SPPD) for Renewable Energy Parks

Under Mode 1 to Mode 6, the SPPD is tasked with acquiring the land for the park, cleaning it, leveling it, and allocating the plots for individual projects. Apart from this, the SPPD are also entrusted with providing the necessary facilities like approved land for installation of solar projects and required permissions including change of land use, etc.; road connectivity to each plot of land; water availability for construction as well as running of power plants; flood mitigation measures like flood discharge, internal drainage, etc.; power during construction; centralized weather monitoring station; telecommunication facilities; power evacuation facility consisting of pooling stations to allow connection of individual solar projects with pooling station through a network of underground/over ground cables or overhead lines; housing facility for basic manpower wherever possible; parking, warehouse, etc.

- Land and power evacuation are the two most critical elements for the successful achievement of this target. If these two inputs are facilitated by the Government, then the private developers would be enthused to participate in establishment of RE projects in the country.
- Recognizing this critical factor, the Ministry constituted five teams for detailed planning of identified solar and wind zones. Accordingly, different teams visited the renewable rich states, such as Andhra Pradesh, Gujarat, Madhya Pradesh, Karnataka, Rajasthan, Tamil Nadu, and Telangana. The teams have identified potential sites for development of renewable energy projects in the above states and identified around 995,000 acres of land in Andhra Pradesh, Karnataka, Madhya Pradesh, Tamil Nadu, Rajasthan, and Gujarat. In the first phase of this, it is planned that about 25% of the identified land in Gujarat, Madhya Pradesh, and Rajasthan and about 30% of the identified land in Andhra Pradesh, Karnataka, and Tamil Nadu can be targeted, totalling 257,000 acres which can act as a land bank for hosting around 50,000 MW capacity of Solar/Wind/Hybrid/Other RE power parks. However, based on the actual availability, the extent of land to be covered in any state would be finalized by the implementing agency, i.e., SECI.

Based on that, a new mode (Mode 7) under the existing Solar Park Scheme has been introduced for development of Renewable Energy (RE) Parks (Solar or Wind or Hybrid or other RE parks) through SECI.

Under Mode 7 (Renewable Energy Park), SECI acts as SPPD for Renewable Energy (RE) Parks (Solar or Wind or Hybrid or other RE parks) and all the above tasks would be done by the Solar Project Developers (SPDs). States have to offer and facilitate acquisition of land to SECI for development of these RE parks. The salient features of Mode 7 are as follows:

- With assistance of the State Government, SECI will make both government and private land available to be used by successful bidder for setting up RE power projects. The State Government providing such facilitation for land identification and making its right of use available to SECI would be paid a facilitation charge of ₹0.02/unit of power being generated in these parks. This facilitation charge would be paid by the RE project developers for setting up projects in these lands, in addition to any land cost in terms of outright sale or lease rent. No funds from CFA will be used for procurement of land.
- SECI will get the external power evacuation infrastructure of the parks developed by External Transmission Development Agency (ETDA) such as CTU, STU as the case may be. However, the internal infrastructures of the RE park like internal power evacuation system, road, water, levelling of land, fencing, telecommunication, and other facilities as mentioned in the Solar Park Scheme and also battery storage if required would be done by the RE Project Developers (REPDs) at its own cost and would be factored in the tariff to be bid by the REPD. The REPD will not be provided with any CFA for development of internal infrastructures of the RE park. However, the essential components of internal infrastructure which need to be put in place by the RE project developers may be indicated separately by the RE project developers and the same may be eligible for availing line of credit if the financial institution has separate product to fund the RE parks.

- Under the existing Solar Park Scheme, there is a provision of providing CFA of ₹20 lakh per MW or 30% of the project cost whichever is less for setting up of both internal infrastructure and external power evacuation infrastructure. Now the CFA will be utilized for development of external power evacuation infrastructure. Since ₹20 lakh per MW provided under Solar Park Scheme may not be enough to set up transmission system, an additional mechanism has been decided.
- The total cost of any transmission network for any parcel of land would be divided by the total capacity of RE projects planned to be set up on that land parcel and utilizing the said transmission capacity to get the per MW cost.
- Forty per cent of the cost of transmission system, subject to a minimum of ₹10 lakh per MW (or the total cost if it is less than ₹10 lakh per MW) and a maximum of ₹30 lakh per MW would be borne by the RE project developers. The successful RE project developers selected through competitive bidding process shall be charged as upfront charges and collected by SECI. SECI will make this amount available to the ETDA for putting up the external transmission system.
- The balance CFA @₹20 lakh/MW or 30% of the total cost for development of external power evacuation system, whichever is less, [provided that the total of second and third points above does not exceed the total cost for development of external power evacuation system] to the ETDA for putting up the external transmission network.
- Remaining cost, if any, shall be socialized as is done presently for RE projects.
- Further, to make the setting of RE projects in such parks, a Payment Security Mechanism will be set up to ensure continuous payment to the power developers and mitigate any payment risk due to default in payment by the DISCOMs in any month. This will be in the form of a common dedicated Payment Security Fund (PSF) for all projects in the RE parks created under the scheme. This PSF would be build up over time by SECI by levying a charge of ₹0.02/unit from the RE project developers setting up projects in these RE parks.
- The facilitation charges of ₹0.02/ unit to the State Governments, the share of cost of transmission system

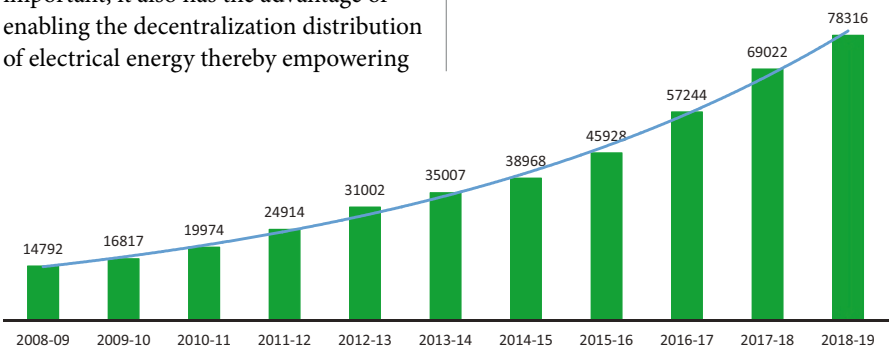
and Payment Security Fund charges of ₹0.02/unit from the RE project developers would be included by SECI while calling bids for selection of RE project developers.

PROGRESS AND STATUS

Year-wise Cumulative Capacity of RE in the last 10 years

Growth of Solar Capacity

Solar energy has a significant potential as a future energy source but equally important, it also has the advantage of enabling the decentralization distribution of electrical energy thereby empowering people at grassroots level. Prior to the launch of the NSM, only 11 MW of solar capacity had been installed. However, after the launch of the NSM and other State policies encouraging solar energy generation, the solar capacity has grown at a rapid pace. In the last ten years, the installed cumulative capacity of solar projects has increased from 2.82 MW in 2008–09 to 28,180 MW in 2018–19.



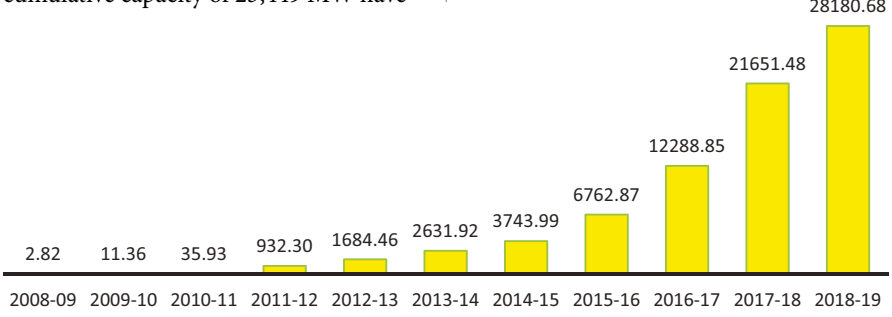
» **Figure 1:** Year-wise cumulative capacity of RE in last 10 years (in MW, till March 31, 2019)

PRESENT STATUS OF SOLAR PARKS IN INDIA

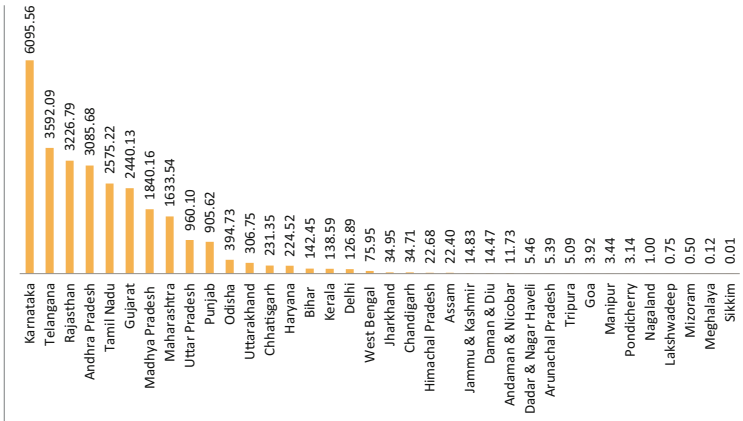
As in March 2019, 42 solar parks with cumulative capacity of 23,449 MW have been approved in 17 States. As shown in Table 1, these solar parks are in different stages of development.

Land of around 139,115 acres has been identified and 76,436 acres of land has been acquired in various solar parks. Hundred per cent land has been acquired for 15 solar parks, less than 100% but more than 90% for 6 solar parks and for balance land under acquisition.

Tenders have been issued for 13,245 MW out of which power purchase agreements (PPAs) have been signed for around 9,145 MW of solar projects inside various solar parks; out of which 5,835 MW of have been commissioned as shown in Figure 4.



» **Figure 2:** Year-wise cumulative capacity of solar power installed (in MW, till March 31, 2019)



» **Figure 3:** State-wise solar capacity installed (in MW, till March 31, 2019)

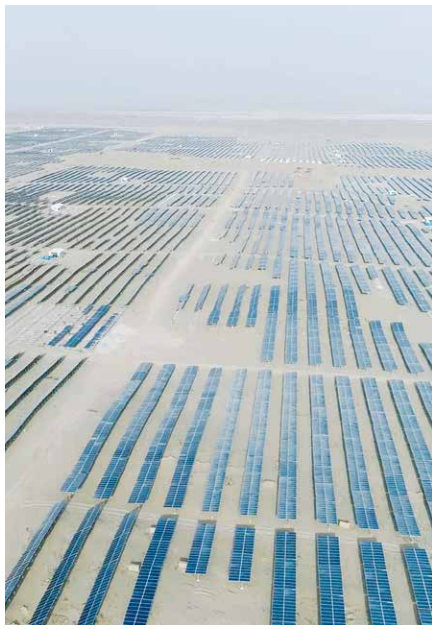


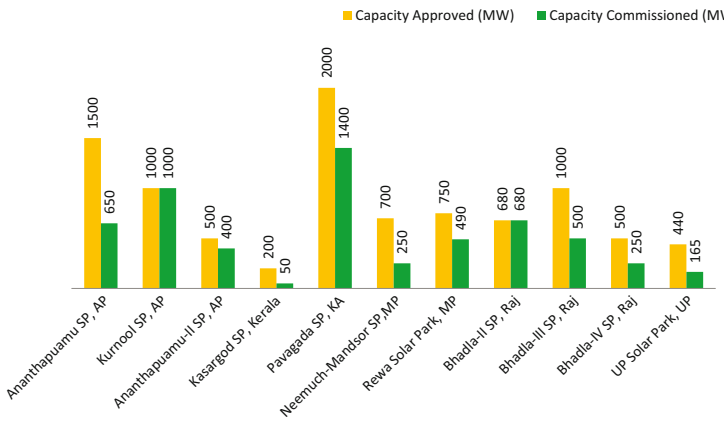
Table 1: Solar parks in India

Solar Parks in India (Capacity in MW)									
S. No.	**State**	**Solar Park-1**	**Solar Park-2**	**Solar Park-3**	**Solar Park-4**	**Solar Park-5**	**Solar Park-6**	**Solar Park-7**	**Total Capacity**
1	Andhra Pradesh	1500	1000	1000	500	160			4160
2	Arunachal Pradesh	30							30
3	Gujarat	700	500	5000					6200
4	Jharkhand	150							150
5	Karnataka	2000							2000
6	Kerala	200							200
7	Madhya Pradesh	750	700	550	500	250			2750
8	Maharashtra	500	500	500	60	170	75	145	1950
9	Manipur	20							20
10	Meghalaya	20							20
11	Mizoram	20							20
12	Nagaland	23							23
13	Odisha	275	100						375
14	Rajasthan	680	1000	500	750	421	980		4331
15	Tamil Nadu	500							500
16	Uttar Pradesh	440	50	50	30				570
17	West Bengal	200							200
Total									**23499**
		36	Govt. SPPD		4	JVC of Govt & Pvt		2	Pvt SPPD

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. In the several solar parks, the tariff arrived is at a lowest level and have continuously decreased from ₹6.16/kWh to ₹2.44/kWh in solar parks. It has been achieved by using better tools for solar projects and by enhancing the interest of bidder.

Challenges and the Way Forward

- Clear land allotment by the State Government
- The willingness of DISCOMs to purchase the solar power from the solar parks
- 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
- Levy of transmission charges for delay in commissioning
- Submission of Bank Guarantee (BG) by private SPPDs to SECI equivalent the amount of CFA to be released against each milestone.In order to address the two most critical elements such as land and power evacuation infrastructure for solar parks, a new mode (Mode 7) has been introduced for development of Renewable Energy Parks by SECI. However, the availability of identified land is much larger than the subsidy amount available, proper selection method should be in place to identify projects for which the ₹20 lakh/MW CFA would be available.



» **Figure 4:** Solar projects commissioned inside various solar parks (as on March 31, 2019)

Mr Radhey Shyam Meena, Mr Dilip Nigam, Mr Anindya S Parira, and Mr Sunil Kr Gupta, National Solar Mission Division, Ministry of New and Renewable Energy (MNRE), New Delhi, India. Email for correspondence: rshyam.mnre@gov.in

OFFSHORE WIND ENERGY IN INDIA

In this article, **Prabir Kumar Dash** discusses India's efforts towards offshore wind through a robust programme based on sound resource assessment.

Wind energy stands tall amongst all the renewable energy sources in terms of installation capacity and energy generation in India. Out of the total renewable energy installation capacity of 78 GW, wind energy contributes to more than 35 GW as on March 2019 and the national target is to achieve 60 GW of wind energy installations by 2022. The onshore wind energy potential estimated by the National Institute of Wind Energy (NIWE) stands at 300 GW at 100 m hub height. However, it has been observed in recent past that, many onshore wind energy projects are adversely affected due to land acquisition issues. Further, the tariff discovered through e-auction started moving upwards on account of exhaustion of best wind sites.

In this scenario, offshore wind can be seen as a viable option in order to protect the precious land resources. India is blessed with a coastline of nearly 7,600 km with relatively shallow waters (within 12 nautical miles of the coast) near to shore in most parts showing good prospects of harnessing offshore wind energy. With this objective, the national offshore wind energy policy has been notified on October 2015 to provide a legal framework for development of the offshore wind sector in India. Policy authorises, the Ministry of New and Renewable Energy to work in close coordination with other government entities for development of offshore wind energy within the entire exclusive economic zone (EEZ) of the country and NIWE has been designated as the nodal agency to carry out or facilitate necessary resource assessment activity for offshore wind development and demarcate blocks and facilitate developers for setting up offshore wind energy farms.

GLOBAL SCENARIO

Globally, offshore wind is nearly three decades old history with total installation capacity of 23.35 GW as on December 2018 in 17 different countries of which important ones are—the UK (6,836 MW), Germany (6,410 MW), China (4,558 MW), Denmark (1,358 MW), The Netherlands (1,118 MW), Belgium (1,178 MW), and Sweden (206 MW). Annual capacity additions of more than 4 GW have been observed in the last couple of years. As per the 'Wind Europe Outlook' offshore wind installation capacity may reach up to 70 GW in Europe by 2030. IRENA estimates that roughly 400 GW offshore wind installations may be possible by 2045 globally. The price of offshore wind energy has been reducing owing to technological innovation and emerging of new markets. The lowest tariff discovered in November 2016 was $49.9/MWh in Denmark. Further, in many European countries, the offshore wind energy tariff has already became competitive vis-à-vis onshore wind tariff.

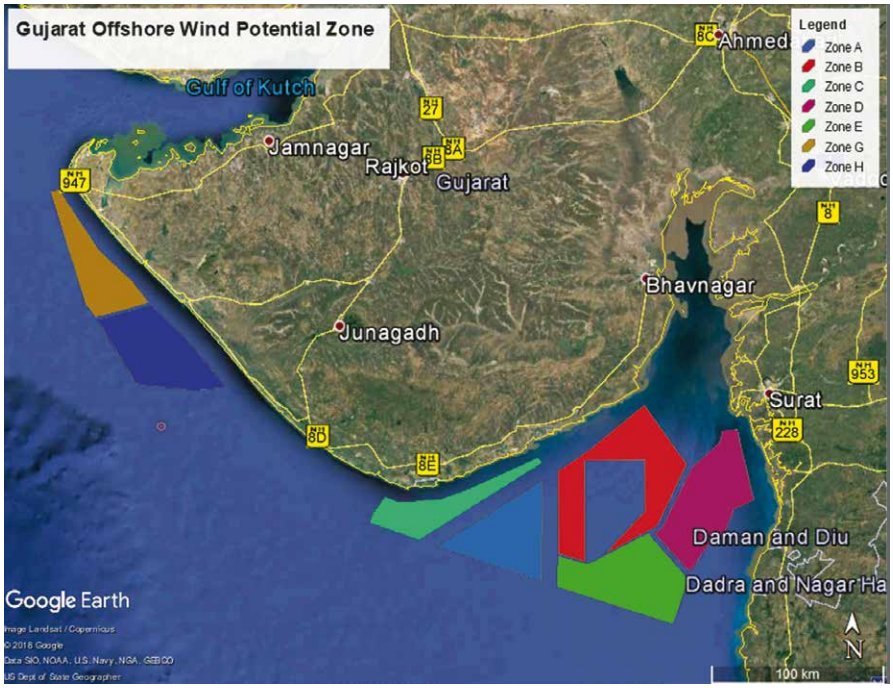
OFFSHORE WIND STATUS IN INDIA

NIWE assisted by various multilateral agencies carries out estimation of offshore wind energy potential in India. A preliminary estimate suggests good potential exists off the coast of Gujarat and Tamil Nadu. Under the FOWND project supported by the European Union, eight zones each in Gujarat and Tamil Nadu were identified as potential zones for development of offshore wind energy projects, through techno-commercial analysis and preliminary resource assessment based on satellite data and data available from other sources. Further, assessment by NIWE excluding the

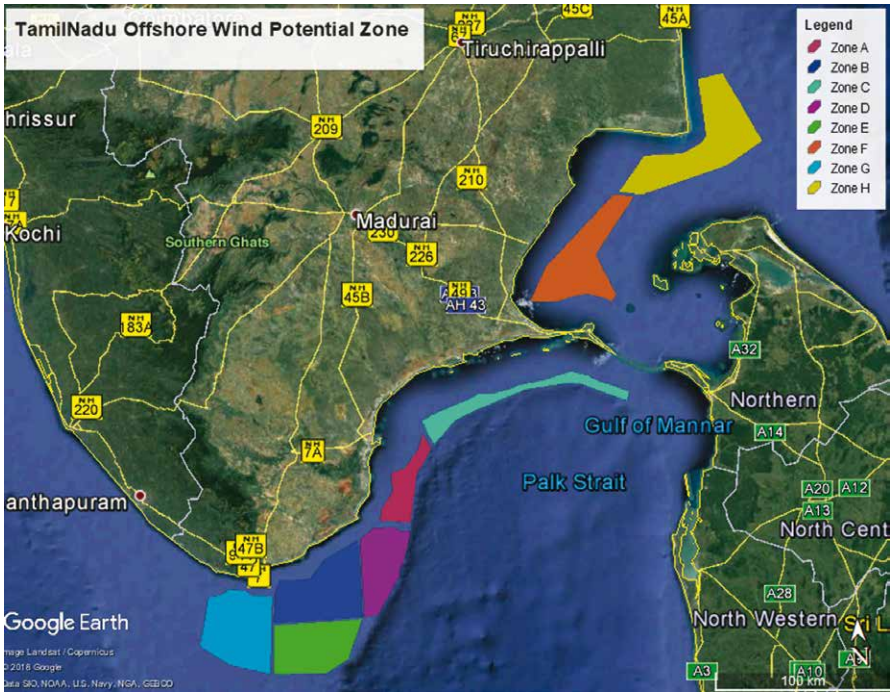
areas in consultation with various line ministries/organizations suggests 36 GW of offshore wind energy potential exists off the coast of Gujarat and 35 GW off the Tamil Nadu coast only. In order to exploit the potential and keeping the falling global tariff trend in view, the government has announced its intention of installing 5 GW of offshore wind installations by 2022 and 30 GW by 2030. This announcement may give confidence to the Indian and global project developers along with financing institutions in India market.

OFFSHORE WIND RECOURSE ASSESSMENT THROUGH LIDAR

In order to enhance the confidence of project developers and financing institutions on the estimated potential of a site, more precise measurement campaigns are required. Wind resource measurement campaign deploying light detection and ranging (LiDARs) along with geophysical, geotechnical, and oceanographic studies in selected zones off the coast of Gujarat and Tamil Nadu needs to be carried out. One LiDAR commissioned in November 2017 (in identified zone-B off the coast of Gujarat which is nearly 23 km away from the port of Pipavav) by NIWE has completed more than one year of data collection. One year analysed data published by NIWE along with the raw data suggest annual average wind speed of about 7.52 m/s at 104 m hub height, which seems to be more than the earlier estimation based on satellite data (Vortex data). The month wise measured wind speed is given in Table 1. The LiDAR measured data indicates that, the Vortex data under-predicts the average wind speed by 12.5% at 100 m above sea level (ASL). Based on this, the long-term average wind speed may increase from earlier estimation of 7.1 m/s–8.0 m/s, at 100 m ASL. This increase in the wind speed may result in 21%–25% increase in the capacity utilization factor (CUF) in comparison to the earlier prediction reported (which is 30%) under FOWPI project. It is worthwhile to mention here that, the reported capacity utilization factor from onshore wind energy projects in India varies from 22%–30% depending on the site of installation. Further, sometimes nearly 35% of CUF



» Identified zones off Gujarat coast



» Identified zones off Tamil Nadu coast

Table 1: Month wise measured wind speed

Month	Nov,17	Dec, 17	Jan, 18	Feb, 18	Mar, 18	Apr, 18	May 18	Jun, 18	Jul, 18	Aug, 18	Sep, 18	Oct, 18
WS in (m/s)	6.06	7.44	5.63	6.39	7.11	6.90	8.71	9.82	10.58	9.81	6.94	4.85

» Offshore LiDAR structure and LiDAR off Gujarat coast (23 km from Pipavav)

is also being claimed by some of the manufacturers and developers. The best onshore windy sites in India have average wind speed of 6 m/s–7 m/s. Accordingly, it can be expected that the offshore wind projects in the identified location may operate at a CUF of about 45%. Reportedly, the government is planning to deploy five more LiDARs (two off Gujarat coast and three off Tamil Nadu coast) for carrying out the offshore wind measurements to validate the estimated offshore wind energy potential and gather precise bankable data. Further, interested private players can also carry out the required studies/surveys for establishment of offshore wind projects within the EEZ of India under the 'Guidelines for Offshore Wind Power Assessment Studies and Surveys' issued by NIWE.

THE PROPOSED FIRST OFFSHORE WIND ENERGY PROJECT IN INDIA

Looking at the global success of offshore wind energy technology and tariff trend in the last couple of years, the government has planned to develop the first offshore wind energy project of 1 GW capacity in the identified zone-B off the coast of Gujarat in a commercial scale. This may be due to the fact that the logistics and ecosystem development cost for offshore wind energy projects are quite high. Accordingly, a small capacity demonstration project will be too costly and only solve the purpose of technology feasibility. The project size of 1 GW may realize the economy of scale and bring down the tariff in the first project itself. The Expression of Interest (EoI) for this project was floated in April 2018 and 35 international/Indian developers/ OEMs had participated and consulted for preparing the final bidding document. Being the first of its kind, all the perceived risks associated with the project needs to be identified and taken care of by the government in order to keep the tariff at a lower level. Although, substantial information on execution of offshore wind energy projects is available globally, specific customizations in Indian context will be a key challenge.

CONCLUSION

Owing to the vast potential in the entire coastline, offshore wind energy in India can provide the desired results to realize the climate commitment and energy security, the country is thriving for. Although, it will be very challenging to achieve a cost competitive tariff for the proposed first offshore wind project, it will open up a complete new sector for India to contribute to its overall economy and India may emerge as a global leader in this sector similar to onshore wind due to its experience in providing quality systems at a lower cost.

Disclaimer: The views expressed in this article are personal views of author and not endorsed by the Government.

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SOLAR AGRICULTURAL FEEDERS IN MAHARASHTRA

Providing Reliable Day-Time Electricity While Reducing Subsidies

In this article, **Ashwin Gambhir** and **Shantanu Dixit** highlight that the availability of the electricity grid in every village coupled with the national feeder separation programme makes Maharashtra's solar feeder programme and KUSUM's decentralized ground-mounted grid solar power plant programme quite feasible across India. The urgent need for providing agriculture with reliable and affordable daytime electricity makes it imperative for the sector to adopt such an approach. This policy framework is a win-win situation for the farmers, government, and discoms, and offers a much needed farmer-centric yet fiscally prudent pathway for the power sector.

Agriculture is the main source of livelihood in rural India, contributing to food security. Two-thirds of the total irrigated area in India uses groundwater pumping, powered by more than 2 crore electric and 75 lakh diesel pumps. Thus, agriculture is a major consumer of electricity, accounting for nearly one-fifth of the total consumption in the country. In many states, this is much higher at one-fourth or one-third of the state's total consumption. Access to groundwater depends on reliable and affordable electricity supply. This is an important issue as it concerns livelihoods of the rural poor and food security of the country.

Since the 1970s, agriculture in many states has been receiving electricity at either low tariffs or for free. Much of this supply is un-metered. Subsidized supply has played a key role in the growth of groundwater irrigation and agriculture production. Due to the lower tariff and poor revenue collection, agricultural sales are often seen as a major reason for the financial losses of distribution companies (discoms). Part of this loss is then recovered through higher tariffs for other consumers such as industry and commercial (called cross-subsidy), and the remaining through direct subsidy from the state governments. Because it is seen as a loss-making sector, agriculture often gets poor quality supply leading to problems such as frequent pump burn-outs and power failures. Restoring supply takes a lot of time and so does getting new connections. Further, the supply is unreliable and often available during late nights. All these factors make farmers distrustful of discoms and both of them are caught in a low level equilibrium.

Electricity demand for agriculture is expected to double in the next 10 years and as the average cost of supply keeps increasing, the problem of agriculture subsidies will become worse. Unless new ideas are tried out, the quality of electricity supply to agriculture will worsen. Any solution must first provide reliable, adequate day-time electricity supply to farmers at reasonable tariff,

leading to a gradual increase in the mutual trust between the discom and the farmer. This should also reduce the subsidy requirement for it to be truly scalable across the country. Further, the long standing and vexed nature of the agriculture–electricity issue means that solutions should also be flexible enough to incorporate the ground realities of the state in question.

Three ongoing developments in the power sector allow for an exciting possibility. One, low-cost electricity from solar photovoltaics, at ₹2.75–₹3 per unit and at a fixed price contract for 25 years due to absence of any fuels is already a reality. Second, states have to exponentially increase their solar procurement to fulfil the national mandate of increasing the use of solar power through the instrument of solar purchase obligations. Both these developments mean a cost-effective increase in the share of renewables, thereby enhancing energy security and contributing to climate mitigation. Finally, the electricity grid has reached every village in India and agriculture feeder separation, where lines carrying electricity to pumps and villages are physically separated, has progressed significantly, with nearly two-thirds of the target completed. Budgetary support for complete feeder separation is already earmarked under the Deendayal Upadhyaya Gram Jyoti Yojana (DDUGJY) scheme of the Government of India (GoI).

INNOVATIVE SCHEME

An innovative programme taking advantage of these developments has started in Maharashtra under the aegis of the 'Chief Minister's solar agriculture feeder programme'. A solar agriculture feeder is essentially a 1–10 MW community-scale solar PV power plant, which is interconnected to the 33/11 kV sub-station.

A 1-MW solar plant can support around 350, 5 hp pumps and requires around 5 acres of land to set up. The plant can be set up in few months and there is no change at the farmer's end. Pumps need not be changed and farmers do not have to take responsibility of installation and operation. All the pumps connected to the separated agriculture feeder will be given reliable day-time electricity for 8–10 hours between 8 a.m. and 6 p.m. When solar generation is low, maybe due to cloud cover, balance electricity can be drawn from the electricity grid. Alternatively, when pumping demand is low, maybe during rains, excess solar

electricity will flow back to the grid. This allows for optimal sizing of the power plants. Project developers are selected through a competitive-bidding process and the entire electricity would be bought by the discom through a 25-year contract. The discom would continue to distribute the electricity to farmers on concerned feeders. The policy has notified that Maharashtra Electricity Distribution Company Ltd (MSEDCL) and Maharashtra State Power Generating Company (MahaGenco), both would be the implementing agencies. To ease project development, state government land near substations can be made available on lease at nominal rate. Lease of private land is also possible under the policy. Finally, groups of farmers can also develop projects through bidding process and sign PPA with MSEDCL. A simple schematic of the solar feeder is shown in Figure 1.

The major advantages of this approach are that apart from ensuring day-time reliable power for the farmers, it requires no capital subsidy from the government. Rather, it is cost-effective in comparison to the existing supply from the centralized grid, thereby enabling reduction in subsidy.

Additionally, no new large transmission lines are needed, which has become a bottleneck for various large-scale wind and solar power tenders. Further, since load being served will primarily be only during generation hours (day-time) coupled with the value of geographic diversity unlike large centralized solar parks, this minimizes the grid integration costs of such a form of distributed solar development. Deployment is possible under the existing regulatory framework, and the generation also qualifies for Solar RPO of the participating discom.

Finally, this approach will also provide jobs to local youth in construction, operation, and maintenance of the plant. More significantly, these jobs will be geographically distributed across the state. After demonstrating the benefits of this approach, future programmes could link deployment of such solar feeders to reduce unauthorized use/connections, improve metering and tariff recovery, energy efficient pumps, water saving approaches, etc.

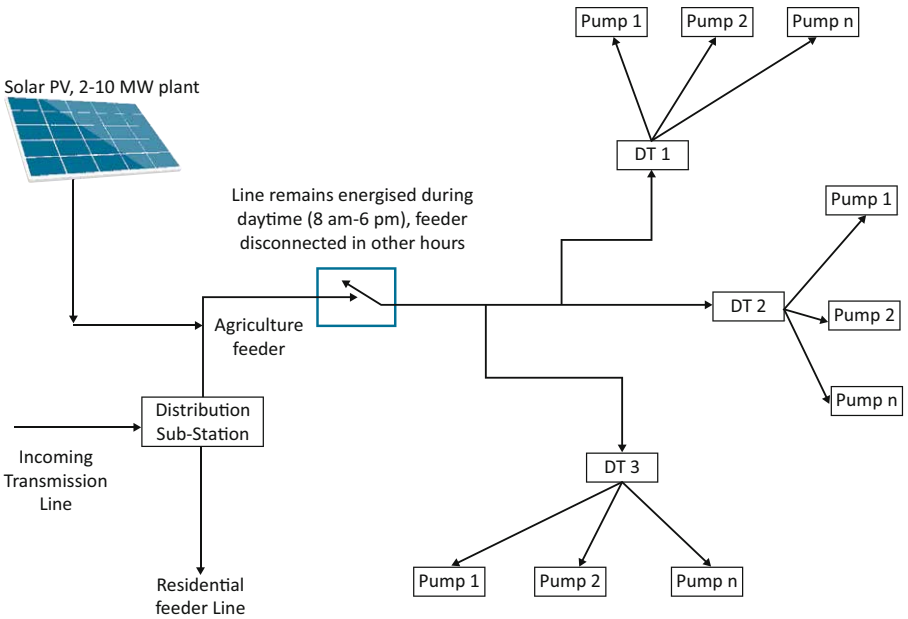
Currently, solar plants with overall capacity of around 2,500–3,000 MW are under various stages of tendering and implementation under this scheme in Maharashtra. This is equivalent to supplying solar power to 8–10 lakh pumps, or 20%–25% of the pumps in Maharashtra. As of December 2018, nearly 10,000 farmers are already getting reliable daytime power under this scheme and the discom is planning to scale this significantly beyond initial target of 7.5 lakh in next three to five years.

A CLOSER LOOK AT THE ECONOMICS OF SOLAR FEEDER

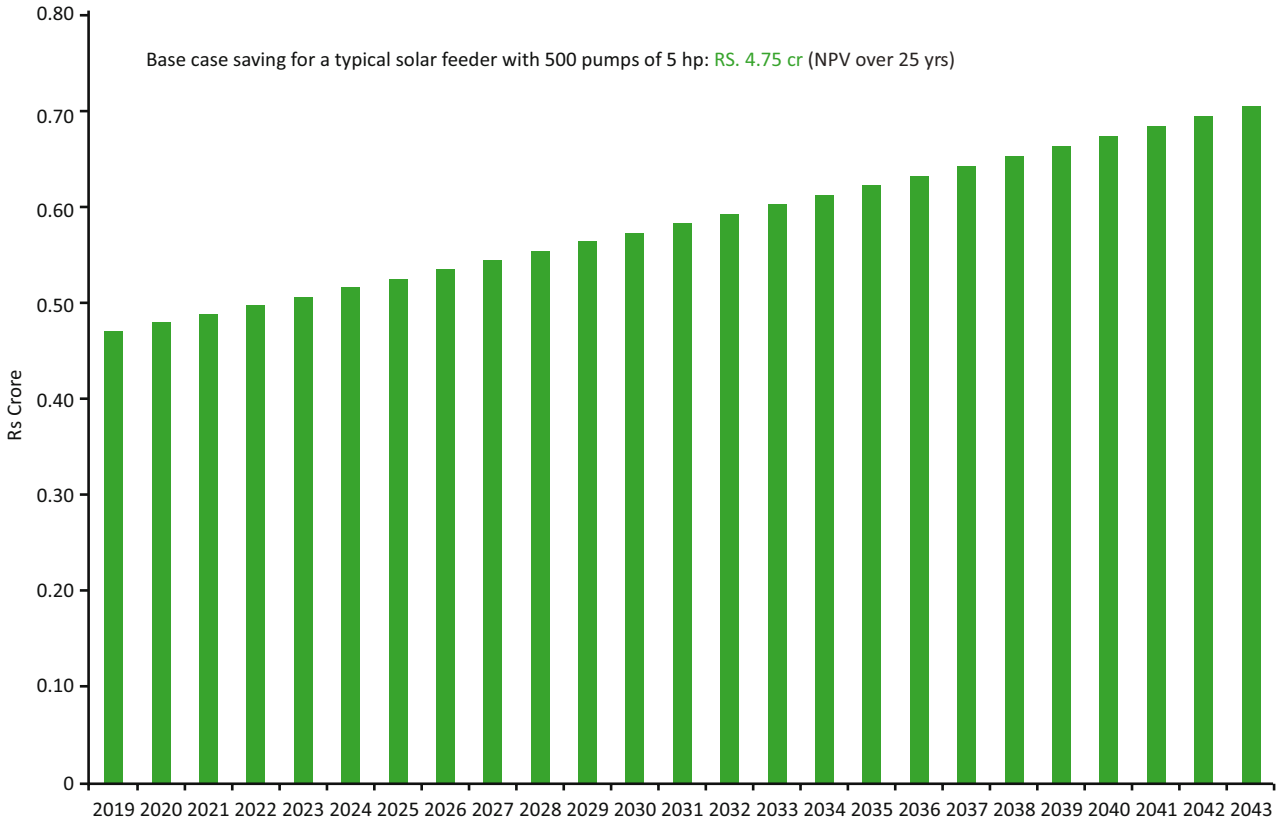
Assume a separated 11-kV agriculture feeder with 500 pumps of 5 hp each. Further assume that they operate for 1,250 hours each year with losses of 6% in the 11-kV line. This translates to an annual energy requirement of 2.47 million kWh (MUs) for the feeder.

In the existing situation, this energy is supplied from the central grid. Assuming an average power purchase cost of ₹4/kWh, transmission charges of ₹0.4/kWh and 9% losses (state transmission losses + 33 kV wheeling losses), the landed cost works out to ₹4.85/kWh in the first year. Thus, the total input cost for this feeder is ₹1.2 crore/year. A modest 0.75% yearly increase in the landed cost would mean that the cost would be ₹1.35 crore/year by the 25th year. In stark contrast, the cost of solar power is fixed for 25 years and assuming it to be ₹3/kWh, the annual input cost for the solar feeder is only ₹0.74 crore/year. These yearly savings for such a typical feeder are shown in Figure 2. The net present value of the total savings over 25 years is roughly ₹4.75 crore per feeder. In nominal terms, this is equivalent to a saving of just over ₹10,000 per pump per year. This saving could be used for various purposes including increasing farmer incomes, water saving measures, loan waivers, etc.

At the national level, the GoI has also proposed a scheme for the use of solar power in agriculture, namely, 'Kisan Urja Suraksha evam Utthaan Mahabhiyan (KUSUM)'. The



» Solar feeder schematic



» Yearly savings (Rs cr) per feeder to MSEDCL from solar feeder over grid supply over 25 years

recently published draft guidelines under this scheme detail out three sub-components. Component-A involves setting up of 10,000 MW of decentralized ground/stilt-mounted grid connected solar or other renewable energy-based power plants. This approach is very similar to the solar feeder programme underway in Maharashtra and hence has all the advantages enlisted above.

Components B and C involve setting up of 17.50 lakh stand-alone solar agriculture pumps and solarization of 10 lakh grid-connected agriculture pumps, respectively. While stand-alone off-grid solar pumps may be a good option in places where the grid has not reached or where the water table is relatively low, solarization of existing grid connected pumps (component C) warrants a comparison with Component A which is an alternate way of achieving the same end result.

Grid-connected solar pumps will be given a total 60% capital subsidy, equally from the central and state governments while the farmer will have to make a contribution of 10%, which is nearly ₹42,500 considering the cost of the pump. Thus, 10 lakh pumps will need a capital subsidy of ₹25,500 crore and ₹4250 as a contribution from farmers. Unlike the capital subsidy which is linked to capacity deployment and not to performance, deployment under Component A (decentralized ground-mounted solar plants) will be given a performance-based incentive of ₹ 0.4/kWh for a period of 5 years. This works out to be a total of ₹3,300 crore for a capacity of 10,000 MW which in turn would support nearly 33.5 lakh pumps of 5 hp each. Even after accounting for the surplus power which would be exported to the grid from these over-sized solar pumps, one sees that ground-mounted solar power plants are much more economically viable. Finally, Component A is high scalability with low gestation period while Component C has much lower scalability due to higher project and transaction costs. Hence, considering the favourable economics and ease/scale of implementation, focusing effort on Component A would be appropriate. This should be significantly scaled up over time and should be rolled out quickly.

CONCLUSION

In summary, the availability of the electricity grid in every village coupled with the national feeder separation programme makes Maharashtra's solar feeder programme and KUSUM's decentralized ground-mounted grid solar power plant programme (10,000 MW) imminently feasible across the nation. The urgent need for providing agriculture with reliable and affordable daytime electricity makes it imperative for the sector to adopt such an approach. This policy framework, a win-win situation for the farmers, government, and discoms, offers a much needed farmer-centric yet fiscally prudent pathway for the power sector.

Mr Ashwin Gambhir and Mr Shantanu Dixit, Prayas (Energy Group).

IMPLEMENTING THE CO-BENEFITS APPROACH IN INDIA

In climate and sustainable development literature, the approach of studying, implementing, and replicating positive externalities of an action is what we may understand as the co-benefits approach. **Aayushi Awasthy** and **Kavya Bajaj** highlight that the co-benefits approach presents itself as an exceptionally apt mainstreaming practice for initiating such an approach, where resources can be pooled to streamline multiple goals and ensure we have true accounts of sustainable development. The authors also feel that India needs to work on three vital fronts—energy access, valuable employment generation, and ensuring basic environmental services for all.

In climate and sustainable development literature, the approach of studying, implementing, and replicating positive externalities of an action is what we may understand as the co-benefits approach. Implementing this approach requires fostering an environment for problem solving by encouraging the idea that the solution to global problems, such as climate change and development, have more synergies with each other than trade-offs. It aims to peel through the layers of international politics and diplomacy to bring to reality solutions on-ground. For India, ensuring that its principal developmental challenges are met would require significant investment; not only in terms of infrastructure but also in terms of research and development. The co-benefit approach endorses an approach recommending multiple benefits, a significant one being economies of scale from collaborations, which would not be accrued by individual country action. Another benefit is that this approach can be studied at disaggregated levels and emulated successfully under similar circumstances.

For a large developing country like India, climate mitigation presents unique challenges. There already exist challenges of basic provision to the people, and bearing in mind India's size, these provisions further add up. Given the current state of mature technologies in the country, India continues to rely on fossil fuels for these provisions. Further, the rate of inequality remains high; despite being the third largest economy of the world, India's per capita income is a measly $6000 per annum, and per capita energy consumption is approximately 1,000 kWh, a third of the global average. To address the problem of basic provisioning, India needs to work on three vital fronts—energy access, valuable employment generation, and ensuring basic environmental services for all. Below, we discuss what it would take to address these objectives through a co-benefits lens.

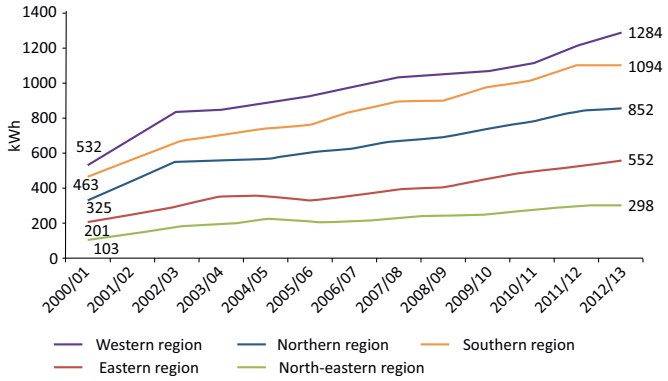
CHALLENGE 1: ENERGY ACCESS

Being one of India's foremost challenges, significant efforts have been made towards energy access, particularly electricity access. As of March 2018, the Ministry of Power (MoP) claims, on average, complete electrification of villages in India. India had also set the ambitious target of complete household electrification by 2018 end. Despite these laudable goals, energy access surveys conducted by CEEW and TERI suggest that the current state of 'electricity access' to these villages is not enough for households to sufficiently consume and utilize electricity.

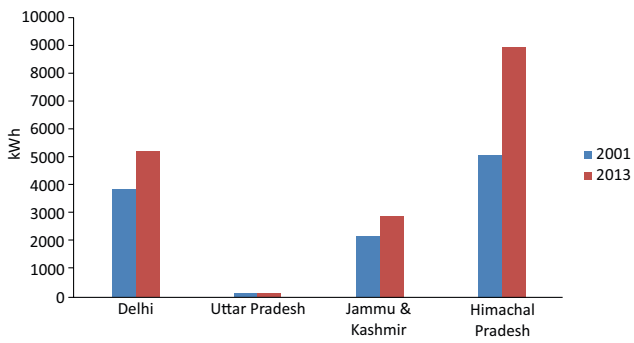
Electricity consumption in India has increased threefold in the past decade. However, this increase is not uniform across sectors. Despite the MoP claim, a close examination of electricity consumption figures presents a grim picture. Figure 1 (a) tracks the electricity consumption per capita, by the five regions of the country. There are a few observations from this graph, firstly that consumption has increased across all regions, second that the variation between the regions is quite significant, and thirdly that the gap does not seem to be bridging. It seems to be that there is little scope for convergence of consumption between different regions in the near future. On looking into one region in detail [Figure 1 (b)], it is observed that there exists significant contrasts in consumption even within regions.

A survey conducted by CEEW in 2015 for the poorest six states covering about 8,500 households found that 50% of these households are in the lowest tier of electricity access, despite having an electricity connection. Further, more than half of the other 50% households that did not have an electric connection had grid connectivity near them. This indicates that despite being classified as electrified, the majority of households in these villages do not gain the benefits of electrification. Another analysis done by TERI, which combines the national sample survey organization (NSSO)'s data with a survey for 6500 households, tried to understand the factors affecting transition towards modern energy. They find that energy transition is a complex decision, which is influenced not only by the price of the fuel but also by other demographic factors such as type of house, influence of women in decision making in the households, social status, occupation, amongst others.

The co-benefit approach in this case would entail that instead of a complete grid-based electrification approach, India should target distributed generation to compensate for wherever the grid is unable to provide the complete benefits of electrification. There are provisions



» **Figure 1 (a):** Per capita electricity consumption of the 5 Indian regions



» **Figure 1 (b):** Northern region

in the Electricity Act, 2005, that ensure investments made in off-grid systems are protected. Over and above this investment requirement, the viability of off-grid systems needs to be revaluated. Given the potential to supplement RE-based systems into distributed generation, it is possible to subsidize these systems to ensure economical affordability. The approach hence implies providing solutions to both these challenges, and hence, drawing resources mutually – from investment and mitigation.

CHALLENGE 2: ALIGNING EMPLOYMENT GENERATION TO THE NEEDS OF THE FUTURE

Considering the high employment generated in the energy sector, especially in the coal mining sector, a transition towards low-carbon solutions for India has been looked at in askance by many.

The co-benefit approach proposes a solution here by expanding the horizon of our thinking – to look at the problem of carbon lock-ins through a human lens. There will be a significant lag between freezing financial investments in the fossil technologies and employment in these fields. It is also true that the skills required for these jobs would be different. Therefore, the earlier we transition from fossils, the less encumbering it would be to transition the labour force from coal towards renewables. About 1 million jobs would be generated to achieve India's solar and wind energy targets, most of which would be in the solar rooftop space.

There is an urgent need for India to start capacity building programmes to ensure the people who will be joining the labour force in the next 2–3 years are prepared for it. Moreover, there is also a need to ensure that there is no expansion of the labour force in the fossil sector. Additional governmental resources should be provisioned for future jobs, considering the fast paced changes in technologies and aiming to avoid fossil industry relevant skill lock-ins. With challenges relating to robotics, automation and sustainability today, there arises the vital challenge of disseminating appropriate skill development when creating jobs.

CHALLENGE 3: ENSURING ENVIRONMENTAL QUALITY

Ensuring environmental quality, an integral aspect of well-being, has been falling back as a priority for India, currently ranking at 177 out of 180 countries on the Environmental Performance Index. The two most pressing issues to ensure environmental quality in India relate to air quality and water availability. Air pollution and water scarcity have detrimental developmental impacts, and can be seen to directly affect human health and well-being. This, when considered with the 1.3 billion population, becomes an even further gruelling challenge. With the issues of urbanization and climate change exacerbating, these issues are reaching a crisis level, needing to be dealt with urgently.

Multiple studies conducted by TERI on air and water underline the gravitas of this challenge. According to WHO, several Indian cities are amongst the world's most polluted cities. The TERI study on nationwide urban air quality points at several factors—rapid urbanization, transportation, industrialization, power generation, and agricultural activities. On studying water availability, TERI observed that India had very rapidly gone from water abundant to water stressed, and is heading towards being water scarce considering the rate at which per capita water availability is declining. The catalysts of this issue are pointed towards inefficient water use and supply across several sectors, and water pollution.

The synergies under the ambit of air and water are clearer and need immediate action. Appropriate interventions are hence necessary to address these linkages. Further, we observe common sectors between water and air, that is, industry and agriculture. Incorporation of renewables and technological and efficiency improvements in key contributing sectors can significantly improve both air quality and water availability. For example, installing

solar pumps in agriculture can directly bring about the co-benefits of water use efficiency and air quality improvements.

CONCLUSION

While these are the broader and more upfront challenges, the buck definitely does not stop here. Even from the human right point of view, in order to have the 'opportunity' to exercise the rights to freedom, against exploitation, to education and foremostly, to equality, citizens should be provided access to electricity, jobs, and mobility. Providing these basic rights at the cost of the environment would be a violation of these very rights. The co-benefits approach presents itself as an exceptionally apt mainstreaming practice for initiating such an approach, where resources can be pooled to streamline multiple goals and ensure we have true accounts of sustainable development. Further, the approach, like and along the lines of the Talanoa Dialogue, inspires problem solving through the outlook of sharing benefits, and hence must also be looked at through the lens of the three Talanoa questions—where are we, where do we want to go, and how do we get there. The key is to move our method of thinking away from *burden sharing*, and towards *opportunity sharing*.

Ms Aayushi Awasthy, PhD Scholar, University of East Anglia; Ms Kavya Bajaj, Project Associate, Centre for Global Environment Research, Earth Science and Climate Change Division, TERI, New Delhi.

Rooftop Solar PV

A Win-Win Situation for Discoms

In this article, **Rishabh Sethi** and **Er. Alekhya Datta** highlight that TERI has proposed a DISCOM-oriented and utility-based implementation model to promote rooftop solar PV. It is based on demand aggregation and agreements between various parties, keeping the utility as the 'key-anchor' party for the implementation of rooftop solar systems in their licensee areas.

In its commitment to renewable energy, India had set an ambitious target of setting up an additional installed capacity of 175 Gigawatt (GW) through renewable energy by 2022. Of this target, 100 GW has been apportioned for solar photovoltaic (PV), out of which further 40 GW target has to be met through rooftop solar (RTS) PV systems. With the falling capital cost of installation leading to solar tariffs falling significantly over the years, there has been a dramatic growth in this sector.

While the solar PV industry in itself has seen overall growth, the rooftop solar PV segment is expected to achieve momentum in the coming years. Of the 40 GW to be installed by 2022, around 3.58 GW has been installed so far by March 2018. This number is mainly due to some distribution companies (Discoms) showing inhibition in promoting rooftop solar PV systems, fearing revenue loss.These Discoms also anticipate technical and operational challenges from such systems. Further, due to the small size of solar rooftop projects and issues of payment security, financing for these projects is not available easily.

However, the solar rooftop systems are actually quite beneficial to the very Discoms wary of them.

MANAGING DEMAND

Industries, which are Discoms' highest paying customers, are already moving to open-access (mostly 'short-term' open access) system to buy cheaper electricity, irrespective of rooftop solar PV coming into the picture. Under open access, large consumers have access to the transmission and distribution (T&D) network to get electricity from suppliers other than Discoms. Distribution utilities incurring high Aggregate Technical & Commercial (AT&C) losses due to large amount of rural/non-paying consumers would be affected the most by this transition as they would lose a significant share of their revenue stream. Discoms also feel that the charges paid by open-access consumers are not sufficient enough (as they are exempted from certain charges) for them to cross-subsidize their low paying consumers.

If these open access consumers shift to rooftop solar PV for their electricity needs, the electricity demand of utilities would drop. In turn, these Discoms would not need to buy expensive electricity from the open market to meet their peak demand. Thus, promoting such customers to go solar would in their best interests.

Motivating their low-paying consumers (that are mostly residential) to implement rooftop solar PV at their premises can also help the distribution utilities offset the cross-subsidy burden to some extent. Currently, this is being practiced only by some utilities (such as BRPL, DGVCL, Torrent Power and MPCZ) in the country. It would benefit both the consumers and Discoms, especially in areas where the solar tariff is lower than utility tariff. At the end, they would be able to retain all their customers.

CUTTING TRANSMISSION LOSSES

The Discoms' AT&C losses would be reduced with the help of rooftop solar PV

systems as the power would be generated on consumer's rooftop itself. Such systems can, thus, help manage peak demand during the day. Such systems can also be utilized in meeting the demand locally post sun set, by storing any excess energy generated coupled with electric vehicles (EVs) and battery energy storage systems (BESS) near their premises, considering economic feasibility of such systems. They can thus help utilities reduce sudden grid loading (also known as duck-curve effect) and optimizing the scheduling of costly power through power stations or, power exchange which, thereby, reduces their power purchase costs.

COST SAVINGS

Rooftop solar PV systems can also help reduce commercial losses, especially among rural/ non-paying consumer categories. Along with these benefits, such systems installed on the rooftops of consumers, which are non-obligated entities, would also help Discoms' meet their renewable purchase obligation (RPO) targets and in turn claim the benefits of the same.

As there would be less power flowing through the distribution network, network congestion and loading would also come down, thereby reducing the network burden. This, too, would help the utilities defer some of their capital expenditure as the infrastructure would last longer, and reduce operation and maintenance expenditure. As Discoms are part of "pass-through" business, all the monetary benefits could be passed on to the consumers through a reduced Aggregate Revenue Requirement (ARR) and thereby, reduced utility tariff.

A SUSTAINABLE BUSINESS MODEL

For Discoms to promote the use of rooftop solar PV systems and make the best use of the same, TERI proposes a 'utility-based' business model. It is based on demand aggregation and agreements between various parties, keeping the utility as the *'key-anchor'* party for the implementation in their licensee areas.

The Discom can aggregate the demand for rooftop solar in their licensee area through a centralised platform and allocate the project to a developer through a competitive bidding process. The advantage of aggregating the demand would be increased project size and reduced risks of identifying locations/ sites, which would lead to reduced up-front investment cost for the developer and lower electricity tariff for the consumer. A similar approach was carried out with the Discoms in Delhi (BRPL[1,2]) and Surat (DGVCL and Torrent Power along with SMC[3,4]) with the help of TERI to implement their rooftop solar programme. Madhya Pradesh Urja Vikas Nigam Limited (MPUVNL) saw the lowest bid for the development of 8.6 MWp of grid-connected rooftop solar under RESCO model; it was observed at a record low of ₹1.38 /kWh[5] for central government buildings (CPSUs). This was because of the result of pre-identified locations for the project and huge subsidy (about 43% of capital cost) from central and state government.

Discoms can allocate the project with aggregated project size to a selected developer under RESCO mode via competitive bidding process. Discoms can enter into agreements with consumers and developers respectively to ease the financial process. Based on these agreements, consumers can pay the Discom for their installed systems, which would in turn pass this on to the developer, thus ensuring timely payments and increasing the bankability of such projects. For this arrangement, the Discom can charge a service fee and have a financial incentive to implement rooftop solar in their licensee areas.

Consumers can choose to go for either net metering or gross metering connection for the grid connectivity of these systems. Under net metering connection, Discoms can bill the consumers for electricity consumed from the grid and rooftop solar system; the latter could be considered as a part of the

1 Garud, S S (2018, May 8). Solar rooftops: A Delhi neighbourhood takes the leap. Retrieved from The Energy and Resources Institute: https://www.teriin.org/blog/solar-rooftops-delhi-neighbourhood-takes-leap

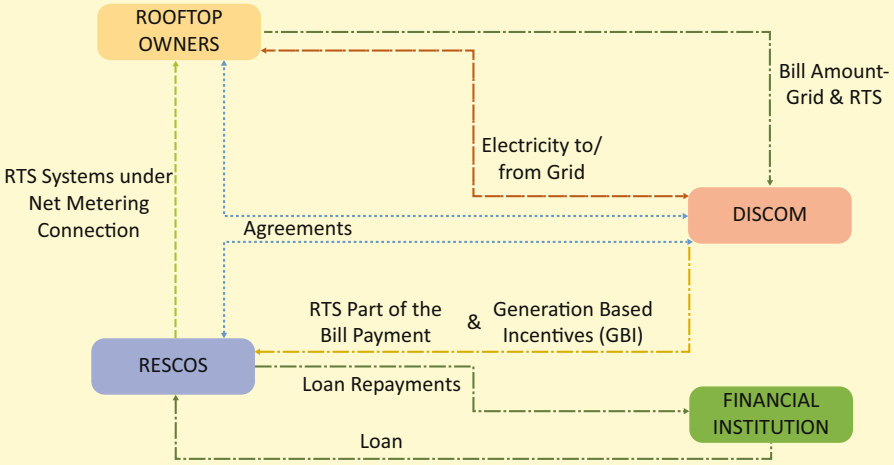
2 https://www.solarbses.com/#

3 Datta, A. (2018, March 7). It takes a village – Surat's united effort to embrace solar power. Retrieved from The Energy and Resources Institute: https://www.teriin.org/interview/it-takes-village-surats-united-effort-embrace-solar-power

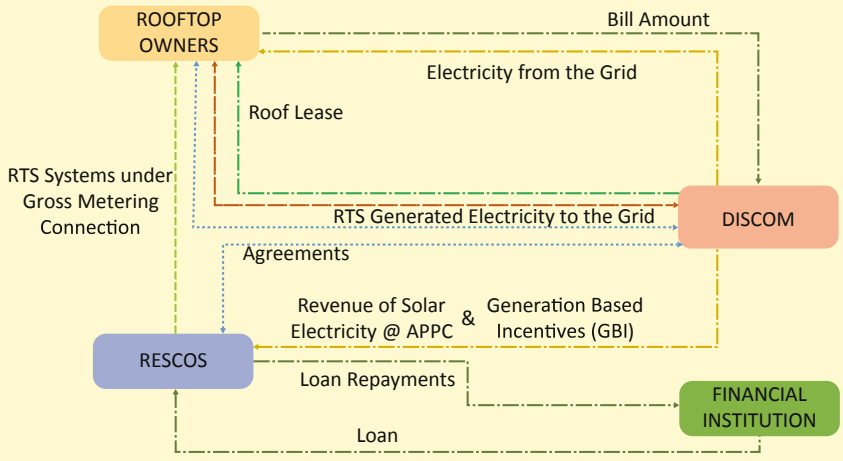
4 http://suratsolar.suratmunicipal.gov.in/#

5 Kabeer, N. (2018, October 5). Lowest Tariff Drops to ₹1.38/kWh in Madhya Pradesh's 8.6 MW Rooftop Solar Auction. Retrieved from Mercom India: https://mercomindia.com/l1-tariff-1-38-mp-solar-rooftop-auction/

payment for the system to the developer. Under gross metering connection, Discoms can bill consumers on their consumption and pay for the electricity exported to the grid; the payment for the system could be included as a part of the bill or the system can be installed on roof-lease arrangement, where the owner is paid lease for utilizing its rooftop by the developer and Discom.



» **Figure 1:** Proposed utility-based business model based on net metering connection



» **Figure 2:** Proposed utility-based business model based on gross metering connection and roof-lease arrangement

India is looking at achieving an ambitious target of 40 GW from rooftop solar by 2022. In order to achieve the target, involvement of all the stakeholders is required to accelerate the growth of this sector. Rooftop solar provides various benefits to the Discoms, by reducing their technical, financial and operational burden. Discoms, thus, need to undertake a more anchoring role in the implementation of solar rooftop projects within their licensee areas. Looking into more innovative approaches in rooftop solar implementation, such as Discom-based business models, consumer targeted awareness and demand aggregation can help the Discoms overcome any challenges faced in promoting rooftop solar. This would not only help the Discoms, but would be beneficial for all the stakeholders involved in the sector. This might provide the overall push to this sector which is needed to achieve the targets and also avail the benefits of this clean and green source of energy.

Mr Rishabh Sethi, Consultant, Electricity and Fuels Division, The Energy and Resources Institute (TERI), New Delhi; Er. Alekhya Datta, Fellow & Area Convenor, Electricity and Fuels Division, TERI, New Delhi.

FINANCING OFF-GRID SOLUTIONS FOR THE POOR

A Success Story About Overcoming Obstacles

In this article, **Sashi Kumar** highlights the Indo-German Energy Programme – Access to Energy in Rural Areas (IGEN-Access) that undertook a pilot project aiming to create an effective, scalable ecosystem of product–market–finance by establishing a robust business and distribution model and fostering entrepreneurship. During the course of the pilot, the market mainly evolved over access to finance, capacity building for the end consumer, an anchoring body to provide sales and post-sales services, and the appropriate technology. The identified states for developing the business model were Assam, Bihar, Jharkhand, Chhattisgarh, and Odisha.

Shri Moon Kalita lives with his wife and two children in a small settlement close to the banks of the Brahmaputra River in upper Assam. Depending heavily on costly kerosene for lighting in the evening, he has been considering for quite some time to buy a small solar home system which would make him and his family more independent when it comes to electricity supply. However, the upfront costs for the system were far too high and although he works as a labourer on one of the tea plantations he did not have the cash at hand to invest in such a system. He talked to banks to get a loan but to his utter surprise the loan amount he asked for was too little and the banks refused point blank to give him the money.

In a decentralized or stand-alone mode, renewable energy is an appropriate, scalable, and viable solution for providing electricity to power-deficient villages and hamlets. Moreover, the energy demand of the last-mile households in rural areas is still an underexplored opportunity. There are many challenges in meeting this demand. The scenario described above shows exemplarily one of the major ones. The loans many households in India require for relatively small investments in renewable energy technologies do not justify the transaction costs for the banks to process the loan application. Even the thresholds of micro-finance institutions are often too high. This is where the Indo-German Energy Programme IGEN-ACCESS of GIZ intended to undertake a pilot project. The Indo-German Energy Programme – Access to Energy in Rural Areas (IGEN-ACCESS) seeks to create a conducive environment for rural renewable energy enterprises in order to make energy services easily accessible to the rural population. Its aim was to create an effective, scalable ecosystem of product–market–finance by establishing a robust business and distribution model and fostering entrepreneurship. IGEN-ACCESS is a bilateral cooperation project carried out by the Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH on behalf of the German Federal Ministry for Economic Cooperation and Development (BMZ) and the Ministry of New and Renewable Energy (MNRE), Government of India. Off-grid renewable energy products were comparatively new to the customers. This lack of knowledge was coupled with an underdeveloped market due to missing distribution and service channels for sale, marketing, and after-sale services of solar products and systems, and the absence of an ecosystem for energy financing. During the course of the pilot the market mainly evolved over access to finance, capacity building for the end consumer, an anchoring body to provide sales and post-sales services, and the appropriate technology. The identified states for developing the business model were Assam, Bihar, Jharkhand, Chhattisgarh, and Odisha.

THE MAIN ACTORS

In the pilot, a social enterprise was in charge of client awareness generation, product promotion, sales and distribution, servicing, and market development. The social enterprise acted as a facilitator of the product, aggregated demand, and guaranteed the quality and safety of the product. Also, additional service features, such as after-sales service and a two years product warranty, protected consumer interests. There are several companies in the market that manufacture and supply solar lighting and other solar products, such as water pumps, fans, etc. The social enterprise undertook a due diligence process to identify the right technology partner. Since the start of the pilot, a microfinance institution has provided financial assistance to households which were already its customers. A non-governmental organization (NGO) supported and incubated the social enterprise by way of providing knowledge and capacity development, facilitated the interactions between the stakeholders, supported the monitoring and evaluation of the pilot and the subsequent sharing of gained experiences.

THE PROCESS

The social enterprise has built on the trust established by the microfinance institution over several years with the households to introduce the unfamiliar concept of solar energy to potential clients. The microfinance institution has reached out to villages and households through the so-called doorstep banking service operators. Weekly meetings of the operators with microfinance customers at the village level have been used for product demonstration to end-customers. Through this interaction, the clients understood that the products were simple to install and operate. They were taught that the quality and the reliability of the products were ensured through the

microfinance institutions' due diligence process. They learned about the two-year warranty for the products and about the post-warranty service provided by the manufacturer. Interested clients were informed that, if eligible, they could avail financing support from the microfinance institution and were taught about the documentation process for getting a loan. At the end of the product presentation, the doorstep banking service operator after gathering all relevant information on the client's credit history, income, and character, decided on the loan application. Then, the loan documents were sent to the DSC (local branch office) for scrutiny and clearance by the 'Credit Information Bureau of India Limited' (CIBIL). In general, rejections so far have been very rare since the clients were already known to the banking service operators. The loans were paid back during the weekly meetings between microfinance customers and microfinance operators. This approach reduces the transaction costs for the microfinance institution and makes it financially viable for the institution to even process lower loan amounts. On the other hand, it helped the social enterprise to cut costs on setting up its own distribution channels.

THE RESULTS

The pilot started in October 2017. The progress as of January 2019 is as follows:

- 650 job opportunities were created by the social enterprise under this business model. Every expansion of the intervention resulted in more employment.
- Around 200,000 households were approached.
- Around 139,502 renewable energy/ solar home lighting systems were sold through loans. As many customers bought more than one product, a total of 130,565 households or around 652,825 people, respectively, got access to energy.
- Two solar micro water pump loans were financed. There were some technical issues with the micro solar water pumps (capacity 0.1–0.5 HP).

The pumps when tested in the field did not give adequate water yield. The cost of the product (up to ₹24,000) was also too high. Based on the yield and usage rate, the communities did not see any value in them.

- The total amount of loans disbursed under the intervention by microfinance institution was ₹536,428,755.
- Around 18,000 tCO_2 emissions were reduced and the social enterprise received carbon credits as claimed by the social enterprise.
- The tangible results of the pilot made the management of the microfinance institution and the social enterprise aware of the potential business opportunities. Thus, without any additional support from GIZ, the microfinance institution together with the social enterprise have already extended their services to other regions in India.
- The project resulted in the development of a robust business model for the sale, distribution, financing, and servicing of renewable energy products.
- It further resulted in the availability of and accessibility to customized financial products for individual households, particularly for those at the bottom of the pyramid, to invest in renewable energy products. A sustainable model was developed that started showing self-sustainability within the project time.

CONCLUSION

The key success factors of the pilot were a shared vision, an effective close coordination at all levels, the alignment of processes of all stakeholders, reduced costs due to economy of scale, and the use of existing distribution channels.

The project has resulted in the increased use of renewable energy products, which in the long run will have a positive impact on both the environment and the climate. The social impact of the project, although not quantified yet, has witnessed multiple positive ramifications for households including higher disposable income, additional free time, better education prospects for children, increased productivity of small and marginal farmers and enterprises, and increased safety for women and children.

Mr Sashi Kumar, Technical Expert - IGEN Access project of GIZ India.

THE ELECTRIC VEHICLE CHARGING NETWORK

Electric vehicles or EVs, an eco-friendly mode of transportation, have captured everyone's attention and fostered discussions on their increased acceptance. Identified as eco-friendly insofar as they release no tailpipe emissions, EVs seem to be the preferred vehicles in today's day and age with growing concerns over air pollution. However, in order to retain their usefulness, there is an urgent need to establish a dense network of EV charging stations. **Atanu Dasgupta**, through this article, explains the need and significance of EVs; he also presents the technological requirements of a basic EV charging, and the road ahead through a detailed discussion.

The idea of greater usage and adoption of electric vehicles (EVs), besides being futuristic, presents an impactful and constructive opportunity for India. The motivation to adopt sustainable mobility solutions lies in reducing greenhouse gas (GHG) emissions and the dependency on imported energy sources as well as mitigating the adverse impacts accruing from transportation. Interventions in this context exist towards ensuring a more sustainable and climate-compatible Indian transport growth in order to accommodate the development and climate change agendas. In fact, the growing popularity of EVs amongst the consumers may be attributed to the following factors:

- Increasingly stricter norms on emission for fossil-fuel driven vehicles
- Depleting reserves of fossil-fuel and fluctuating prices
- Decreasing cost of battery and maintenance of both EV and battery
- Matured technologies both for EV and battery
- Increasingly affordable and cost-effective vehicle options
- Rising availability of EV charging stations with increasing demand for EVs

It is pertinent to note at this juncture that, so far the EV charging network has not seen the kind of growth as expected due to serious constraints in the growth of EVs in India.

GROWTH OF ELECTRIC VEHICLES

The growth of the EV segment in India has been constrained owing to lack of EV charging points/stations, high battery cost, and the typical users' anxiety over the manageable range of travel. In India, Mahindra and Tata Motors offer electric vehicles, such as the e20 hatchback, e-Verito compact sedan, and Tigor electric sub-compact sedan. Global automakers, such as Audi, Mercedes, and Porsche also have plans to introduce their EVs in India. In the manufacturing

sector, there has been some development in the EV space in India with companies, such as Suzuki, Toshiba and Toyota-owned Denso partner together to produce lithium-ion battery mules in the country. Maruti Suzuki aims to roll out EVs by 2020; the batteries for the same will be supplied by Suzuki. The Japanese carmaker has recently initiated testing its range of the Electric Wagon R in India. At the same time, Hyundai is all set to bring in an electric car next year in the country.

However, so far the range of travel in each case is limited to about 130 km and the cost is around 45% more than their internal combustion engine-powered counterpart. Additionally, the charging time is high at 6–8 hours for the batteries, thus making urban commute tedious.

In order to promote EVs on road, the government has finalized the Faster Adoption and Manufacturing of Electric Vehicles (FAME)-2 policy. However, no additional subsidy on the import of EVs has been provided therein and the latest financial budget has increased the duty on components. The industry has been demanding a reduction in the GST rate (8%) of EVs and to subsidize modules and components—steps focussed to making EVs a viable option. There is a possibility that EVs imported from advanced countries in a knockdown condition and assembled in India will have to pay reduced duties and this will be one way of encouraging proliferation of EVs in India with reasonable impetus on growth of the automotive industry. However, the biggest concern is the lack of charging infrastructure in the country as a result of which the industry has been suffering significantly.

REGULATORY HURDLES AND INITIAL PROGRESS

The Ministry of Power, Government of India, recently cleared the regulatory hurdles for setting up charging stations by considering charging of EVs as a sale of service. India plans to convert about 30% of its vehicles as battery-powered by 2030. In order to infuse initial activities in this space, several state energy utilities, such as National Thermal Power Corporation Ltd (NTPC), Power Grid Corporation of India Ltd, and Gas Authority of India Ltd (GAIL), have been roped in. As a part of this initiative, Power Grid Corporation of India Ltd is mandated to set up 26 electric-vehicle charging stations in three cities, as India takes first steps towards promoting the use of electric vehicles. Around 24 of these charging stations will come up at every halt of the Hyderabad Metro, each station with a capacity of 15 mWh. The Power Grid Corporation of India Ltd and NTPC have pledged to support the ecosystem until more private investors come in the picture.

The goal is to usher in faster deployment of electric vehicles and state-of-the-art mobility system in India by creating a safe, reliable, accessible, and affordable charging infrastructure and matching ecosystem suitable for all types of EVs. A significant component towards the aforesaid implementation is formalizing an affordable electrical tariff chargeable both from the EV owners/operators on the one hand and the charging infrastructure operators/ owners on the other. This initiative is also expected to adequately prepare and sanitize the electrical distribution system to match the requirements of the proposed charging stations and networks good enough for 24X7 hours of capability round the year with 99.9% of availability. This is also going to establish a satisfactory scenario to promote and support smart grid and smart city environment. Accordingly, the accompanying intense economic and technological activities will promote employment generation and sustainability.

BASIC INFRASTRUCTURE FOR EV CHARGING STATIONS

If the current momentum and government initiatives continue, charging stations should be more visible at workplaces, community areas, gated housing societies, and shopping malls. According to worldwide statistics, the sales of EVs will see immense growth by 2040. A vendor-agnostic electric vehicle charging network in the urban areas and along the national/state highways, to begin with, can provide turnkey solutions to a wide band of users. Suitable technologies and solutions that work in conjunction with EV manufacturers to upgrade their chargers into smart-chargers are available and in use. Such smart chargers can be remotely managed and monitored with least possible human intervention. The Government of India has already set the momentum in connection with these by allowing the setting up of distributed public charging stations (PCSs). Such PCSs will be established complete with electric vehicle service equipment (EVSE) and other facilities as a de-licensed activity with guaranteed performance criteria, standards, and robust infrastructure. In addition to PCS, under the said initiative, an individual can set up charging stations even in private residences (for personal use) with the priority servicing by DISCOMs.

The EV charging station management network software needs to be reliable, secure, durable, and efficient. Focussed on reducing global carbon dioxide (CO_2) emissions by accelerating the adoption and use of EVs in cities around the world, various approaches have been considered to provide turnkey EV charging solutions. The core aspects of such services may be considered as per the following pointers:

1. **Electric Vehicle Charging Network:** This will be a network interconnecting the distributed charging stations and the central control/monitoring and support centre using state-of-the-art information and communication technology (ICT). For this purpose, a mix of fibre optic and radio communication technologies will be used with reliable and secure connectivity all the time. This network will help in monitoring the health of the charging station equipment, activating and terminating charging events, initiating transactions, and collecting usage data from charging stations. For this purpose, suitable international

protocols need be used so that the monitoring/servicing stations ensure two-way data communication with the individual vehicle under service.

2. **EV Charging Network Mobile Application:** This will allow the prospective user to locate the nearest charging station, query about available charging slot, and navigate to the same. In this connection, information about ownership and charging technologies are also important including those based on pricing. This will eventually help to complete a paperless charging, including 'prepaid/postpaid' options with adequate security and other mandatory requirements during such transactions.
3. **Central Control/Monitoring & Support Centre:** Equipped with ICT-based facilities, such as fibre optics-based telecom links, various servers dedicated for specific functions, etc., such centres will typically provide 24X7 support for consumers at charging stations being managed under the charging network. This will also include web-based support and online chat-based service assistance directly on the mobile app for the benefit of the customers.

ELECTRIC VEHICLE CHARGING TECHNOLOGIES

The automotive industry standards classify charging stations into three basic levels based on the charging power, methods, and charging type. EV charging technology is based on several standards—international, region-specific, and even country-specific—all of which are incompatible with each other. It is, therefore, an onerous task to arrive at a single technology acceptable to all automakers and countries.

THE ROLE OF ENERGY EFFICIENCY SERVICES LTD (EESL)

The potential of EVs in addressing India's aims for an energy-ready and environmentally sustainable future has been well recognized by the Government of India (GoI). As a consequence, the government installed the National Electric Mobility Mission Plan (NEMMP) in 2013 with a roadmap to bring 6–7 million EVs on Indian roads by 2020; this is in keeping with the GoI's commitment to achieve 30% e-mobility by 2030.

Inspired by the Government of India, the Energy Efficiency Services Ltd (EESL) has applied their proven demand aggregation model for bulk EV procurement. The procurement price discovery via the international competitive bidding (ICB) mechanism encourages competitive prices, presenting the more exacting scenario for future demand in India's EV space. Upon procurement, EVs are planned to be leased out at rentals that equals the present market rates for petrol and diesel cars hired by government organizations. Such organizations can also buy EVs and EVSEs directly from EESL; the EVs so procured and dedicated to the mobility of government staff are likely to be supported by a network of charging stations that are being set up by NTPC and Power Grid Corporation of India Ltd, as stated earlier.

BATTERY SWAPPING

The large-scale proliferation of EVs is restricted partly owing to high cost of ownership. If the battery can be taken out of the cost consideration somehow, the overall cost of ownership will be reduced. A third party may have the ownership of the battery and will be responsible for replacing the drained batteries with fresh, fully charged, and standard ones keeping the compatibility with the beneficiary EVs in view. This particular service can also be eventually vested to the PCS owner and can be part of the EV Charging Network. If this facility can be implemented with due care and keeping in view the necessity of quality control and standardization in the process, the waiting time at the PCS for the EV users will reduce considerably. Worldwide this is the trend and there is no reason why the methodology cannot be implemented successfully in India. This will also help the largely unorganized

areas of EV business considering large-scale spread and usage of electric scooters and e-rickshaws in the country.

RENEWABLE ENERGY AND V2X TECHNOLOGIES

The PCSs shall be supplied electric grid power by arranging dedicated transformers and feeders (1+1) from DISCOMs to ensure continuity of secure and reliable service by the former round the clock. Some of the PCSs may also have their own generation of renewable energy using solar and/or wind power. The excess energy so generated from such PCSs may conveniently be fed back to the grid. This arrangement will be similar to Vehicle to House (V2H) and Vehicle to Grid (V2G) that can also be implemented in households, offices, factories, etc. V2H and V2G, already a reality around the world, will greatly aid in smart grid and Smart City deployment.

Mr Atanu Dasgupta has been a regular contributor to Akshay Urja and is currently associated with VVR Consultants & Enterprises Ltd, Gurugram, and works in the areas of 'smart grid', 'smart city', etc.

COMPRESSED BIOGAS (CBG)

Its Potential as a Source of Green Energy in India

In this article, **Himanshu Kumar**, **Prof. V K Vijay**, **Prof. P M V Subbarao**, and **Dr Ram Chandra** discuss about compressed biogas (CBG) and its potential in India. They conclude that currently, 32 million tonnes of CBG potential is estimated in the country; though, of the total estimated potential, only 0.06% CBG is being produced currently on an annual basis. The research on biogas purification and its utilization as a vehicular fuel and power production are getting more concern from the government bodies. Huge scope of setting up of CBG plants is available in India.

Compressed Biogas (CBG) is an enriched form of biogas containing more than 90% methane (v/v), carbon dioxide up to 4% (v/v) and other traces of gases such as hydrogen sulphide, moisture, oxygen, and nitrogen. It is produced through a series of processes like compression of raw biogas, removal of impurities (CO_2, H_2S), and storage of purified gas in a high-pressure vessel at around 200–250 bars for the vehicular application. It is very similar to the compressed natural gas (CNG) in terms of its fuel properties, economics, engine performance, and emissions.

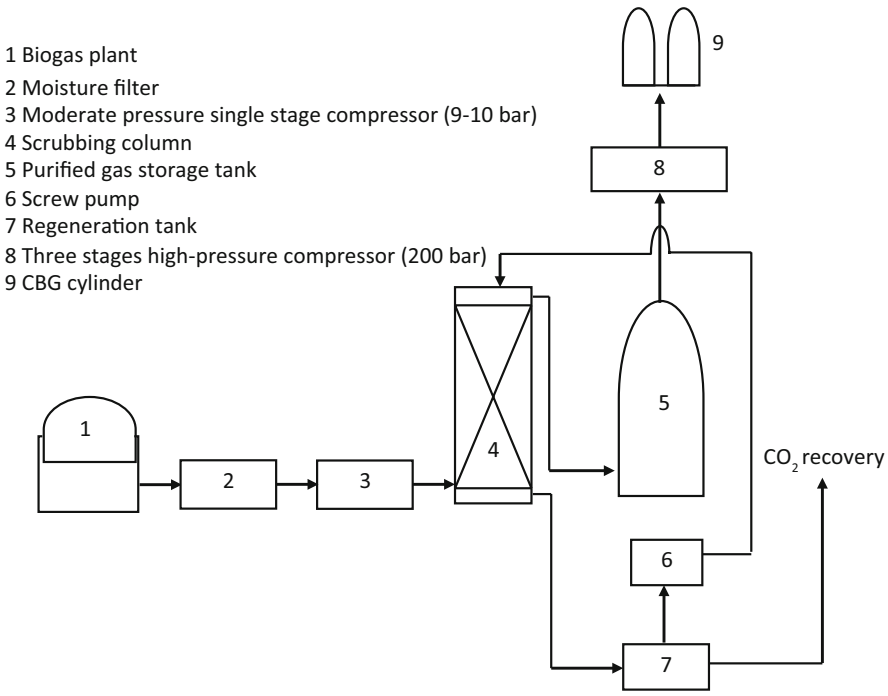
THE PROCESS OF CBG PRODUCTION IN THE COUNTRY

Biogas is produced through anaerobic digestion of biodegradable materials with methane (55%–65%) and carbon dioxide (25%–35%) as major constituents along with some traces of other gases like hydrogen, hydrogen sulphide, ammonia, oxygen, and water vapour. Except for methane and hydrogen, all are accounted as impurities, which reduce the calorific value of the fuel and corrodes the engine parts.

The process of removal of the impurities from the raw biogas is known as biogas cleaning and the adjustment of carbon dioxide to enhance the calorific value to an optimal level is called biogas purification which increases the methane concentration up to 80%–99% in the gas mixture. There are various technologies, such as water scrubbing, chemical absorption, pressure swing adsorption (PSA), membrane separation, cryogenic separation, and biological filtration method, used for CBG production worldwide. Though in India, water scrubbing and PSA systems are most prominently used for the same.

WATER SCRUBBING TECHNOLOGY

The working principle of water scrubbing is based on the solubility of different gaseous components present in raw biogas. In this process, water is used as an absorbent, because the solubility of CO_2 in water is much higher than that of CH_4, and is almost 25–26 times higher at 25 °C and atmospheric pressure. Simultaneously, H_2S can also be removed since it is more soluble in water than that of CO_2. This technology consists of a vertical column, where water and pressurized gas, almost at around 9–10 bars is allowed to flow counter-currently. The water is supplied at the top of the column while the pressurized raw biogas is allowed to pass from the bottom as shown in Figure 1. The column is filled with the packing materials to provide more surface contact area and retention time. Consequently, CO_2 and H_2S get absorbed in the water and CH_4 with some traces of other gases along with moisture left the purification column at the top. On the other hand, the impurities which are soluble in water leave the column at the bottom and sent to the regeneration tank, where water is depressurized, and CO_2 released. The regenerated water is re-circulated back to the scrubbing column, and CO_2 is collected whereas the purified biogas is stored in a cylindrical gas storage vessel. The purified biogas is compressed in a high-pressure compressor at around 200–240 bars to produce CBG for vehicular application and subsequently stored in a high-pressure cylindrical vessel as same as CNG. The purification efficiency of this technology ranges from 88.9%–96% with less than 2% CH_4 loss.



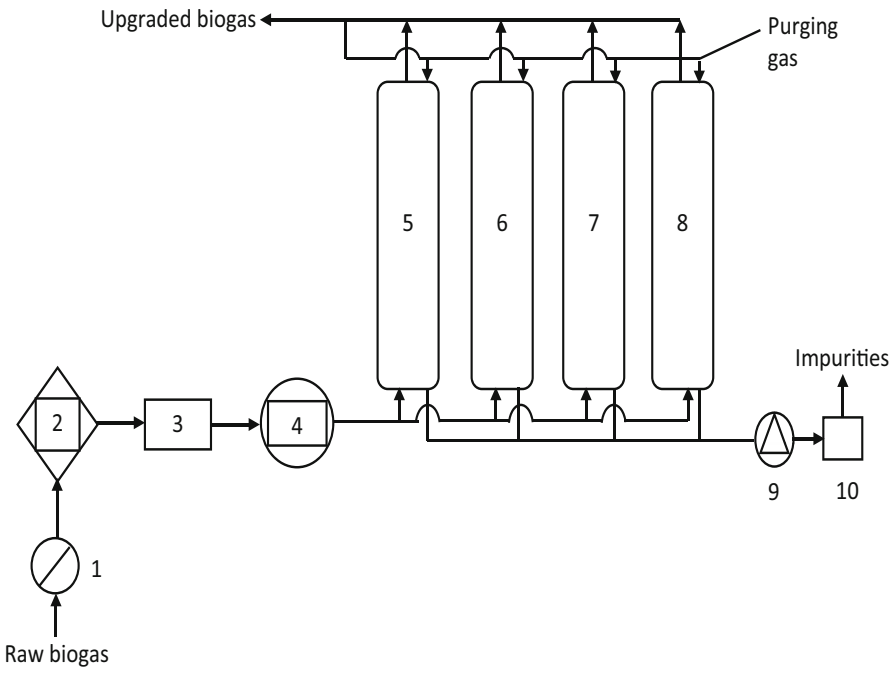
» **Figure 1:** Schematic flow diagram of Water Scrubbing Technology developed by IIT Delhi

PRESSURE SWING ADSORPTION (PSA) TECHNOLOGY

The separation of impurities of the biogas is based on the adsorption of the different molecules in a solid surface as per the molecular size. This method is particularly used to remove N2, O2, CO2, and water vapour present in raw biogas. The purification process is completed in four sequential steps, viz., adsorption, depressurization, desorption, and pressurization. The dry biogas (after moisture removal) enters at the bottom of the adsorption column as shown in Figure 2, where the impurities are adsorbed, and CH4 leaves at the top. When the adsorbent material gets fully saturated the pressure is released to desorb the CO2, and the raw biogas is sent to another vessel, in which the regeneration is already done. The CO_2 is sent to the off-stream channel after desorption. Pressurization is done by equalizing the pressure with the depressurizing vessel. Activated carbon, activated charcoal, natural and synthetic zeolites or alumina, synthetic resins, silica gel, carbon molecular sieve, etc., are commonly used as an adsorbent material. This technique employs biogas purification up to 96%–98% methane concentration with 2%–4% CH_4 loss.

POTENTIAL OF RAW MATERIALS FOR CBG

Biogas can be produced using any biodegradable biomass. India has a huge potential of these biodegradable materials for the production of CBG. The details are depicted in Table 1.



1-Water filter, 2-Compressor, 3-Dryer, 4-Desulphurization, 5-Adsorption
6-Depressurization, 7-Desorption, 8-Pressurization, 9-Vacuum pump,
10-Post pretreatment

» **Figure 2:** Schematic diagram of biogas purification through PSA technique

Table 1: The potential of CBG in India

Source of biogas	Potential in India (year^{-1})	Biogas potential (Million m^3 year^{-1})	CBG (Million kg year^{-1})
Agricultural waste	234 MT	16,717.0	7,522.65
Cattle waste	-	18,240.0	8,208.00
Dairy waste	-	80.1	36.05
Distilleries effluent	34.6 million m^3	1,048.4	471.60
Food waste/ kitchen waste	110.4 MT	5,780.0	2,601.00
Human excreta	176.7 MT	15,019.5	6,758.78
MSW	90 MT	8,550.0	3,847.50
Poultry waste	-	159.9	71.96
Pulp and Paper Industries	1.07 MT	150.5	67.73
Slaughter house	194.8 million m^3	545.4	245.43
Sugar Factory	-	846.8	381.06
Vegetable market waste	50 MT	4,000.0	1,800.00
Total		**~71,138**	**32,011.76**

AN OVERVIEW OF CBG PLANTS IN INDIA

In India, researches on water scrubbing and PSA-based purification systems are common. Presently, there are 12 commercial CBG plants installed in the country with a cumulative CBG production capacity of 18,461.7 tonnes per year, which is only 0.06% of the total potential. The details of the CBG plants are presented in Table 2.

Table 2: Commercial CBG plants in India

Sr. No.	Company & Location	Raw material for biogas	Plant capacity (m^3 day^{-1})	Biogas Enrichment Technology		CBG production (kg day^{-1})
1	Spectrum Renewable Energy Ltd. Kakodi, Kolhapur (Maharashtra)	Pressmud (100 TPD)	20,000	For H_2S removal	Adsorbent bed	8000
				For CO_2 removal	Water Scrubbing	
2	Mahindra Group's Vehicles @ Mahindra World City, Near Chennai (Tamil Nadu)	Food & Kitchen waste (8,000 TPD)	1,000	-		400
3	Primove Engineering, Pirangut, Pune (Maharashtra)	Agricultural waste & plants materials (AgroGasTM)		Modified PSA		100 (Existing) 5000 (Target)
4	Amul, Vadodara, Anand (Gujarat)	Dairy effluent	1,000	MPSA		
5	Brajdham Power Pvt. Ltd., Jaipur (Rajasthan)	Sludge from waste water treatment plant (JMC)	8,400	LPSA		3,780
6	Manas Agro Industries and Infrastructure Limited, Nagpur (Maharashtra)	Molasses sludge	Planning to set-up the CBG dispensing unit within 8-9 months			
7	Tajpur Dairy Complex, Ludhiana (Punjab)	Cattle dung	12,000	-		4,000
8	M/s. Bharat Biogas Energy Ltd., Ahmedabad (GJ)	MSW	14,000	PSA		6,538
9	M/s Arc Bio Fuel Pvt. Ltd, Barnala, Punjab		5,000	PSA		1,842
10	M/s. NRB Bio-Energy, Hanumangarh, Rajasthan	Cattle Manure	2500	MPSA		1,000
11	M/s Green Elephant India Pvt. Limited, Satara (MH)	Distillery effluents	19,200	PSA		7,920
12	Noble Exchange Environment Solution Pvt. Ltd., Pune-India	Food waste (350 TPD)		-		17,000

TPD: Tonnes per day; PSA: Pressure swing adsorption; MPSA: Medium pressure swing adsorption; LPSA: Low-pressure swing adsorption

» Water scrubbing technology for biogas upgradation plant installed in Biogas Enrichment and Bottling Lab, CRDT, IIT Delhi

ENERGY EXPENDITURE AND ECONOMICS OF THE DIFFERENT CBG TECHNOLOGIES

A comparative study of the different purification technologies respective to the cost of biogas purification (₹ m^{-3}), the maintenance cost of the plant (₹ $year^{-1}$), energy expenditure for purification (kWh Nm^{-3} enriched gas), and purification efficiency (%) is given in Table 3.

Amongst the various biogas purification technologies, water scrubbing technology is found to be most suitable concerning cost competitiveness, power consumption, and ease of operation.

CONCLUSION

Presently, 32 million tonnes of CBG potential is estimated in the country. Though, of the total estimated potential, only 0.06% CBG is being produced currently on an annual basis. The research on biogas purification and its utilization as a vehicular fuel and power production are getting more concern from the government bodies. Huge scope of setting up of CBG plants is available in the country.

Looking forward to this, on October 1, 2018, Shri Dharmendra Pradhan, Union Minister of Petroleum and Natural Gas, Government of India, announced 5,000 Compressed Biogas (CBG) plants would be set up by 2025 with an investment of ₹1700 billion under the scheme of "Sustainable Alternative Towards Affordable Transportation (SATAT)". The scheme will open up a new window of green energy corridor in the transport sector and employment as well.

Table 3: The CBG production technologies

Method (s)	Purification efficiency range (%)	Energy consumption (kWh Nm^{-3} enriched gas)	Cost of operation (₹ m^{-3})	Maintenance cost* (₹ in Million $year^{-1}$)
Water scrubbing	88.9–96	0.2–0.5	11.6	1.16
Chemical absorption	88.5–97.7	(0.12–0.27) + 0.44 (for heat)	21.9	4.56
Pressure swing adsorption	84.8–93.6	0.3–1.0	19.9	4.33
Membrane separation	82.4–98.0	0.25–0.43	16.	1.93
Cryogenic technique	84.9–96.7	0.8–1.54	30.9	NA
Biological process	90–99	NA	NA	NA

*The maintenance cost is estimated as per the 1,000 m^3 per hour biogas input capacity of CBG plant

Mr Himanshu Kumar, Prof. V K Vijay, and Dr Ram Chandra, Centre for Rural Development and Technology, IIT Delhi; and Prof. P M V Subbarao, Department of Mechanical Engineering, IIT Delhi, India.

MNRE HOLDS 'CHINTAN BAITHAK' WITH THE STAKEHOLDERS OF RE SECTOR

The Ministry of New and Renewable Energy (MNRE) held a 'Chintan Baithak' with the stakeholders of renewable energy (RE) sector on May 7, 2019 in New Delhi. The 'Baithak' (meet) was chaired by Secretary, MNRE, Shri Anand Kumar and saw good participation from the RE sector including the representatives of major RE developers, equipment manufacturers, financers, regulators, think-tanks, industry bodies, and skill developers.

The day-long meet deliberated upon various issues pertaining to the RE sector, viz., solar, wind, bio-energy, small-hydro, regulatory issues, bidding and pricing, demand forecasting, financing of RE projects, energy storage, Make in India, skilling India's RE work force, etc. Various policy interventions were suggested for the sector by the stakeholders at 'Chintan Baithak' and MNRE will consider these suggestions.

Shri Praveen Kumar, Additional Secretary, MNRE and other senior officials of the Ministry were also present during the meet.

Source: http://pib.nic.in

» The Secretary, MNRE, Shri Anand Kumar chairing a 'Chintan Baithak' with the stakeholders of Renewable Energy Sector, in New Delhi on May 7, 2019.

IFS OFFICER IN MP USES BIODIGESTER TO MEET HOUSEHOLD ENERGY NEEDS

Kshitij Kumar is an IFS officer, deployed in Sagar, Madhya Pradesh. At the government bungalow where he lives with his family, the kitchen needs are not met through LPG cylinders like most of the households across the country. Instead, the fuel is generated by an integrated 'biodigester', which has also been providing organic fertilizers, and pesticides to nurture the floral and kitchen gardens in his compound for the last two years.

The inspiration came from a few organic farmers that Kshitij and his wife, Neelam Kumari interacted with some years ago. These farmers were sustainably utilizing everything produced in their farms, including waste from the livestock.

However, this plant is not a regular biogas plant. "The plant comprises both biogas and vermicompost units that are connected through an automated pipeline. The pipeline carrying the gas is connected to our kitchen while the vermicompost unit is connected to six beds thriving with earthworms. The latter supplies us with both vermicompost as well as vermiwash. The slurry from the biogas plant is routed back to the beds to keep them active," explains Kshitij.

The plant does not just produce these substances but also recycles the water used and adds cow dung to the biogas unit. Kshitij feels that we can save about 30%–35% of the water which is routed to an inlet chamber. With the exception of extreme winters, they have been sourcing all their household energy needs through the plant as the earthworms go dormant during this period. As for energy consumption, Kshitij mentions that the plant produces two cubic metres of gas, which is enough to meet the daily kitchen requirements for four hours at a stretch. This easily covers about 70% of what a regular LPG cylinder would provide.

Source: www.thebetterindia.com

MNRE ISSUES TESTING GUIDELINES FOR BATTERY STORAGE

The Ministry of New and Renewable Energy (MNRE) has issued draft guidelines for performance testing of batteries (lead-acid and nickel-based chemistry type) series approval for mandatory registration with the Bureau of Indian Standards (BIS) on April 8, 2019.

The draft copy was prepared with inputs from stakeholders, including experts from test labs, BIS, and the battery storage industry. Battery energy storage system (BESS) was brought under the ambit of the Solar Photovoltaics, Systems, Devices, and Component Goods (Requirement for Compulsory Registration under the BIS Act Order 2017) which was implemented on April 16, 2018. As the Indian renewable energy industry expands, the government is trying to catch up with quality issues and is setting up testing guidelines to ensure all products sold meet established standards. MNRE issued a new National Lab Policy in December 2017 to improve the quality and reliability of renewable energy projects in India. Because batteries are of varying sizes, ratings, and types, each category of batteries is to be grouped when submitting samples to test labs and will be granted approval for the series (group) of products based on testing of representatives' models.

Grouping by category for testing is an apt move by the MNRE. Grouping had become an issue with testing inverters where labs had no clarity on this issue, and testing of individual models became cumbersome, expensive, and delayed. According to MNRE, the information regarding the material of the containers, the separator used, and the type of sealing adopted (in the case of sealed batteries) and the overall dimensions must be provided by the manufacturer while submitting the batteries for testing.

The manufacturer will need to recommend the procedure to be followed to charge the cells and batteries. If the information is not provided by the customer, the procedure described in applicable standards will be followed.

The short-term tests (capacity test, retention of charge, sulphation test, and water loss test) will be performed on all ratings included in the series. In case any test samples fail any one of the short term tests, the particular rating will be resubmitted for the testing. Amongst the product range of cells and batteries from a manufacturer, the representation model of that particular cell and battery will be tested. The highest rated capacity sample will be subjected to all tests (including endurance tests), and the qualifying product will be issued test reports to all samples covered in the series. For cells and batteries to be considered in the same series, the manufacturer has to submit an assurance to the test lab that all the models have been manufactured with no change in the grid alloy composition, grid purity, grid thickness, ingredients used in the electrode preparation, method of preparation and the thickness of the electrodes and quality systems followed for manufacturing. The government issued a proposal to set up a National Mission on Transformative Mobility and Battery Storage Initiatives earlier in 2019. The Cabinet has also approved the creation of the Phased Manufacturing Program (PMP) to support the development of large-scale, export-competitive integrated batteries and cell-manufacturing giga-scale projects in India. The Phased Manufacturing Program will be valid for five years until 2024 and help in localization of production across the entire electric vehicles value chain. The program is expected to be finalized by the National Mission on Transformative Mobility and Battery Storage. Unlike for solar components, battery testing guidelines are being established before the announcement of the national mission for battery storage.

Source: https://mercomindia.com/mnre-testing-guidelines-battery-storage/

INTERNATIONAL SOLAR ALLIANCE FUNDING TO NO LONGER CARRY FOREIGN SOURCE TAG

The International Solar Alliance (ISA), a global body for cooperation amongst solar resource-rich countries, will no longer be classified as a foreign source of funding for non-governmental organizations in India. The decision was taken as part of India's efforts to assist and help achieve the goal of increasing the use of solar energy, officials said. The United Nations, Intergovernmental Panel on Climate Change, International Labour Organisation, and International Monetary Fund are amongst 109 organizations exempted by India from foreign funding licences. The previous addition to the exempted list was Global Development Network in June 2011, officials said. NGOs seeking foreign funding are required to obtain licences from the Union home ministry and are required to state the purpose of the funds being brought into the country.

The Central government, exercising the power conferred by the Foreign Contribution [Regulation] Act, 2010, specified that the International Solar Alliance shall not be treated as 'foreign source,' the home ministry said in a notification on April 24, 2019. According to the order, funds received by NGOs and other entities from the ISA will not be governed by the FCRA. Prime Minister of India Shri Narendra Modi and former French President Mr François Hollande had unveiled the ISA in 2015 in a bid to combine the efforts of both countries to work against climate change and adopt renewable energy as a replacement for fossil fuels blamed for contributing to global warming.

Source: economictimes.indiatimes.com

BOLIVIA SIGNS THE FRAMEWORK AGREEMENT OF ISA

Bolivia has signed the framework agreement of the International Solar Alliance (ISA), joining hands with India towards a common goal of sustainability. With the joining of Bolivia, a total of 74 countries have signed the framework agreement of the ISA. The agreement between Bolivia and ISA was signed during President Ram Nath Kovind's visit to Bolivia. Bolivia is the second South American country after Argentina to sign the ISA framework agreement. In February 2019, Argentina and Saudi Arabia signed the framework agreement of the ISA. Recently, ISA and the European Union signed a joint declaration for cooperation on solar energy. The declaration was inked at the 24th conference of United Nations Framework Convention on Climate Change held in Katowice, Poland. In November 2018, the Indian government submitted a resolution to the first assembly of the ISA for the amendments in the framework agreement to open ISA membership to all the countries that are members of the United Nations. Before the resolution, the ISA mandate addressed overcoming the obstacles to deploying solar energy at scale through the improved harmonization and aggregation of demand from solar-rich countries located fully or partially between the Tropic of Cancer and the Tropic of Capricorn.

Source: https://mercomindia.com

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DEEP ELECTRIFICATION POWERED BY RENEWABLES

Key for a Climate-Safe Future

New report by IRENA charts pathways to further accelerate energy transformation which meets climate objectives while creating jobs and fostering economic growth.

Increased use of renewable energy, combined with intensified electrification, could prove decisive for the world to meet key climate goals by 2050. This study from the International Renewable Energy Agency (IRENA) highlights immediately deployable, cost-effective options for countries to fulfil climate commitments and limit the rise of global temperatures. The envisaged energy transformation would also reduce net costs and bring significant socio-economic benefits, such as increased economic growth, job creation and overall welfare gains.

The report – the second under the Global Energy Transformation banner – expands IRENA's comprehensive roadmap, which examines technology pathways and policy implications to ensure a sustainable energy future. Ramping up electricity to over half of the global energy mix (up from one-fifth currently) in combination with renewables would reduce the use of fossil fuels, responsible for most greenhouse-gas emissions.

As the urgency to take bold climate action grows, new analysis by the International Renewable Energy Agency (IRENA) finds that scaling-up renewable energy combined with electrification could deliver more than three quarters of the energy-related emission reductions needed to meet global climate goals. According to the latest edition of IRENA's *Global Energy Transformation: A Roadmap to 2050*, launched at the Berlin Energy Transition Dialogue in Berlin on April 9, 2019, pathways to meet 86 per cent of global power demand with renewable energy exist. Electricity would cover half of the global final energy mix. Global power supply would more than double over this period, with the bulk of it generated from renewable energy, mostly solar PV and wind.

"The race to secure a climate safe future has entered a decisive phase," said IRENA Director-General Francesco La Camera. "Renewable energy is the most effective and readily-available solution for reversing the trend of rising CO_2 emissions. A combination of renewable energy with a deeper electrification can achieve 75 per cent of the energy-related emission reduction needed."

An accelerated energy transition in line with the Roadmap 2050 would also save the global economy up to $160 trillion cumulatively over the next 30 years in avoided health costs, energy subsidies and climate damages. Every dollar spent on energy transition would pay off up to seven times. The global economy would grow by 2.5 per cent in 2050. However, climate damages can lead to significant socioeconomic losses.

"The shift towards renewables makes economic sense," added Mr La Camera. "By mid-century, the global economy would be larger, and jobs created in the energy sector would boost global employment by 0.2 per cent. Policies to promote a just, fair and inclusive transition could maximize the benefits for different countries, regions, and communities. This would also accelerate the achievement of affordable and universal energy access. The global energy transformation goes beyond a transformation of the energy sector. It is a transformation of our economies and societies."

But action is lagging, the report warns. While energy-related CO_2 emissions continued to grow by over 1 per cent annually on average in the last five years, emissions would need to decline by 70 per cent below their current level by 2050 to meet global climate goals. This calls for a significant increase in national ambition and more aggressive renewable energy and climate targets.

IRENA's roadmap recommends that national policy should focus on zero-carbon long-term strategies. It also highlights the need to boost and harness systemic innovation. This includes fostering smarter energy systems through digitalization as well as the coupling of end-use sectors, particularly heating and cooling and transport, via greater electrification, promoting decentralization and designing flexible power grids.

"The energy transformation is gaining momentum, but it must accelerate even faster," concluded Mr La Camera. "The UN's 2030 Sustainable Development Agenda and the review of national climate pledges under the Paris Agreement are milestones for raising the level of ambition. Urgent action on the ground at all levels is vital, in particular unlocking the investments needed to further strengthen the momentum of this energy transformation. Speed and forward-looking leadership will be critical – the world in 2050 depends on the energy decisions we take today."

Renewables already make up more than half of newly installed power-generation capacity. Yet their overall share in the energy mix (including power, heat and transport) needs to grow six times faster, IRENA's analysis shows.

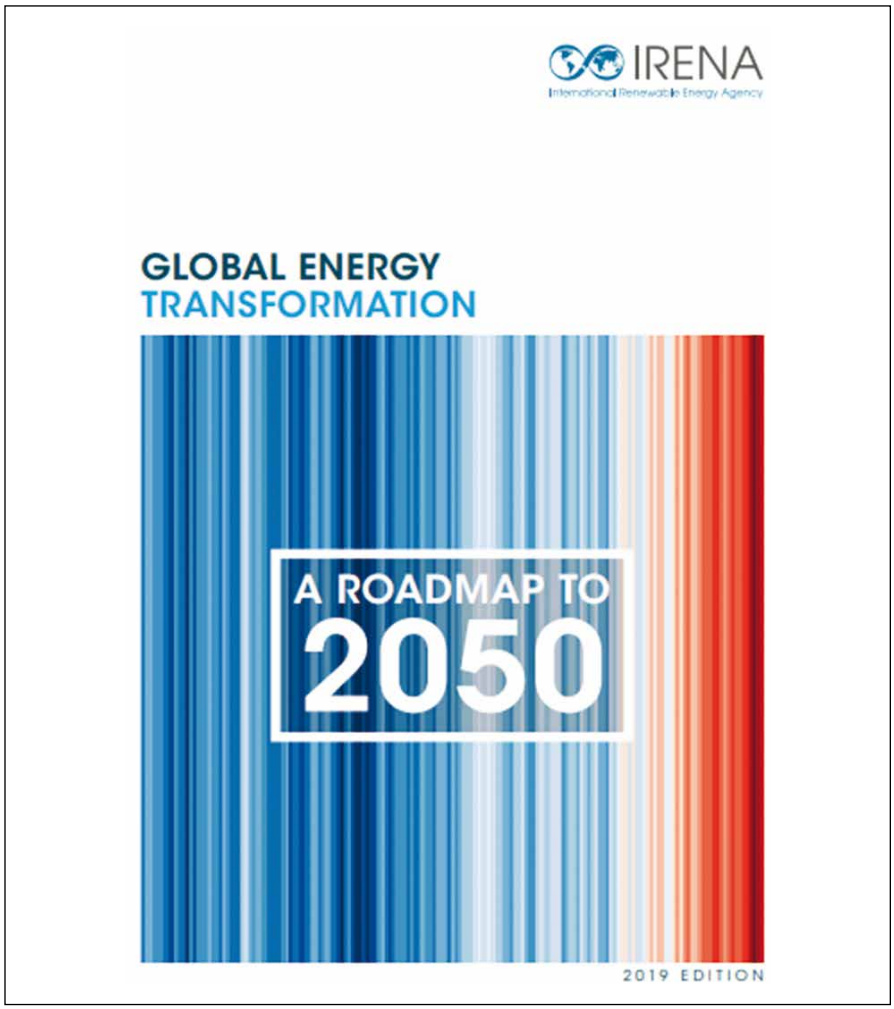
National climate commitments under the Paris Agreement largely hinge on energy decarbonization. The historic 2015 climate deal, endorsed nearly worldwide, calls for keeping the rise in average global temperatures "well below" two degrees Celsius (2°C) during the present century, compared to pre-industrial levels.

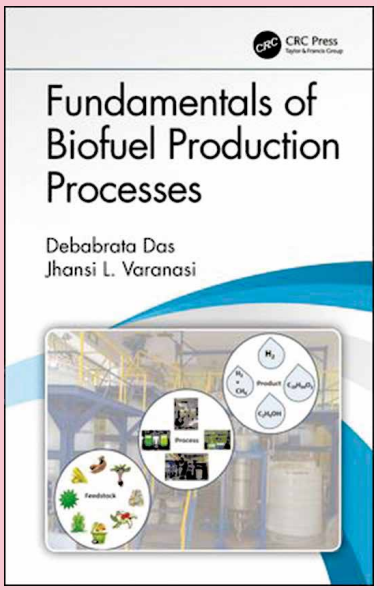
Achieving a climate-safe future, however, depends on swift global action. Current plans and policies, including Nationally Determined Contributions (NDCs), fall far short. Energy-related emissions have risen around 1% yearly since 2015, while the world's "carbon budget" looks set to run out within a decade.

Among other findings:

- Based on IRENA's analysis, energy-related CO_2 emission reductions would have to decline 70% by 2050, compared to current levels, to meet climate goals. A large-scale shift to electricity from renewables could deliver 60% of those reductions; 75% if renewables for heating and transport are factored in; and 90% with ramped-up energy efficiency.
- With electricity becoming the dominant energy carrier, global power supply could more than double, the report finds. Renewable sources, including solar and wind, could meet 86% of power demand.
- The energy transformation would boost gross domestic product (GDP) by 2.5% and total employment by 0.2% globally in 2050. It would also bring broader social and environmental benefits. Health, subsidy and climate-related savings would be worth as much as USD 160 trillion cumulatively over a 30-year period, the report finds. Thus, every dollar spent in transforming the global energy system provides a payoff of at least USD 3 and potentially more than USD 7, depending on how externalities are valued.
- Renewables, meanwhile, would create more new jobs than those lost in fossil-fuel industries. Policy inputs can further improve the socio-economic footprint of the transformation.

Source: www.irena.org

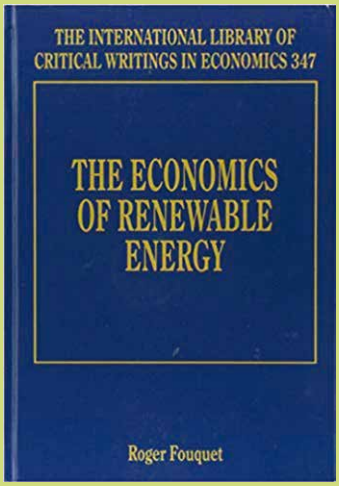




FUNDAMENTALS OF BIOFUEL PRODUCTION PROCESSES

Debabrata Das, Jhansi L Varanasi; CRC Press, 264 pages

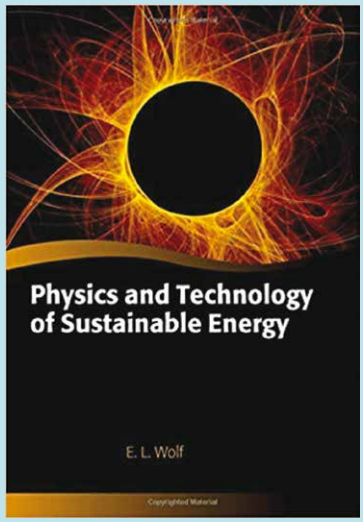
Biofuels have exhibited enormous potential as a renewable and sustainable source of energy. Apart from dealing from energy crisis, biofuels have attracted renewed interest for addressing resource limitations, global warming, waste management, etc. *Fundamentals of Biofuel Production Processes* focusses on the essentials of biofuel production from renewable energy sources and also offers a complete understanding of bioconversion processes. This book is aimed at a wide audience, mainly undergraduates, postgraduates, energy researchers, scientists in industries and organizations, energy specialists, policymakers, research faculty, and others who wish to know about biofuels and also wish to get abreast with the latest developments. Each chapter in the book begins with the fundamental explanation for general readers and ends with in-depth scientific details along with scale up, case studies, and economic analysis of production processes, suitable for expert readers.



THE ECONOMICS OF RENEWABLE ENERGY

Roger Fouquet (Editor); Edward Elgar Pub, 992 pages

This major reference work brings together for the first time key articles on the economics of renewable energy. From a modest role as a backstop technology in the 1970s to a central role in low carbon transitions today, this collection reveals the emergence and growing importance of this sub-field of economics. Topics covered in this timely volume include the costs of renewable power (taking account of issues related to technological development, intermittency, and interconnection), policies that promote renewable energy development, its public and private demand, and its impact on the environment and the economy. This indispensable collection is complemented by a comprehensive introduction that will serve as an essential source of reference for students and researchers. It contains 44 articles, dating from 1974 to 2016.



PHYSICS AND TECHNOLOGY OF SUSTAINABLE ENERGY

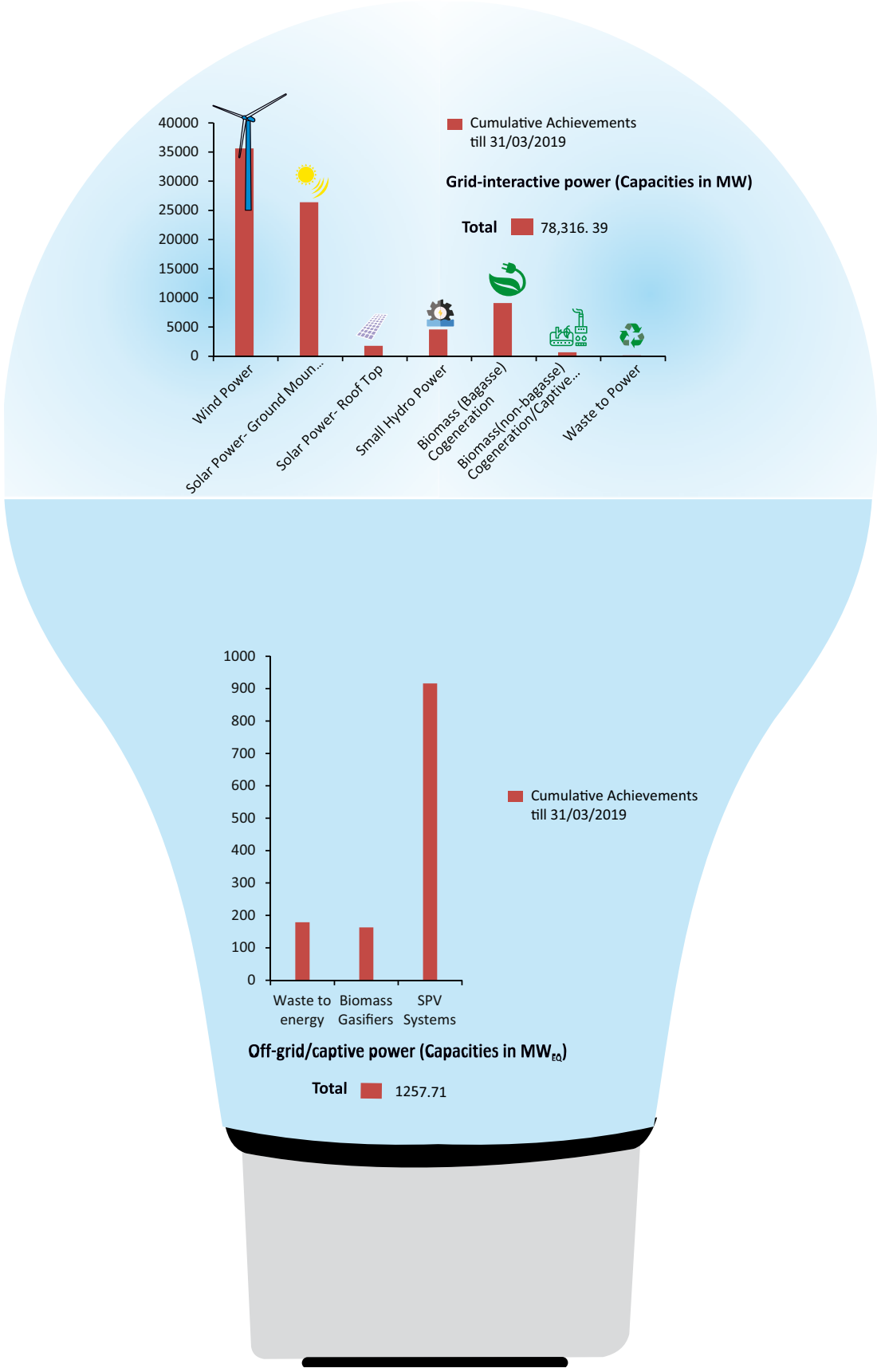
E L Wolf; Oxford University Press, 432 pages

This textbook explores the science and technologies needed for renewable energy. It examines the properties of the Earth's atmosphere for transmitting light from the sun and mediating outflow of infrared energy from the ground, a role that has an effect on the temperature of the Earth. It begins by explaining how the sun works, that is by nuclear fusion, and the basic concepts of quantum tunnelling needed are later expanded to allow a competent treatment of semiconductor physics, the discipline behind solar cells. The book covers wind turbine technology, hydroelectric power, and pumped-hydro energy storage. It also talks about the history of the Earth's climate and discusses the effects that the present fossil fuel burning, leading to large emission of greenhouse gas, may have on the future temperature of the Earth.


NATIONAL
June 6–8, 2019 | Kochi, India
Energyour Expo
Website: http://tradeshows.tradeindia.com/energyourexpo/
June 14, 2019 | Ahmedabad, India
SolarRoofs Gujarat 2019
Website: https://www.solarquarter.com/index-.php/events4/all-events/business-events/43-solarroofs-gujarat-2019
June 27–28, 2019 | Bengaluru, India
Electric, Hybrid, Solar Vehicle & Eco Green 2019
Website: http://tradeshows.tradeindia.com/ehse/
August 2–4, 2019 | Chennai, India
Solar South (5th Edition)
Website: https://solarsouth.in/
September 18–20, 2019 | Greater Noida, India
Renewable Energy India Expo
Website: www.renewableenergyindiaexpo.com/


INTERNATIONAL
June 4–6, 2019 | Moscow, Russia
WasteTech 2019 - 11th International Trade Fair and Conference for Waste Management, Recycling, Environmental Technologies and Renewable Energy
Website: hhttps://www.jetro.go.jp/en/database/j-messe/tradefair/detail/58201
June 11–13, 2019 | Bosnia and Herzegovina
Energa Sarajevo
Website: https://www.tradefairdates.com/Energa-M8664/Sarajevo.html
June 19–21, 2019 | Gyeonggi-do, South Korea
Expo Solar
Website: https://www.exposolar.org/2019/eng/about/sub01.asp
July 10–12, 2019 | Yokohama, Japan
Grand Renewable Energy 2019 International Exhibition
Website: https://www.jetro.go.jp/en/database/j-messe/tradefair/detail/62279
August 1–3, 2019 | Yangon, Myanmar
Myanmar Renewable Energy Expo 2019
Website: http://www.renewmyanmar.com/

RENEWABLE ENERGY AT A GLANCE: INDIA



Source: https://mnre.gov.in

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