October–December 2014

ENERGY FUTURE

The Complete Energy Magazine

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MICROGRIDS

Hope of Millions to Secure Power

Electrifying Remote Areas: Innovations by OASYS South Asia Project

Microgrids: The Solar Way

VIEWPOINT

Sanjoy Sanyal

Country Director, New Ventures

teri

ENERGY FUTURE

The Complete Energy Magazine

By looking at the technologies, policy decisions, and business ventures that have the potential to overcome energy shortage and our crippling dependence on depleting fossil fuels, Energy Future draws from a deep well of expertise at TERI (The Energy and Resources Institute), India's leading research institute on energy and green growth. Knowledge of energy security and development is a critical requirement in the modern global economy, and Energy Future aims to educate and inform you about the wide world of energy; its history, its future, how the energy industry works, how it has affected the world, and how it continues to affect you and me.

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From the editor's desk...

Today, while everyone is talking about bigger and bigger power plants, i.e., in terms of ultra mega power plants in capacities that run into giga watts, a revolution is quietly taking place that has nothing to do with the size but with its potential to serve those billions that do not have access to electricity. Ironically, several mega power plants are being set up in the country. And just like in electronics today, this energy revolution pertains to micro, mini, and even nano grids. The beauty of these small-sized grids (or plants) lies in the very fact that they are local unlike traditional, centralized power plants. By their very nature, most of the large-sized power plants are constructed near the fuel sources; be it coal mines or hydro resources. Thus, to transport electricity produced at these plants to the actual load centres, long-distance transmission lines are laid down. However, transmission over long distances, especially in country like ours, entails its own penalty as a significant amount of electricity is lost in the process. And ironically, even after such elaborate arrangements, such grids are unable to serve a huge chunk of the populace that is located in remote and rural areas dispersed off geographically.

It is here that micro and mini grids, especially those based on renewable energy technologies, have proven their utility. Since renewable energy resources too are dispersed and decentralized, it makes sense to use them in the decentralized fashion whereby using locally available resources—like solar, biomass, wind, or micro hydro—electricity is generated as well as distributed locally through micro/mini grids. Besides being technologically feasible, such solutions also provide opportunities to local level entrepreneurs and service providers that are able to develop locally-appropriate business models. Incidentally, here lies a scope for lot of innovations. It is obvious that future energy supplies are not going to be constrained by conventional thinking.

Amit Kumar

Amit Kumar
Director, TERI

Editor: Amit Kumar Radheyshayam Nigam
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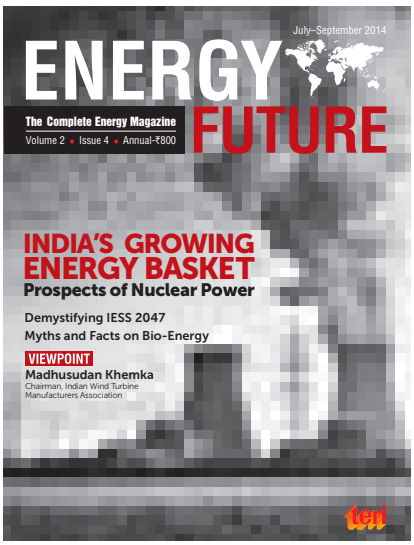

I found the cover story amazingly good. It also gives us a background on the evolution of India's nuclear programme, which is new for the readers like us. In addition, it is also a very informative article. The article discusses the current and future perspectives of India's nuclear power. This once again is equally useful. I congratulate you on bringing out the issue so well.

Santoshi Verma
New Delhi

I would like to say that the July-September issue of Energy Future was very informative. I am a student of energy background form Chennai. I must say the article on energy efficiency, which also discusses the state scenario, is one of the highlights of the magazine. I am looking forward towards the next issue of this very useful and informative magazine.

Venkat Swami
Chennai

I live in Mumbai and I love cars. I have already studied so much about cars. I found your article on e-cars very useful for myself. I would like to have an e-car for myself, as they are eco-friendly as well as save lots of energy. Other articles in the magazine were also good. Thanks.

Amit Gavaskar
Mumbai

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.

Email: teripress@teri.res.in

Editor
Energy Future

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24 X 7 POWER: WORLD BANK OFFERS CENTRE A PLAN

The World Bank has submitted a detailed action plan that could help the government meet its objective of supplying power 24 X 7 in the country, with focus on bringing down distribution losses, improving infrastructure, and expanding solar power.

The proposal includes a state-wise turnaround plan for the key seven or eight states that together account for about 80 per cent of the $20 billion (₹ 1.2 lakh crore) annual power distribution losses.

Officials said the Bank has identified Delhi, Andhra Pradesh, Rajasthan, Uttar Pradesh, and the six north-eastern states of Assam, Mizoram, Manipur, Meghalaya, Tripura, and Nagaland for the 24 X 7 plan with six ultra mega solar power projects (in excess of 500 MW) and large-scale decentralized rooftop solar projects of 100 MW.

"The Bank will help the states undertake the required, difficult turnaround actions and evaluate and implement state-specific programmes by providing long-term rupee bonds or credit enhancement products," a government official said.

"For Delhi, the Bank will help by partnering with the state transmission utility, Delhi Transco, and address transmission bottlenecks caused by years of underinvestment in the network," the official said.

The Bank's plan also talks of setting up large-scale 100 MW rooftop solar projects. The solar rooftop policy was rolled out by Prime Minister Narendra Modi when he was Gujarat chief minister. Solar panels were set up on the roofs of houses and institutions, and connected to a smart grid to supply clean electricity. EF

Source: www.hindustantimes.com

BIOFUEL PRODUCTION: 1.17 LAKH HECTARES IDENTIFIED

The Karnataka State Biofuel Development Board has identified the Hyderabad–Karnataka region as the best site in the State, with its vast wastelands, for the cultivation of biofuel plants to increase its production manifold.

Satellite images provided by the Indian Space Research Organization show that more than 1.17 lakh hectares of wasteland is available in the six districts of Hyderabad-Karnataka region. This land is best suited for cultivation of biofuel plants like Pongamia, Neem, Simarauba, and Jatropha. EF

Source: www.thehindu.com

KERALA SCHOOLS TAP SOLAR POWER

In the past one year, at least five schools in Kerala have opted to depend on solar power for all their electricity needs.

"When we thought of shifting to solar power, a few companies approached us. In the first phase, it was tried out in the Holy Angel's Convent last year. It was found to be successful as the power bills came down, and then we decided to replicate it in the entire school. In the boarding facility, the power bills have come down from ₹ 28,000 to ₹ 5,000. We still use normal power for things such as geysers," says Angel Thomas, manager of the Convent.

While Holy Angels' School opted for 78-KW plant that costs upwards of ₹ 1 crore, St Mary's School at Poojappura opted for a 27 KW one, which costs ₹ 35 lakh.

"We installed solar panels in one of the blocks on a trial basis last year, and later extended it to the other block too. Though the initial cost is a bit high, in the long run it will be beneficial as the power bills will come down drastically," says Sarosh Abraham, Principal, St Mary's School.

It is not just private schools that are going the solar way. The City Corporation installed solar panels at the Government Teachers' Training Institute (TTI), Manacaud. "The civic body installed solar panels at the Manacaud school on an experimental basis, and it has been found to be successful with surplus power being generated. With a proper system, we can even channelize it to the nearby

school. The Corporation is planning to extend it to 10 other schools, though on a smaller scale. We are awaiting the estimates from ANERT," says K S Sheela, Education standing committee chairperson of the Corporation. EF

Source: www.thehindu.com

NHPC TO SET UP ITS FIRST SOLAR PROJECT IN UTTAR PRADESH

State-run National Hydro Power Corporation (NHPC) has signed an agreement with Uttar Pradesh New and Renewable Energy Development Agency for setting up its first solar power project in the state at a cost of ₹ 400 crore.

"Promoters' Agreement has been signed between Uttar Pradesh New and Renewable Energy Development Agency (UPNEDA) and NHPC for setting up a Joint Venture Company for implementation of solar power project in Uttar Pradesh," NHPC said in a statement.

Initially this joint venture company proposes to implement a 50 MW grid connected solar power project at Parason, Uttar Pradesh, the statement said. The project will be completed by mid-2016. EF

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

1,000 GUJARAT FARMERS TO GET SOLAR PUMPS FOR IRRIGATION FROM STATE GOVERNMENT

The Gujarat Government has decided to provide solar-powered water pumps to 1,000 farmers to reduce usage of conventional power and ease its financial burden due to subsidy on electricity provided for irrigation.

The project will be implemented under the aegis of Gujarat Urja Vikas Nigam Ltd (GUVNL) and four distribution companies (DISCOMS)—Daxin Gujarat Vij Company Ltd, Madhya Gujarat Vij Company Ltd, Paschim Gujarat Vij Company Ltd and Uttar Gujarat Vij Company Ltd, according to a state government notification.

These submersible pumps will be of 3 to 5 horse power (HP) and cost ₹6 lakh per unit to the government, totalling ₹60 crore for 1,000 pumps. The main aim is to reduce the burden on our existing power plants and encourage the farmers to opt for solar powered pumps for their regular irrigation needs. A go ahead was given to this project after successful testing of 25 such pumps for last one-and-half years. The solar-based water pumps will be given to those who have already applied for regular agriculture electricity connection as on March 31, 2014. At present, 1,000 such pumps will be distributed across the state with the help of DISCOMS. EF

Source: www.dnaindia.com

PUNJAB GOVERNMENT TO START CAMPAIGN FOR CLEAN, GREEN SCHOOLS

In a bid to make government schools clean and green in Punjab, the state education department has started a month-long campaign from November 1, 2014.

This decision was taken during a high-level meeting held under the chairmanship of Education Minister Daljit Singh Cheema, an official spokesperson said.

The "Sohna School Campaign" started from Government Senior Secondary School Mothawal in Kapurthala district where a state-level function was held by the education department.

To make this campaign a success, the Minister and other senior department officials visited different schools of the state and personally supervised cleanliness in schools.

During the campaign, competitions related to cleanliness, environment, painting, and essay were organized in schools. The spokesperson said that each school was directed that the toilets in their premises be cleaned regularly and non-functional toilets be repaired. EF

Source: timesofindia.indiatimes.com

SAY NO TO BUSINESS TRAVEL, YES TO VIDEOCONFERENCING

A report released by the Carbon Disclosure Project India (CDP), with the Indian Institute of Management, Bangalore (IIM-B), has revealed that business travel contributes over 55.04 lakh tonnes of carbon-dioxide equivalents (CO_2e).

"Savings achieved through video-conferencing and telecommunicating with moderate Information and Communications Technology (ICT) penetration in 2030 can offset greenhouse gas emissions more than 70 times the present emissions owing to annual air traffic between New Delhi and Mumbai," the report quoted as an example.

The report *'ICT sector's role in climate change mitigation: An analysis of climate change performance and preparedness of global ICT companies'* analysed 320 ICT companies (10 from India) in over 35 countries in 2012–13. Companies which participated included Infosys, TCS, Wipro, Accenture, Google, and Microsoft.

The study categorized emissions into: direct emissions, indirect emissions from consumption of purchased electricity, heat or steam, and other indirect emissions such as fuel and transport (vehicles not owned or controlled by the company). In the third category, use of sold products accounted for 56 per cent of emissions, followed by purchased goods and services (35 per cent). These were followed by sources that included business travel and employee commuting. The first two categories include data

centres and provision of network and connectivity services as sources of emissions.

Interestingly, the first two categories account for a significant percentage of emissions in emerging economies, such as India, China, and South Africa. In comparison, the third category of emissions is significant in the US, Japan, the UK, and France. EF

Source: www.thehindu.com

SOLAR PANEL MAKERS EYE OVERSEAS MARKETS

Domestic overcapacity is prompting solar panel makers to turn their sights back to overseas markets although exports are unlikely to rise fast enough to absorb the spare capacity.

Industry demands for an anti-dumping duty on cheap solar panel imports from China has been turned down by the government, meanwhile, suggesting that the domestic market is unlikely to improve anytime soon.

Installed solar module manufacturing capacity in India stands at around 2.7 gigawatt (GW), according to the Ministry of New and Renewable Energy (MNRE). Solar power installations have stagnated at around 1 GW in the last two years, as per the data from Mercom Capital Group LLC, a clean energy consultancy group.

"Considering the current installation forecast of about 900–1,000 MW in calendar 2014, even if the entire market was laid open for domestic manufacturers, their capacity utilization will be not be more than 35–40 per cent," said Raj Prabhu, Chief Executive Officer, Mercom Capital.

H R Gupta, Managing Director of solar cell manufacturer Indosolar, adds that recent announcements hinting domestic manufacturers would be given preference are a positive.

"Power Minister Piyush Goyal has said that whatever can be made by domestic manufacturers would be bought. National Thermal Power Corporation (NTPC) also announced a 1 GW tender that was purely domestic in nature," said Gupta, adding that between the Jawaharlal Nehru National Solar Mission (JNNSM) and procurement by various central government agencies like defence and railways, existing capacity can be absorbed. There is scope for 100 per cent additional growth over the next five years. EF

Source: www.livemint.com

CHINA, US, INDIA PUSH WORLD CARBON EMISSIONS UP

At the time when more than 100 world leaders met at the UN Climate Summit to discuss how to reverse the emissions trend, scientists came out with a study which stated that spurred chiefly by China, the United States, and India, the world spewed far more carbon pollution into the air in 2013 than ever before. The world pumped an estimated 39.8 billion tonnes (36.1 billion metric tonnes) of carbon dioxide into the air last year by burning coal, oil, and gas. That is 778 million tonnes (706 metric tonnes) or 2.3 per cent more than the previous year.

"It's in the wrong direction," said Glen Peters, a Norwegian scientist who was part of the Global Carbon Project international team that tracks and calculates global emissions every year. Their results were published in three articles in the peer-reviewed journals *Nature Geoscience* and *Nature Climate Change*. The team projects that emissions of carbon dioxide, the main heat-trapping gas from human activity, are increasing by 2.5 per cent this year. The scientists forecast that emissions will continue to increase, adding that the world in about 30 years will warm by about 2 °F (1.1 °C) from now. In 2009, world leaders called that level dangerous and pledged not to reach it. "Time is running short," said Pierre Friedlingstein of the University of Exeter in England, one of the studies' lead authors. "The more we do nothing, the more likely we are to be hitting this wall in 2040-something." Chris Field, a Carnegie Institution ecologist who heads a UN panel on global warming, called the studies a stark and sobering picture of the steps that need to be taken to address the challenge of climate change.

The world's three biggest carbon polluting nations — China, the US and India — all saw their emissions jump. No other country came close in additional emissions.

Emissions in India grew by 5.1 per cent, in China by 4.2 per cent, and in the US by 2.9 per cent. EF

Source: www.usatoday.com

TOCARDO TIDAL TURBINES FORMS AGREEMENT WITH SOUTH KOREA'S EKORNERGY

The tidal turbines will be installed in the coastal waters of the Mokpo Jeonnam region. The Mokpo Jeonnam region has one of the strongest tidal streams on the planet, with bi-directional tidal speeds of up to 4 metres per second. Electricity generated will be fed into South Korea's national grid. "This is a major step towards accelerating Tocardo's expansion into large-scale tidal energy projects across the globe," said Hans van Breugel, CEO of Tocardo. "We are looking forward to working with Ekornergy and other Korean partners to seize this opportunity to supply the Korean grid with significant amounts of clean and reliable energy, helping reduce the country's carbon emissions."

Manufacturing of the first 15 T2 kW Tocardo turbines is expected to start in late 2015 as part of a 3 MW demonstration project. In 2016, Tocardo expects to start producing its bigger T3 turbines, which are to be installed in a commercial tidal array with a total capacity of 25MW. EF

Source: timesofindia.indiatimes.com

EU WANTS INDIA TO SHOW 'FLEXIBILITY' ON CLIMATE CHANGE TALKS

Europe has reached out to India to set aside its hardline stance on climate change negotiations. The European Union (EU) has asked New Delhi to show 'flexibility' to ensure that the new global compact on climate change, which is to be finalized in Paris next year, reflects the realities of the 21st century.

Ahead of the Lima round of climate negotiations under the aegis of the United Nations, the European Union wants 'to seek a dialogue' with New Delhi and the new government India and the EU have been at odds in the negotiations, with Europe pushing for a legally binding agreement and asking developing countries to make more efforts to tackle climate change. India has long maintained that developed countries, which industrialized early and contributed the most to carbon emissions, should take on the burden of efforts to reduce emissions.

"Everyone needs to bend towards each other," said European Union Commissioner for Climate Action Connie Hedegaard. "I am here for an open-minded engagement to listen to the minister."

Stressing on the important role India plays in the climate change negotiations, the outgoing EU climate boss sought to allay New Delhi's fears that it would be called on to reduce emissions when its economy needed to grow.

"Nobody disagrees with India's need for growth. There are 400 million people in India without access to electricity. Nobody is asking India to reduce emissions in absolute terms. We know that India is not Europe, but then again remember that India is not China," Hedegaard said, referring to India's close ally in the climate talks.

China, which has emerged as the biggest greenhouse gas emitter, and India work closely under the umbrella of the Like Minded Developing Countries group and the BASIC, coordinating positions in the negotiations held under the aegis of the United Nations Framework Convention on Climate Change (UNFCCC). EF

Source: www. articles.economictimes.indiatimes.com

INDIAN OIL CORPORATION TO INVEST $4 BILLION IN BRITISH COLUMBIA PROVINCE IN CANADA

Indian Oil Corporation (IOC) will invest $4 billion in the British Columbia province, Canada, to source Liquefied Natural Gas (LNG) from the region. Premier of British Columbia, Canada Christy Clark said, "Indian Oil is poised to make its biggest investment in Canada to secure natural gas for India from BC."

IOC, in May 2014, signed a deal to buy 10 per cent stake in shale-gas assets and a linked liquefied natural gas (LNG) project in British Columbia. The Canadian asset will produce as much as 19.68 million tonnes of LNG a year for 25 years starting in 2018. That apart, Clark said, GMR Group of India and IC-Impacts of her province will now work together on safe and sustainable infrastructure like innovative pavement technology, construction design, and water and waste water infrastructure. Wooing domestic investors, she said, "We, in British Columbia, would like to partner with this great country to realize its potential by providing LNG to power its future. We recognize that there will be a mix of energy sources—coal, oil, solar, and wind." She added, "India needs a million skilled workers a year, every year, for the next 15 years. We can help. If we can help train 3,000 and 300 of them help us build an LNG industry." EF

Source: www.thehindubusinessline.com

JAPAN'S QUEST FOR CLEANER ENERGY

Japan is looking at hydrogen as a main energy source in future to power its transport systems and generate electricity, as the economic giant makes an effort to reduce its dependency on fossil fuels and nuclear energy. In the Kitakyushu city, a unique project is already underway in which hydrogen generated during iron manufacturing processes can be utilized to provide energy to vehicles as well as homes.

An official at the Kitakyshu Hydrogen station explained to a team of journalists that vehicles which can run on hydrogen fuel cells can be refulled here.

The hydrogen used at the station was a byproduct generated during iron manufacturing.

"Hydrogen is a cleaner fuel compared to gasoline as it is almost zero emission," the official said, adding that the cost of vehicles which can run on hydrogen is slightly higher than those which run on gasoline at present.

"Some Japanese companies are front-runners in research in this area and with increase in production the cost of such vehicles is expected to come down."

"Moreover, it is likely that the network of such hydrogen stations will also be expanded to attract more and more people to use these eco-friendly vehicles," the official added. EF

Source: www.thestatesman.net

NEW YORK HOSTS LARGEST CLIMATE CHANGE MARCH

An international day of action on climate change brought hundreds of thousands of people onto the streets of New York City on September 21, easily exceeding organizers' hopes for the largest protest on the issue in history.

Organizers estimated that some 310,000 people, including United Nations Secretary-General Ban Ki-moon, former US vice-president Al Gore, actor Leonardo DiCaprio, and elected officials from the United States and abroad joined the People's Climate March, ahead of United Nations hosted summit in the city to discuss reducing carbon emissions that threaten the environment.

"This is the most important issue of our time", DiCaprio said. "I'm incredibly proud to be here."

President Barack Obama galvanized international support in the fight against climate change through his addresses at the United Nations, with time running out on his hopes of leaving a lasting environmental legacy.

Mr Obama warned that failure to act on climate change would be a 'betrayal' of future generations, but faced with a Congress reluctant to even limit greenhouse gas emissions let alone ratify an international agreement his options appear limited. The New York rally, the largest single protest ever held on the topic of climate change, followed similar events in 166 countries including Britain, France, Afghanistan, and Bulgaria. 'The March numbers are beating our wildest expectations,' said Ricken Patel, Executive Director of activist group Avaaz, which organized the March.

A crowd, including US senators Bernard Sanders, an independent from Vermont and Democrat Sheldon Whitehouse of Rhode Island, marched along the city's Central Park, through midtown Manhattan to Times Square, where they stopped for a moment of silence at 12.58 pm.

Mr Ban, wearing a T-shirt that read 'I'm for climate action' marched arm-in-arm with British primatologist Jane Goodall and French ecology minister Segolene Royal. "This is the planet where our subsequent generations will live," Mr Ban told reporters. "There is no 'Plan B,' because we do not have 'Planet B.'" Organizers said another 270,000 people had participated in related events outside New York. EF

Source: www.reuters.com

RUSSIA'S ROSNEFT OFFERS ONGC STAKE IN VANKOR OILFIELD

On the heels of selling 10 per cent stake in its Vankor oilfield to China for $1 billion, Russia's biggest oil company Rosneft has offered a similar stake to India's Oil and Natural Gas Corporation(ONGC).

Rosneft has made a formal offer to sell 10 per cent stake in the strategic oilfield in Siberia to ONGC Videsh Ltd, the overseas arm of the state-owned explorer, sources privy to the development said.

Rosneft sold a 10 per cent stake in the Vankor cluster fields in northern Siberia to China's CNPC for about $1 billion.

Vankor is the largest field to have been discovered and brought into production in Russia in the last 25 years. As of January 1, 2014, the initial recoverable reserves in the Vankor field are estimated at 500 million tonnes of oil and condensate, and 182 billion cubic meters of gas.

Vankor will reach peak output of 500,000 barrels per day or 25 million tonnes a year in 2019. The field, which has driven recent Russian output growth, pumped 435,000 bpd in the month of September. Russia is the world's top oil producer with current output of 10.5 million bpd but its key producing region—West Siberia—is maturing.

Russia and Rosneft are courting China and India after the European Union and the USA slapped sanctions on them for Moscow's involvement in Ukraine.

The sanctions would further restrict Rosneft's access to foreign loans, prohibiting the company from receiving any loans with more than 30 days maturity. Rosneft's finances have been strained by the EU and US sanctions.

Prior to offering stake in Vankor, Rosneft had sent a formal proposal to OVL for joint development of Yurubcheno-Tokhomskoye oilfield in eastern Siberia. The field is estimated to hold 991 million barrels of oil equivalent reserves and is planned to start production in 2017. EF

Source: www.rosneft.com

WITH AGREEMENT ON PRICES, INDIA AND PAKISTAN SET TO SEAL GAS DEAL

India will soon be ready to seal a deal with Pakistan for sale of liquefied natural gas (LNG) to the country as a consensus on pricing seems to have emerged. Pakistan wanted India to revise the price that was offered initially, while had insisted on a sovereign payment guarantee.

"There is just one more meeting that is required to finalize the deal and after that India will be ready to sell gas to its neighbour," a government official said.

Landed cost of imported gas on India's LNG terminals averaged at about $15/mmBtu (long term), while spot rates were $16/mmBtu, this is excluding re-gasification, local taxes and levies, transmission charges, and marketing margins. With these components, the rate of the gas for the end consumer is around $18–20/mmBtu.

Pakistan has decided to do away with the customs duty component. Sales will start once the pipeline from Jalandhar to Wagah to transport the gas is in place which could take up to an year.

The Minister of State for Petroleum and Natural Gas (Independent Charge) Dharmendra Pradhan had told the

Parliament that negotiations are under way between GAIL (India) and Inter State Gas Systems, Pakistan, for supply of five million metric standard cubic meter a day (mmscmd) of gas to Pakistan for a period of five years. This is part of the trade liberalization roadmap entered into by the two countries in September 2012. EF

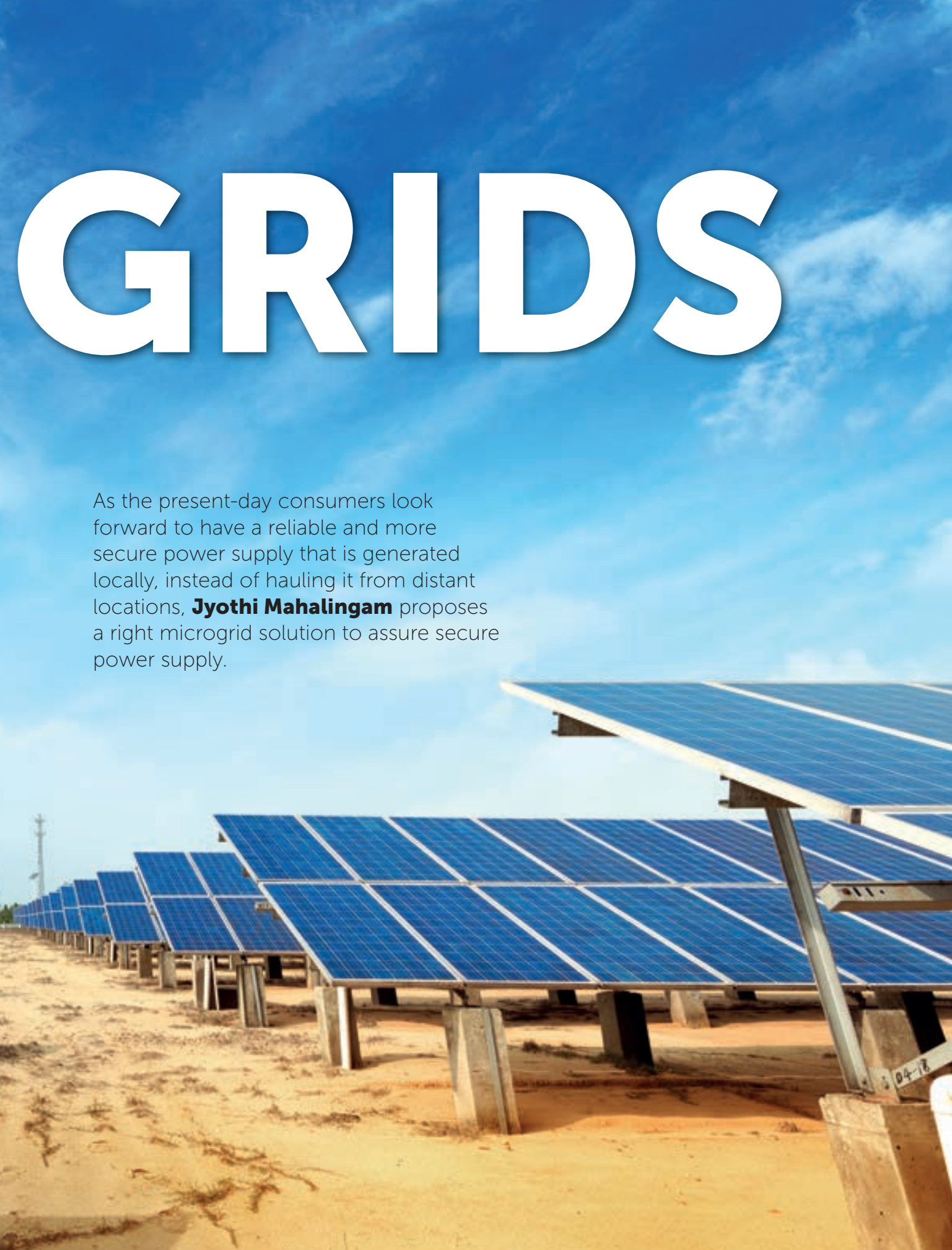
Source: www.thehindubusinessline.com

MICRO

Hope of Millions to Secure Power

GRIDS

As the present-day consumers look forward to have a reliable and more secure power supply that is generated locally, instead of hauling it from distant locations, **Jyothi Mahalingam** proposes a right microgrid solution to assure secure power supply.



We have come a long way after the installation and commissioning of the first ever Alternating Current (AC) power grid in 1886. The power grid designed to operate one-way, distributed the power flow from a central power source or plant, using high voltage transmission lines to the lower voltage lines, through the distribution centres, to reach commercial, industrial, and residential power consumers. The growing industrialization and domestic power consumption necessitated the involvement of more such local power grids, to get interconnected to the centralized power stations. Most of the centralized power stations were constructed in places close to oil, gas, or coal fields, where plenty of raw materials were available for electric power generation. Similarly, hydropower production facilities were placed close to dams built at higher levels and nuclear power plants were constructed near places where plenty of cooling water was available.

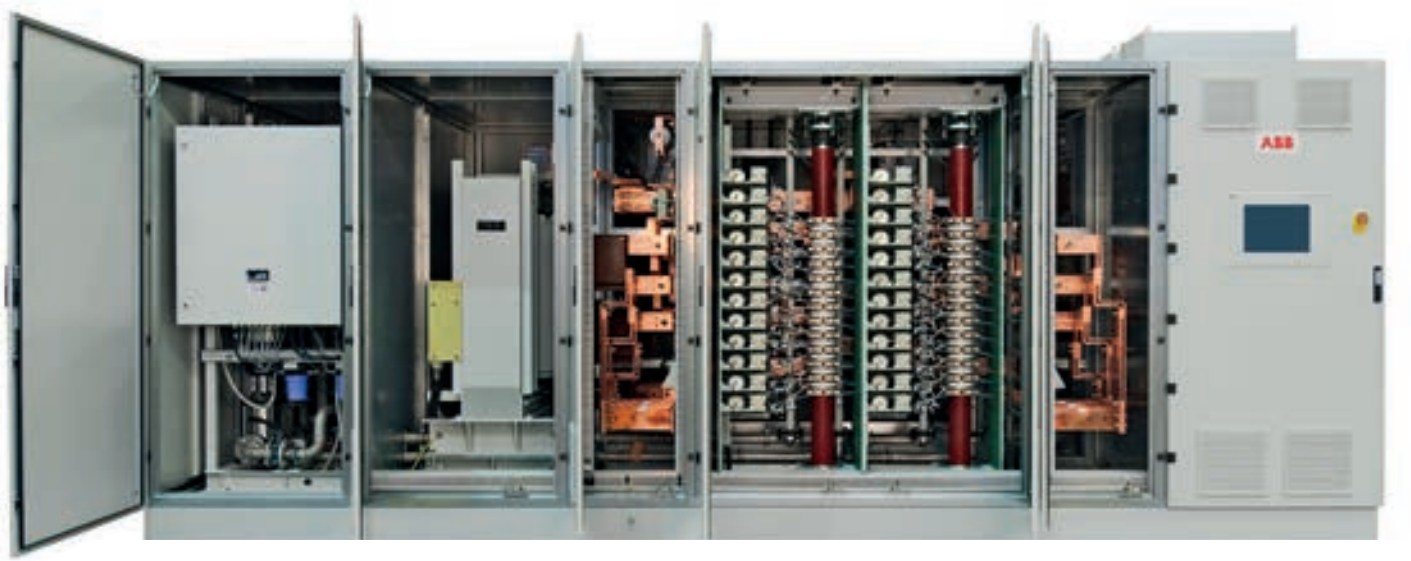
From 1970 to 1990, the demand for electricity increased multifold, especially, in the power supply to run the industries, to meet the lighting, heating, communication needs, and to provide electricity to the households. In the global scenario, the centralized power grids that had served for over hundred years, suffered overload and frequent tripping, which led to blackouts. The spending on peak power generators, purposely installed to meet the growing demand for electric power during the peak hours, increased the production costs to the power supplying companies and resulted in rise of power tariffs. World over, the electric grid infrastructures that served the growth of the nations are at a critical juncture, due to its supply limitations. The irony is that over 1.3 billion people who live in isolated pockets of the world, still do not have access to electricity or get very limited access to electric power.

The latest report from CO2Now.org, a noted non-governmental organization that sources climate data inputs from research institutions, indicates the carbon dioxide (CO_2) emissions have increased from 393.66 parts per million (ppm) in October 2013 to 395.28 ppm in September 2014. It is worth to recall that it was only at 310 ppm in 1958. The environmentalists fear that if we reach the 400 ppm mark or beyond, it will further shrink the arctic ice layers, leading to more climatic problems.

The electricity sector is one of the major contributors to CO_2 emissions. The use of coal, oil, and natural gas in the generation, transmission, and distribution of electricity adds to greenhouse gas emissions. According to a report published by the Environment Protection Agency, USA (EPA) in 2012, the electric power generation and distribution alone has contributed to nearly 32 per cent of the greenhouse gas emissions closely followed by transportation and industrial sector with 28 per cent and 20 per cent, respectively, in the USA. In order to bring down the fossil fuel generated greenhouse gas discharges, the demand for using clean energy power sources such as biofuel, geothermal, nuclear, solar, and wind is on the rise. The existing over-tasked grids, designed for the intake of conventional electric power generation, now face complexity of problems in linking such new generation power sources with the grid. Connecting the grid with such intermittent power sources (barring nuclear) creates technical difficulties and jeopardizes the very security of the power systems.

Re-emergence of Microgrid

Actually, we can call it as the reemergence of microgrids. Present AC model grid transmission systems, covering long distance power distribution, became prominent and replaced the Direct Current (DC)



microgrid modules in 19th century. Now such systems are slowly giving way for the return of microgrids. The conventional electric grid, with a fundamental architecture of unidirectional flow from large power generation plants to the radial transmission systems, is considered as not suitable for today's carbon conscious economy. The trend, in constructing larger power generation facilities, using coal, oil, natural gas, and nuclear as fuel, saw a shift in the 1980s. The newly built power grids included features to receive and manage the electricity generated from clean energy sources such as biomass, geothermal, solar, and wind.

In fact, numerous academic institutions have used microgrids for a number of years to supply uninterrupted power to some of their own facilities. The microgrids in such institutions continue to function even today, to meet 100 per cent electric power, heating, and cooling needs. Presently, the microgrids are drawing the attention of everyone due to change in power generation methods. Latest technological trends, growing commercial activities, and shifts in the societal need of power use, have increased the demand for more microgrid installations. Microgrids, considered only as an important tool for the economic development in the beginning, now play a more diverse role. The microgrids aptly fit into the function to extend locally controlled, highly dependable and efficient clean energy supply to meet the present technology oriented economic progress. Microgrids are found to be more cost-effective especially in places, where connectivity costs to the existing power grids are prohibitive and economically unviable. The energy security offered by microgrids is considered as a critical element for its increased use.

Understanding a Microgrid

Though a number of definitions exist to describe a microgrid, the one offered by the US Department of Energy (DoE) seems to be more appropriate. It defines a microgrid as: 'a group of interconnected loads and Distributed Energy Resources (DER) with clearly defined electrical boundaries that acts as a single controllable entity with respect to the grid (and can) connect and disconnect from the grid to enable it to operate in both grid connected and island mode'.

A microgrid features a power generation model, a delivery system, consumption and storage facilities, and is fitted with advanced monitoring, control, and automation arrangements. One important feature of a microgrid solution is its capability to cut down the intake of gas, water, and electricity. The verifiable cost cutting measures of a microgrid assists in imminent cost savings for the consumer.

A fully functional microgrid has the potential to disconnect automatically from the main grid in case of power disruptions. It will continue to distribute the stored power or the power generated by the on-site generation facilities. By design, it gets connected to the main grid again, once the problem is resolved. Present day microgrids are equipped to manage 20–25 per cent power generation by using integrated renewable energy sources or other on-site power generation facilities.

Presently, the microgrids are drawing the attention of everyone due to change in power generation methods. Latest technological trends, growing commercial activities, and shifts in the societal need of power use, have increased the demand for more microgrid installations.

A microgrid may be kept to perform a simple function in a power generator that uses a combined heat and power source or natural gas, to supply electricity to a building or hospital during the power outage. It can also be exclusively connected to a solar or wind power generating source or fuel cells or any other power generating source, to bring hours of power supply to a particular location or community, in the absence of a grid provided power. A microgrid has a design resilient to manage the load and regulate the power supply.

A grid connected microgrid has features to supply the excess power generated at a location to the grid and similarly draw power from the grid, in case of power shortage at the location. The same microgrid can also function in island mode, when disconnected from the grid in conditions of lower power at the grid due to extreme weather related conditions. Present day microgrids are designed to meet the power needs of either 2–3 houses with a 10 kW power supply or to meet the electricity requirement of a location comprising nearly 25,000 households with a 10 MW capability.

The key element in a microgrid is its control unit which is also known as the master controller. It assists the microgrid to emerge as a solitary managed unit to the distribution network operator, irrespective of the way the power sources or loads function or are handled within the microgrid network. Also known as the brain of the microgrid, the master controller gathers the required data from a range of connected energy resources, such as smart switches, adjustable loads, energy storage devices, and generators, determines the action on them, and transmits the right signals to manage a particular power activity.

The advanced microgrids of today are equipped with fossil fuel power generation facility, energy storage features, and a load controller. The systems designed are as scalable to manage additional loads from the new power generators without impacting its operations.

The capital investment required for microgrid installation varies from tens of thousands to hundreds of thousands of US dollars. The per unit electricity charge collected from the customers connected to the system normally depends on the amount of capital investment, operation and maintenance costs, and other overheads.

Working of a Microgrid

A typical microgrid network can be called as an extension of the main grid network. In the absence of a microgrid, when an outage takes place in the main grid network or while the grid is down for maintenance, the power supply is totally cut off. The working of all the connected appliances, electronic systems, and heating/cooling requirements cease and affects the daily routine of every one. But, when a microgrid is introduced between the main grid and the consumer, in such eventualities it maintains the power supply to the important segments. For this purpose, it uses the power generated from diesel gen-sets, storage batteries, fuel cells, or power produced from other sources such as solar or wind. Depending on the power supply source, a microgrid can run indefinitely providing electricity to the connected units.

The microgrid as an individually governable unit manages the functions in four dissimilar ways. While getting the needed power from the grid, it can

The working of all the connected appliances, electronic systems, and heating/cooling needs will cease and affect the daily routine of every one. But, when a microgrid is introduced between the main grid and the consumer, in such eventualities it maintains the power supply to the important segments.

function either remaining connected to the grid or work in island mode known as operational ways. When it is transferring the power from the grid to the users known as transition ways, either it can work in synchronization with the grid, or opt for island working remaining disconnected from grid supplied power. In grid connected mode, the microgrid determines the Distributed Energy Sources (DERs)—wind, solar, nuclear, or any other power source so as to remain actively connected to supply during shortfall in power or go reactive to supply power only when needed. To manage such situations, it uses the voltage and frequency of the grid as references. When operating in island mode, for the purpose of keeping the frequency and voltage within the prescribed limits, it controls the energy sources.

In a microgrid, the changeover from grid linked and island mode can take place either in a pre-planned or unplanned manner. The pre-planned or scheduled changeover takes place during the maintenance of the grid and an unplanned transition takes place in the event of sudden tripping or other problems at the main grid. The microgrid control is designed to manage such situations to assist correct maintenance of frequency and voltage. The oscillations in power supply, created due to the sudden tripping, are muted to assist the island microgrid to supply a stable power. In case the microgrid becomes unstable subsequent to the transition to island mode, the Distribution Generation (DG) units linked to the microgrid are disconnected and black start is resorted to. A designed controller manages the transition between the island and grid connected modes, to enable the microgrid to get reconnected to the main grid supply. Such self-managed activity of microgrids, especially during unforeseen surges due to peak demand, causes less strain to the main grids.

The flexible design and operational features to get connected to a range of storage facilities, helps in customizing the microgrids to go with the requirements of the customers. Also, the microgrids meet three important elements such as energy security, energy equity, and environmental sustainability suggested by the World Energy Council for energy sustainability.

Reasons for Popularity of Microgrids

The main reason for the popularity of microgrids is its inherent capability to get along with the present technologies, favouring economic growth. By providing most dependable and locally managed clean electric power, the microgrids lend a hand to the information centred and technology combined economic systems of today to move forward. Using reliable power solutions, the microgrids offer assured energy security to research centres, data centres, and high-tech business enterprises and help expand their business and grow.

Globally, the fall in the prices of solar panels, and natural gas, the commonly used power sources in running a microgrid has also increased its popularity and use. The reduction in prices has made the use of microgrids more cost effective. Also, the decline in the price of power storage devices, such as batteries and improvement in the storage capabilities, support in the greater use of solar-powered microgrids.

The newly introduced smart grid technologies, made the microgrids intellectually sophisticated with advanced software and real-time data displays, to manage the grid interfaces effectively in order to achieve maximum efficiency, while handling the resources with greater economy.

More importantly, the proven reliability and security of microgrids in maintaining the power supply during adverse weather conditions, made them more popular among the industry as well as the government segment.

Right Characteristics for a Microgrid

The Lawrence Berkeley National Laboratory popularly known as 'Berkeley Lab' has suggested the following as right characteristics for a microgrid:

Independence in operation

A well-planned microgrid will on its own optimize its power production and consumption levels adhering to the system economics when connected to a grid. When operating under island mode, it will balance the power generation and load requirement in such a way as to upkeep the voltage and system frequency within the prescribed limits. In both operating conditions, it will intake optimum level of renewable power than the fossil fuel generated power.

Stability

It will maintain stability in operating levels when operated normally as well as when experiencing short-lived oscillation in a system or transient events, despite the grid remaining in up or down condition.

Adaptability and compatibility

It remains flexible to changes made in storage systems, generators, and others and takes over the changes for development without problem. The microgrid is compatible to the connected utility grid and assists in the expansion of the grid in an environment-friendly and economical method.

Scalability

It can expand and grow in adding storage systems, generators, and load features in an incremental manner to advance with the electricity generation and consumption levels.

Functional efficiency

It includes a supervisory controller structure to get most from the generators and installed energy storage units to efficiently deal with the consumption. Such an optimized efficiency will extend both economically and environment friendly benefits.

Economics

It will have a higher rating in using the Combined Heat and Power (CHP) systems and improved heat recovery efficiency. Its efficient use of renewable energy sources will contribute in bringing down CO_2 discharge levels.

Key Applications of a Microgrid

Commercial and industrial

Microgrids can be deployed in industrial parks, production facilities, office buildings, and data centres. Among the industries that deploy microgrids include chemical industry, chip manufacturing, and paper and food stuff manufacturing industries. Such installations while improving the security of supply to the users also assure quality maintenance in power supply.

Residential and community

Residential and community developments have more use for microgrid installations. Such installations, while removing the regulatory barriers assure a regulated power supply. The installations ensure security of supply in cases of grid failures or natural calamities and enable increased use of renewable energy sources.

Remote and off-grid locations

Microgrids installed in remote and off-grid locations away from any grid transmission or distribution facilities are connected through renewables as well as fossil fuel-based power production facilities.

Educational institutions, hospitals, and others

The microgrids installed exclusively in such locations are designed to grow with the demand. Most of the times such installations function in island mode. CHP units and biogas

Residential and community developments have more use for microgrid installations. Such installations, while removing the regulatory barriers assure a regulated power supply.

power plants are normally used for the continuous power supply and for providing heat during winters.

Military

Microgrids installed at military establishments function either in grid connected or island mode. Such installations ensure regulated supply and offer security against grid-related events and natural happenings and encourage the use of renewable energy sources.

Utility microgrid

Utility microgrid applications normally include a distribution feeder, a medium voltage distribution substation, or a number of low voltage substations in the area, where, supervisory control and data acquisition (SCADA), distribution management system (DMS), distribution state appraisal, and flow reckoning features are included to the system . To cut down the outage time during disturbances within the microgrid, Outage Management System (OMS) and feeder automation substation are added.

Microgrids and Renewable Energy

According to *'Renewables 2014 Global Status Report'*, the renewable energy contributes to nearly 22 per cent of the global energy generation and 19 per cent to the energy intake. It is a fact that, renewable energy-based power generation is not constant and regular. Especially, the wind and solar power generation undergoes off-production periods due to weather vagaries.

Unlike fossil fuel managed energy sources, the renewable energy sources such as solar and wind are installed globally, in many geographical locations. Technologies have enabled increased power generation from such installations and linked them to the power generation systems, which were earlier run using only fossil fuels. Such integration, while offering hybrid solutions for power generation, also makes the communities less susceptible to the erratic power generation and increasing fuel prices. But, the inconsistent power generation by renewable sources such as solar and wind and occasional surges in power generation crippled such facilities.

The flexibility of microgrids in accommodating and managing a range of generation sources comes handy to manage such situations. The installation of microgrids between the power generation and consumption points acts as a buffer to receive the extra power surge in order to prevent tripping of power. The DER feature in the microgrids allows them to run independently in island mode by disassociating from the conventional grid. Such intelligent feature installed in the microgrid enables it to connect it to the conventional power grid or other sources for the most economical running.

The Microgrid Energy Manager (MEM) in a microgrid manages and controls the operations which includes functions such as SCADA generator and load management, energy management, reconfiguring of system to assist black start after a detected error, monitoring of the system efficiency, analysis on CO_2 emissions, supervising the system health, and other functions.

The energy manager in a microgrid is linked to the major power generators and load features within the system. Additionally, when linked with a renewable energy power generator, weather forecast data is fed to the microgrid from the weather services. After analyzing the data input, the microgrid energy managers determine the needed renewable energy power generation.

According to '*Renewables 2014 Global Status Report*', renewable energy contributes nearly 22 per cent to the global energy generation and 19 per cent to the energy intake.

Implementing a Microgrid Solution

A microgrid solution is not normally implemented fully at one stretch. It is carried out in phases to get maximum benefits from the microgrid installations. In the first phase, efforts are taken to cut down the consumption demand, in the second stage on-site generation and storage solutions are accomplished, in the third phase efforts are taken to make the microgrid network intelligent with effective control systems and in the fourth phase, efforts to make independent in working without grid connectivity for extended hours are completed. Such a phased implementation ensures lowest lifecycle cost.

Demand reduction

The first phase primarily focuses on cutting down the demand for electricity, use of natural gas, and consumption of water. After briefing the customer on the outcomes of demand reduction the power conservation methods are adopted. Some of the popular and widely accepted power conservation solutions include installation of efficient lighting, occupancy sensors, and programmable temperature controllers, envelop improvements in building, upgrades/retrofits for boiler and chiller, right variable frequency

drives (VFD) for HVAC systems and advance metering.

Installing on-site power generation and storage features

In the second phase, power generation, using renewable and conventional energy sources, and power storage facilities are implemented. The preference in power generation is given to cleaner renewable energy power production using solar panels, wind turbines, fuel cells, biomass, or methane collected from landfills. The option of generating power using small-sized gas turbines is also included.

Including advanced controls

An intelligent microgrid network will include Distributed Intelligent Automated Demand Response (DIADR), building management system, and a SCADA system for controlling the network features. The focused lucidity into all devices right from the power producing systems to power consuming devices will enable proactive response from the power systems. The installed automated monitoring and controls will assist in making optimal use of power systems in tone with the demand and in detecting, isolating, and repairing the faults. The installed advanced controls assist the system to function within the laid down performance adhering to economics, reliability and leaving of carbon footprint. The inclusion of advanced demand response systems will support automatic peak load shedding and transfer the extra energy to outside market sale.

> World over, microgrid market is fast changing and gaining more importance.

Grid sovereignty

On conclusion of the three phases the microgrid will acquire the capability to function on its own for an extended period of time without connecting to the main grid. The automated controls installed in the grid will decide on the independent status or grid connected status of the microgrid.

Independent working of the microgrid without remaining connected to the main grid can be carried out in two ways. The microgrids featuring internal combustion engines with reactive power compensation to regulate voltage and frequency can use relays, switches, and breakers to connect to the grid or remain disconnected from the grid. In the second method, the power generation and storage features of the microgrid can get linked to the main grid using orderly placed inverters to assume full control of power flow between the microgrid and the main grid.

Microgrids Benefit Rural Folk

Improving health

Microgrids installed in rural locations enabled the people to use electric lights instead of using conventional kerosene lamps. Discontinuing the usage of kerosene lamps that caused respiratory diseases, lung infections, tuberculosis,eye problems,and cataract saved many villagers from these health problems. Sanitation features in rural health centres witnessed improvement to extend right treatment to the hospitalized, reduction in maternity related mortality, and cut down infant mortality rate. The refrigeration facilities made available in the rural hospitals enabled storing of lifesaving drugs. Electric lighting enabled the rural folks to save themselves from venomous snakes and other reptiles.

Social benefits and income generation opportunities

The electrical power extended to the schools through the microgrids enabled the children to use educational aids and computer labs at school for quality education. The availability of light at home assisted them in home study. The rural homes which previously used carbon releasing kerosene, coal, and wood have now started using clean electric power, for cooking and storing food. The supplied electric power to cafe, carpentry workshops, basket weaving facilities, and tailoring centres provided job opportunities to the rural folk to earn extra income.

Others

Microgrid powered centralized refrigeration services allowed storage of perishable food items, which otherwise will go waste. The powering of community television and radio enabled them to know the worldwide happenings. The installation of communication facilities became possible in the rural locations with the supply of power from the microgrids.

Worldwide Use of Microgrid

World over, microgrid market is fast changing and gaining more importance. According to a report released by Navigant Research in the second quarter of 2013, microgrids generated, released, and handled approximately 3,793 MW of power globally. North America leads the race with the production of 2,505 MW, followed by Europe with 508 MW, countries in Asia Pacific region with 387 MW, and rest of world with 393 MW capacities. On the consumption side, educational institutions consumed a maximum of 1,021 MW, followed by community and utility with 928 MW, remote systems with 754 MW, military services with 657 MW, and commercial establishments and industries with 433 MW. The report finds a rapid growth

in the microgrid installations among the commercial and industrial segment. The remote systems which use around 20 per cent of the generated electricity are expected to have more number of individual projects than the other segments.

On-going Research and Development Activities of Microgrid

The flexible feature of microgrid systems is gaining attention among the researchers to further its development and usage for improving the quality and quantity of power delivered.

An EU research at Kythnos island close to Greece built a microgrid using a 10 kWp solar panels, 53 kW battery storage, and a 5 kVA diesel gen-set to power 12 houses in a small valley. In parallel, the microgrid is connected through three Sunny-island battery inverters designed to operate both in isochronous and droop mode to form a single phase. The research aims to assess the performance of microgrids in both centralized and decentralized control methods.

Another research that took place in the same region involved integration of a wind turbine with load management to test the operation of the system. The research also attempted in the inclusion and implementation of latest communication know-how in the microgrid functioning.

A research performed by Consortium for Electric Reliability Technology Solutions (CERTS) of the US Department of Energy aims at finding ways, firstly to attain seamless transition between off- grid and grid-connected conditions, secondly to protect the microgrid working without relying on unreliable power supply, and thirdly to introduce a feature that will ensure frequency and voltage stability when working on autonomous mode without the need to use high speed communication to correct the errors.

A Japanese research developed a microgrid drawing different levels of power from sources such as solar photovoltaic, fuel cell using phosphoric acid, and two gas-powered engines. The microgrid survived a destructive earthquake and robustly operated for providing power.

Microgrid Investment vs. Payback

Rapid proliferation of microgrid solutions is hampered by heavy initial investments and slow Return on Investments (RoI). Due to high level of capital investment, presently fully formulated microgrid solutions, which include on-site power generation and storage facilities, demand reduction features, grid independence capabilities, and advanced control systems, are deployed only by establishments with such critical needs and have the patience to wait for a longer duration to get right returns on the investment made. Continuous researches on cost reduction in the implementation of microgrids and fall in cost of renewable energy generation are perceived as indications for the increased implementation of microgrid projects in the days to come.

Conclusion

Electricity has become part of our life and has an effective role in shaping our personal lifestyle and the economy of the nation. A microgrid is the latest effort to make it possible for every individual. Though the implementation of a fully developed microgrid will take two to five years, it assures increased benefits to the power utility, the end user, and to the overall society. Presently, it faces hurdles and challenges in its installation. Continuing researches to improve the working of microgrids with latest technologies are fast taking shape. Progress has already been made, in the use of hardware and software solutions, to provide more functional autonomy to the microgrid and system integration features, to support improved automatic control on the management of the system. Such innovations are expected to bring positive gains in microgrid implementation soon.

Present-day consumers look forward to have a reliable and more secured power supply that is generated locally, instead of hauling it from distant locations. The rapid changes taking place in technological innovations make it difficult to visualize the shape of power grids in the coming years. You will not be surprised, if you find the real estate value of a location sky rocket in future, because, it implemented a right microgrid solution to assure secured power supply. Who knows, it may be demanded and valued as one of the essential features along with a good school, road, supermarkets, and other services at the location. EF

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ELECTRIFYING REMOTE AREAS

Innovations by OASYS South Asia Project

The issue of electrifying inaccessible areas is the need of the hour today. To address this problem, various efforts have been made by different authorities. In this article, **Debajit Palit** and **K Rahul Sharma** describe an innovative effort of the OASYS South Asia Project to electrify remotely-located villages in India.

The OASYS Project

Globally, there are more than 1.3 billion people who do not have access to electricity. Although conventional grid connection has been the predominant mode of electrification, it has, however, not been able to successfully reach numerous remotely located regions both in India and in many countries across the globe. In addition, many households in grid-connected areas in India also do not take connections from the grid, the primary reason being unaffordability and unreliability of the central grid. The problem of electricity access requires solutions which are techno-economically viable, institutionally feasible, socio-politically acceptable, and environmentally sound. Such solutions need to be identified and targeted in order to propel a conscientious and collective effort aimed at improving the quality of life for targeted sections on all fronts and tangents. Given that institutional issues and development of viable business models for rural electricity and energy supply have not been receiving the attention they require, it is necessary to carry out a systematic analysis and research.

The 'Off-grid Access Systems for South Asia' (OASYS South Asia) project aims to develop a systematic analysis and research foundation in order to find appropriate local solutions for sustainable rural electricity supply, especially for the off-grid areas. The project was devised to answer two key questions—whether there exist cost-effective, secure, and reliable local off-grid electricity supply solutions which can meet the present and future needs, and if local solutions have the potential for scaling-up and replication potentials which can be brought to the mainstream for wider electricity access in the developing world.

The efforts entailed a thorough review of the prevalent off-grid electrification sector, a detailed investigation of a suite of alternative decentralized business solutions, and corresponding institutional frameworks for rural electricity and energy supply, along with a special focus on South Asia as the targeted region, for the evaluation of case studies, demonstration projects, and applied academic research, respectively. As part of the OASYS project, an important component was to develop an off-grid delivery model framework and implementation of demonstration project(s), covering un-electrified villages, to test the framework. Demonstration projects have thus been implemented in four different locations situated in the states of Odisha, West Bengal, and Uttar Pradesh in India, through three distinct business and institutional models aligning with site-specific conditions.

Demonstration Project(s) under OASYS

The demonstration projects implemented under the OASYS South Asia project employed mini-grids, microgrids, and pico-grids providing either AC or DC power to

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electrify households and shops/micro-enterprises in the project areas. The three models employed are as follows:

- Community-managed model with NGO (AC and DC microgrids of different capacities in five villages) in Dhenkanal district, Odisha. They serve around 150 households.
- Community-managed model with district administration (20 kWp AC mini-grid in one village) in Kandhamal district, Odisha to serve around 250 households.
- Privately-operated (micro-utility) model: Selected through a competitive bidding from eligible project developers. This model implements the following:
  - » Solar DC microgrids in Uttar Pradesh to serve around 4,200 households.
  - » Solar AC pico-grids in West Bengal. They serve around 500 households and shops.

Community-managed Model with NGO

This demonstration project is located in the Dhenkanal district of Odisha, where a community-managed and NGO-supported business model has been developed to set up five solar mini and pico-grids. The village cluster, namely Rajanga village (and its Hamlet), Kanaka village, Baguli village and Chadoi hamlet, with a total population of 555 inhabitants, are completely un-electrified and are located within the Kandhara Reserve Forest, thereby making electricity access relatively difficult. Furthermore, the targeted areas have not been considered under the national rural electrification scheme, namely the 'Rajiv Gandhi Grameen Vidyutikaran Yojana' (RGGVY), steered by the Ministry of Power, Government of India, due to their location within a forest area. Owing to this remoteness and the fact that private developers

> "We were sustaining on roots and fruits collected from the forest and didn't even know what light was. Now my children are able to study at school during the daytime and at home during the evening. They even take tuitions in the evening. I am really grateful for the light."
>
> **Lalita Pradhan**
> Member
> Village Energy Committee,
> Dhenkanal project

were unwilling to invest in such a high business risk area (due to low population and paying capacities), a subsidy-based community-managed model was developed.

The Energy and Resources Institute (TERI), along with its grassroots partner, the Institute for Research and Action on Development Alternatives (IRADA), identified different household electricity needs and new livelihood activities which could be initiated post stable electricity intervention. Through this assessment process, active participation of the village community was ensured by the formation of a Village Energy Committee (VEC), which is responsible for the management of the electricity project. Three of the villages have an AC microgrid while the hamlets (with 12–15 households) have a low voltage DC microgrids, respectively, based on the population of the villages and the potential for livelihood-generating activities. However, considering that this is a community based project and it is therefore important to maintain homogeneity, regardless of whether the village has an AC or DC system, the quality and quantity of services provided to each household has been kept exactly the same. This project has enabled numerous livelihood opportunities, which include activities that use applications, such as grinders for spices, packaging, 'Saal leaf' plate-making, better irrigation facilities, functioning water purifiers, and installation of fans and street lamps in community areas/institutions like clinics and schools, etc. Moreover, smart grid interactive inverters and battery management system, with auto load cut-offs or timer-based operation, enable users to efficiently manage the limited energy produced by the AC and DC microgrids. The project was commissioned in March 2014 and is supposed to be completely independent by early 2015 by which time TERI will exit the project and the management will be completely handed over to the VEC and IRADA.

Community-managed Model with District Administration

While the community-managed models can ensure local decision-making and contribute to sustainable long-term operation of the power plant, this model extends the concept to include the district administration as a key stakeholder. The district administration of the Kandhamal district of Odisha is supporting this project through the contribution of land, a room for housing the battery and inverters, and the power distribution network and the OASYS project is supporting the installation of the solar power plant, training and capacity-building of stakeholders, and other soft support to make the project sustainable. The district administration is also a member of the management committee and on TERI's exit from the project, the project then will be handed over to the district administration. The involvement of the local administration is essential for the scaling-up of such initiatives, in order to ensure smoother revenue transactions, maintenance, and repair, and funds allocation in case of a need to enhance the system capacity. This project will support over 250 households from a 18 kWp capacity solar power plant. Further, once the mini-grid concept is tested and its efficacy in providing clean electricity is demonstrated, the district administration is also expected to cover other un-electrified villages and hamlets in the district using fund available under the District Innovation Fund and/or other developmental programmes to scale-up the initiative in the district.

Privately-operated micro-utility model

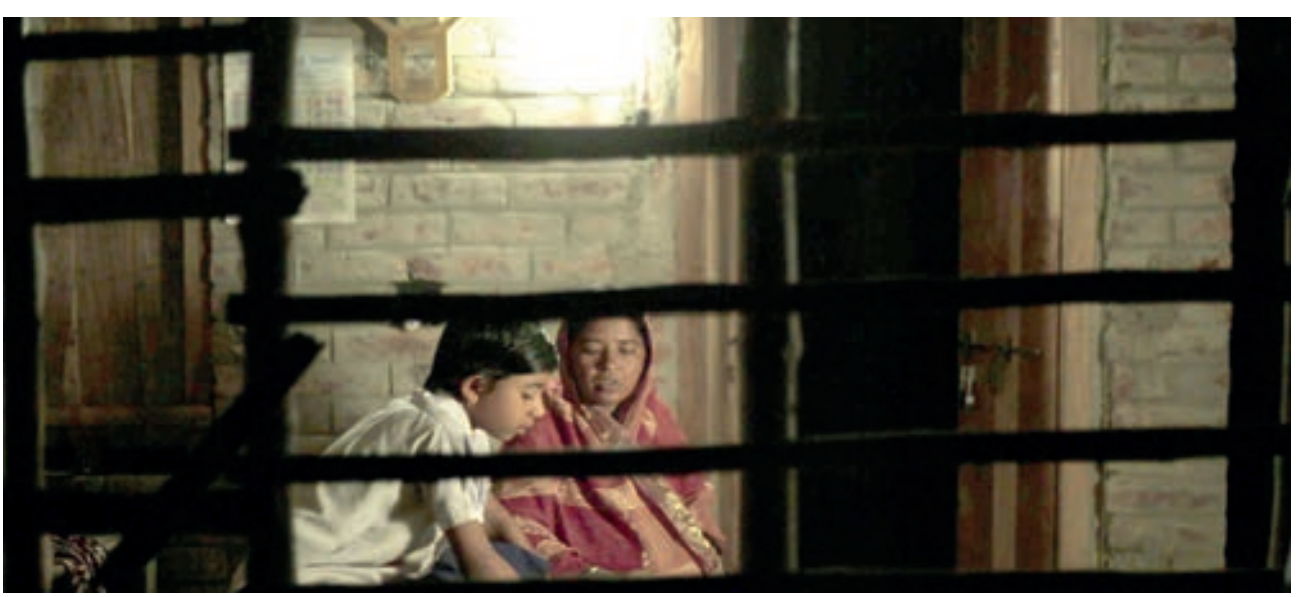
In this model, a cluster approach for implementing solar DC microgrids

> "People of these islands are unable to come up with collateral, and hence the banks are reluctant to give them loan. So NABARD came up with this instrument called the joint liability group. This belongs to agriculture sector basically, but now they have extended it to the energy sector. With these groups they were able to give loans without any collateral. So we sanctioned around 45 loans initially and it worked out well. We have been getting hundred percent repayments on that. Seeing this, other banks like United Bank also came forward to give loans."
>
> **Col. Vijay Bhaskar**
> Country Director
> Mlinda Foundation

and solar AC pico-grids is used. Mera Gao Power and the Mlinda Foundation has been supported as parts of this initiative in Uttar Pradesh and West Bengal, respectively, with the objective to enhance participation of private sectors in rural electrification. A formal bidding process was invited from around 25 private players in the off-grid electrification space who were asked to submit a proposal requesting for Viability Gap Funding (VGF) from the OASYS project. After an intensive process of evaluation, Mera Gaon Power and Mlinda Foundation were selected and were recipients of the VGF for ensuring sustainable supply of electricity for basic lighting and mobile phone charging facility.

In the case of Mera Gaon Power, the VGF supports the installation of microgrids for connecting 2,900 household initially, with the condition that an additional 1,500 households are to be given service connections over the next two years, by re-investing part of the revenue generated from the first 2,900 connections, thus reducing the overall subsidy from OASYS project to around 30 per cent. MGP is responsible for all operations, maintenance and management on its own using its human resource. Sandeep Pandey, Director at the Mera Gao Power states, 'The fund that was allocated to us under the OASYS project in 2013 was utilized to open a new branch in Laharpur block. At that time, we were in need of funds, and the aid was very helpful. We are still using the leftover fund to install new microgrids. Although Laharpur block has 1,000 villages and hamlets, our base is in 500–600 villages and we are looking at a potential of around 7,000–8,000 customers. With the help of the fund, we not only bought new systems, but also trained our staff.' This is, by far, the biggest of the OASYS projects in place, planned to serve over 4,200 households by using low-cost modular solar microgrids. Under this model, an auto switch (on/off) for basic lighting (2–4 light points) and mobile phone charging is provided for community members. MGPs key focus is on strengthening operations and ensuring timely collection and thus they have formed Joint Liability Groups (JLG) with all the users of a single microgrid acting as one JLG. The JLG assures payment based on weekly tariff and a collection efficiency of around 90 per cent has been observed. The connection charge is ₹ 50 and collections of ₹ 25 per week are made by users to MGP on a prepaid basis. Users may also choose to pay in advance for more than one week as well.

In the case of Mlinda Foundation, the users themselves have availed small loans from a local bank (with Mlinda Foundation providing the risk guarantee) for establishing the solar AC pico-grids in their homes and repayment period for the loan is around 3 years. The OASYS project has supported Mlinda Foundation for about 30 per cent of the total project cost to make the repayment amount affordable to the users. Each pico grid consists of adequate capacity of solar modules, which are mounted on one of the houses in which the inverter and battery bank is also installed,



> When we first started it was very difficult selling particularly to the investors and many other players in this field. So, there was a feeling that what we offered was too little; it wasn't enough for what people wanted. They think everybody wants fans, TVs, coolers, grinders ... but the fact that we prioritized basic needs ... and in this case it is light. So as long as kerosene is being used in households then MGP provide better solution, but once kerosene is eliminated then we can look at offering more.
>
> **Brian Shaad**
> Director
> Mera Gao Power

and shared by 6–10 households. Each system provides a household with three light points of 2W LED bulbs and a point for mobile charging. Here also, a JLG model is used for revenue collection. The JLG is responsible for receipt of payments and operation of the systems. Secondly, a 'Market Segment' is also in place, where JLG is formed consisting of the shop owners and members of market committee, who will be responsible for operations and collection of the payment. The installations have recently been completed in all the beneficiary households as well as in the market.

The Way Forward

All the projects implemented focus not only on technology, but also on other critical aspects that enhance ownership and therefore revenue generation, such as training and capacity-building on skills relevant to the target group, sustained monitoring and evaluation of project performance, inflows and outflows of revenue, and lastly, enhancing energy development income-generating linkages to foster consistent project sustainably. The three examples showcased in this article also demonstrate innovative ideas that can create enabling environments for different stakeholders working within the rural energy access space. Based on the specific characteristics of the socio-economic development of the user community, maturity of the business model and the strengths and weaknesses of local institutions, the article aims to substantiate the point that a 'one size fits all' approach is either not applicable or not required in every situation. Government subsidies should be continued in scenarios where the viability of business models is low, and restructured to enable scaling up of interventions in other scenarios. The roles of different actors will vary, depending on the socio-economic characteristics and geographies. Where in some cases local governance is important, in others it may be more suitable to promote a micro utility-like model. The OASYS project team is also carrying out intensive monitoring of the different technical and institutional models to draw lessons based on the operational experiences and document such lessons for future reference. EF

This article is based on experiences from implementation of off-grid electrification projects in India by The Energy and Resources Institute, as part of a multi-consortium research project titled 'Decentralized off-grid electricity generation in developing countries: business models for off-grid electricity supply' (Alternatively called Off-grid Access System in South Asia), led by the De Montfort University and lasting from October 2009 to April 2015. The research project is funded by the Engineering and Physical Sciences Research Council (EPSRC) / Department for International Development (DFID) research grant (EP/G063826/1) from the Research Council United Kingdom (RCUK) Energy Programme. The Consortium Partners are: De Montfort University, the UK; The Energy and Resources Institute, India; TERI University, India; University of Manchester, the UK; and Edinburgh Napier University, the UK.

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Acceptance Issues of Non-Conventional Energy

A Case Study

In a case study on solar power technology in the Sundarbans, **Anwesha Haldar** finds out that the solar power system is very slowly gaining acceptance from the people as compared to other sources of power.

Inevitable Shift to Non-conventional Energy

Modern man needs energy in everyday life and the more developed the technology becomes, the more it enhances the need, leading to an urge for further innovations. With rapid increase in world population and an even greater rise in the variety of energy resource exploitation, it is time to put a check on the uncontrolled use of these traditional non-renewal sources of energy. Their reserves are not only fast depleting but are also causing extensive pollution. The soot and dust particles in the air and the oxides of carbon, sulphur, and nitrogen emissions contribute to the greenhouse effect and subsequently global warming. According to a research conducted by the World Health Organization (WHO), around 13,000 people die every year in India because of pollution caused by fossil fuel-based electricity generation pollutants. To reduce the emissions from coal generation, many of the new plants are based on super-critical technology that emits 15 per cent less carbon dioxide, but this has not been widely accepted. Thus, an alternative source of power generation is of utmost need to curb emissions and attain a sustainable way of development.

Solar Power Technology in the Sundarbans

Among the five major sources of alternative renewable energy (RE), the coastal parts of West Bengal are most suitable for generation of solar power as the sun's radiation can be utilized extensively, throughout the year, at a minimum cost. Solar energy needs to be converted to electrical

energy to provide power by using a device called solar panel, which can convert light energy into electrical energy. Solar panel is a group of solar cells working on the principal of photoelectric effect which is enough to meet all our energy demands if used properly. Solar technology can be used to light a small 1W LED bulb to mega watt utility scale. The infrastructure is easy to set up and it is both noise and emission free. Only about two per cent of the total power requirement of West Bengal is met from RE sources.

As the vulnerability of the rich biodiversity due to climatic changes is very high, the carbon emissions, a principal anthropogenic factor to global warming, must be kept in check. The Sundarbans are an energy deficient region and most reclaimed villages on the islands and at the fringes of the densely populated mainland are yet to be connected to the conventional power grid. According to a study, many villages in the forested islands coming under the purview of the Sundarbans Development Area are not likely to be electrified through conventional power, at least in the near future, due to remoteness, lack of proper accessibility, low affordability of the locals, and non-feasibility to connect with overhead lines. At this point, it is advisable to shift to off-grid, Decentralized Distributed Generation (DDG) energy systems using renewable sources like solar or biomass.

With the constant rise of population density, using solar energy seems the most eco-friendly way of power supply to this region. But no technology, however good, can be imposed on a community. It takes time, experience, and level of development in accepting them. Despite a large drop in capital costs and an increase in fossil fuel prices, solar energy technologies are not yet competing with conventional technologies for electricity production. Besides the economic disadvantage,

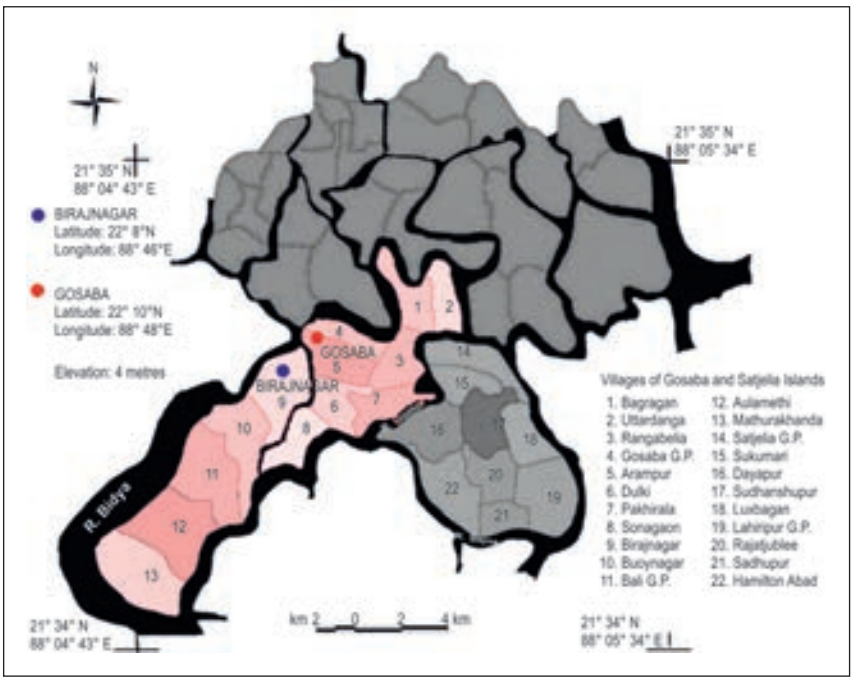

Figure 1: Map of Gosaba Island

solar energy technologies face a number of technological, financial, and institutional barriers that further constrain their large-scale deployment. It is to be noted that even though large programs and projects have been sanctioned by the Union and State Governments, almost negligible amount of subsidy or awareness have reached the remote islands of Gosaba Block (see Figure 1).

Hence, I had chosen this island under South 24 Parganas in West Bengal for a case study, as a part of my research project. The two places, namely the Gosaba town and Birajnagar village, are separated by a narrow creek which can be easily crossed over by a boat, but there is a huge discrepancy in the level of their development. This area lies at the junction of the densely populated Basanti area and the forested tracts of the Sundarbans with a population of more than 6,000 in about 200 sq.km. area. For such inhabitants, who are constantly struggling with climatic challenges such as floods, cyclones, and storm surges, lighting facility is of utmost importance in the face of storms, wild animals, and diseases. They are mostly agriculturalists or local businessmen who earn a bare minimum to sustain their livelihood and their prime requirement is a source of light at a minimum cost. Hence, a study of their views and an awareness of the power resources give an idea of the developments and hindrances to policy and technology implementation in this part of the country.

The study was preliminarily done through focus group interviews and 150 households in Birajnagar village and Gosaba town were selected by random sampling method for survey from January 2013 to January 2014. Here, I highlight the issues of differences in acceptability of a renewable eco-friendly energy supply in the Gosaba Island, in addition, to explore the perceptions of people regarding the use of solar power and to get an idea of the advantages and disadvantages faced by the people in this region. The observations raise a query about whether solar power should be bringing in development or an established minimum level

of development is required for technology to have widespread utility.

Present status and adaptation problems of solar power electrification development is a socio-economic and technological process with the prime objective of raising the standard of living of the people and a crucial determinant is the regular supply of energy. The State and Indian Government emphasized the role of rural electrification by renewable energy sources with great importance. Power lines in rural areas were seen as synonymous with providing the essential infrastructure for boosting rural development. A reliable energy source in Gosaba Island can lead to the expansion of rural industries like agro-food products, zari work by women, rice milling, etc., which can give them higher income and improve the quality of their life. In the long run, it is expected that modern energy services would provide indirect social benefits,

diversified income opportunities, higher educational quality and enrollment, higher standard of living and equity in the society.

However, in this particular region, development is measured by increasing agricultural gain and income, excluding other much important parameters like higher standards of education, improved health care facilities, and women empowerment. The villagers have to depend on conventional fuel sources for lighting, cooking, heating, irrigation, etc. The main power sources in the village areas are still firewood, straw, cow dung, dried twigs, leaves, kerosene, and diesel, all of which have undesirable impacts on the local environment. The other major requirements in the region for which solar power has become a necessity are street lighting and the satellite television, in the absence of other entertainment options, followed by mobile charging facilities. Even though LED bulbs are fast capturing the conventional market with its low consumption rates, use of solar power is restrictive. It is majorly being used for lighting by the children for studying and by the men-folk for doing extra jobs even after sundown. Fan is still a luxury for the below average income group who cannot afford larger solar panels.

Tables 1–2 show the dependence of the rural residents of Gosaba Island on fuel sources in their daily life as per the data collected from our surveys.

Table 1: Primary fuel usage for cooking

	Wood	Cow dung	Straw	Dried twigs and leaves within house	Gas
% of households	30	26	24	19	1

Table 2: Primary power usage for lighting

	Solar	Kerosene	Electric current
% of house-holds	33	53	14

It can be seen that cooking is still done through traditional methods of heating while some changes are seen in case of lighting. Another important factor to be noted here is that the women in these villages, due to lack of awareness, have lower propensity to adapt to the changing technologies. Solar cookers have not been introduced here. Kerosene still rules the remote rural market due to its multipurpose usage and wider availability through fair price shops. Another one of its advantage is that unlike most other energy sources that are available, kerosene can be stored for moths for future use, without any depletion in its quality.

Based on the above energy usage figures, a consumption rate chart was devised from the field data which is represented by Tables 3–4.

The surveys undertaken showed that the level of education and awareness regarding environmental issues were low in case of rural parts of the inhabited Gosaba Block while it was comparatively higher for the town area, as seen from the Figures 2 and 3.

Recently, the residents here are being encouraged to replace the traditional sources by solar power. It is being observed that the expected increase in demand for standalone rooftop solar panels did not amount to much in the Gosaba Block mainly because the supply of subsidized solar kits was far less than the demand. Frequent malpractices with the kits and funds have been reported by the locals. Almost no subsidy is available for private consumption from the government but the local cooperative banks have tried to lend their hands

Table 3: Amount of consumption of the cooking fuel used

Fuel Type	% of household usage per day			Per 3 months 1 LPG cylinder can be availed
	Below 5 kg	5–10 kg	Above 10 kg	
Wood	18	27	55	
Cow dung	45	30	25	
Straw	38	28	33	
Dried twigs and leaves within the house	52	32	17	
Gas	-	-	-	3

Table 4: Average cost of lighting borne by percentage of households

Type of Lighting	Per Month Cost (₹)			Initial Cost	
	Less than ₹150	₹160–200	More than ₹200	With Govt. Subsidy	Individual Cost without subsidy
Kerosene	27	57	17	-	-
Solar power				(₹5000)	(Around ₹14000)
	0	0	0	38	62
Electric current				-	(₹550–600)
	22	16	13	-	50

and in turn are making small business for themselves. The scheme is that a certain percent of the down payment is waivered and an equal monthly installment facility is provided to clients buying more than 40W solar panels and having their own bank account in that branch. As most of the poor farmers do not have a bank account or are reluctant in using larger solar panels, they cannot avail this subsidy, hence widespread use of solar still lags behind today. Other factors like sparse scattered population of the islands interspaced by extensive agricultural lands, lack of awareness and poor purchasing powers hinder solar power development especially in Birajnagar. Hence, the expected socio-economic benefits have been slow in materializing, i.e., if it can materialize at all. In case of Gosaba town, the situation is different. Gosaba town had the privilege of having electricity from the biomass gasifier plant from 11 am to 9 pm and sometimes till 11 pm that was set up in June 1997 by the West Bengal Rural Energy Development Authority (WBREDA). This was India's first biomass gasifier-based mini grid of 500 kVA. The gasifier plant initially met most of the power demands of the village. According to interviews given by the locals, there were no voltage fluctuations and that power could be used for heavy load charging too. Hence, this encouraged the fast evolution of Gosaba village into a prime town in this area. Most job opportunities, market, government offices, schools, and residence of the comparatively affluent locals developed in this center.

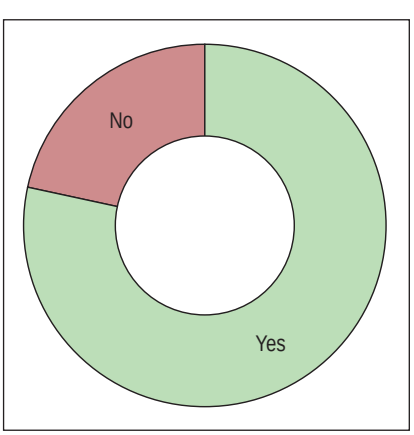

Figure 2: Awareness of environmental pollution from burning fossil fuels in Gosaba

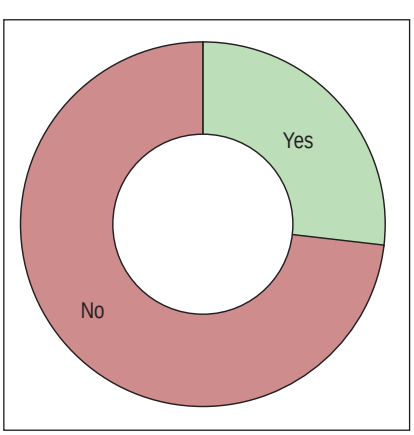

Figure 3: Awareness of environmental pollution from burning fossil fuels in Birajnagar

The gasifier power supply was time bound hence in emergencies after 11 pm, kerosene had to be used. Shortage of large amount of firewood and a cumbersome process to the run the gasifier plant, was also a major problem. Even though the gasifier plant had its own share of disadvantages, most of the locals were satisfied with this power connection. Nevertheless, the major issue that cropped up was that the state electricity board wanted to extend their supply to Gosaba town and both power sources could not be heavily subsidized by the government. Hence, the biogas plant was closed down the day electricity was introduced to this locality in April 2012. Now the electricity is a costly source of power, with frequent voltage fluctuations and power failures. As people have been already introduced to electricity and related comforts of life, they have no choice but to install another alternative power source. So, more and more people are installing solar systems to be assured of a constant and better source of alternative power.

In our field study, it was seen that the level of education, occupational diversity, and income is poor and about 70 per cent and 15 per cent of the houses surveyed were below poverty

line in Birajnagar and Gosaba town, respectively. Most of the working age group population have either never been to school or have only completed education hardly up to class eight. The rest 30 per cent of our surveyed population on the entire Gosaba Island had the opportunity to pursue studies after class eight. Therefore, about 72 per cent of the population are either engaged in agriculture, fishing industry, or have to work as daily labourers with a meager salary. About 35 per cent of the surveyed population on the island earn less than ₹2,000 a month and about 51 per cent earn above ₹2,000 but less than ₹5,000 per month. Hence, there is a predominance of thatched mud houses in remote villages with little or no basic amenities of living. This has affected their awareness regarding climatic hazards, pollution, and use if advanced technology for a better living.

In Birajnagar, it had been observed that only the comparatively higher income groups had access to the authorities and cooperative banks who were the major suppliers of subsidized solar kits. The price ranges from ₹ 7,000–16,000 depending on the wattage value, mostly without Equal Monthly Installemnts (EMI) facility except when the dealer is personally acquainted. It is definitely a burden on a majority of households, whose total family income is less than ₹ 5,000 a month. Still, many houses have been electrified in this area as they feel that solar systems last them for about five years within which time, apart from a few repairing costs of around ₹200–300, no other expenditure is incurred. Another reason for their shift to solar power is the increase in the cost of kerosene. Only 2.5 litres oil is available from fair price shops every 15 days at ₹40–45. This is insufficient for most houses with large families and kerosene has to be purchased from the market at ₹50 per litre, twice or thrice a month. This makes fuel expenditure rise to ₹300 per month, amounting to a cumulative minimum expenditure of ₹18,000 in five years. In comparison solar systems incur an average expenditure of ₹14,000 for standard sets with about twice repairing charges of ₹300 each, amounting to just ₹14,600 for five years.

Table 5: Cost of solar panels (Including 2 Batteries, extra two CFL Lamps, and a Charge Regulator may also be supplied with the kit.)

75 W	40 W	20 W
₹16,000	₹8,400	₹2,200

The demand of 40 W Solar Panels is 70 times more than 75 W Solar Panels (Table 5). Though the kit, a combination package of Tata BP panels and Exide battery, comes with a warranty of five years, in some cases the battery has to be changed and about ₹2,000 is charged each time. Lack of awareness on its maintenance and use has hindered widespread installation of individual rooftop solar sets. It has also been noticed that street lighting is a major problem in the solely solar powered village of Birajnagar as poor maintenance reduces its life and no one is willing to take the responsibility of repairing. In Gosaba town, it is mostly used as a substitute source of power, unlike Birajnagar where it is the only main source. A perception study on the attitude of the respondents without solar power at home (Figures 4 and 5) markedly differs in the two study areas. According to the people in Gosaba town, they wanted solar power due to three major reasons—a) they were already used to light during the night time, b) faced problems with the state electric supply lines, and c) wanted an alternative source of power during emergencies. While no one in Birajnagar claimed that they would not want a solar system if they could afford it, in Gosaba the percentage of people willing to get a substitute connection was more, even though they already had the electric supply line, most backed out due to high initial cost. Some did not want another source as they felt that it would add to their expenditure. From their conversations, it was evident that the residents of Birajnagar did not know about the benefits or problems of grid based, thermally generated electric supply connection, so the next available alternative source was solar

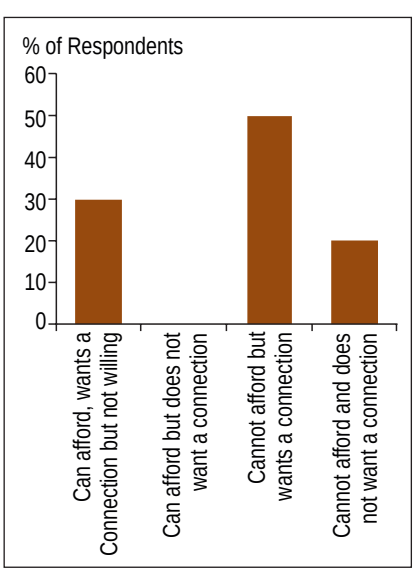

Figure 4: Attitude of households without solar connection in Birajnagar village

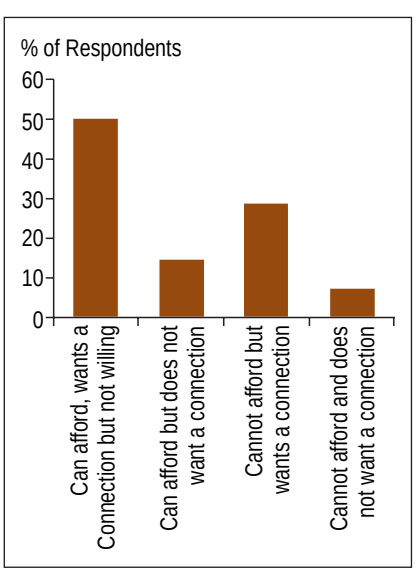

Figure 5: Attitude of households without solar connection in Gosaba town

power. It can also be inferred that the residents of this area are not very open to the idea of a rapid change in their lifestyle, especially among women, who are still the major controllers of household affairs. Men who have forayed into the outer world are more eager to try out new solar technologies for irrigation, lighting, etc., but when it comes to cooking, winnowing, milling, or any other household electrical work done by women, they are reluctant to alter their existing ways of work. They would rather prefer a time-tested introduction of any technology, how so ever beneficial it might be.

People here still dream that thermally generated electricity through the grid system can bring in more development in this region as it has done in large cities. Hence, they can never be fully satisfied with individual solar power panels. A comparative and overall satisfaction level status has been represented in Figures 6 and 7. Their increased dependency on electric appliances have caused higher wattage consumption which falls short. Even so, it can be inferred that solar power has a wider acceptance as it is much cheaper, non-polluting, and does not leave black soot marks on walls. The users also marked that solar connection was much safer to use and does not cause any short-circuit fires, shocks, or other electric hazards. The users have the discretion of using the power as and when required, hence can curb power wastage. Solar Power is mainly used in Gosaba for night time lighting, as a substitute in running a fan and a light, during long power cuts of the main connection. In Birajnagar, it is used for running televisions, charging mobiles, apart from lights and fans throughout the day. Shops can be opened even in the evening. Students remarked that they get an extra 3–3.5 hours to study in the evening and women can do some knitting and *zari* work for a living.

Future of Solar Power in this Region

Since climate change is a major concern, the inhabitants near vulnerable ecosystems should be introduced to environmentally viable livelihood activities and aim towards sustainable development. Such technologies are often not cost effective, hence, heavy subsidies must be provided by organizations and government in order to save them from long-term hazards. The shortages of fuel energy in New India have lead to the use of alternative sources of power. To eliminate dependency on kerosene, over a decade ago, the government started a programme to offer off-grid solutions at subsidized prices. Under the Remote Village Electrification Programme (RVEP), the Ministry of New and Renewable Energy (MNRE) offers a solar home lighting system (SHS) with a kit of 1–2 CFLs, a solar panel, a battery, and a solar charge regulator. The landmark programme of Rajiv Gandhi Grameen Vidyutikaran Yojana (RGGVY) of the power ministry proposed that, 400 million households who were burning kerosene for lighting were to get at least 1 kWh of electricity a day to meet their basic needs by 2012. The Jawaharlal Nehru National Solar Mission (JNNSM) aimed to play a major role in India's preventive and mitigation measures against climate change. But none of these ever reached the remote parts of these villages. This shows that underdevelopment in terms of lowered purchasing power and poor education is a barrier to the acceptance of a cost-effective eco-friendly power source, as seen in most parts of Gosaba Island.

In conclusion, it can be said that the solar power system is very slowly gaining acceptance from the people in compared to other sources of power. Most respondents have backed from future use of solar systems only due to its low capacity to run television sets, motor pumps, and inefficiency to be properly charged under overcast skies. If these problems can be mitigated to some extent or if a large solar power generation plant is installed in the vicinity, people will readily shift to such non-polluting, shock-proof, user-controlled, and cheap source of power. Thus, our aim should be to create awareness and widely introduce the product, so that people themselves realize solar power benefits from long-term use. EF

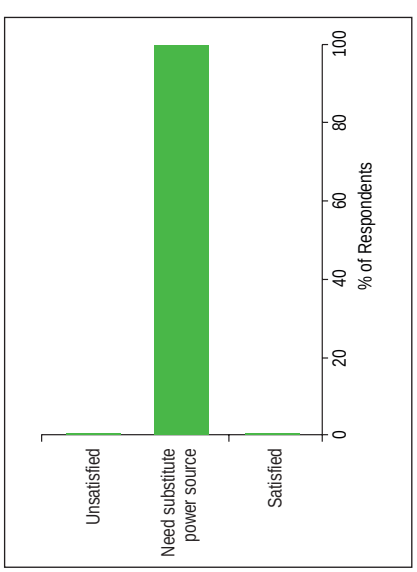

Figure 6: Degree of satisfaction after solar power connection in Gosaba

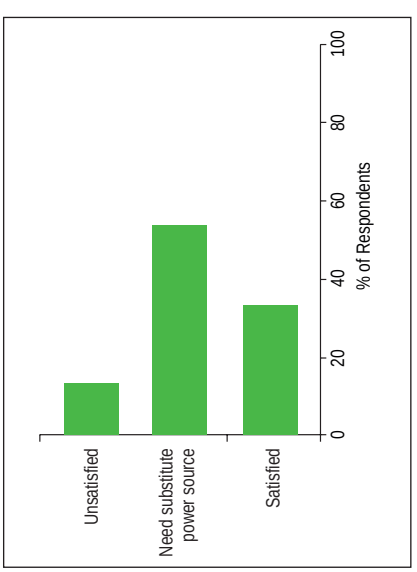

Figure 7: Degree of satisfaction after solar power connection in Birajnagar

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SOLAR OVER

Last year was another record-breaking year for photovoltaic (PV) installations, with nearly 39 gigawatts (GW) of new capacity produced—some 8 GW more than in 2012. PV's biggest market, China, saw around 9 GW installed in the fourth quarter of 2013 alone. The last-minute rush was sparked by the reduction on January 1, 2014 in the feed-in tariff for large grid-connected projects from CNY 1 ($0.16) to CNY 0.9 ($0.15) per kilowatt-hour. State support for solar projects has helped to end the two-year slump for PV manufacturers, which are generally now seeing rising profitability. On March 3, 2014 Jinko Solar Holding Co. posted its highest quarterly earnings in almost three years, with net income in the fourth quarter of 2013 of CNY 164.3 million ($26.7 million) compared with a loss of CNY 761.1 million in the last quarter of 2012. Though Trina Solar Ltd.'s results for the last quarter of 20 13 were generally comparable to those for the third quarter, China's second-largest PV panel maker had a significantly better year overall compared with 2012, reporting a 281per cent increase in gross profit to $218 million, although its earnings per share were still negative, with a loss of $1.09 in 2013—compared with a larger deficit of $3.77 a year earlier.

Solar on the Up and Up

Indeed, the market is not wholly out of the woods yet: on January 7, 2014 Tianwei Sichuan Silicon filed for bankruptcy, while two months later Shanghai Chaori Solar Energy Science & Technology Co. failed to pay the full interest due on onshore bonds, becoming the first firm to default in China. Chaori Solar ran into trouble because it expanded into building solar farms to produce power—rather than only concentrating on manufacturing PV products—according to Bloomberg New Energy Finance. Most surviving solar companies have become more cautious about expansion.

TAKES WIND

For the first time, more solar than wind was installed in 2013, i.e., 38.6 GW versus 30.6 GW. Solar also retained the highest share of investment at $114 billion in contrast to $80 billion for wind. All other renewables lagged far behind, but there was a 72 per cent rise in electric car sales, says **Victoria Cuming**.

Attractive feed-in tariffs in Ontario also helped to spur a record PV installation level in Canada last year, with a high of 435 megawatts (MW) installed nationwide in 2013. Still, it will be all change for the province's support system this year, with projects of over 500 kilowatts moving to a competitive bidding process and an end to local content requirements after a World Trade Organization ruling in May 2013. Canadian Solar Inc.—the second-best performer on the NASDAQ Stock Market last year—returned to profitability in 2013, with earnings of $0.63 per share compared with a loss of $4.53 in 2012. It shifted its focus towards developing solar farms in the first three quarters, but its module business regained ground in the last quarter, accounting for 77 per cent of total net revenue, up from 59 per cent in the first three quarters.

In contrast to installation levels, PV investment in 2013 at $114 billion was 28 per cent down on 2012, principally due to a shift towards utility-scale assets in China and lower system costs worldwide. However, module prices have stabilized, and the average polycrystalline silicon spot price climbed by 15 per cent in the last five months, according to Bloomberg New Energy Finance's monthly pricing index. Overall system prices have continued to decline in

> We have done our homework and in this way created favourable conditions to continue our business successfully and return to profitability in 2015.
>
> **Frank Asbeck**
> SolarWorld AG

expensive markets toward levels seen in Germany. Supply and demand for PV are expected to balance approximately this year, as rising prices are driving up existing facilities' utilization rates and new capacity is due to come online this year.

The China–US solar spat is likely to rumble on this year: America's International Trade Commission voted on 14 February in favour of a complaint against imports from the Asian country. In 2012, the US imposed anti-dumping duties of up to 250 per cent on solar cells from China, as well as anti-subsidy penalties of some 15 per cent. It is now expanding its investigation into Taiwan-made solar cells to close a loophole that I SolarWorld Industries America said allows Chinese competitors to avoid the tariffs.

China's dispute with Europe will probably die down after the Asian country's Ministry of Commerce decided not to levy duties on polycrystalline silicon imported from the EU because of a 'special market situation'. China and the EU agreed on a minimum price and volume limit on European imports of Chinese solar panels until the end of 2015 in return for an end to the EU's duties.

Like Asian solar manufacturers, European players have also made progress. SolarWorld AG, Germany's biggest solar panel maker, has halved its financial liabilities from some EUR 1 billion ($1.38 billion) thanks to a debt restructuring programme that it began in January 2013. Part of its remaining debt was converted into two new secured bonds. On February 19, 2014, the company said that it expected higher sales in 2014 and a return to operating profit in 2015. Over a dozen German solar companies have filed for insolvency in the last two years, with Chinese competitors being blamed for selling below cost.

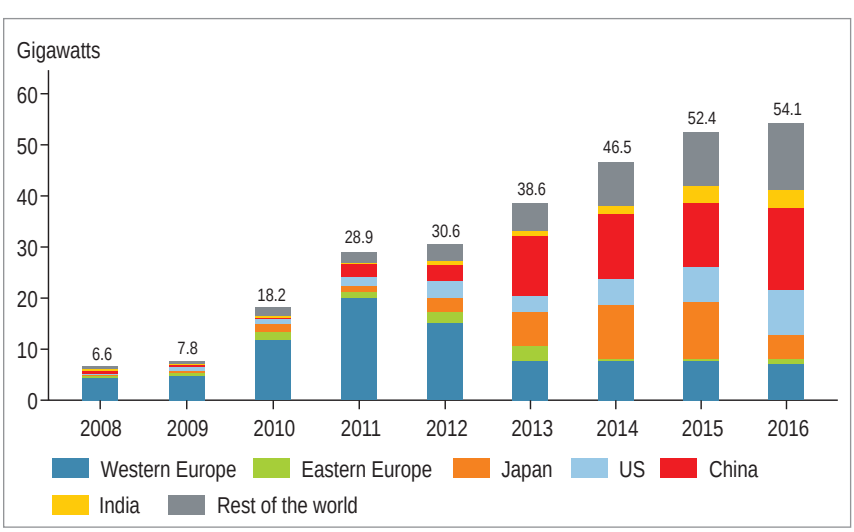
Nevertheless, the resurgence of European solar may be in jeopardy since recent months have seen several countries enforce or pass laws that could curb enthusiasm for the technology. New commercial and industrial renewable electricity generators in Germany will have to pay a charge on the power they consume, according to a plan backed by the German cabinet on 8 April. The proposal would make the economics of installing a larger PV system much less attractive. The law is expected to go to the Bundestag for a vote in June. In addition, the Spanish Government has passed a regulation to implement a new 'backup fee' for existing and new self-consumption systems of up to 100 kilowatts. Spain also plans to cap the return earned by renewable energy projects at 7.4 per cent, according to draft rules seen by Bloomberg News on February 3, 2014.

Wind in Decline

The wind sector saw a 31-percent drop in installation levels and its third annual decline in new investment in 2013—albeit of only a moderate two per cent to $80 billion—even with a strong fourth quarter for asset finance. Merger and acquisition activity totalled $32 billion, down by four per cent on 2012 levels. Most of the 39 asset acquisitions in the fourth quarter of 2013 came from the US, including a sizeable expansion from MidAmerican Energy Holdings Co., which bought our development assets in Iowa totalling over 1 GW. Pricing for turbine and operations and maintenance contracts stabilised at the end of 2013, and will only dip slightly this year, according to Bloomberg New Energy Finance. This will be due to a less competitive turbine market and more geographic and product differentiation, with some markets commanding a premium over others.

Margins have continued to improve for most turbine manufacturers, due to rigorous cost-cutting exercises. On February 3, 2014, Denmark's Vestas Wind Systems A/S reported its first quarterly profit since 2011: net income in the final quarter of 2013 amounted to EUR 218 million ($295 million), beating both analysts' and its own expectations. Last year, Vestas cut over 30 per cent of its workforce and sold or closed 12 of its 31 factories, selling six to VTC Partners GmbH for EUR 1 ($1.35). Following a two-year turnaround plan, the Danish company is now seeking to raise capital and sold 20.4 million new shares in an oversubscribed private placement.

However, the news has not been good for everyone: Acciona SA reported a surprise $2.7 billion loss in



2013, equating to more than half its market value. The main reason was regulatory changes, some of them retroactive, in its home market of Spain. To combat cuts in renewable energy payments, the company agreed last December to sell 18 German wind farms to Swisspower Renewables AG for $215 million.

As European wind-turbine manufacturers keep cutting costs, governments are continuing to reform their clean-energy policies: Poland released another draft, proposing to move from a feed-in tariff to a feed-in premium with contracts for difference awarded via a tender. Such a system may help to secure capacity, provided that other legislative developments do not hinder the process: the Landscape Protection Act was initiated to regulate outdoor advertising, but could well block wind-farm development.

In the Americas, new financing of wind farms remained low in the US until the fourth quarter of 2013, when the country saw a record high of $10.1 billion as developers sought financing to begin construction or make safe-harbour down payments on turbines 1:0 qualify for the expiring production tax credit.

Wind developers also performed well again at Brazil's third and fourth reverse auctions of 2013, selling a record 4.7 GW of energy over the year as a whole. Competitive prices were one reason for the sector's success: the sale on December 13, 2013 saw the lowest average price of the year at BRL 109.93 ($46.70) per megawatt-hour. In addition, wind power encountered weak competition from other technologies. As of January 1, 2014, wind developers must use locally manufactured equipment in towers, blades, nacelles, and hubs if they want to access discounted financing. These new local content rules have been set by the Banco Nacional de Desenvolvimento EconÔmico e Social.

Thus, only compliant companies such as Spain's Acciona and France's Alstom SA will be able to sign contracts for the 2 GW of capacity won in the 2013 auctions still without a supply agreement. Even stricter rules will come into force on 1 July.

Wind also did well in the third round of South Africa's renewable energy tender programme, accounting for 52 per cent of the 1.5 GW up for grabs. Ireland-based Mainstream Renewable Power was the preferred bidder for three wind farms worth ZAR 9 billion ($912 million) and a total capacity of 360 MW Bidding has become progressively more competitive during the programme, with the average price for wind in round three at ZAR 737 ($72.80) per megawatt-hour–36 per cent lower than in the first round. The average prices for solar PV and thermal declined even further (by 64 and 39 per cent, respectively between rounds one and three. An increasing amount of foreign investment is flowing into the country's clean energy sector–none of the preferred bids announced to date was led by a domestic company. Like Brazil, South Africa has imposed local content requirements on the bids, with the local content value amounting to just under ZAR 16 billion ($15 million) in the latest round.

Dramatic Rise in Electric Car Sales

Wind installations in Asia remained flat in the final quarter of 2013 due to continued grid constraints in China, delays in the release of generation-based incentives in India, and land restrictions and local opposition in South Korea. Manufacturers in the region are refocusing their strategies: Korean suppliers are looking overseas and in particular at Europe for engineering, procurement, and construction. In contrast, Chinese turbine suppliers are concentrating mostly on recovering their domestic market, which will add 14.7 GW of new wind power capacity this year compared with 14 GW in 2013, forecasts Bloomberg New Energy Finance. There was good news for the Chinese wind sector when the National Energy Administration announced it had given conditional approval to 27.6 GW of new wind projects, potentially increasing capacity by some 36 per cent. If implemented, the proposals would strengthen the country's position as the world's biggest wind market. The next step is for the provincial authorities to assess whether the transmission grids can handle the new flows and if there is sufficient consumer demand.

Electric vehicle sales were just over 205,000 units last year—a 72 per cent rise on 2012. Competition in this oversupplied market continues to push down electric vehicle battery prices, which averaged $568 per kilowatt-hour in the second half of 2012, according to Bloomberg New Energy Finance's index published on 31 January, compared with $599 in the June 14, 2013 edition. The top models are Nissan Motor Co. Ltd's Leaf, General Motors Co.'s Volt and Tesla Motors Inc.'s Model S.

The US remains by far the dominant market, with North America as a whole accounting for just under half of global electric vehicle sales last year. Spurring demand, corporate average fuel economy standards in the US call for a doubling of fuel economy for light-duty vehicles by 2025 compared with 2011 averages. In addition, eleven states and Washington DC are following California's Air Resources Board's Zero Emission Vehicle programme.

Europe saw a record 140 per cent growth in electric vehicle sales in 2013, which was driven by three countries: France offers generous subsidies and is the home market of Renault SA, which has launched four electric models. The Netherlands is in second spot thanks to subsidies and careful municipal planning for charging infrastructure; and Norway is third, as it started

supporting electric vehicles decades before other markets by offering subsidies and non-financial incentives such as premium parking access.

Still, the EU may have done itself no favours with its new Clean Power for Transport Package, which was progressively weakened through a number of policy decisions. A European Parliament committee agreed on to reduce the mandatory minimum number of public charging points and on December 5, 2013, transport ministers deleted the quantitative target for minimum public electric vehicle infrastructure for 2020, proposing that each member state should set its own goals. The moves to weaken the legislation may be driven by countries' reluctance to commit to binding targets, which they fear may affect economic growth. Member states also agreed in November to postpone the introduction of stricter emission targets for vehicles from 2020 to 2021.

Elsewhere, electric vehicle sales may have risen by 56 per cent in Japan in the first quarter of 2013 but the year as a whole saw only a seven-per cent increase. This was largely due to the recall of Mitsubishi Corp.'s Outlander plug-in hybrid electric car because of a possible defect in the motor controls computer programme and the model's battery problems. These events reduced consumer choice and exacerbated concerns about the safety and reliability of electric cars.

Sales remain limited in China too, thanks to insufficient quality options and poorly located charging infrastructure. Still, prospects rose last month when the government said that subsidies for 2014 would be cut by five per cent–rather than the previously announced ten per cent. Pressure is mounting for the country to contain air pollution, while it lags behind on its target for five million electric vehicles by 2020 due to high costs. The past year has seen significant improvements in electric vehicle economics: after Nissan and General Motors cut their prices, the fourth quarter of 2013 saw Toyota Motor

Corp. and Mitsubishi follow suit. As a result, electric models are close to total-cost-of-ownership parity with internal combustion-engine-powered vehicles—without incentives—for the first time. Including incentives means that models such as Mitsubishi's iMiEV are among the lowest upfront cost choices.

Despite the growth in sales and declining battery prices, the second half of 2013 saw several high-profile bankruptcies. One of the US' largest electric vehicle charging infrastructure players, Ecotality Inc., filed for bankruptcy, citing several reasons

> We are now on a trend of 3,000 e-cars a month in the US. The next step is moving up to 4,000 a month.
>
> **Carlos Ghosn**
> Nissan

including low commercial sales and failure to secure financing. Car Charging Group Inc. paid $3.3 million in cash for Ecotality's $230-million infrastructure network. Together with its acquisitions of 350 Green LLC, Beam Charging LLC and EV Pass LLC in 2013, Car Charging Group has emerged as the largest US electric vehicle supply equipment company, owning 13,430 charging points across 35 states and three countries.

Another casualty in the fourth quarter of 20 13 was Fisker Automotive Holdings Inc., which filed for bankruptcy on 22 November, listing debt of as much as $1 billion. In October, an affiliate of Hybrid Technology LLC won a Department of Energy loan on which Fisker defaulted.

But unsecured creditors objected to the price and helped to bring Wanxiang Group into the case. The Chinese automotive parts maker topped Hybrid after 19 rounds of bidding, with an offer of $150 million. The purchase requires US anti-trust clearance. Two factors may have played a role in Fisker's fate: it chose to manufacture plug-in hybrids—a more complex drivetrain technology compared with pure battery electric vehicles—and it relied on start-up battery supplier A123 Systems, which filed for bankruptcy in 2012.

Nevertheless, electric vehicle manufacturers are confident about the next few years: Nissan is optimistic that it can soon double deliveries, said CEO Carlos Ghosn on 8 January, after the company sold 22,610 units in 2013. Mitsubishi is working to strengthen domestic sales and to introduce new plug-in models in North America to exceed the 5.2 per cent operating profit margin in its mid-term business plan, which ends in March 2017, company president Osamu Masuko told reporters in February. Meanwhile, Tesla has plans to raise Model S sedan production by 56 per cent this year in order to build its $5 billion Gigafactory, for which it raised $2 billion of convertible debt on February 28, 2014. According to Bloomberg New Energy Finance forecasts, over 300,000 electric vehicles will be sold worldwide this year, and they are on track to beat conventional vehicles in terms of total costs of ownership by the latter years of this decade. EF

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