October–December 2016

ENERGY FUTURE

The Complete Energy Magazine
Volume 5 • Issue 1 • Annual ₹800

MICROGRIDS
A Perspective on Technology to Bring Utility Electricity Delivery Systems

PETROLEUM SECTOR GOING THE NATURAL ENERGY RESOURCES WAY
A look at use of renewable energy by petroleum giants

SMART GRID
THE FUTURE OF ELECTRICITY

VIEWPOINT
Aim to Empower Off-Grid Families with Clean Energy

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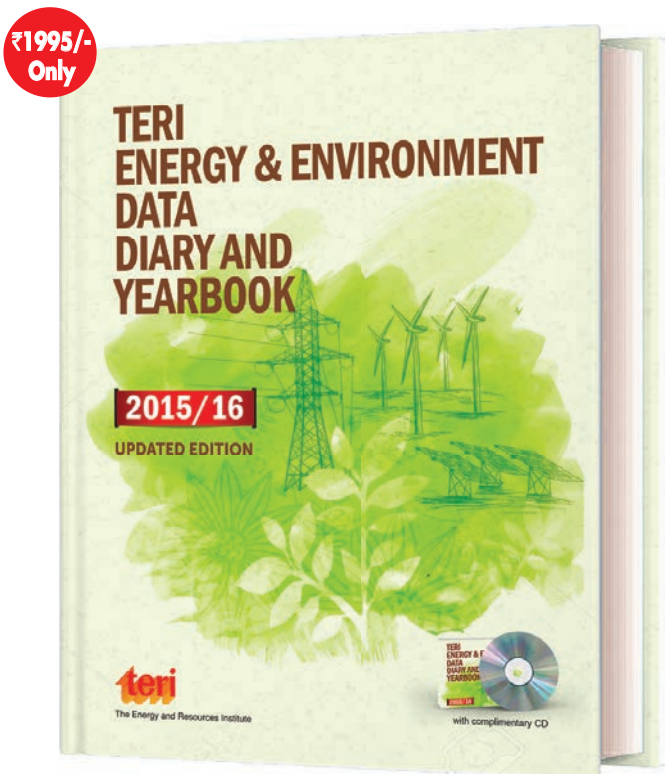
The Most Comprehensive Annual Data Diary and Yearbook on India's Energy Sector and Its Impact on Environment



ISBN: 9788179935910

Key features

- Exhaustive compilation of data from energy supply and demand sectors
- Recent data along with data from the past years covered in the form of structured and easy-to-understand tables
- Recent advances made in the energy sectors
- Self-explanatory figures and graphs showing the latest trends in various sectors
- The "Green Focus" at the end of every chapter highlights a topical issue
- A complimentary CD that contains all the chapters and additional tables

Topics covered

Energy, environment, and sustainable development • **Energy supply:** Coal and lignite, Petroleum and natural gas, Power, Renewable energy • **Energy demand:** Agriculture, Industry, Transport, Household energy • **Local and global environment:** Environment, Climate change

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From the editor's desk...

Now that India is going to ratify Paris agreement on climate change on October 2, 2016, the focus would shift to its operationalization, especially implementation of two main covenants of India's Nationally Determined Contribution, namely (i) to reduce the emissions intensity of its GDP by 33%–35% by 2030 from 2005, and (ii) to achieve about 40% cumulative electric power installed capacity from non-fossil fuel-based energy resources by 2030. It is not that the country is sitting idle on this front—indeed it is already moving ahead with a number of ambitious programmes on demand as well as supply sides of energy. Nevertheless, the aforementioned goals require transformative changes in not only the way energy is being generated but also in our overall approach to energy usages. In addition to a variety of enabling measures, the importance of different kinds of collaboration cannot be overemphasized for these intended goals to become a reality, not to mention the behavioural changes so central to the envisaged scenario.

Beside changes on the generation side of energy, many disruptive concepts are going to alter the delivery of that energy. While smart grids are already becoming a hot topic of discussion; what has still not been captured fully is the extent these smart grids—in conjunction with Internet of Things—would bring benefits to the whole electricity sector and the consumers. With numerous solar rooftop systems becoming a norm in years to come, such smartness alone would pave the way for smoother transition in the businesses. And rather than being based on centralized grid network only, as is the convention now, the way forward is an amalgamation of centralized and distributed grids with many micro-grids as well as electric vehicles embedded in larger networks in a mutually complementing fashion. And that is how an intelligent energy future looks like!

Amit Kumar

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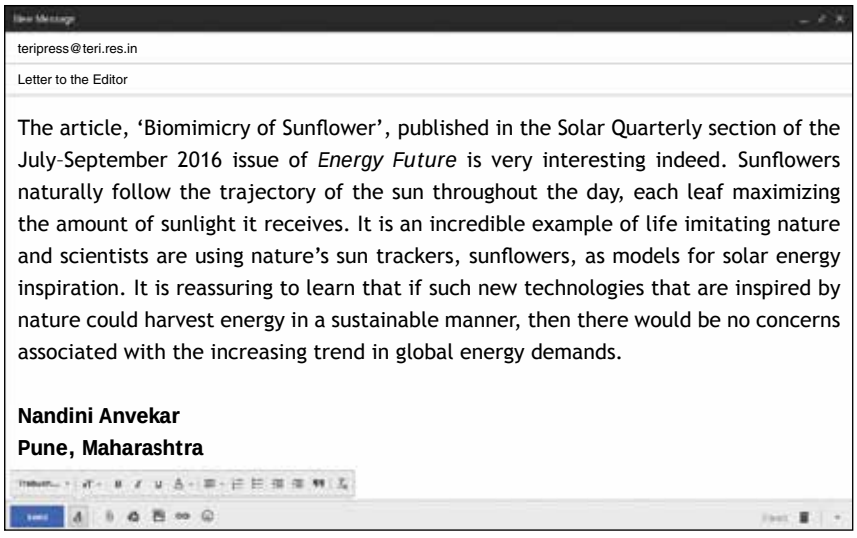
Printed and published by Dr Ajay Mathur for The Energy and Resources Institute, Darbari Seth Block, IHC Complex, Lodhi Road, New Delhi- 110 003. Tel. +91(11) 24682100, 4150 4900, Fax +91(11) 2468 2144 or Email: teripress@teri.res.in, and printed by Batra Art Press, A-41 Naraina Indl. Area PH- II, New Delhi-28.



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Letter to the Editor

The article, 'Biomimicry of Sunflower', published in the Solar Quarterly section of the July-September 2016 issue of *Energy Future* is very interesting indeed. Sunflowers naturally follow the trajectory of the sun throughout the day, each leaf maximizing the amount of sunlight it receives. It is an incredible example of life imitating nature and scientists are using nature's sun trackers, sunflowers, as models for solar energy inspiration. It is reassuring to learn that if such new technologies that are inspired by nature could harvest energy in a sustainable manner, then there would be no concerns associated with the increasing trend in global energy demands.

Nandini Anvekar
Pune, Maharashtra

"I read the July–September 2016 issue of *Energy Future*. The Cover Story on Green Buildings and Sustainable Habitats reinforces the fact that green environment has deep impact on human as well as environmental health. Building material, designs, location, and maintenance are key aspects of safety and health of people living in them. It is vital to create a sustainable environment to ensure better human resource. The concept of green buildings is the combination of every aspect that fosters healthy lifestyle. I particularly liked reading about the UPVC 'green windows' that are extremely energy efficient. UPVC windows are best suited for weather conditions throughout India and are also economical in comparison to teak and other good grade wood."

Aniket Bagchi
Asansol, West Bengal

Thank you very much for your encouragement. The editorial team of Energy Future will ensure that the magazine caters to your information and knowledge needs. We welcome your suggestions and comments to further improve our content and presentation.

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Editor
Energy Future

"The case study published in the July 2016 issue on paddy straw-based power generation and biogas is quite informative for renewable energy professionals like us. Agriculture is a major contributor to India's gross domestic product (GDP). With a large agricultural produce comes equally large agricultural waste. Regrettably, management of agricultural waste is not up to the mark in our country. Burning of crop residue is a common practice that leads to pollution, which further creates health hazards. It was nice to read about a novel initiative wherein agricultural waste is used to generate clean energy. The initiative to generate electricity using biogas produced from paddy straw is really commendable. It will also be beneficial for employment generation, extra income for farmers from sale of straw, and production of organic manure. It was also curious to read that harnessing solar and wind energy in one device could power the 'Internet of things'.."

Dhritiman Bandyopadhyay
Indore, Madhya Pradesh

"The article on steam optimization measures in energy-intensive industries published in the Energy Insights section very appropriately reflects that steam system optimization is a low hanging fruit and industries should reap the rewards of energy savings, reduced down times and maintenance crises, and also minimization of the safety hazards. There is a need to make the stakeholders in the industry aware about the importance of using steam optimally in order to save money, natural resources, such as coal, water, oil and encourage a culture of uninterrupted improvement in steam usage and its management in all energy intensive industries.."

Harshdeep Gulati
New Delhi

CONTENTS

HARVESTING SOLAR POWER COULD PROPEL GROWTH IN FARM INCOME

India has set an ambitious target of achieving 100 000 MW of solar power capacity by 2022 as well as doubling farm incomes by the seventy-fifth year of Independence. Both these targets can be a game changer for rural India, if implemented in unison, suggests new research. According to a recent study by New Delhi-based International Council for Research in International Economic Relations, access to solar power can help water crop fields, build cold storages, and augment farm incomes by feeding the surplus power generated into the grid.

Research also stated that although farmers can earn guaranteed tariffs by feeding surplus power into the grid—akin to harvesting a second or a third crop—solar-powered irrigation pumps will insure access to irrigation for farmers when rains fail and also replace polluting diesel pumps.

Indian farmers currently use more than 20 million diesel and electric pumps, and replacing these with solar-powered ones can help reduce the annual power subsidy bill of the government to the agriculture sector. Also, solar pumps can save farmers more than ₹1 lakh in costs over a decade due to high maintenance and fuel costs of diesel pumps. EF

Source: www.livemint.com

BIODIESEL BUSES FOR KSRTC SOON

After being satisfied with the performance of the 100% biodiesel bus that were being operated on trial basis, the Karnataka State Road Transport Corporation (KSRTC) has now decided to induct biodiesel buses in its fleet. To start with, the Corporation will buy eight to ten such buses. Managing Director of KSRTC, Rajender Kumar Kataria, said that each bus of this kind costs about ₹1 crore. Kataria said, 'During the trial, our officials studied the performance of the bus on a daily basis. They felt that biodiesel buses perform on par with petro–diesel buses. The functioning of its engine, fuel efficiency, low emission, passenger satisfaction in terms of comfort and others parameters were all found to be satisfactory. Following the positive response, we are now going in for a few of these buses in the coming days'. The official claimed that the KSRTC would be the first state-run road transport corporation in the country to introduce 100% biodiesel buses.

Biodiesel is biodegradable, non-toxic, and free from sulphur. Studies have revealed that biodiesel has a less negative environmental impact than petro–diesel as it is made from vegetable oils and fats. Operation of biodiesel buses is also cost effective. The fuel costs ₹5 less than petro-diesel. The Corporation has already tied up with a contractor to supply biodiesel. The Corporation is running its existing fleet on a fuel that is a blend of 80% petro–diesel and 20% biofuel. Their existing buses do not require any modification as they have been designed as per specifications fixed by the government. However, to operate 100% biodiesel buses, they need to retrofit the engine. EF

Source: www.bangaloremirror.com

AERIAL MAPPING OF BENGALURU'S SOLAR ENERGY PROSPECTS

The Bangalore Electricity Supply Company (BESCOM) has entered into an agreement with Karnataka Renewable Energy Development Limited and the Centre for Study of Science, Technology and Policy (CSTEP) to build a roadmap to boost the quantum of power generated using solar energy. For this purpose, a helicopter or a small aircraft will soon be flying over the city sending pulses of light, which will get reflected back from objects on the ground. Receivers will translate this reflected light into data points, accurately mapping buildings, trees, poles, wires, and antennae.

'It is basically a sophisticated GIS mapping exercise. LIDAR will be used to create a digital surface model (DSM) for the city. We need to know which rooftop is suitable across various categories—domestic, industrial, etc.—and also analyse and improve the existing distribution network infrastructure. Solar energy is fluctuating, and its impact on distribution transformers has to be studied. Shadow is not a concern for ground-mounted solar plants, but even a small shadow can wreak havoc on generation from rooftop PV plants and destroy the associated business case', said Saptak Ghosh, research scientist, CSTEP.

The one-year project begins in September. Ranks will be given to each rooftop and the top ones will be chosen for the roadmap.

At present, BESCOM generates 14.8 MW of solar energy from 524 solar rooftop plants across the eight districts it caters to. But this is woefully short of the target set by the Central and State governments. The target for Bengaluru alone is expected to be 1 GW. EF

Source: www.thehindu.com

IN INDIA, SOLAR–WIND HYBRIDS EMERGE TO BEAT VAGARIES OF SEASON, LAND DEALS

Wind turbine makers in India are looking at building more renewable energy projects that would combine solar and wind in a bid to provide a reliable and cost-effective power supply. Gamesa Corp. Tecnologica SA, the largest wind-turbine maker in India by market share, is preparing to announce its first wind–solar project. Suzlon Energy Ltd India's largest domestic manufacturer of wind turbines, expects to focus on hybrids starting next year. 'We feel that hybrid projects will make 50%–60% of our sales over the next three years', said Ramesh Kymal, the CEO of Gamesa's India operations.

The major advantage of a solar–wind hybrid is boost to reliability of the system from two different sources that supplement each other. 'Hybrid projects offer advantages in sharing of resources for construction and maintenance of a project, as well as power transmission', according to Shantanu Jaiswal, a Bloomberg New Energy Finance analyst in New Delhi. Combining the two technologies and sharing a grid connection can also increase capacity, developers say. Hybrids hold an additional appeal in India where land acquisition remains a challenge.

The interest in hybrid projects comes as India pushes aggressively to develop its clean energy capacity. Under an effort led by Prime Minister Shri Narendra Modi, India is aiming to install 100 GW of solar capacity and 60 GW of wind power by 2022. EF

Source: http://www.huffingtonpost.in

ECO-FRIENDLY RICKSHAWS TO MAKE GRAND ENTRY ON SOUTH MUMBAI ROADS

Horse carts may be on their way out, but Maharashtra State Transport Department wishes island city commuters could get eco-friendly electric autorickshaws instead. The three-wheelers, which run at a speed of 25 km/h, are fast emerging as an eco-friendly substitute to vehicles running on petrol, diesel, or compressed natural gas (CNG). In its advisory issued on June 9, 2016, the Centre has included the Greater Mumbai region on the list of cities that are allowed to introduce the facility.

The state transport department has sent the advisory to the regional transport authority and state transport authority for further analysis. 'No decision has been taken yet on the cities or areas where the electric autorickshaws (e-rickshaws) will be introduced. The authorities will speak to all stakeholders to zero in on the feasible routes and also study the technicalities involved. It is too early to comment on whether the facility will be introduced in Greater Mumbai or not', said State Transport Commissioner Sonia Sethi. Apart from Greater Mumbai, introduction of e-rickshaws have been permitted in Nagpur, Nashik, Pune, and Mumbai. Auto unions, however, are against the plan, as it would mean high operation and maintenance cost, setting up of more recharging stations, and raise questions over the safety of drivers and passengers. EF

Source: http://www.hindustantimes.com/

TATA POWER APP TO HELP TRACK DAILY CONSUMPTION

In a first, Tata Power consumers in Delhi will soon be able track their daily electricity consumption and find out the reasons for technical fault in transmission line with the company working on a ₹100-crore project to modernize its communication network.

Under the one-of-its-kind initiative, the Tata Power Delhi Distribution Ltd (TPDDL) will introduce smart meters so that its consumers can better understand their energy usage. The company has floated a global tender to rope in world's leading tech giant for its ambitious project.

According to TPDDL CEO and Managing Director, Praveer Sinha, the domestic consumers will be able to use an app in their smartphones to access a host of information such as consumption during peak and off-peak hours, details of consumption for any period in the current fiscal compared to corresponding period a year ago, etc.

According to him, the TPDDL is also augmenting its infrastructure for introduction of the time-of-day metering, which involves dividing the day, month, and year into tariff slots and with higher rates at peak load periods and low tariff rates at off-peak load periods. EF

Source: http://www.asianage.com/

HOUSE IN JAYANAGAR BUILT WITHOUT BESCOM POWER

For those civil engineers and architects who are sceptical about using solar power in construction, a Bengaluru-based industrialist has demonstrated that one could complete the construction of a house without even obtaining a temporary connection.

Setting a new example in harnessing solar energy, Dinesh Pagaria has accomplished the construction work of his house in Jayanagar by using only solar power. From foundation to completion of his new house, Dinesh has not availed electricity from Bangalore Electricity Supply Company Limited (BESCOM) and instead relied on the abundant solar power available at the site to complete the construction work.

While it is common for people to install solar units on rooftops after completion of construction, Dinesh set up the unit on his empty site a year ago and began with the foundation and the subsequent civil work. As the work progressed, he not only shifted the unit on top but even upgraded it to a higher capacity, thereby saving ₹7 to 8 lakh alone on temporary power connection with BESCOM during the construction.

Dinesh has used solar panels made of thin films, generally used in commercial solar power generation, that can generate full power even during dim light or intense cloudy conditions. Despite initial inhibitions, Dinesh's idea was backed by his architect, Ganesh of Studio69, and engineers of JJJSolar firm that executed the ambitious project.

Source: http://www.bangaloremirror.com/

ADANI UNVEILS WORLD'S LARGEST SOLAR POWER PLANT IN TAMIL NADU

Adani Green Energy, part of the Adani Group, dedicated to the nation the world's largest 648-MW solar power plant in Tamil Nadu, entailing an investment of ₹4550 crore.

'The plant is set up at Kamuthi, Ramanathapuram, in Tamil Nadu with an investment of ₹4550 crore. It is part of the state government's ambitious target of generating 3000 MW as per the solar energy policy unveiled by the government in 2012', said a statement from the company. The entire 648-MW plant is connected with Kamuthi 400 kV sub-station of TANTRANSCO, making it the world's largest solar unit at a single location.

'This is a momentous occasion for Tamil Nadu as well as for the entire country. We are happy to dedicate this plant to the nation. A plant of this magnitude reinstates the country's ambitions of becoming one of the leading green energy producers in the world', said Gautam Adani, Chairman, Adani Group.

The plant consists of 3.80 lakh foundations, 25 lakh solar modules, 27 000 MT of structure, 576 inverters, 154 transformers along with 6000 km cables.

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

COSTA RICA RUNS ON 100% RENEWABLES FOR TWO MONTHS

Costa Rica ran on 100% renewable energy for 76 straight days between June and August this year, according to a new report, demonstrating that life without fossil fuels is possible. This is the second time in two years that the Central American country has run for more than two months straight on renewables alone, and it brings the total to 150 days in 2016 and counting.

According to Costa Rica's National Centre for Energy Control, June 16, 2016, was the last day this year that fossil fuels-based energy was used by the national grid. (Data for September is still forthcoming.) Since then, the country has been powered on a mix of hydro, geothermal, wind, and solar energy, with hydro power providing about 80.27% of the total electricity in the month of August. Geothermal plants contributed roughly 12.62% of electricity generation in August, while wind turbines provided 7.1%, and solar 0.01%.

Gallucci reports a massive hydroelectric project called Reventazón, run by the Costa Rica Electricity Institute (ICE), will come online later this month, after six years of construction, which means even more hydro power is in store. EF

Source: http://www.sciencealert.com

WIND POWER PRICE DRIVEN TO RECORD IN NORTH SEA

Vattenfall AB won a tender to build two offshore wind farms in the Danish North Sea with a record-breaking bid of 60 Euros ($67.33)/MWh.

That's 20% cheaper than the last record set by Dong Energy A/S in the Netherlands in July 2016. The total capacity of the projects is expected to be 350 MW, Sweden's largest energy company said in a statement.

'With our bid for DNS, we have demonstrated that we are able to reduce the costs of offshore wind faster than had been expected, only a few years ago', said Gunnar Groebler, head of Vattenfall Wind. 'This again proves that renewable energy is going to be competitive. We contribute to this growth, and we will continue to do so for the next few decades'.

The site for the Vattenfall wind farm is unusually close to the shore, leading to lower costs for foundations and transportation. The Danish government has already developed the area, which will result in shorter construction time and potentially lower equity-hurdle rates, according to Bloomberg New Energy Finance.

The wind farms are planned to be on the west coast of Jutland near the towns of Hvide Sande and Thyboroen. Construction is expected to start in 2019 with first power in 2020. The projects still need final approval from the government. EF

Source: www.bloomberg.com

SAUDI TO CUT OIL PRODUCTION, SAY SOURCES

Saudi Arabia has offered to reduce oil production if rival Iran agrees to cap its own output this year, in a major compromise ahead of talks in Algeria next week. The offer, which has yet to be accepted or rejected by Tehran, was made in September 2016.

A source familiar with Iranian thinking declined to comment on details of the proposal but did not rule out the possibility of a compromise next week. There was no official comment from Saudi Arabia or Iran.

Saudi output usually drops in winter and spikes during hot summer months, hence Iran could dismiss the proposed reduction as an attempt by Riyadh to present a natural decline as a cut.

Previously, the Saudis have refused to discuss production cuts. OPEC officials

from Saudi Arabia and Iran met this week in Vienna. According to sources, the gathering did not discuss the Saudi proposal, focusing instead on baseline production figures. Saudi Arabia, by far the largest producer in the OPEC, will shoulder the biggest cut, the sources said.

The proposal can be seen as a shift by Riyadh, which orchestrated the current OPEC policy in 2014 by refusing to cut output alone to support prices and chose to defend market share against rivals, particularly high-cost producers. EF

Source: www.bloomberg.com

CALIFORNIA PASSES NEW BIOENERGY, CLIMATE LEGISLATION

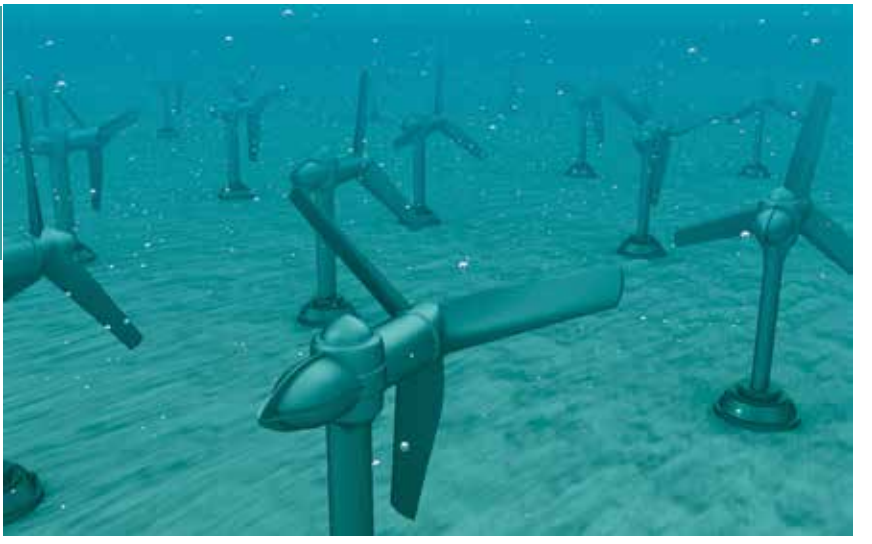
The Bioenergy Association of California (BAC) said it worked with its members to help pass several important bills that will significantly increase renewable gas production and use; increase incentives and revise standards for pipeline biogas; remove barriers to interconnection for small-scale bioenergy projects; extend the state's climate and low carbon fuels programmes to 2030; and set targets for the reduction of methane, black carbon, and other short-lived (super) climate pollutants. According to the BAC, the bioenergy and climate bills that passed are:

- SB 1383: A major amendment requires adoption of policies and incentives to significantly increase renewable gas production and use. The bill also requires a 75% diversion of organic waste by 2025 and various measures to reduce methane emissions from dairies.
- SB 32: Requires 40% reduction in greenhouse gas emissions by 2030 and extends the low carbon fuel standard and other important climate programmes.

- AB 2313: The important bill increases incentive for pipeline biogas interconnection from $1.5 to $3 million per project, and up to $5 million for a dairy digester cluster project. It also requires the California Public Utilities Commission to consider rate-basing and other options to promote pipeline biogas.
- SB 840 (Section 9): Removes a fatal barrier to small-scale (3 MW and smaller) forest bioenergy projects by revising the interconnection requirements for forest BioMAT projects. The bill removes the exorbitant deposits required to remain in the interconnection queue while forest BioMAT projects wait to obtain a contract with the utility.
- SB 840 (Section 11): The bill requires the CPUC to hire the California Council on Science and Technology to review and make recommendations to revise the pipeline biogas standards for BTU(heating value) and siloxanes. EF

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

MAURITIUS TAKES GREAT STEP FORWARD FOR WAVE POWER, MICROGRID DESIGN



Australian marine energy developer Carnegie Wave Energy has embarked on an ambitious project in the Indian Ocean nation of Mauritius to establish new benchmarks in microgrid solutions tailored for high penetration renewable energy.

'The Mauritius project will clearly show how islands can achieve very high penetration of renewables by using a combination of wave energy, solar PV, wind energy, battery energy storage systems, and smart microgrid control systems', Project Manager Neil De Tisi told *Renewable Energy World*.

In meeting its goals, the project will showcase several innovative solutions split over the main island of Mauritius and the island of Rodrigues.

While the microgrid will serve to demonstrate how multiple sources of renewable energy may be effectively incorporated into an isolated grid, it will also provide a test bed for deployment of Carnegie's latest generation of wave energy capture technology, CETO 6. The microgrid will also incorporate a new desalinization plant—being developed by Mak Water—to serve the neighbouring island of Rodrigues.

The project's scope includes provision of a renewable energy road map for Mauritius, outlining the technical and financial feasibility of high-penetration renewable energy. EF

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

ARGENTINA AUCTION ATTRACTS PROPOSALS FOR 6 GW OF SOLAR, WIND

Renewable energy developers in Argentina applied to sell 6366 MW of power in an October auction, more than six times the amount the government plans to sell.

Wind farms accounted for more than half, or 3478 MW of capacity, according to Sebastian Kind, undersecretary for renewable energy at the Argentina's Energy Ministry. Solar projects represented 2834 MW, while biogas and biomass each had 53 MW.

'I've never expected 6000 MW', Energy Minister Juan Jose Aranguren told reporters in Buenos Aires. 'The first round of our programme meets our goal to diversify the energy mix, having new energy costs so that we have enough to power the country's development and to reduce the impact of these activities on climate change'.

President Mauricio Macri has made renewable energy development one of his government's main priorities since taking office in December 2015 by establishing new regulations and organizing auctions. The government expects to attract between $1.5 billion and $2 billion in investments at the October 12, 2016, auction.

The auction is expected to spur as much as 1 GW of new capacity, led by wind and solar farms. It will include 600 MW of wind power, almost triple the 215 MW in operation now, and 300 MW of solar power, up from almost nothing, as well as 65 MW of biomass, 20 MW of small hydropower, and 15 MW of biogas. Developers will be competing for 20-year contracts to sell power from planned power projects, which should be completed within two years after the auction. EF

Source: www.bloomberg.com

SHARP ENTERS NEW MEXICO SOLAR ENERGY STORAGE MARKET

Sharp Electronics Corporation's Energy Systems and Services Group (Sharp) recently installed its SmartStorage system at Roadrunner Food Bank in a project with its channel ally and Albuquerque-based Affordable Solar Installation, Inc. (ASI).

This installation, which signals Sharp's entry into the New Mexico market, is the state's first commercial solar-plus-storage installation. The project features two Sharp 30-kW SmartStorage systems, paired with the site's existing 366-kW solar energy rooftop array. Sharp's SmartStorage system reduces the property's peak demand usage.

Peak demand charges are the fastest growing part of utility bills for commercial and industrial customers and can represent up to 50% of a company's monthly utility bill. For charities such as Roadrunner Food Bank, every dollar saved allows them to use the savings and redirect it to solving hunger. Currently, the food bank pays on average US$180 000 a year in utility bills, with an estimated 30% going toward demand charges. The solar-plus-storage system is expected to save the food bank approximately $30 000/year in utility charges. The annual savings equates to approximately 150 000 meals in food distributed every year.

ASI opted for Sharp's 10-Year Asset Management Service Agreement and Demand Reduction Guarantee, meaning all routine and unscheduled maintenance is included, and if guaranteed demand reductions are not met, Sharp will compensate for the deficit in promised peak demand reductions. EF

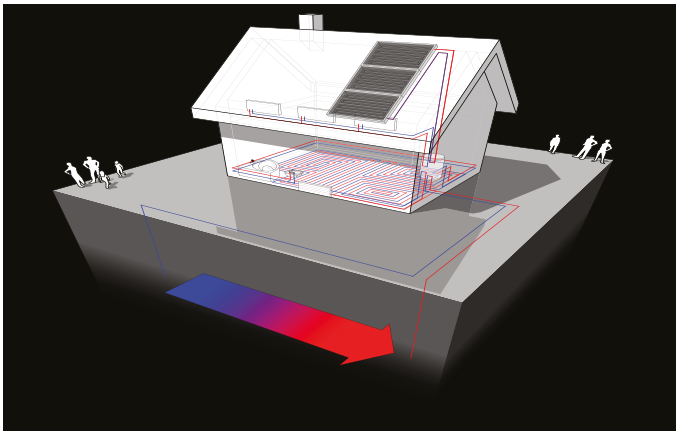
Source: www.pennenergy.com

NOVEL HYBRID SOLAR PV–GEOTHERMAL ENERGY SYSTEM PILOTED IN SWEDEN

Research by SP Technical Research Institute of Sweden has provided proof of concept for a novel hybrid renewable energy system featuring combined hybrid solar PV and geothermal power. The concept is based around a system integrating hybrid solar PV, ground-source heat pump (GSHP), and borehole thermal energy storage technologies. The result is a system in which outputs of each technology are highly complementary to one another and carry the potential to increase energy efficiency and cost effectiveness of individual components.

'It's one of the first demonstrations of hybrid solar combined with GSHP in Sweden', Pernilla Gervind, one of the lead researchers on the project, told Renewable Energy World.

Hybrid solar PV modules consist of conventional PV cells with embedded systems containing some form of cooling agent, typically water or air, which is circulated through PV panels. The intention here is to reduce PV cell temperatures, as it is known that overheating reduces PV cell efficiency significantly. The new system advances the hybrid solar PV concept by making use of the output water within a vertical loop GSHP system through which it flows.



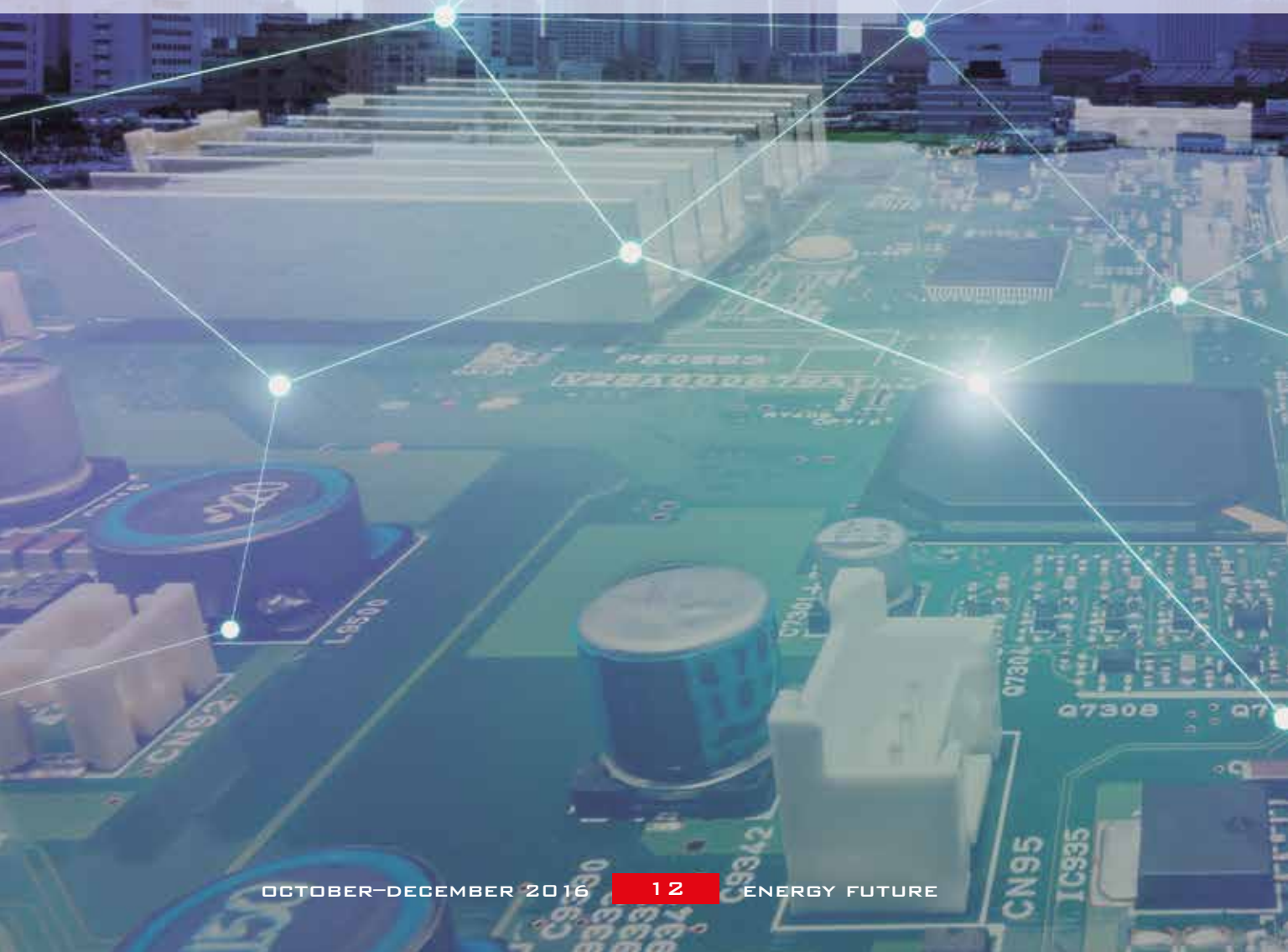
The system stands to be especially useful in Sweden, where geothermal energy is dominated by low temperature, shallow systems featuring GSHPs used for space heating and domestic hot water heating. About 20% of the Swedish buildings use GSHPs, according to the International Geothermal Association.

In the study, which was supported by the Swedish Energy Agency together with Energiförbättring Väst, the system was piloted through 2015 on the west coast of Sweden over 70 terraced houses. 'Our focus was on evaluating the system, and ensuring it worked', Jessica Benson, Gervind's co-researcher, told *Renewable Energy World*. 'On this level, we're very confident in the potential of the system'. Owing to relative success of the pilot, the researchers are looking towards future studies. EF

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

SMART GRID

THE FUTURE OF ELECTRICITY



In the modern age, electricity is perhaps the most widely used form of energy and its demand—domestic and global—is growing continuously at a fast pace. However, the widespread use of electricity also leads to increased carbon dioxide emissions and in the process a significant contributor to climate change. In this context, it is important that electricity and its distribution mechanisms undergo adjustments and modifications to balance the demand for power and at the same time, reduce the impact on the climate. **Atanu Dasgupta**, in this article, describes the smart grid as an evolved grid system that manages electricity demand in a sustainable, reliable, and economic manner, built on advanced infrastructure and tuned to facilitate the integration of all the stakeholders.

Smart Grid is poised to revolutionize our thinking and style of operation in areas of electric power generation and its transportation and distribution to end-users, thus, maximizing all-round societal benefits to all concerned. A culmination of technological innovation and efforts amongst its stakeholders, Smart Grid aims at achieving all-pervading efficiency and economy. In other words, Smart Grid is nothing short of a revolution that involves power plant operators, transporters of electrical energy, distributors, associated industry, and end customers.

Essentially, an energy delivery system becomes a Smart Grid when it is distributed in a wide area, automated to a very large extent, and implemented for establishing a bi-directional flow of electricity and data. This is created for monitoring and control of the entire power system and facilitating response to changes in everything from choices of power plants to the preferences of the individual customer; the latter may even be extended to home appliances.

The Smart Grid is also conceived as a means for reducing carbon footprint because of lesser emissions and increased deployment of renewable energy resources with a view to empowering the 21st century society through unprecedented quality of power.

The Smart Grid will allow the highest level of convergence of power system operational technology and Information and Communication Technology (ICT) applied to the electric grid, offering cheapest alternatives to customers and improved security, reliability, efficiency, and profitability to utilities. The Smart Grid, also known as 'electricity with a brain', 'the energy internet', and 'the electronet', is poised to offer a convenient operational umbrella over generation, transmission, distribution, metering, and, beyond the energy meter inside customer premises.

Methodology for Implementation

In light of the foregoing discussion, the Smart Grid implementation can be strategized holistically from beginning to end with various components therein over specific timeframe and methodology. The Smart Grid shall cover various components such as generation, transmission, distribution, metering and the end user, as visible in Figure 1. The successful delivery of the Smart Grid solution shall, however, be contingent on the strategic convergence of three industries/sectors with dedicated contents as per the following:

- The Physical Power Layer (the power transmission and distribution network)
- The Data Transport and Control Layer (telecommunications infrastructure and control system)
- The Application Layer (applications and services using IT)

The Smart Grid is poised to run applications among the different constituents, for instance, the utilities and consumers, can operate only piggy-back on an end-to-end telecommunication network.

As a general practice, power utilities maintain their own local area networks (LANs) and wide area networks (WANs) for internal data traffic and voice communication amongst the utility's operational offices as well as to and from the substations/control centre(s). However, at present, no dedicated

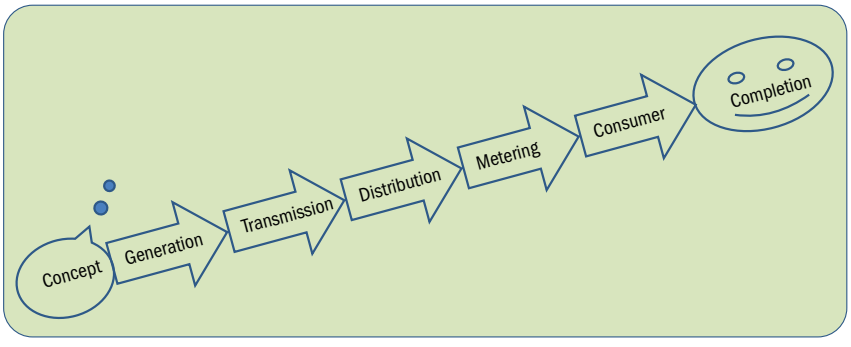


Figure 1 Smart Grid implementation: Conceptualization to completion

communication link exists between the utility and the end consumers. As many new applications are being developed to improve and optimize the generation, delivery, and consumption of electricity in a Smart Grid environment, the necessity of end-to-end communications layer cannot be ignored.

Similar to the bi-directional data traffic in a typical data communication scenario, electric power is also incredibly but certainly expected to flow bi-directionally in a Smart Grid environment. The intelligent grid of the future will deploy large-scale distributed power sources, such as photovoltaics, micro-wind turbines, micro hydels, and stationary fuel cells, etc., and storage capacities. As a first step to achieve these, the typical mechanical energy meters are being replaced by gadgets known as Smart Meters as a component of the Advanced Metering Infrastructure (AMI), covering a wide area environment. Smart meters will maintain an account of export and import of energy and will provide bi-directional communication having dedicated transmit and receive ports. This arrangement will also facilitate development of an intelligent Field Area Network (FAN) with an idea to provide the data communication links among the consumers and distribution companies, control centres, operational offices, etc.

The AMI will typically comprise the following layers:

- Transport layer for two-way communications between the Smart Meter at the utility end and the wide area network using the intelligent FAN.
- Application layer that is embedded with metering specific 'applications' as required by the utility companies.

Large-scale deployment involving AMI and FAN will eventually peep into individual homes and buildings and become integrated with Home Area Network (HAN)—another inseparable partner in the Smart Grid environment.

The future world is, thus, getting ready for extensive end-to-end

communication facilities bridging the power/utility companies and numerous intelligent appliances and non-conventional generating resources. This arrangement will help utility companies to assess the demand side response more accurately, helping both sides, and resulting in reliable and economic operation.

Consequently, the strategic convergence of three sectors, viz. power, communications, and applications will bring a new flexibility in grid operation, thus, pushing the era of Smart Grid. Figure 2 highlights the layers, technologies, and applications that are required to be considered under Smart Grid solution end-to-end.

Elements of Smart Grid Implementation

While considering implementation of Smart Grid, certain basic elements need to be in place. Such elements, as listed, need to be understood, analysed, and finalized during the conceptual stage itself with the extent of their deployment individually with specific timelines.

- Demand Response (DR)
- Grid Optimization
- Distributed Generation

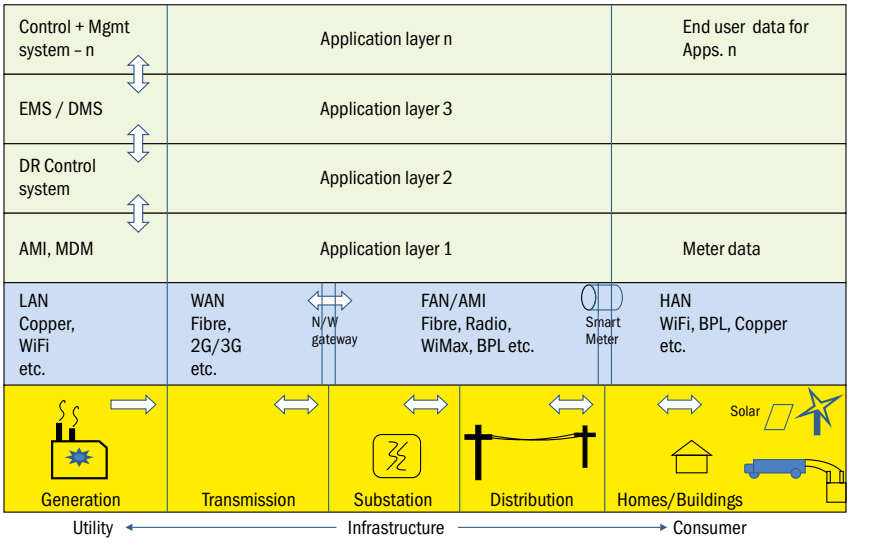


Figure 2 Smart Grid implementation: Convergence methodology

- Energy Storage
- Plug-in Hybrid Electric Vehicles (PHEV): Smart Charging and Vehicle to Grid (V2G)
- Integrated Energy Management
- Home Area Network and Management System

A detailed description of these is as below briefly:

Advanced Metering Infrastructure (AMI) and Field Area Network (FAN)

AMI, in association with FAN, is perhaps the most important component of end-to-end multilayered Smart Grid implementation. Metering data collection has been made easy using AMI/FAN infrastructure as the former no longer depends on manual visits to the concerned locations, saving time and money.

In addition to running advanced metering applications, the AMI/FAN network can also be used to transport all other traffic in respect of variety of other Smart Grid applications. The utility can fetch the required data from the consumer end instantaneously about the performance of the grid, outages, faults, and other unwanted incidents. Further integration of distributed generation and storage and Demand Side management (DSM), etc., can be managed more effectively once the last mile network, that is, AMI/FAN is in position.

Demand Response

DR happens to be a great tool towards achieving true Smart Grid implementation. Both utilities and customers are going to be benefitted by DR since this will help in achieving real DSM. During the period of peak consumption, consumers can be motivated to optimize their consumption of electricity by using Smart Grid communication networks. Agreements in this regard can be in place to persuade consumers to use the energy in a pre-determined manner considering time-of-day metering. This concept, if implemented, can help both customers (residential and industrial) and utilities to achieve maximum economic operation. With DR implemented in the system, utilities need not go for expensive generator-operation for meeting the peak demand and consumers also save money by using off-peak period electricity rates for the same functions in a modified schedule. DR is considered as a more economical solution than operating peaking plants such as gas turbine generators and is faster too. Consequently, an environment-friendly arrangement can be created that will certainly contribute towards lowering the carbon footprint.

Grid Optimization

The delivery of power efficiently and economically through the transmission

grid as well as distribution system requires fastest possible control of the network from the utility or grid control centres. Various factors contribute to the economy of operation in an integrated grid scenario, including optimization and delivery of power. Under such situations, the Grid Optimization tool is really handy and effective, which is ensured through the proper deployment of AMI/FNI infrastructure and proposed ICT in the entire power chain (refer to Figures 2 and 3). Needless to say that this infrastructure will improve visibility of the entire network and further operations-related analytics. Transmission and distribution losses can also be cut down considerably using the visibility, which will enable the power companies to improve their bottom lines. The general performance of the grid will improve offering better security, reliability, and efficiency, once the aforesaid visibility and analytics are properly developed and stabilized. It will also be possible to pinpoint the faulty segments in a distribution network and help in taking the corrective action.

Adding Distributed Generation to the Grid Smartly

As a concept, distributed generation began with electrification in the country and the world. Similarly, various technologies for generation of renewable energy, such as solar PV and solar thermal, wind turbines, etc., have also been around for some time, although the technologies used therein today are vastly updated. However, the importance of distributed generation, with particular focus on renewable energy, lies in the fact that they can effectively be a part of the Smart Grid initiative. As is visible in Figure 2, using the AMI/FNA and other ICT infrastructure, the utilization of the solar plants as per actual requirements of the grid can be made faster and easier and grid-quality power can be fed into the grid even from homes and buildings efficiently and economically. Other renewable energy sources such as wind turbine, fuel cells, etc., can also be integrated to the grid likewise and the beneficiaries will be utilities and homeowners. Will it not make perfect economic sense to make or save extra money this way? Reducing the dependence on large thermal plants will be another advantage of this initiative, effectively cutting global warming and reducing the carbon footprint.

Energy Storage

The concept that electric energy cannot be stored easily and needs be consumed as and when generated has been traditionally ingrained but the same faces a challenge in the changing environment of Smart Grid. Storage is going to be inseparable in this game and needs to be delivered as a viable component. Although the storage of electric energy needs no central location, generally the necessity, of the same, at times needs be recognized. In the Smart Grid scenario, the storage facilities can be distributed as per requirement considering perspectives of distributed generation and load centre. The storage concept has not been felt historically in the light of its impracticality and traditional belief. However, with possibility of large-scale introduction of renewable energy sources, the intermittency associated with it, points to the feasibility of energy storage in a Smart Grid scenario.

INTEGRATED ENERGY MANAGEMENT UNDER THE SMART GRID ENVIRONMENT SHALL MAKE USE OF A SET OF ADVANCED TOOLS AND APPLICATIONS FOR MONITORING AND CONTROL OF SMART NETWORKS, POWER PLANTS OWNED BY VARIOUS UTILITIES, HOMES/ BUILDINGS UTILIZING THE SMART GRID AND POWER SYSTEM INFRASTRUCTURE, AND RELATED ICT AND VARIOUS APPLICATIONS.

Plug-In Hybrid Electric Vehicles (PHEV): Smart Charging and V2G

This concept appears to be totally out-of-the-box, yet one has to accept the same in view of the revolution that has already started. The large-scale introduction of PHEV is on the cards, and the automobile industry is experiencing a flurry of activities in the related

fields— rising cost of conventional fuel and its depleting stock around the world being the motivation. However, in the backdrop of the revolution called Smart Grid, there is a possibility that this initiative may also be fruitfully utilized in a much larger perspective. With such efforts, the societal benefits accruable consequently would be much larger than that was considered earlier. Under the proposed new environment, PHEVs can get their large batteries charged using decentralized renewable energy resources, for example, solar, wind, etc. As a consequence, peaking of the grid on a large scale can be avoided, and the much needed energy for automobile battery-charging can be made available concurrently in a safe and economical way. The energy so stored in PHEV batteries can be fed back to the grid during high demand. The automobile industry, in appreciation of this development, is gearing up to introduce better technologies and procedures. Thus, the idea of V2G power feeding in times of need would be quite feasible with the magic of Smart Grid.

Integrated Energy Management

Integrated Energy Management under the Smart Grid environment shall make use of a set of advanced tools and applications for monitoring and control of Smart Networks, power plants owned by various utilities, homes/buildings utilizing the Smart Grid and power system infrastructure, and related ICT and various applications.

Generally, in power sector various utilities have not been interconnected so intimately prior to the availability of Smart Grid solutions. With Smart Grid in operation and a supporting communication infrastructure, including AMI/FAN, etc., in place, utilities would have the necessary wherewithal to interact faster amongst themselves. The real potential of Smart Grid initiatives can be realized only when utilities would interact mutually to gain financially and operationally, simultaneously taking complete care of the consumers. Using similar principles, tools, and applications, such peer-to-peer collaboration can also take place at the base level for the benefits of all concerned.

Home Area Network and Management System

Enabling appliances at homes and buildings (and small commercial premises), with networking capabilities, and impregnating them with required intelligence will be the first priority so that they can perform as required.

This done, appliances at the base level, such as lighting and A/C systems, washing machines, refrigerators, etc., can be made to work keeping in view energy conservation, optimization, and reduction of running cost. This is going to help utilities perform efficiently, thus, avoiding or flattening peak loading patterns, etc.

The Home Area Network (HAN) begins on the customer side of the meter and will connect plug-in hybrid electric vehicles, renewable and/or distributed generation, HVAC systems, and myriad intelligent appliances (Figure 2). Customers can accordingly be educated and utilities can run the power system in a cost-effective manner, avoiding unnecessary burden on thermal generation and gas turbines, etc., during peak hour loading. Thus, the Smart Grid initiative is intended to convert ordinary consumers of electricity to 'prosumers' who will proactively participate in the operation of the holistic power system.

Various Requirements for Smart Grid Implementation

In order to operationalize and integrate the elements in Smart Grid solution, as discussed, the following facilities and issues are required to be understood and addressed.

Communications

Smart Grid cannot be implemented without an end-to-end communication facility with highest degrees of availability and reliability. For this purpose, the utility WAN is implemented to host applications for safe and reliable operation of the electric utility

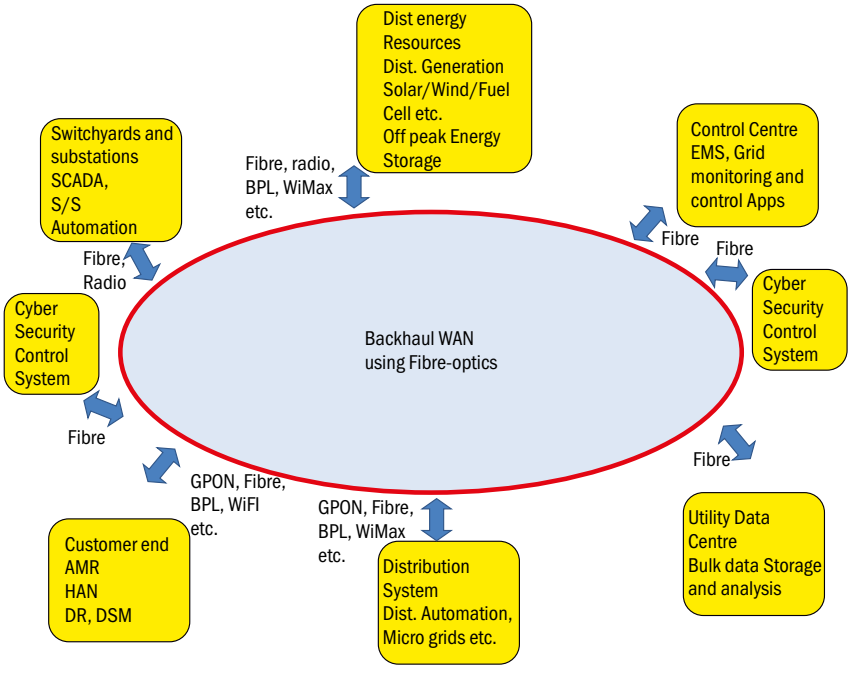
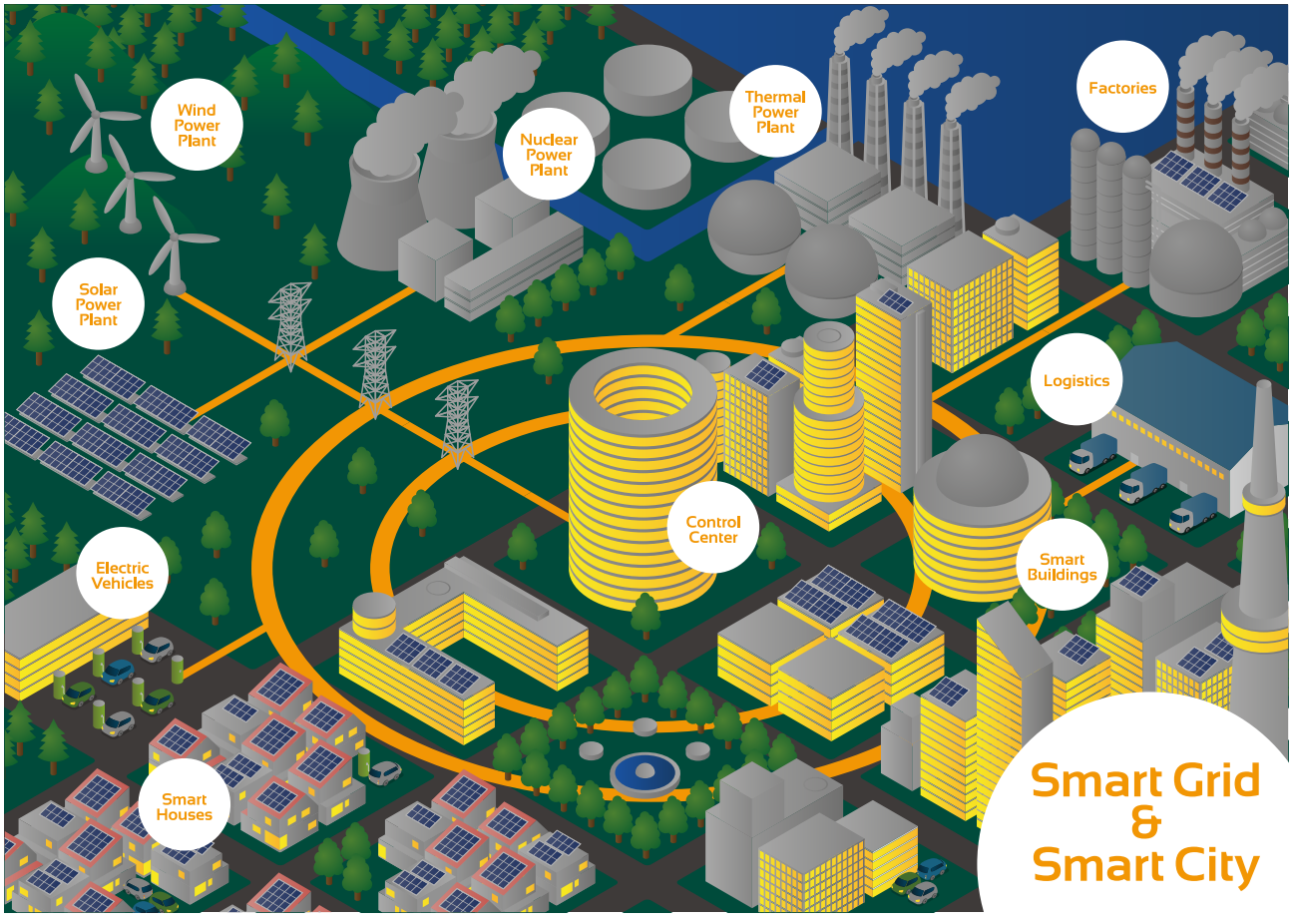


Figure 3: Communication media at various levels



infrastructure that may include SCADA/EMS, Asset Management System, mobile voice and data services, plant/substation automation, distribution feeder automation, protection signalling for EHV lines and substation equipment, remote surveillance, disaster management, etc. Routine business applications such as corporate voice and data networks, which are relatively less important, are also suitably supported.

The WAN in a typical electric utility environment consists of a high capacity transport backbone network that backhauls large numbers of channels and applications from the utility service areas to the control centre(s). Lower bandwidth segments, or spurs, interconnect individual or small groups of facilities to the backbone. Fibre optics and/or digital microwave radio are usually the technologies of choice for backbone transport, whereas the spurs may combine these technologies with lower bandwidth media, such as copper twisted-pair wire lines, power line carrier, VHF and UHF radio links, unlicensed wireless systems, and even satellite communication system.

Of late, Information Communication Technology (ICT) utilizing Internet Protocol (IP) transport over ethernet has placed IP as a desirable standard for data transport covering traditional utility power delivery applications along with enormous volume of new data owing to the wide implementation of the Smart Grid. The Smart Grid implementation will typically require upgradation of existing backbones to backhaul Ethernet/IP data traffic at speeds ranging from one to 10 gigabites per second. The most modern Multi Protocol Label Switching (MPLS) platform may also be used for the data network in the utility environment.

Data Integration and Management Issues

The Smart Grid environment will embrace billions of data points with thousands of system devices and customers in millions. This data shall be converted to quantum of information through a specific process in which the data from meters and appliances and substations/distribution systems shall be processed and integrated for further action. Considering this background, a suitable action plan needs be generated as a tool for better understanding of load factors, energy usage patterns, equipment status, voltage levels, etc.

The first phase of the knowledge management effort and a key component in the system of information ecosystem is data conservation in a data warehouse. Obviously this will skyrocket data storage needs with increased concerns of data security. Fortunately,

the huge growth potential in this area has been recognized by IBM, Oracle, and Microsoft, and they have been vigorously marketing their solutions.

Improving Load Factors

The electric utilities' load factor can be improved by using DR and DSM programmes. The introduction of such tools will enable customers to enjoy lower Kilo Watt Hour rates in return for the utility's right to curtail power delivery during peak hours. DSM is the way to incentivize customers to opt for time-of-use rates in consonance with cost of production of electricity. The application of DR and DSM is intended to move electric load as prompted by the power system and thus help in raising electric utilities' load factor.

Standardization

The success of Smart Grid implementation on a large scale is feasible when each of the components in the chain (Figures 1 and 2) perform smoothly without creating undesirable hindrances toward inter-operability and overall performance. The meaningful transition of the Indian power sector to Smart Grid environment will be the result of tightening industry standards encompassing the system architecture and performance of the applications. The great convergence of electrical and ICT infrastructure shall be suitably coordinated by system architecture and standards. Such architectures and standards must be inflexible in quality but flexible enough to be tailored with needs of the day.

Cyber security in this highly complex scenario is vitally important, cannot be in place unless system architectures and associated standards are followed strictly. Last but not the least is the electrical power environment that will require highest standards of EMI/EMC and RFI compatibility concerning all the equipment, components and modules, systems and subsystems, associated with the Smart Grid implementation. Keeping this goal in view, various international authorities and organizations have been busy in generating appropriate standards and codes. The IEEE Standards Association (IEEE-SA) is at the forefront of such initiatives globally besides other organizations such as the North American Electric Reliability Corporation (NERC), Utilities Telecom Council (UTC), CIGRE, etc.

Cyber Security

The Smart Grid scenario will require interconnection of various entities, as described, through the intensive ICT system. The entire network might be interconnected with internet also at certain points for meeting various operational requirements. Under these circumstances, the Smart Grid network may be dangerously exposed to the world outside its territory making it vulnerable to hacking and unsecured/ unlawful/unsafe operations by outsiders. Therefore, cyber security will be a great concern that needs to be addressed at each stage of implementation and during the operation of the Smart Grid.

Disaster Management

This is another area that is usually missed out during any project implementation. Often, the requirement is realized after operationalization of the project and occurrence of a few disasters. A half-baked retrofit never works with its intended objectives towards fulfilling the requirements.

Indian Initiative

Despite POWERGRID's initiatives in the recent past in the EHV transmission sector, India is considered to be a country with one of the weakest electrical grid system in the world that has not been designed for high-capacity, long-distance power transfer. The overall distribution system has been highly inefficient, as is visible by the customers' continued sufferings. Although economic growth in India in the last few years has been impressive, it is recognized that with expansion of its electrical grid, India loses money for every unit of electricity sold due to its weak infrastructure. With a view to empowering India to continue its path of economic growth, it needs to develop an intelligent and efficient grid. Only a reliable and financially secure Smart Grid can create a conducive environment for investments in electric infrastructure. Large-scale implementation of Smart Grid projects are expected to address some of the significant challenges such as weak infrastructure, power thefts, transmission and distribution losses, and higher quality of power, with reducing frequency of blackouts. As a bonus, Smart Grid implementation is

One can see some areas in which Smart Grid standards by IEEE-SA are being developed:
IEEE C37.118TM: PMU performance specifications and communications
IEEE 1547TM Series: Interconnections between utility and DR and storage
IEEE 1686TM -2007: Substation IED functions and features
IEEE 1588TM: Time management and clock synchronization
IEEE P1703TM: End Device Tables communication over any network
IEEE 1901TM: Broadband communication over Powerline MAC and PHY protocols
IEEE 802 Family: Standards developed by LAN/MAN Standards Committee
IEEE 2030TM: Guide for Smart Grid Interoperability of Energy, IT, and Electric Power Systems and End Use applications
IEEE 1159.3TM: Applications using power quality data
IEEE C37.111TM -1999: Applications using transient data from power system monitoring
IEEE C37.232TM: Naming time sequence data files for substation equipment
IEEE C37.2TM -2008: Protective circuit device modelling numbering scheme
IEEE 1379TM -2000: Substation Automation – IEDs and RTU

expected to introduce a fresh pool of talents, skills, and knowledge. Hopes are high that implementation of Smart Grid technologies will reduce electricity transmission and distribution losses by 510% annually in India.

However, serious challenges in adopting Smart Grid, such as theft of electric power, perhaps unthinkable in the developed world, need to be handled.

The distribution sector in India is in shambles with shoddy implementation and total mismanagement. Regulatory controls are either absent or too weak to be felt or seen for its effects. A Smart Grid has, therefore, been identified among the most important solutions to meet the increasing demand for power and to ensure better energy efficiency. A Smart Grid will also enable exploitation of the huge potential in the generation of renewable sources, particularly solar and wind.

In order to boost the systemic growth of the Smart Grid in the country, 'India Smart Grid Forum', 'India Smart Grid Task Force', and 'National Smart Grid Mission' (NSGM) have been active under the aegis of the Ministry of Power. The Ministry of Power's India Smart Grid Task Force (ISGTF) is an inter-ministerial group and shall serve as the government's focal point for activities related to 'Smart Grid' and to evolve a road map for implementation of Smart Grids in India. Besides, the NSGM has been spearheading a number of pilot projects on Smart Grid implementation.

Conclusion

In the light of possible proliferation of Smart Grid projects as described earlier, the electric power industry, in general, is getting ready for a large transformation on technologies and volume and there will be bewildering challenges and opportunities.

The implementation of Smart Grid starting from conceptualization to development of infrastructure with host of technological innovations/challenges, handling management issues, arranging finance, and finally completion of the project with total customer satisfaction, is nothing short of a revolution.

Obviously, Smart Grid is not going to be a readymade solution served on a platter; on the contrary, it will be a long-drawn evolutionary process, which is a time-consuming, methodical, and evolutionary transformation. The implementers of such projects shall have to intimately involve multiple sectors across industry and society with the tenacity and sagacity of preachers. It is wise to sensitize all concerned well in advance before starting any Smart Grid implementation so as to prepare all the stakeholders with clear vision and objectives. It is, however, important that the government becomes more proactive and leads Smart Grid implementation in a unified manner, through a single agency for the entire country for the sake of standardization, quality, and economy. EF

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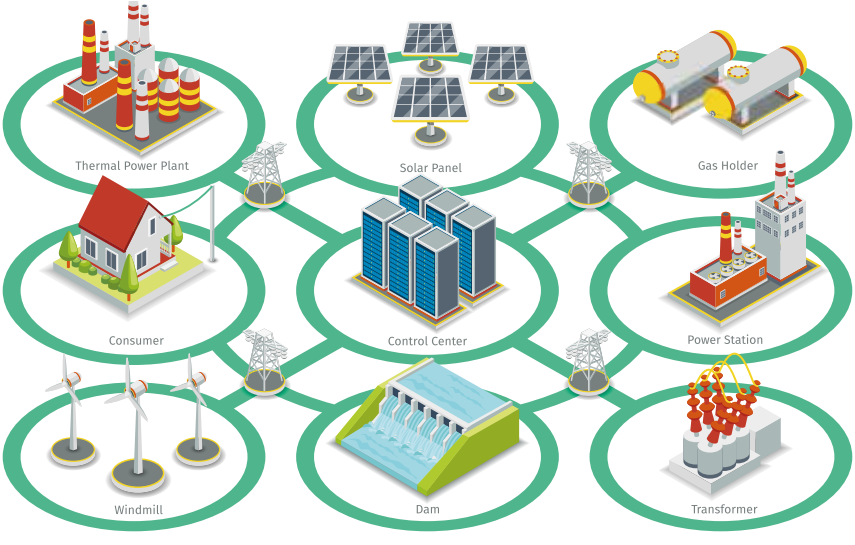
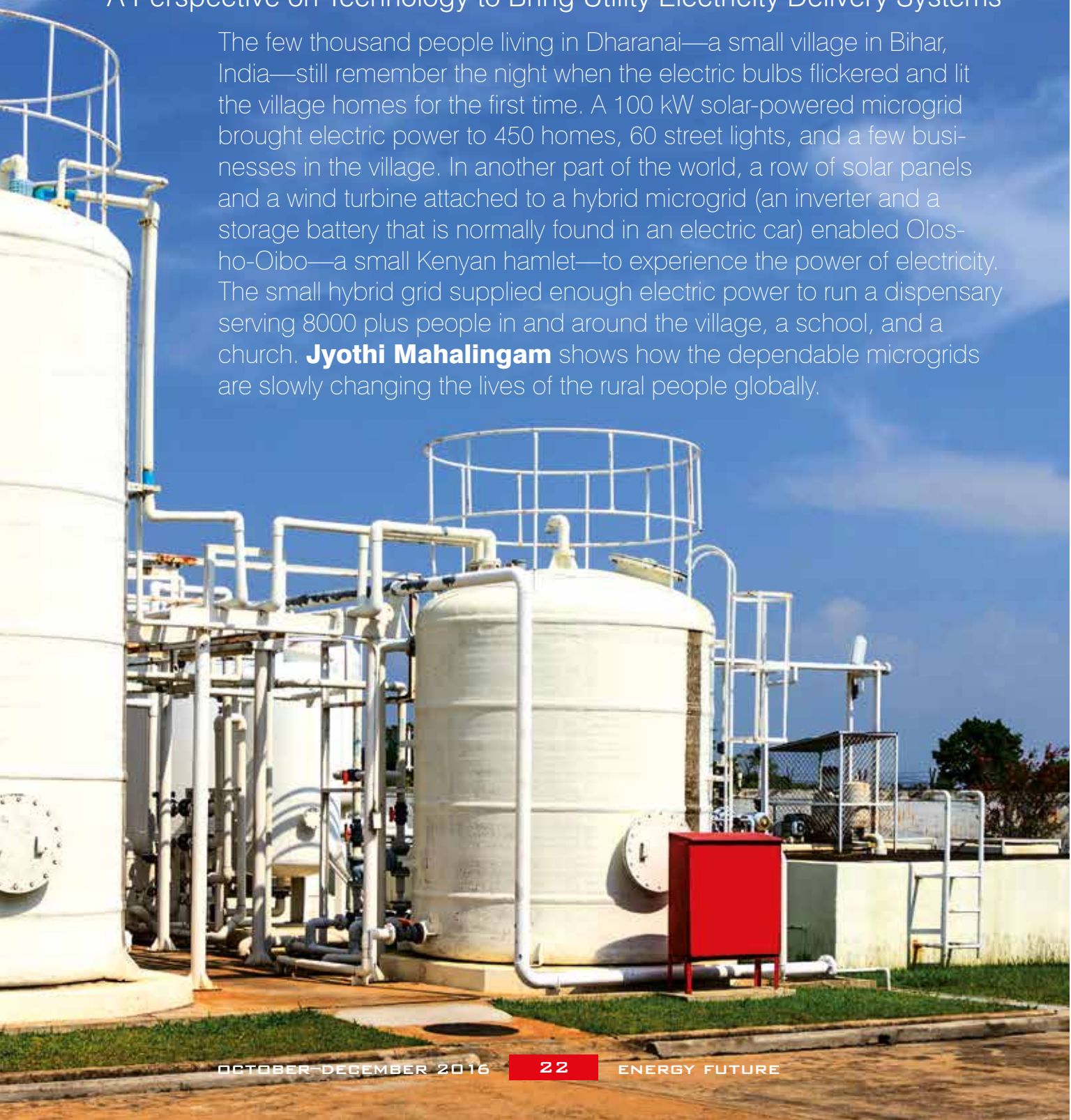


MICROGRIDS

A Perspective on Technology to Bring Utility Electricity Delivery Systems

The few thousand people living in Dharanai—a small village in Bihar, India—still remember the night when the electric bulbs flickered and lit the village homes for the first time. A 100 kW solar-powered microgrid brought electric power to 450 homes, 60 street lights, and a few businesses in the village. In another part of the world, a row of solar panels and a wind turbine attached to a hybrid microgrid (an inverter and a storage battery that is normally found in an electric car) enabled Olos-ho-Oibo—a small Kenyan hamlet—to experience the power of electricity. The small hybrid grid supplied enough electric power to run a dispensary serving 8000 plus people in and around the village, a school, and a church. **Jyothi Mahalingam** shows how the dependable microgrids are slowly changing the lives of the rural people globally.



Worldwide demand for electric energy is growing due to increase in population and economic growth. Access to electric power has become an important element in the social and economic development of a country. But, millions of people still live in dark due to steep installation costs and constraints in extending conventional power grid to remote locations. According to 'World Energy Outlook 2015', a report published by International Energy Agency, globally nearly 1201 million people, that is, 17% of the world population, still live without connectivity to electricity. The sub-Saharan Africa leads the table with 634 million people, followed by developing Asian countries with 526 million (in which India accounts for 237 million), and Latin American and Middle East countries each with 22 million and 17 million, respectively, people.

During the last two decades, global electric power generation, delivery, and consumption have undergone significant changes. Rise in demand keeps the power segment dynamic, showing spectacular growth. But, existing old grids are unable to cope-up with the surge in power loads and suffer from frequent outages; also, extreme weather vagaries often cripple their functioning. Such regular power interruptions disrupt manufacturing sector leading to huge economic loss. The top-down radial grid architecture that supplies power from a centralized power plant is becoming obsolete. Also, in wake of global warming, there is a paradigm shift in use of carbon-emitting centralized coal- and oil-using power plants. The grid is slowly getting replaced by localized systems known as microgrids. The microgrids, while providing right solution to sudden power outages, also address concerns about the power quality and reliability issues faced by centralized grid system.

About Microgrids

As the name stands, microgrids are mini editions of normal electrical grids. The increase in use of renewable energy sources, also known as distributed energy resources (DER), such as solar, wind, and biomass, paved the way for on-site generation (OSG) of power using microgrids. The modular systems feature unique technologies to function as an independent power system or to run in parallel with a utility grid. Present day advanced microgrids are equipped with a power generation module, an energy storage feature, a distribution system, voltage regulation controls, and switch gears, which enable efficient operation.

The design architecture enables a microgrid to work in island mode or in grid-connected mode. In island mode, the microgrid uses renewable energy sources, such as solar, wind, biomass, etc., to supply the power. In the grid-connected mode, it operates either using grid power or DER. It employs in-built advanced monitoring and automated power management systems to regulate power supply. The present grid-connected microgrids, by design, continue to keep up uninterrupted power supply in case of power failure, while safely disconnecting from the grid.

Microgrids Join the Mainstream

The last five years saw a great deal of advancements in microgrids technology. It is steadily moving to join the main power stream due to the following factors.

Fall in renewable energy generation costs

In the initial stages across the globe, government subsidies played a crucial role in penetration of solar and wind energy power generation. Technical advancements in the use of raw material and consequent fall in installation and power generation costs assisted the growth of renewable energy sources. According to a report released by American Wind Energy Association, the cost of wind-generated electricity saw nearly 66% drop in the USA during the last six years. The Bloomberg New Energy Finance report released in April 2016 quotes that the cost of generating solar power has come down by nearly 1/150th level of the costs in 1970s. The agency report further observes that the number of solar installations have gone up by nearly 115 000 fold during the period. Drastic drop in distributive power generation (solar, wind, etc.) costs, fuelled a shift towards decentralized power production globally, favouring acceptance of microgrid technology.

Sophisticated energy storage systems and technologies

Most of the present day microgrids deploy DER and use a voltage source to regulate the generated power. Unlike the older versions that used a backup diesel generator, present day microgrids employ energy storage systems (ESSs) as

backup. The use of advanced lead-acid, lithium, and nickel-cadmium in storage systems radically increased the storage capabilities while cutting down on space occupancy.

Though designed to work even with 50% power load, such microgrids continue to have ESS as a norm. The ESSs, other than offering a constant voltage, also assist in smooth power flow, peak shaving, and volt ampere reactive support. The ESS also extends islanding and black-start support to renewable distributed generation microgrid systems. The smart grid technologies, real-time availability of computer data, and use of advanced software to manage grid outage problems further assists microgrids to join the main stream.

Offer cost-effective solution to obsolete grids

The existing grids managed by utilities in most of the countries, including the developed countries, became outmoded, needing regular maintenance or replacement. Also, the staggering investment costs involved to update the old grids or install a new grid, to carry both conventional and renewable power, worries both the developed and developing economies. The microgrids that use locally controlled distributed energy sources are now favoured as cost-efficient electricity infrastructure replacement.

Types of Microgrids

Campus microgrids

Autonomous and isolated campuses, such as military, corporate, and university, use campus microgrids. Supported by renewable energy generation facilities and distributed ESS, the microgrids also function independently when needed.

Community microgrid

Most of the community microgrids are utility linked and utility operated. The DER used are also approved by the utility. Such microgrids are often

deployed to get better grid resiliency and support essential services of the community in case of grid outages.

Islanded microgrid

The microgrids installed to supply power to isolated industrial locations or remote communities are known as islanded microgrid. Equipped with distributed power generation and advanced storage facilities, such grids do not depend on main power grid and use diesel power as standby.

Nanogrid

The term Nanogrid defines the miniature version of a microgrid. Nanogrids are usually installed to supply electricity to a building or to run a machine.

Hybrid microgrid systems

Hybrid microgrids use lead acid batteries with valve regulators to store the power, a microgrid controller to manage the renewable energy power supply are known as advanced system. Such systems deploy a diesel generator as standby.

Challenges Faced by Microgrids

The microgrids achieved resilience by getting connected to a variety of distributed generation (solar, wind, biomass, etc.) and used storage devices to deal with the intermittent nature of renewable power generation. During the time of grid power outages, such storage devices stayed alive with power in islanded condition, instead of tripping along with the grid, thus posing danger to the line men. To overcome the problem, present day microgrids use advanced inverter technologies and software programs, to shut down when an alert is received from the tripped substation.

The standard P1547.4, introduced by Institute of Electrical and Electronics Engineers as criterion in 2011, suggests best practices for safe islanding and reconnection of microgrids with the main grid, while providing uninterrupted power supply to the clients. In 1999, the Consortium for Electric Reliability Technology Solutions provided a set of standards to improve the functional dependability of the US electric power system and promote microgrid development.

The prohibitive investment in installing microgrids once posed problem in bringing the technology into main stream. But, continued decline in production costs of renewable energy sources (wind, solar, etc.), power storage systems (super capacitors, batteries, etc.), sophisticated load controls, and smart switches helped in cost-viable installation of microgrids along with conventional power sources.

Potential Benefits of Microgrids

- Use sustainable energy to assist in cutting down the emission levels of greenhouse gases.
- Supports the grids in optimizing the supply and to reach more customers.
- OSG of power is more economic than drawing it from a long distance.
- Resilience to palliate the impact of power outages during extreme weather conditions.
- Reliable to assure maximum uptime power facility to the users.
- Asset optimization due to inherent feature to work with diverse DER.
- Increases the asset value of the local economy.

Global Microgrids Market

The microgrid market is growing globally. Especially in geographic regions that are not covered by established grid power supply offer tremendous opportunity. A latest Transparency Market Research report titled 'Microgrid Market - Global Industry Analysis, Size, Share, Growth, Trends, and Forecast 2014–2020' presents a rosy picture on the future of microgrids. It estimates the global microgrid market will go up from US$9.8 billion in 2013 to US$35.1 billion by 2020. It reckons the growth will be around 20.70% during the period from 2014 to 2020. The report predicts the segments such as remotely located islands, commercial and industrial, military and defence, educational campus and institutions, utility and community will fuel the growth of microgrids.

According to Navigant Research, the worldwide microgrid market is growing despite lack of government support in certain segments. It finds presently Asia Pacific presents the largest market for microgrids and anticipates North America will surpass it in 10 years' time. The report forecasts the global microgrids capacity will reach 7.6 GW in 2024 from 1.45 GW in 2015. The research, as of second quarter of 2016, has identified nearly 1568 projects operating globally, generating nearly 15 600 MW power. It also states that about 147 new projects planned are under various stages of implementation. The research highlighted a 211 MW project managed by Blue Pillar in the USA, a 202 MW project in Sampolo, Corsica, and a proposed 200 MW solar-powered project in Senegal, Africa, as most notable among them.

The report points out that the remote microgrid segment continues to grow in African region, Middle East, Asia-Pacific and Latin American countries. It estimates, globally, the collective value of assets and services related to the remote microgrids, will grow from $10.9 billion in 2015 to $196.5 billion in 2024. The report cites technologies such as combined heat and power, micro-storage, and solar photovoltaic as key technology drivers.

'The Global Energy Storage for Microgrids Market 2014-2018', a report released by RnR Market Research, forecasts the global microgrid energy storage market will achieve a CAGR of 19% during the period from 2013 to 2018. Some of the leading players in the global microgrid market include ZBB Energy Corporation, Siemens AG, Power Analytics, Lockheed Martin Corporation, ABB Group, GE, Honeywell International Inc, Microgrid LLC, Toshiba Corporation, Schneider Electric, Viridity Energy Inc, Spirae Inc, Echelon Corporation, and Pareto Energy.

Microgrids in India

In June 2016, the Ministry of New and Renewable Energy (MNRE) has issued a draft 'National Policy for Renewable Energy based Micro and Mini Grids'. As per the policy, the government is planning to install around 10 000 micro and mini grids connected to renewable power in the next five years. The microgrids, planned to be located in unserved locations, will generate a total of 500 MW power and serve nearly 237 million people.

The proposed microgrids will generate less than 10 kW power and the mini grids will produce 10 kW or more power. The microgrids will use either single renewable energy source or function as a hybrid one connected to a mix of renewable energy sources.

The government is planning to involve Public Sector Organizations, rural energy service providers, financial institutions, and village panchayats to implement the projects. The locations identified to install the microgrids include Uttarakhand, Himachal Pradesh, Jammu and Kashmir, Andaman and Nicobar, Lakshadweep Islands, and North East States.

Looking Ahead

The global energy landscape is changing and DER are emerging as major contributors to the future power grid. The microgrid technology, though really has been there for decades, is now moving into mainstream from a niche segment using smart inverters and advanced energy storages. Making huge investment on grids to carry power for hundreds of kilometres from power plants is no more favoured. The innovative, flexible, and more complex microgrids offer potential to change the power distribution landscape. It is hoped the emerging joint ventures between the industry and technology vendors will resolve the nagging microgrids standardization issue soon.

Deployment and growth of microgrids faces the biggest challenge in the form of government regulations and utility reluctance to accept the technology. Only the support from government and utilities or grid market will quicken its entry into the mainstream to sustain the growth of communities. Quicker transition of microgrids into energy infrastructure will benefit the poor living in remote locations and contribute to cut down the CO_2 emission levels. EF

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INDIA WALKING THE TALK ON INDC COMMITMENT

India's commitment to green and sustainable practices

In October 2015 during CoP21, India put forth before the world its new climate plan, formally known as Intended Nationally Determined Contribution or INDC. India is the third-largest emitter in the world and is highly vulnerable to the impacts of climate change, it is encouraging to see the government and administration's interest in taking steps to mitigate climate change. **Saurabh Kumar** talks about the India's INDCs and what it means for India vis-à-vis energy efficiency, renewable energy, green practices, and so on

Consider these figures: Electricity consumption in India is expected to grow at a rate of 7% (CAGR) during the Twelfth Plan period and go beyond 1 trillion units by the end of 2017. With 363 million people, India is home to the largest proportion of global poor. It is expected that about 40% of India's population would be living in urban areas by 2030, as against 30% currently. These statistics show that in less than five years, India's energy consumption will go through the roof. Against the backdrop of these figures, one can form an idea of the global energy scenario in the future.

Today, almost every nation is talking about the significance of 'energy efficiency' in ensuring consistent growth and a sustainable planet. In 2015, at CoP21 in Paris, India not only took the centre stage by contributing significantly towards prevention of climate change, but reinforced its development imperative.

While Indian policymakers and leaders from different industries had known the concept of 'energy efficiency', things have moved fast in the last few years.

Launched in 2008, India's National Action Plan on Climate Control outlined existing and future policies and programmes addressing climate mitigation and adaptation. One of the eight core areas of the plan, which is to be implemented by 2017 is 'energy efficiency'. Under the National Mission for Enhanced Energy Efficiency (NMEEE), the Government of India is endorsing introduction of energy incentives and financing for public–private partnership to reduce energy consumption. Continuation of NMEEE for the Twelfth Plan was approved by the Cabinet on August 6, 2014, with a total outlay of ₹775 crore. The Mission seeks to upscale the efforts to unlock the market for energy efficiency, which is estimated to be around ₹74 000 crore and help achieve total avoided capacity addition of 19 598 MW, fuel savings of around 23 million tonnes per year, and greenhouse gas emissions reductions of 98.55 million tonnes per year at its full implementation stage.

Demand side measures focussing on energy efficiency can play the crucial role of moderating the increase in demand without compromising on the quality of output. Unlike the conventional power resources, energy efficiency resources (i.e., energy savings) can be acquired in short gestation periods, and investments required for installation of 1 MW of energy savings is only 20%–30% of installation costs of 1 MW of conventional energy sources. Additional benefit includes reduction of emissions. Therefore, saving energy comes out to be much cheaper than producing it in the first place.

However, India lies at the cusp of catching up with other countries with their initiatives related to the implementation of energy-efficient systems across various regions and landscapes. Although the government has set up and launched a number of initiatives, the global landscape has changed significantly since the last Five Year Plan with many countries from the West and across the Pacific Ocean taking long strides in establishing greener methods of consuming energy.

Energy Efficiency: A Global Endeavour

Globally,[1] many countries have jumpstarted various measures to bring in a new wave of energy-efficient procedures in their region, for example, Canada is a significant player. Canada's[2] ecoENERGY initiative, where the government has invested nearly $5 billion to help Canadians use energy in an efficient manner and boost renewable energy supplies, is also showing its mark in the country. Initiatives have been segregated according to buildings, industries, equipment standards, housing, and vehicles.

Similarly, South Australia[3] has planned a target of improving energy efficiency in houses up to 15% by 2020—a 5% increase in the target that was set in 2014. Various initiatives, such as managing energy use of air conditioners,

[1] https://en.wikipedia.org/wiki/Fossil-fuel_phase-out#Studies_about_fossil_fuel_phase-out

[2] http://www.nrcan.gc.ca/ecoaction

[3] https://www.sa.gov.au/topics/water-energy-and-environment/energy/government-energy-efficiency-initiatives

water heaters, ensuring six-star energy efficiency requirements for new homes, and a retailer energy efficiency scheme have been proposed and implemented by the government. The target is set higher for government buildings in the region, at 30% by 2020. Energy efficiency improvements have been achieved by moving to energy-efficient buildings, upgrading buildings, and inculcating refurbishments that use more efficient fittings.

Solar Alliance: Key Aspect of Energy Efficiency in the Future

India,[4] the third largest consumer of coal in the world, already has plans to stop coal imports in the next 2–3 years, a move that will save the country about ₹40 000 crore. India and France launched the International Solar Alliance at the UN Climate Change Conference in Paris in December 2015. With 25 countries as participants and a pledge to mobilize $1 trillion in investments in improving solar energy, the initiative will look to scale up solar technologies that are currently deployed only at a small scale and heavily invest in research and development of future solar technologies and capacity building. This will help in improving the efficiency and integration of solar energy as well as result in a spurt in number of solar applications available.[5] As a first step, all parties would begin analysing and sharing needs, objectives, and obstacles with each other, followed by the steps to implement initiatives. However, the work does not stop there. From India's point of view,[6] PSUs will play a major role in providing the necessary infrastructure to

boost solar power by the year 2022 and at the moment, 36 Central PSUs have given their commitment to develop 18 988 MW of renewable energy projects as part of the Green Energy Commitment.

EESL's Long-term Commitment to Energy Efficiency

With the vision of proliferating energy-efficient solutions as a must-have around the world, the Ministry of Power was established by the Energy Efficiency Services Limited (EESL) as an implementing agency for carrying out energy efficiency programmes in India. EESL was set up as a super energy services company, which is a Joint Venture of NTPC Limited, PFC, REC, and POWERGRID. Since then EESL has been working relentlessly to push faster adoption of energy-efficient solutions to meet energy demands of the people in India. The overall size of energy efficiency market is estimated at ₹74 000 crore. Till now, only 5% of this market has been tapped through ESCO (Energy Services Companies) mode mainly in the areas of lighting and industrial applications. It goes without saying that potential of energy efficiency in a country with a population of more than 1.2 billion is immense.

The establishment of EESL[7] was an important step in the larger context of India's new climate plan, the Intended

[4] http://www.dnaindia.com/money/report-india-to-stop-coal-imports-in-2-3-years-save-rs-40000-piyush-goyal-2202657

[5] http://cleantechnica.com/2016/04/27/international-solar-alliance-mobilise-1-trillion-solar-investment/

[6] http://pib.nic.in/newsite/pmreleases.aspx?mincode=28

[7] http://indianexpress.com/article/india/india-news-india/here-are-indias-indc-objectives-and-how-much-it-will-cost

Nationally Determined Contribution (INDC). The aim is to reduce emission levels by 35% by 2030 with new, efficient, and cleaner technologies in thermal power generation, reducing emissions from the transportation sector, and promoting energy efficiency in various sectors with a special focus on industry, transportation, buildings, and appliances as it is one of the biggest mitigation strategies for climate change. Besides, India will also look at developing climate-resilient infrastructure and produce 40% of its electricity from non-fossil fuel based energy resources by the year 2030.

EESL has stepped on the gas to make energy efficiency an integral part of the lives of Indian consumers. The electrical demand-supply power gap is a disturbing reality of our current situation, and measures are being taken to bridge this deficit. Several regulatory, policy, and market mechanisms to capture energy efficiency opportunities have already been taken up by the government through EESL. Here are some of the key initiatives that comes under the gambit of EESL.

Street Lighting National Project (SLNP)

The lighting sector accounts for about 20% of the total energy consumption in India. With inefficient and conventional lamps that light up the various roads and lanes of India, there's a significant scope for saving and promoting efficient lighting by promoting Light-Emitting Diode (LED) based lighting. Besides improving lighting levels, LEDs also have the potential to save both energy and costs up to 50%.

Launched in January 2015 by the Hon'ble Prime Minister, Shri Narendra Modi, the 100 cities National Programme for LED-based Homes and Street Lighting is currently in process under the close supervision of EESL. The objectives of SLNP are to mitigate climate change by implementing LED-based street lighting, reduce energy consumption that will eventually help DISCOMs manage peak demand of electricity, provide a sustainable service model that illustrates the need for capital investment to procure LED lights and enhance municipal services at no capital cost to municipalities.

Besides replacing conventional street lights with LEDs at its own cost, EESL will also provide 100% upfront investment with no additional budget allocation from municipalities. The goal is to recover the cost of investment through reduction in energy and maintenance over a period of time. Added features include a free seven-year replacement warranty for the lights installed, with the level of light increasing by as much as 50% as compared to conventional light. An enhanced lighting system is crucial in the safety and security of citizens and also mitigates accident rates. Well-lit streets have been a boon for local retail businesses' owners who indicate that footfalls in their shops have increased since the installation of LED bulbs.

The success of this programme can be measured by the 92 000 LED street

lights that have been installed by EESL in Vizag. The project is expected to reduce energy consumption by 50%. This working model is expected to save the municipality ₹31 crore annually.

Efficient Buildings Scheme

Early into its journey, EESL understood that energy efficiency has to be at the core of all breakthrough ideas that come from different industries. This building sector programme enables government and other public and private stakeholders to overcome technical barriers to promote energy efficiency in commercial buildings. The programme design for the efficient building model identifies energy conservation potential of new and existing buildings, works on the Energy Efficient Lighting approach, and helps to reduce the overall energy consumption of the place. EESL retrieves its initial investment cost on the basis of shared savings. Efficient Building Scheme has been implemented in Maharashtra, Kolkata, and New Delhi. Three large Government of India buildings, namely Niti Aayog, Shram Shakti Bhawan, and Indraprastha Estate have been transformed with this scheme.

India has seen a tremendous spurt of infrastructure projects in the last decade. With the right energy efficiency measures for buildings, energy consumption can be reduced whilst maintaining and improving the level of comfort for individuals in the building. The aim of this scheme is to enable government, public, and private stakeholders to overcome the technical barriers to promote energy efficiency in commercial buildings.

The maximum projects have been completed in New Delhi and the range of annual energy saving per building is estimated up to ₹11 lakh.
The implementation adheres to a strict model that identifies conservation potential of new and existing buildings, interventions that reduce a building's energy consumption.

Agricultural Demand Side Management (AgDSM)

Agriculture is the backbone of the Indian economy and about 70% of rural households depend on agriculture as their principal means of livelihood. Managing agricultural electrical load is increasingly becoming a challenge for electric utilities in India. The upgradation of existing pumping systems is the need of the hour. AgDSM is crucial as energy bills for agricultural pumps are being paid by the government in the form of subsidies. Saving energy in this sector will result in great benefits for both, the government and DISCOMS.

A few measures, such as replacement of foot valves, control panels, optimum sizing of pump sets and pipes, and replacement of pump sets with more efficient models are required. The

agriculture sector accounts for 18.5% of the total energy consumption in India, with an estimated 21 million agricultural pump sets connected to the power grid in India.

EESL has replaced about 2,000 irrigation pumpsets in Hubli and Mysore till date, and the project has already achieved savings of 37% (8.6 million kWh per annum), leading to at least ₹4 crore being saved till now. An AgDSM project is also under implementation at Rajahmundry to replace 2500 pumpsets in the next four months. AgDSM programme has a number of benefits as there are no upfront cost to the farmer and free repair and maintenance is provided during the project period and the cost of implementation is recovered from the annual energy savings. The reduction in power purchase costs, peak load, and load shedding is an added advantage for DISCOMS. As a part of this scheme, workshops on best irrigation practices and crop cultivation, medical camps, and insurance are also provided to the farmers.

National Energy Efficient Fan Programme (NEEFP)

The humble ceiling fan is a fixture in almost every Indian household. With 40 million fans being manufactured in India every year, a 2011 estimate pegged the number of fans in Indian households at 350 million. Even though it has an ubiquitous nature, the ceiling fan has been overlooked for decades in conversations that discuss energy efficiency.

This initiative, which has the potential to impact citizens from all socio-economic bands, functions based on a STAR rating programme for fans. However, energy-efficient fans are perceived as expensive when compared to the regular fans, a key reason in the lack of penetration of the former. Currently, the scheme has been implemented in Andhra Pradesh (AP) and Uttar Pradesh (UP). In AP, EESL plans to distribute nearly two lakh fans to the consumers and in UP over three lakh fans will be distributed. EESL has distributed about 16 256 energy efficient fans in AP and about 3276 fans in UP. Distribution in both regions is currently ongoing. Preliminary discussions with the Governments of Rajasthan and Bihar are underway. EESL plans to expand the operations of the scheme throughout India.

Unnati Jyoti by Affordable LEDs for All (UJALA)

UJALA scheme will replace 77 crore incandescent bulbs in the residential sector over a three-year period, making it the largest LED-based lighting programme in the world. The annual electricity savings from

reduced consumption is estimated to be at 109 999 GWh, which will mean a reduction of about 85 million tonnes of carbon dioxide in the atmosphere. The programme is also the largest no-subsidy public scheme in the world as it's built on the concept of monetization of energy savings and aggregation that will result in low cost through bulk procurements. UJALA will save the consumer an annual bill of ₹40 000 crore and will avoid new capacity of 21 500 MW, which will result in a deferred investment of $13.5 billion in the generation of electricity.

The design to implement UJALA is to use the basic architecture and best practices of the Bachat Lamp Yojana (BLY) and overcome the cost barrier in promoting LEDs. The key features entail providing high-quality LED bulbs to domestic consumers at a concessional rate of ₹75–95, opposed to the market price of ₹350. There will be 100% upfront investment by EESL with no additional budget allocations from DISCOMs. In order to raise awareness and visibility of the programme, state-wide multimedia marketing campaigns are also being undertaken. Every domestic household that has a metered connection from a DISCOM will be eligible to get LED bulbs under the UJALA scheme.

Under the UJALA model, EESL will make the entire upfront investment for distribution of bulbs. EESL has already distributed over 100 million bulbs that have impacted over 33 million consumers in the country. Currently, running in over 125 cities across India, energy savings from the UJALA scheme are estimated to be 1350.5 crore kWh annually and the scheme has also helped avoid peak demand of over 2708 MW.[8] The end result is a reduction of over 1.09 crore tonnes of carbon dioxide every year, a boon for the health of our atmosphere. The UJALA programme is already active in more than 16 states and the efforts are being made to cover as many regions as possible soon. Besides playing a significant role in creating awareness about energy-efficient lighting, the Government of India is positive that it will achieve its objective of replacing 77 crore inefficient bulbs by March 2019.

Earlier in 2016, UJALA was launched in Gujarat and Goa. The scheme was launched in Jammu and Kashmir in August 2016. Interestingly, distribution of 1.2 lakh LED bulbs in a day in Gujarat was a record for maximum distribution on any day in a state. Each 9W LED bulb provides the same luminosity as a 100W incandescent lamp, while consuming less than one-tenth of the electricity.

The Way Forward

Today EESL is at a crucial juncture in its journey towards energy efficiency. EESL is expanding its horizon by taking its operations to a number of countries overseas. Going forward, EESL will mainly act as a consultant on related policy matters and assist in building business models for energy efficiency programmes. Collaboration between businesses and governments is critical to the success of energy-efficiency initiatives anywhere around the world. Besides, the only way to fast-track energy efficiency initiatives is to educate the masses about its benefits, especially its importance in creating a sustainable planet. EF

[8] http://pib.nic.in/newsite/PrintRelease.aspx?relid=137826

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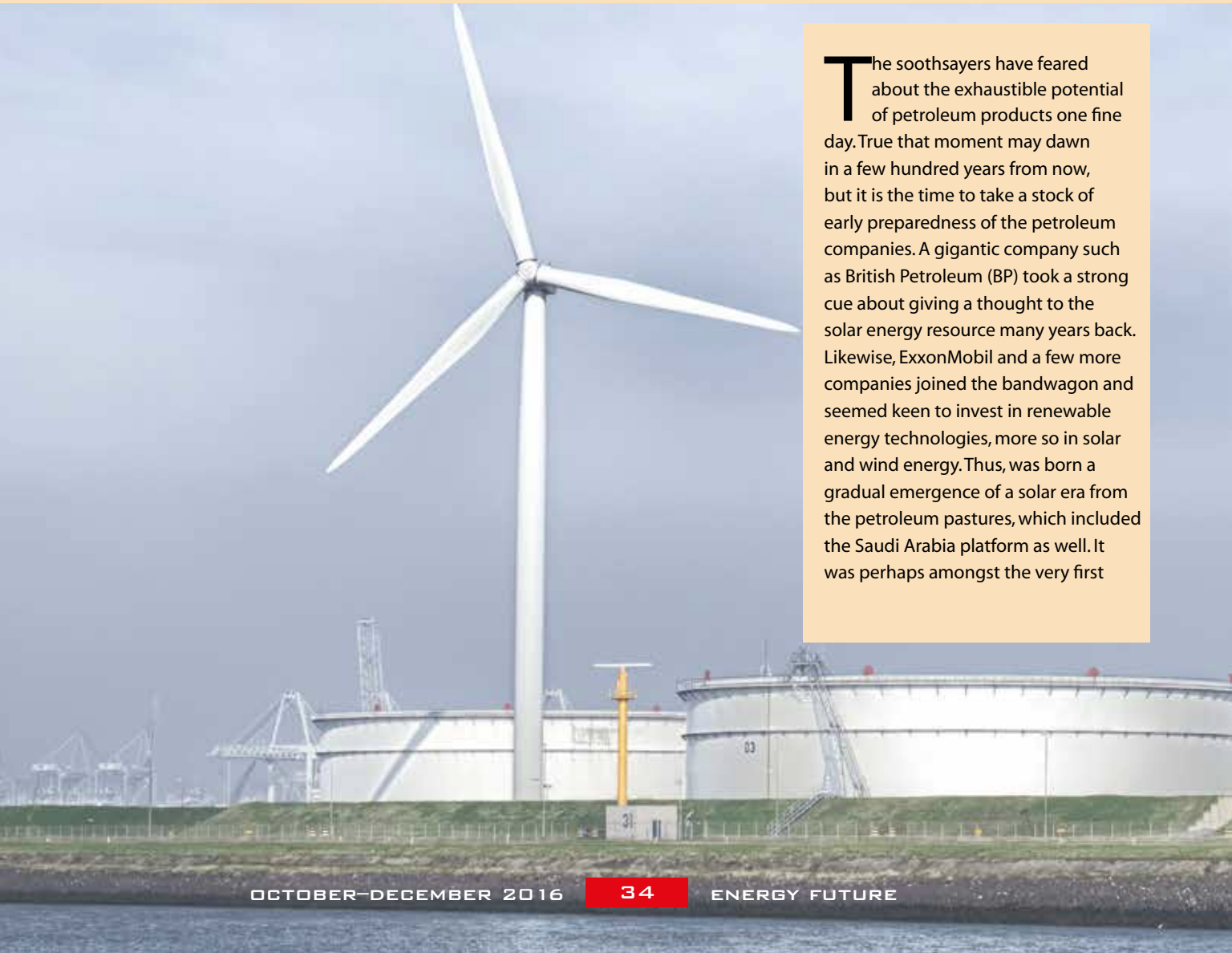
PETROLEUM SECTOR GOING THE NATURAL ENERGY RESOURCES WAY

A LOOK AT USE OF RENEWABLE ENERGY BY PETROLEUM GIANTS

Energy is vital for the socio-economic development of a country. Oil and gas together account for majority of the total primary energy requirements of the world. Nearly 60% of the total primary energy consumption the world over is accounted by oil and gas. At present India is the sixth largest crude oil consumer in the world and the ninth largest crude oil importer. This adds substantial pressure on the economy. To overcome this, use of renewable energy is essential. In this article, **Suneel Deambi** points out the renewable energy initiatives taken by various companies of Indian oil sector.



The soothsayers have feared about the exhaustible potential of petroleum products one fine day. True that moment may dawn in a few hundred years from now, but it is the time to take a stock of early preparedness of the petroleum companies. A gigantic company such as British Petroleum (BP) took a strong cue about giving a thought to the solar energy resource many years back. Likewise, ExxonMobil and a few more companies joined the bandwagon and seemed keen to invest in renewable energy technologies, more so in solar and wind energy. Thus, was born a gradual emergence of a solar era from the petroleum pastures, which included the Saudi Arabia platform as well. It was perhaps amongst the very first

few countries to set up solar powered electrolysers to derive hydrogen fuel for transportation despite being extremely oil rich. Several pilot-scale solar photovoltaic (PV) technology based projects were set up to ascertain its long-term promise as a reliable energy source.

The Indian Context

Sustained economic growth in India has put up a sizable demand for energy, including growing favour for renewable resources such as free flowing wind energy and solar energy. The hard fact is that India imports significant amount of oil, gas, and coal so as to meet its increasing energy demand. Enhanced demand poses a grave threat to the energy security of a country. Presently, India has a total installed power capacity of more than 302 087.84 MW based largely on non-renewable energy sources such as coal, oil, etc. , of which around 60% of energy generation happens to be coal based. This may continue to be the major source of power in the foreseeable future too. High reliance on coal and oil imports leads to significant pressure on the Indian economy. In view of a continuing gap in the demand and supply of power, enough quantities of diesel and furnace oil are being used across different sectors of our economy to meet energy demands. For example, kerosene is used significantly in the rural areas for lighting purposes due to lack of basic electrification facilities. There is a big need to bring down such usage as it is leading to sizeable cost in terms of the subsidies besides increasing dependence on the imported fossil fuels.

Experts believe that India may edge past China in the mid-2020s as the main source of growth in the global energy demand. However, its estimated bearing on the imported oil, coal, and gas may turn out to be major impediment to her plans for becoming a progressive and energy-independent nation. As per the available indications, continuing with the business as usual scenarios by 2035, the expected growth in import of fossil fuels may result in tremendous pressure on Indian economy and environment. Let us now take a close look at the energy requirements within the petroleum sector from several key considerations.

The Petroleum Sector Scenario

The oil and gas industry happens to be a major consumer as well as the energy producer too. Several activities within this industry use energy in one form or the other. For example, the process of oil and gas production is accompanied by oil refining, where demand for energy is extremely high. Further, majority of oil and gas facilities are located in the rural areas bereft of energy facilities such as electricity. Similarly, water-related issues in this specific sector is a matter of concern. No less important is the issue of waste management in this extremely important sector. These few situations enthuse petroleum sector to think about utilization of selective few renewable energy technologies more so solar. Wind energy makes up for a special case of deployment as a large number of petroleum-sector-specific installations are based in the rural areas with strong presence of wind energy.

Activity range of renewable energy within the sector

As per the reliable estimates, the energy intensity within the oil and gas industry has been going up despite substantial investments to improve efficiency. This is mainly due to increasing maturity of oil and gas fields besides the increased use of energy intensity. Further, enhanced recovery methods are also boosting energy needs and increasing productivity on account of the following:

- Operating the pumps so as to extract hydrocarbons in addition to reinjection of water.
- Heating the output stream to allow separation of the oil, gas, and water.
- Steam production enhanced oil recovery.
- Gas reinjection for enhanced oil recovery.
- Energizing compressors and pumps for transporting oil and gas through gathering pipelines to the processing plants.
- Driving turbines to generate electricity and heat needed for on-site operations and living quarters.

As per the available market estimates, nearly a full range of renewable energy technologies can be effectively used in one form or the other within the petroleum sector. For example, solar PV derived electricity could be used in running of various electrical and mechanical equipment. Likewise, low- and medium-grade heat could be utilized for the production stream of various types of lubricants and oils.

Solar PV Energy Supply System

Of all the renewable energy technologies, solar PVs are the most talked about for various reasons. Perhaps the most significant reason is its ability to meet the power requirements in the millwatt to megawatt power capacity range. Presently, solar PV systems in standalone mode are finding increasing use in the oil and gas industry. In some areas with high incidence of wind energy, hybrid combination of solar PV and wind is being utilized. Following is an indicative list of critical applications being run:

- Cathodic protection system
- Remote monitoring and telecommunication system
- Chemical injection skid system
- Instrumentation and control
- Water ozonation system
- Solar pumping system
- Solar water treatment

For example, the cathodic protection system is used to prevent the corrosion of oil and gas pipelines that pass hundreds of kilometres through various soil conditions. Solar PV system is capable of producing a small voltage that opposes building up of metallic corrosion. Likewise, solar power operated telecommunication systems both for onshore and offshore purposes are turning out to be a boon for the petroleum sector as a whole.

Utilization of Solar Thermal Technologies in Oil and Gas Industry

Solar radiation is available to us in the form of both the sunlight and heat. Solar PV technology deals directly with a silent, smokeless conversion of incident sunlight into useful electricity. In contrast, the heat part of the freely available solar energy can be put to numerous uses in the petroleum industry. The technology that deals with the heat part of radiation is commonly known as the solar thermal route. Solar thermal systems fall essentially into three main categories with their specific use in the oil and gas industry for one purpose or the other. These solar thermal systems are mainly classified as low-temperature solar thermal systems and high-temperature solar thermal systems. Amongst the low temperature solar thermal systems are the following few with availability of differing temperature grades:

- Unglazed solar collector (40°C–60°C)
- Flat plate (60°C–80°C)
- Evacuated tubes (50°C–200°C)

In contrast, the high temperature solar thermal systems provide temperature in excess of higher order via: (a) a dish, (b) a parabolic trough, (c) a tower, and (d) a fresnel. Following is a list of potential end-use applications enabled through solar thermal route within the oil and gas industry:

- Water heating
- Space heating
- Air conditioning
- Water treatment

- Solar disinfection
- Power generation

Case-specific applications

Water is used in significant quantities in the oil and gas industry. Renewable energy sources, specifically solar, have been utilized since quite some time both directly/indirectly in water and wastewater treatment. For example, the treatment of wastewater via the solar detoxification route is prevalent in several countries in the world. Similarly, solar energy is still regarded as the simplest of all available technologies for desalination, that is, water disinfection purpose. Availability of fresh water is a must for domestic use in the oil and gas industry habitations and more importantly for enhanced oil recovery application. Solar modules in tandem with the wind turbines still remain a favourite choice of use for desalination purposes.

Miscellaneous yet key uses

Several processes take place at different stages in the oil and gas industry. This industry produces different types of wastes that can be utilized to produce electricity or heat via use of inclinator to provide power and heat. It is mainly to make available power and heat for the production of oil and gas. Bio-diesel is the new formation taking place via the biomass energy route.

Renewable Energy Intervention in the Indian Petroleum Sector

India has a rich history of its petroleum sector-specific achievements and growth, even though not in huge numbers to bring down the import dependence significantly. Several reasons contribute to this glaring fact in one way or the other. Following section gives a bird's eye view of the promising achievements of renewables in this key application sector.

Indian Oil Corporation

This oil giant occupies the first place amongst the Indian enterprises in the prestigious Fortune 'Global 500' listing for the year 2015. In fact, it is country's largest commercial enterprise with a sales turnover of ₹450 756 crore with a profit figure of ₹573 crore during the year 2014/15. The company took up the challenge of initiating renewable energy power generation via wind energy. Presently, it has two wind power projects, one of which is of 21 MW capacity got commissioned at Kutch, Gujarat, in 2009. The other one commissioned during 2012/14 is of around 48.3 MW at Vajrakarur and Gandikota in Andhra Pradesh. As of August 31, 2015, the cumulative wind power generation has crossed the figure of 569 Gown. Importantly, it has succeeded in bringing down the carbon dioxide emission by about 455 TMT CO_2e.

On the solar front, Indian Oil Corporation (IOC) has not stayed behind other companies. A grid-connected solar PV project of 5 MW was commissioned at Rawra, Rajasthan, in 2012. As of August 31, 2015, the gross solar power generation from this project has exceeded 27 GWh and bringing in carbon dioxide reduction of about 22 TMT CO_2e. Another solar power plant of 4 MW capacity is taking shape at Narimanam in Tamil Nadu. It is expected to meet the captive power requirements of green power in several identified locations.

Solar power seems to be a favourite for the company on the off-grid front too. Small capacity solar power systems

are already installed at office buildings. The underlying objective is two-fold: (a) to bring down the power consumption from the grid power; and (b) to minimize the diesel consumption in the diesel generator sets, thus implying the reduced carbon emission too. As of August 31, 2015, 1.3 MW of solar PV power systems stand were installed across various refineries, installations, and office buildings. This is equivalent to a total annual generation capacity of about 1.6 GWh and associated annual carbon reduction potential of about 1.3 TMT CO_2e.

The fuel stations of Indian Oil conglomerate are also benefiting via the solar power use. In order to minimize the diesel use in diesel generator sets at regular fuel stations and Kisan Sewa Kendras (rural outlets) and reduce the emissions, solar PV power generation systems are being deployed since 2011. As of August 31, 2015, a total of 3298 regular fuel stations and Kisan Seva Kendras stand solarized. The sum total of achieved solar power capacity for this specific end-use application is about 12 MW. Total number of electricity generation units, that is, annual generation capacity has already touched the 14 GWh mark with a resultant carbon emission reduction potential of about 12 TMT CO_2e.

Solar PV programme in India began with the earliest demonstration of a hand-held lamp commonly known as a solar lantern. The IOC has so far sold a whopping number of 200 000 lanterns in small towns, semi-urban, and rural areas. Such a measure has been undertaken through various marketing channels/ retail networks of IOC. Additionally, solar energy use is being promoted in GRIHA-complaint green buildings.

The company proposes to set up a renewable power capacity of 260 MWp through solar and wind power in a phased manner between 2015 and 2020. That is not all as IOC's research and development facility located in Faridabad is actively working to develop solar-grade heat transfer fluids as well. It has also set up solar PV modules based on a whole range of commercially available technologies, such as crystalline silicon, amorphous silicon, cadmium telluride, etc. The underlying objective is to assess the long-term technical effectiveness of one of these technologies or a technology mix for possible adoption within the company facilities on a bigger scale.

Hindustan Petroleum Corporation

The Hindustan Petroleum Corporation Limited is deeply committed to climate change and thereby environmental protection. The company has so far installed wind farm projects in the states of Rajasthan and Maharashtra to the tune of about 50.5 MW capacity. In this way, a sum total of 545 lakh units of wind-derived electricity was produced during 2014/15. On the solar front, solar