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ENERGY FUTURE

The Complete Energy Magazine

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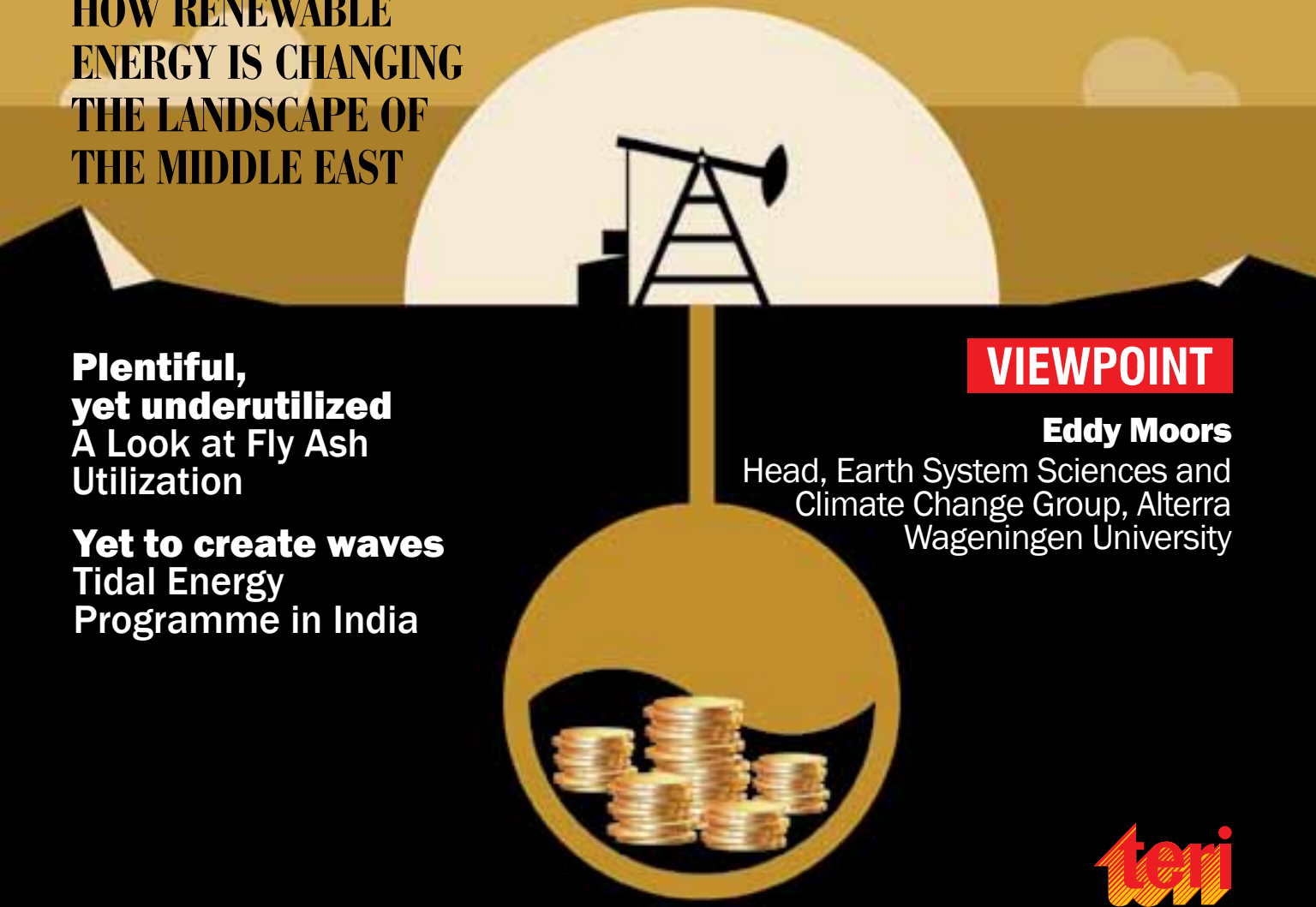
THE GARDEN OF EDEN 2.0

HOW RENEWABLE ENERGY IS CHANGING THE LANDSCAPE OF THE MIDDLE EAST



Plentiful, yet underutilized
A Look at Fly Ash Utilization

Yet to create waves
Tidal Energy Programme in India

VIEWPOINT

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Head, Earth System Sciences and Climate Change Group, Alterra Wageningen University

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From the editor's desk...

The never-ending quest for energy resources to whet the unsatiated appetite of the global populace is changing the geographical complexion in an interesting fashion. Take for instance the case of the Middle East, which is considered to be abundant in oil and gas. But this region has been found to be actively engaged in exploiting its renewable energy resources in recent times, something that is hard to fathom in conventional wisdom. While on the surface it might look counterintitutive, actually it is a well thought strategy. With the increasing pace of economic development and prosperity, the level of oil and gas consumption is also growing rapidly. Also, development of energy-intensive manufacturing industries such as construction materials, cement, aluminum, and plastics means more energy requirement. Simultaneously, to feed their growing economies, these countries may perhaps consider increasing their exports of oil and gas. Wider adoption of renewable energy technologies can stretch the lifeline of the region's oil and gas exports, besides diversifying the energy portfolio. Furthermore, if the region develops its renewable energy sector, oil and gas could be used as high-margin inputs into industries such as petrochemicals with greater value-addition than they currently offer as feedstock for power generation. On a climate change front too, the region's GHG emissions are on the rise, necessitating the shift to more benign energy sources. Nonetheless, better prospects for renewables do not seem to diminish the reliance on fossil fuels. In fact with technological advancements, hitherto inaccessible resources are also being targeted. Unconventional drilling is a case in point that has brought the likes of coal bed methane, shale gas and oil, and extraction of hydrocarbons from tight formations into the realm of possibility. Insofar as their environmental sustainability is concerned, however, the debate has just started. This clearly shows that whether conventional or unconventional, our energy future is going to be driven by cutting-edge technologies.

Amit Kumar

Amit Kumar
Director, TERI

Editor: Amit Kumar Radheyshayam Nigam
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I enjoyed the cover story 'Renewable Energy from Ocean' as it gives a look on the various aspects of harnessing energy from ocean and how Government can make a difference in this regard. In the issue, I found the article on Energy Crisis especially insightful. Both, energy crisis and global economy are inversely proportion to each other, i.e., if energy crisis increases, global economy slows down. It would be interesting to see how both can be balanced in the current rate of urbanization. Also, the article on Renewable energy initiatives in Latin America is very informative as it gives a glimpse of varied array of renewable resources available there. I would like to congratulate the entire team for bringing out this informative issue of Energy Future.

Chandan Sharma
Agra

China's renewable electricity generation is massive; it started from hydropower, then went on to wind, and now has moved to biomass and solar. China is the leader in the world in terms of installed renewable energy capacity, both including and excluding hydro. Renewable energy is an increasingly hot topic in China and is a sector targeted for increasing amounts of government attention and investment before 2020. In the face of the problems of climate change, greenhouse gas emissions and oil prices rising, the public has come to realize the importance of developing renewable energy. China has been facing significant pressure from international organizations to reduce its carbon dioxide emissions. In November 2009, Chinese Premier Wen Jiabao pledged to reduce China's carbon dioxide emissions by 40-45 per cent from 2005 levels by 2020, just before the United Nations Climate Change Conference in Copenhagen. In order to do this, the Chinese government has been continuously investing in renewable energies and increasing the use of sustainable energy sources in its overall energy mix. As a result of this move, China's investment in renewables has grown at around 80 per cent per annum since 2004. Whatever the result may be, China is an example for rest of the world to follow.

Laxman Rao
Kochi

India has abundance of solar energy that can be utilized to generate energy. Despite all the hype and hoopla about the use of this renewable energy, unfortunately, the technology available is either not easily accessible, or extremely expensive. There is a need for initiatives to encourage people to go for this resource that India is rich in.

Shyam Das
Puri

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

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Editor
Energy Future

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SOLAR PV INSTALLED ON UNIVERSITY ROOFTOP IN INDIA

Solarsis, a PV company based in Hyderabad, has installed a unique rooftop solar PV system on the rooftop of Indian Institute of Technology (IIT), Madras. The solar PV system is installed on top of the 50-year old Electrical Sciences Block at IIT-Madras that aims to build 1 MW solar on top their existing buildings.

Making the announcement, Venkat Rajaraman, CEO Solarsis, said the structures are unique because they are non-penetrating, elevated with a minimum clearance of 8 ft above the roof, and are designed to withstand high-wind zone of the Chennai coastal region. The plant also brings high degree of reliability and protection to enable smooth interaction with the grid.

The IIT-Madras Solarsis rooftop solar plant is a mix of mono-crystalline, poly-crystalline, high-efficiency poly-crystalline, and CIGS thin-film modules in which both string and central inverters of various capacities are used. The 90 KW solar plant will generate 1.5 lakh units per annum and will offset 90 tonnes of carbon dioxide.■

Source: www.solarquarter.com

SOLAR PLANTS TO BE MADE MANDATORY FOR HOTELS AND HOSPITALS IN ODISHA SOON

Rooftop solar power plants will soon be mandatory for hotels and hospitals, besides big residential and commercial buildings in Bhubaneshwar. The state government recently approved the revised draft amendment to the Planning and Building Standards Regulations 2008, which makes solar energy compulsory for all such new constructions.

According to the revised draft, individual houses with plinth area of more than 300 square metre will have rooftop solar plant of at least 500 watt, while five-star hotels will have 5 KW plant. Other hotels and commercial buildings with covered area of 500 square metre will have 2 KW plant.

Hospitals will have solar panels capable of heating water at the rate of 10 litre per guest while five-star hotels will have system to heat 15 litre per guest. Similarly, police facilities, army barracks, hostels, and houses having an area of at least 200 square metre will also have solar heating system.

According to the revised draft, all buildings except non-air-conditioned storage space and warehouses; interior and exterior lighting and electrical motors have to comply with the Odisha Energy Conservation Building Code (OECBC).

Under the OECBC, notified in *The Odisha Gazette* in July 2011, all buildings, except manufacturing industries having connected load (the peak load if all electrical devices of the buildings are switched on) of minimum 100 KW, or transformer capacity of 120 KVA require to comply with the code. Developers have to apply to the state designated agency and implement its guidelines to minimize power consumption in all such buildings as a precondition for availing power supply.

The revised draft has retained the mandatory structural safety norms for buildings of 30-metre or above height as proposed in the first draft published in March 2012 in the Odisha gazette.

Pradipta Kumar Biswasroy, president, Real Estate Developers' Association of Odisha, said, "Green energy and green building norms are becoming a focus area in all cities. The revised draft regulation has rightly focused on this aspect."■

Source: www.timesofindia.com

UTTAR PRADESH SIGNS AGREEMENT FOR ELECTRICITY

Uttar Pradesh has signed 10-year Power Purchase Agreements (PPAs) with six developers for electricity from 110 MW of solar photovoltaic (PV) projects in the state.

The largest of these is a PPA with Essel Infra Projects Ltd, Mumbai, for electricity from a 50 MW PV plant. The contracts have been signed under a solicitation through Uttar Pradesh's Solar Power Policy 2013, which aims for 500 MW of PV capacity by 2017. Other winning bidders include Moser Baer, New Delhi, with a 20 MW project Azure Surya Pvt. Ltd, New Delhi, which won a PPA for a 10-MW project, and Jackson Power, Noida, with another 10 MW plant. ■

Source: www.solarserver.com

IBM'S CLOUD PLATFORM FOR RENEWABLE ENERGY IN INDIA

Cloud computing is slowly becoming a part of the way that energy companies and utilities manage their core IT needs. But when it comes to shifting critical grid and power generation control systems to the cloud, they have been far more cautious, driven by concerns about reliability, security, and the challenge of integrating legacy control systems with a modern, distributed IT architecture.

But for a company that is building a renewable energy generation fleet from the ground up, cloud computing can offer a lot of benefits. Bharat Light and Power is looking at its new project with IBM to shift some of its core wind power management tasks to the cloud.

It announced that it is using IBM's SoftLayer cloud platform for asset management, mobile workforce integration, and power generation analytics for its roughly 200-MW fleet of wind farms throughout India. "Those wind farms are scattered throughout the country, many in remote areas, and present a significant operations and maintenance challenge. This opens up an opportunity to centralize those tasks in the cloud," said Mozhi Habibi, worldwide energy and utilities industry leader for IBM.

Bharat wants to expand its renewable portfolio to 1,000 MW of wind, solar, biomass, and hydropower in the next five years through acquisitions and new projects, and also manage wind farms for other clients. It needs to manage its power delivery contracts with grid operators for the wind farms it owns, as well as create service-level agreements for those it manages, to reduce risk and maximize the return on those investments. ■

Source: greentechmedia.com

CENTRE TO GET TOUGH ON STATES NOT MEETING CLEAN ENERGY TARGETS

The Centre is likely to get tough on states which are not meeting the clean energy target. The Union Ministry of New and Renewable Energy (MNRE) has written to the power ministry suggesting that it make it mandatory for states to fulfill their Renewable Purchase Obligation (RPO) if they want to get central support for financial restructuring of their electricity distribution companies.

Once the Power Ministry agrees to the suggestion, the states will have to purchase a certain percentage of their energy requirement from clean (solar or wind) sources. If they fail to do that, they will not be able to get concessions from the Centre to make their ailing distribution companies financial viable. The move will help the government not only achieve its clean energy target under the National Action Plan on Climate Change but also promote renewable energy generation in a big way. India is supposed to increase its share of renewable energy in the total energy mix to the extent of 15 per cent by 2020.

The Electricity Act, 2003 mandates State Electricity Regulatory Commissions across the country to set targets — known as RPO — for distribution companies to purchase certain percentage of their total power need from renewable energy sources. However, most states — except renewable power-rich Gujarat and Rajasthan — miserably failed to comply with their targets in 2012.

The move came in the backdrop of the recent decision of Maharashtra to crack the whip on electricity distribution firms to meet their obligation of buying renewable energy.

In a strongest ever move taken by any state or central authority since the launch of the RPO programme in 2010, the Maharashtra Electricity Regulatory Commission (MERC) had in July 2013 ordered over 90 entities. ■

Source: www.timesofindia.com

100% MADE IN INDIA SOLAR MODULES

Vikram Solar, which is developing a solar module with 100 per cent domestic raw materials, is firmly committed to advancing the public policy goals of the nation. Its endeavour would surpass the domestic content requirements laid down by the Ministry of New and Renewable Energy for the Jawaharlal Nehru National Solar Mission. The guidelines for the ongoing Phase II Batch I of the national solar mission stipulate that 50 per cent of the total 750 MW of solar power projects under this batch must be set up using solar cells and modules which are made in India. Vikram Solar is working on plans to launch its solar modules which will use not only 'Made in India' solar cells as required under the policy but go beyond that also to ensure that other raw material such as glass, EVA, backsheet, and frames are also procured from Indian manufacturers.

Speaking about the efforts, Mr Sunil Rathi, President, Sales, Vikram Solar, said, "Use of local raw materials will ensure low lead-time and inventory benefits while offering faster turn- around time for executing Indian solar project thereby leading to a win-win situation for all".

According to Mr Ivan Saha, President and Chief Technology Officer of Vikram Solar, the company follows a rigorous process of engineering evaluation of the bill-of-materials used in PV modules and is in the process of identifying quality Indian raw material suppliers in order to ensure highest quality and reliability of their 100 per cent 'Made in India' modules, which are targeted for launch by early 2014. "With this effort, Vikram Solar is aiming to develop the eco-system of the Indian photovoltaic sector, and hopes to contribute in a big way to make it competitive", Mr Saha added. ■

Source: www.energetica-india.net

INDIA ADDS 118 MW OF PV CAPACITY

India added 111 MW of grid-tied solar photovoltaic (PV) capacity and 7 MW of off-grid PV in September 2013, according to figures released by the Ministry of New and Renewable Energy (MNRE). This is a slight decline from the previous month but an improvement on prior months, and brings India to 2.08 GW of grid-tied and 139 MW of off-grid PV.

This includes 395 MW of grid-tied and 14 MW of off-grid added from April 1st through September 30th, 2013. Additionally, India added 100,000 square meters of solar water heating capacity, to bring the nation to a cumulative total of 7.27 million square meters. About 270,000 square meters of this has been added from April 1st through September 30th, 2013. MNRE has finalized regulations for Phase II of the nation's National Solar Mission (NSM); however, request for selection (RfS) documentation has not yet been released. ■

Source: www.solarserver.com

BSNL TO OPEN BIDS FOR SOLAR-POWERED 2G MOBILE TOWERS IN NAXAL AREAS: REPORT

Government-owned telecom firm BSNL is likely to open the financial bids for the tender to set up mobile towers in states affected by Naxal violence.

BSNL had floated the tender for supply, installation, testing, operation, and maintenance for five years of 1,315 sites of 2G GSM network in left wing extremist (LWE) areas of Bihar, Jharkhand, Orissa, and West Bengal.

Two companies left in the fray, Vihaan Networks Ltd (VNL) and HFCL are showcasing their solutions onsite, sources said, adding that only after evaluating the technical solution, will the financial bids be opened. The towers, among other things, have to be equipped to use solar power.

State-owned ITI will be given 30 per cent of the work while the rest will be distributed to two players — VNL and HFCL.

"Since only two players are showcasing the technical solution, it is a foregone conclusion that these two firms will be awarded the tender unless they fail in the technical process," a source said.

The Cabinet in June had cleared a three-year old proposal to set up mobile towers at 2,199 locations at cost of around Rs 3,046 crore in nine states, following a Naxal attack that killed 27 people, including senior Congress leaders, in Chattisgarh.

BSNL is mandated to set up the towers, the cost of which will be borne by the Universal Service Obligation Fund (USOF). The towers which have been a long-pending demand of the Home Ministry, will strengthen the telecom network resulting in increased penetration in LWE affected areas and other areas facing security challenges.

The Ministry of Home Affairs had asked the Department of Telecom to get the project completed by BSNL within a year, saying that in the first phase the towers should be installed in the proximity of security force establishments. BSNL had already installed towers at some locations.■

Source: www.gadgets.ndtv.com

PAK, US SIGN $95 MILLION DEAL FOR RENEWABLE ENERGY PROJECT

The US and Pakistan have signed a $95 million financing agreement for a renewable energy project in Sindh province. US Ambassador to Pakistan, Richard Olson inked the deal for a 10-year loan to Sapphire Wind Power Company. Under the agreement, US' Overseas Private Investment Corporation (OPIC) will extend $95 million to build the 50-MW wind power plant in the Ghoro-Keti Bandar wind corridor near Jhimpir in Sindh. "The provision of clean and reliable electricity is an essential building block for any economy," Olson said. "This project affirms OPIC's commitment to support efforts by Pakistan to diversify energy production to include important contributions from renewable energy sources, and demonstrates the US' continued commitment to strengthen Pakistan's economy, and with it, the prosperity of its citizens," a statement released by the US Embassy said.

The 50-MW wind power plant in southeastern Pakistan's Ghoro-Keti Bandar wind corridor will use 33 General Electric (GE) turbines and is designed to generate 133 GW hours of emission-free electricity annually. The statement said US and Pakistan work closely together on projects designed to diversify Pakistan's power generation beyond reliance on high-priced fuel oil and tap Pakistan's vast

renewable energy potential. According to a study funded by the US National Renewable Energy Laboratory, the US Agency for International Development estimates that Pakistan possesses 132,000 MW of potential installed wind capacity — virtually equal to the world's entire installed wind capacity in 2010. OPIC has invested in 123 projects in Pakistan since 1975. Its current Pakistan portfolio includes 14 active projects worth nearly $300 million in key industries including energy, health care, financial services for small and medium-sized enterprises, and telecommunications. ■

Source: www.timesofindia.com

ISRAELI RESEARCHERS DEVELOP ALTERNATIVE ENERGY FROM WATER AND CARBON DIOXIDE

A replacement for oil has become a vital need in the 21st century. Ben Gurion University of the Negev researchers have invented a process to make a green feed alternative for crude oil out of two of the most common substances on earth: water and carbon dioxide, which is detrimental to the environment. Prof. Moti Herskowitz, Prof. Miron Landau, Dr Roxana Vidruk, and the team at Ben Gurion

University's Blechner Center for Industrial Catalysis and Process Development have developed a green feed that can be converted using well-established technologies into liquid fuel and delivered using existing infrastructure to fuel stations. As opposed to other alternative fuel sources, such as electric batteries for cars, which require additional infrastructure, this green feed would merely replace oil as the input for refineries. "The process is patent pending, and we are ready to demonstrate and commercialize it," Herskowitz asserts. Bench experiments have been conducted and scale-up should be relatively simple, he says. Herskowitz unveiled his revolutionary breakthrough at the Bloomberg Fuel Choices Summit in Tel Aviv. "It is an extraordinary challenge to convert carbon dioxide and hydrogen to green feed," says Herskowitz. "The technology is based on novel specially tailored catalysts and catalytic processes. Well-established, commercially available technology can be directly applied to the process developed at Ben Gurion University. It is envisaged that the short-term implementation of the process will combine synthetic gas produced from various renewable and alternative sources with carbon dioxide and hydrogen. Since there are no foreseen technological barriers, the new process should become a reality within five to 10 years." ■

www.jewishbusinessnews.com

THE SWITCH MODEL FACTORY SETS FULL-POWER CONVERTER PRODUCTION RECORD IN CHINA

Using a unique model of collaboration in China, The Switch, supplier of megawatt-class permanent magnet generator and full-power converters for wind power and other renewable energy applications, has set up with its partner Scanfil, a global contract manufacturer and systems supplier for professional electronics, volume production of full-power wind turbine converter cabinets in record time and with exceptional quality, setting a new standard for localized production. Collaboration at the Hangzhou production facility focuses on the core capabilities of partners, allowing shorter lead times and faster reaction times to customer needs. Based on The Switch model factory production approach and execution for the first time for full-power converters in China, ramp-up time took just over one month.

Based on The Switch business concept of agile positioning, The Switch and Scanfil entered a model factory production agreement that has resulted in a new model for successful quality production close to end customers. In addition, it allows both companies to be more responsive to market changes. Scanfil takes care of operations and logistics;

The Switch carries out full-power testing for each cabinet.

The result is high-quality production close to the Chinese customers and a fully operational example of an agile partnership approach deeply rooted in The Switch strategy. The facility is now moving into a stabilized production phase with the production of 15 MW-class full-power converters every five days in two working shifts. The Switch and Scanfil have partnered in production for more than five years both in China and in Finland. ■

Source: www.eai.in

MARKEY INTRODUCES RENEWABLE ENERGY LEGISLATION

Senator Ed Markey, District Massachusetts (D-Mass), has introduced legislation that aims to create a national renewable energy standard that would require utilities obtain at least 25 per cent of their electricity from renewables, including biomass, wind, solar, hydro, and geothermal by 2025. He introduced the bill, titled "The American Renewable Energy and Efficiency Act". The legislation was read twice and referred to the Committee on Energy and Natural Resources.

In addition to the renewable energy provisions, the bill would also require electric and natural gas utilities to implement energy efficiency programmes to save the equivalent of 15 per cent and 10 per cent of sales, respectively, by 2025.

"Clean energy and gains in energy efficiency have been very bright spots for the national and Massachusetts' economy. The American Renewable Energy and Efficiency Act would quadruple renewable energy production in the United States. The programme would create more than 400,000 jobs and save the average American household $39 per year, with cumulative consumer savings reaching $90 billion by 2030. In addition to spurring more than $200 billion in new capital investments, the legislation would also reduce carbon dioxide emissions by 480 million metric tonnes annually by 2025. Under the legislation, utilities that sold more than 1 million MW hours (MWh) of electricity to consumers during the preceding year would be subject to the requirements. ■

Source: www.biomassmagazine.com

NEW YORK CITY TO FIT ALL STREETLIGHTS WITH ENERGY-SAVING LED BULBS

The amber glow of the New York City streetlight is going away. In an energy-saving effort, the city plans to replace all of its 250,000 streetlights with brighter, whiter, energy-saving, light-emitting diode fixtures in one of the nation's largest retrofitting projects, Mayor Michael R Bloomberg and the transportation commissioner, Janette Sadik-Khan, said in a news conference.

The phasing out is part of the administration's long-term plan to reduce its greenhouse gas emissions by 30 per cent by 2017. Mayor Bloomberg described the switch as a "large and necessary feat" that will save taxpayers money and move the city closer to its sustainability goals. The project is also part of the Transportation Department's plan for more environment-friendly operations, Ms Sadik-Khan said.

The news conference was on Eastern Parkway in Brooklyn, where lights have already been replaced, expecting to save more than $70,000 and nearly 248,000 KW-hours an year in energy. Unlike standard lights, which last six years, LED bulbs can burn for 20 years before they need to be replaced, the administration said, and the project is expected to save $14 million a year in energy and maintenance costs.

The project, which began as a pilot programme in 2009, will be completed in three phases. The full removal will start in Brooklyn with 80,000 "cobra-headed" streetlights, with their sodium high-pressured bulbs, then move on to Queens and, eventually, the rest of the city.

The city has already replaced some 3,625 lights along Franklin D Roosevelt Drive in Manhattan; Eastern Parkway in Brooklyn, between Grand Army Plaza and Ralph Avenue; and along pedestrian paths in Central Park. The project is estimated to cost $76.5 million. ■

Source: www.nytimes.com

CHINA TO EMERGE AS CLEAN ENERGY LEADER BY 2035

Renewables will account for nearly half of the increase in global power generation to 2035—with China generating more than the US, Japan, and the EU combined—according to the International Energy Agency's (IEA) latest annual World Energy Outlook 2013 report.

Renewables will make up over 30 per cent of the global power mix by 2035, with rapid expansions in wind and solar making up for the 45-30 per cent of the expected increase in renewables. The International Energy Agency's World Energy Outlook 2013 reports that technology and high costs are opening up new oil resources, and presents a scenario where despite current climate action, global energy demand will rise by one third and emissions by 20-30 per cent by 2035. Authors estimate global energy demand will generally shift to Asia, as India and Southeast Asian nations lead on energy consumption. ■

Source: www.earthtechling.com

WORLD BANK HOLDS CSP ROUNDTABLE

A World Bank-initiated sustainable energy workshop has said that concentrated solar power (CSP) technology would greatly increase energy security and provide clean renewable electricity to developing nations, but strong policy frameworks must be established to ensure big solar projects are funded.

Started on December 6, 2013 for two days in Marrakesh, stakeholders and policymakers from Morocco, Egypt, South Africa, and India, along with officials from European donor agencies, met for the Strengthening the Solar Energy Option and Utility-Scale Solar Power Development & Management meeting. It was co-organized by Moroccan Agency for Solar Energy (MASEN) and the World Bank and forms part of its Sustainable Energy for All (SE4All) Initiative, which aims to, among other things, double the share of renewable energy in the global energy mix.

The workshop was designed to help countries plan for and overcome challenges in making CSP viable through shared knowledge. Although all nations involved in the talks are rich in solar resources, with tracts of desert land ripe for CSP development, regulatory obstacles still remain in attracting big solar projects. Participants agreed that some regulatory requirements such as local content rules for solar developers could serve to push solar prices up and that a balanced approach to domestic manufacturing was needed.

Countries also had different approaches to the roll-out of grid-scale solar. The Moroccan energy security plan involves CSP farms eventually distributing energy across borders into Europe, a plan requiring long-term policy support.

India, however, desires vast amounts of CSP power to meet huge population demand and has used the first stage of its National Solar Mission to establish measures enhancing the integration of photovoltaic solar power into the national grid. ■

Source: www.energymatters.com.au

FINANCING SECURED FOR WORLD'S LARGEST SOLAR PROJECT

Total, Etrion Corporation, and SunPower Corp have secured financing for construction of a 7 MWp solar project in the Atacama region of Chile. Project Salvador will be the world's largest solar power plant based on spot market electricity (merchant) revenues, the companies say.

This is Etrion's first project to be financed and under construction in the Americas. Project Salvador almost doubles the installed capacity and is expected to grow the cash flow by approximately 50 per cent, transforming Etrion into a global solar power generation platform.

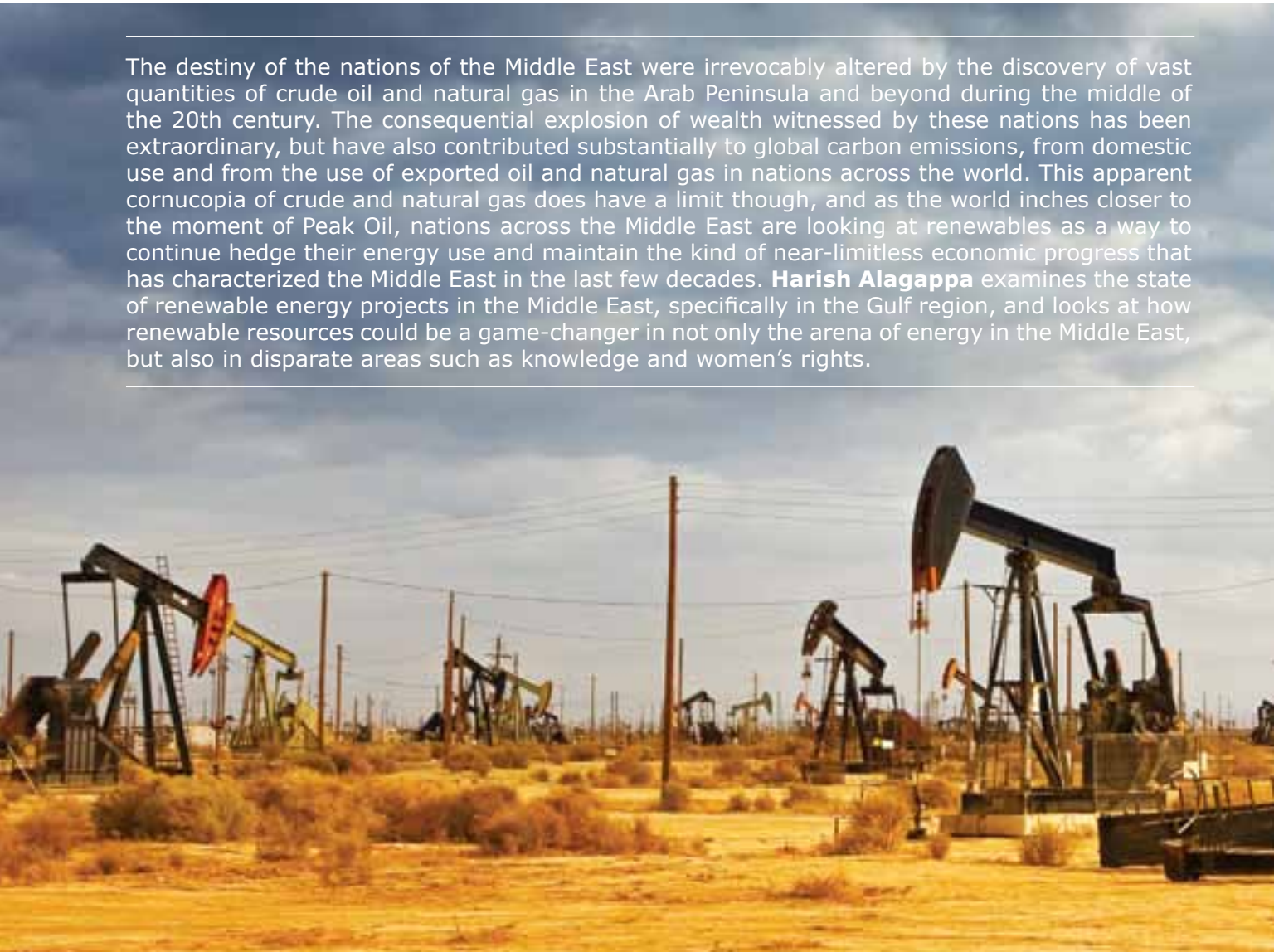
"As the largest solar merchant power plant in the world, this project will deliver advanced solar generation, operation technologies and management practices while creating a significant positive impact on local businesses and people," said Bernard Clement, Senior Vice President, business operations, Total New Energies. SunPower has received notice to proceed with construction in January 2014, with full commissioning achieved in early 2015. The majority of the installation is expected to begin commercial operation during 2014. Once operational, Project Salvador is expected to produce approximately 200 GW-hours of solar electricity per year, enough to supply electricity to approximately 80,000 households in Chile. ■

www.renewableenergyfocus.com

THE GARDEN OF EDEN 2.0

How Renewable Energy Is Changing the Landscape of the Middle East

The destiny of the nations of the Middle East were irrevocably altered by the discovery of vast quantities of crude oil and natural gas in the Arab Peninsula and beyond during the middle of the 20th century. The consequential explosion of wealth witnessed by these nations has been extraordinary, but have also contributed substantially to global carbon emissions, from domestic use and from the use of exported oil and natural gas in nations across the world. This apparent cornucopia of crude and natural gas does have a limit though, and as the world inches closer to the moment of Peak Oil, nations across the Middle East are looking at renewables as a way to continue hedge their energy use and maintain the kind of near-limitless economic progress that has characterized the Middle East in the last few decades. **Harish Alagappa** examines the state of renewable energy projects in the Middle East, specifically in the Gulf region, and looks at how renewable resources could be a game-changer in not only the arena of energy in the Middle East, but also in disparate areas such as knowledge and women's rights.



Arabian nights and days

The lands that begin around the Eastern coast of the Mediterranean Sea and extend up to the modern nation of Pakistan have in many ways remained the centre of human civilization for the last 10,000 years or so. This area, known as the Middle East or the Near East — names that reveal a rampant Eurocentric bias in the worldview of the individual who coined the phrase — is evocative. Depending on the individual, it creates images of ancient cities and civilizations, mysterious sand-dune filled deserts that were the home of Scheherazade and the Arabian Nights, or oil-rich Sheikhs and armed militia in a near-constant state of war. The name Middle East is an attempt at generalizing a broad geographical area consisting of a diverse cross section of people who speak different languages, eat, and dress differently from each other in many ways and share little in the way of custom, habit, or even religion. It is a name that suited the convenience of the European establishment at that time and suits the convenience of media houses today. The Middle East is far from a unified, homogenous geo-political entity. It even extends across two continents. While commentators, both within and outside the region, disagree on the specifics, the consensus is that the region known as the Middle East extends from Turkey and the Levant coast of the eastern Mediterranean to Iran on its eastern edge. It includes the Arab Peninsula and the nation of Egypt, and is bordered by the Caspian Sea to its north. The region includes large expanses of the Arabian and Sahara deserts, but is also replete with towering mountains, verdant river-fed valleys, and the half of the island of Cyprus in the Mediterranean Sea. Gross generalizations of the Middle East are the by-product of a very limited understanding of a region that has seen the rise and fall of the some of the world's oldest and grandest civilizations, the birth of the great monotheistic faiths that dominate the world (Judaism, Christianity, and Islam), and which supplies over 31 per cent of all the oil produced in the world today. That last figure might come as an underwhelming surprise to many, seeing that the general consensus in the world is that the global economy is at the mercy of oil from the Middle East. The fact remains that while oil exports are largely responsible for the explosion of wealth seen in nations such as Saudi Arabia, the United Arab Emirates, Qatar, and Kuwait, nations such as Russia and very soon, the United States will produce much more oil than the Middle East region's largest oil producer, Saudi Arabia. However, the population of the Middle East, currently standing a shade under 400 million, makes the export of oil a highly lucrative trade. Five of the 10 largest oil exporting countries in the world are from that region, and an astonishing 71 per cent of the oil produced in that region is exported. One would believe, then, that the Middle East is a nation that heavily invested in the existing system of energy prevalent in the world today. But that, again, is a severe misconception. Over the last few years, the renewable energy market has seen some of its most active proponents emerge from the fertile crescent and beyond, and the sand dunes that were once the purvey of camels, white horses, and myths are now replete with solar panels and wind turbines.

A deluge in the desert

The last few years have seen some extraordinary sums of money being invested in renewable energy projects in Middle Eastern countries, most of which is currently focused in harnessing the power of solar energy in the region. Most of the Middle East is replete with abundant solar energy resources, and with very little cloud cover and rainfall in its expansive desert regions, is ideal for exploiting the potential of solar energy. Awareness of these resources, along with a desire to be able to supply the high amounts of energy required by Middle East countries that are experiencing population growths twice the global average, have led to substantial investments in building solar power plants across the land. A report released by the Gulf Cooperation Council (GCC) in July 2013 revealed that over a 100 projects have been initiated in the region at an estimated cost of US$32.7 billion. This includes an investment of $740 million by Saudi-based Acwa Power on the Noor 1 Independent Power Project, a

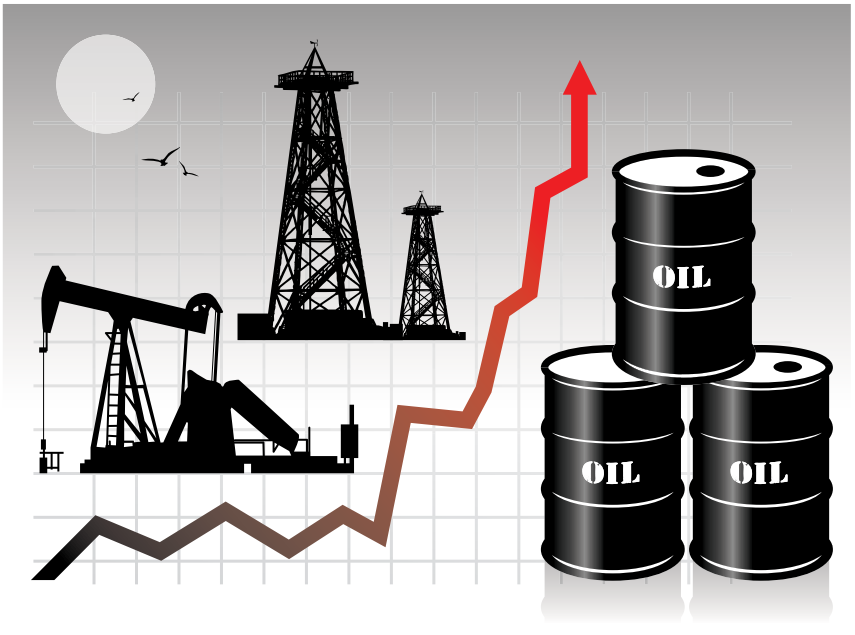
Concentrated Solar Power (CSP) in the Kingdom of Morocco that is expected to reach a total power production capacity of 38,000 MW by the end of 2018. Noor 1 won the 'Project of The Year Award' and 'Acwa Power International the Utility Company of the Year Award' at the Middle East Solar Industry Association Awards (MESIA) held in Abu Dhabi, UAE in the end of November 2013. The United Arab Emirates has seen investments in the range of $1.5 billion, with $580 million going towards the second phase of the Emal Power Plant that aims to increase its energy capacity to 3,000 MW in addition to constructing a water desalination plant to provide the desert nation with fresh water. Kuwait, meanwhile, has seen a series of substantial investments in renewable energy and water security, with $4.2 billion being invested towards as many as 19 projects, notable in its targets is the $1.7 billion Al-Zour Independent Water Treatment facility that is expected to supply 102 million gallons of desalinated water a day to the nation. The World Energy Council has estimated that the Gulf region within the Middle East alone will need to generate at least 100 GW of additional power by 2020 to meet the area's insatiable mounting demand, which is growing at 7.7 per cent annually, thanks to a population boom that has seen the region's population grow by 61 per cent in the last two decades.

Leading the intensive shift towards renewables in the region is the Kingdom of Saudi Arabia, which has stated its intent at generating a third of all of its power from renewable energy sources by 2032, and is in the process of raising a staggering $109 billion in funds to invest in the nation's substantial solar energy resources. A royal charter issued by King Abdullah bin Abdulaziz Al Saud in April 2010 founded KA Care and clearly outlined a strong statement of intent towards investing in alternative forms of energy generation, stating that "(KA Care is to be) the driving force for making renewable energy an integral part of a national sustainable energy mix, creating and leveraging the competitive advantages of relevant technologies for the social and economic development of the Kingdom of Saudi Arabia". The solar energy roadmap for 2032 includes a target of 54 GW of total energy

capacity from renewable energy resources, whereby 16 GW will come from Solar Photovoltaic (PV), 25 GW is to be derived from Concentrated Solar Power (CSP), 9 GW is expected to be obtained from wind energy resources, 3 GW from waste-to-energy treatment plants, and a further 1 GW from the Kingdom's geothermal resources. Interestingly, this proposed energy mix's aims are technology and use-specific. For example, the wind energy resources are dedicated to powering the Kingdom's desalination plants only, with Photovoltaic meeting total day-time demand and geothermal and waste-to-energy meeting night-time demand. The Kingdom's CSP power plants are expected to meet the maximum demand difference between Photovoltaic and baseload technologies, while the substantial hydrocarbon wealth of the region is expected to provide the remaining 60 GW that's required. This shows that Saudis have done their homework and are crucially utilizing the resources for uses that best incorporate the benefits and disadvantages of each. These projects are also expected to reduce total CO_2 emissions from the Kingdom of Saudi Arabia's power plants by 60 per cent. With the Middle East becoming one of the world's largest per capita GHG emitting regions, this target is of considerable importance to nations across the globe.

RE in the UAE

December 2, 2013 saw the United Arab Emirates celebrate its 42nd National Day, and the future has never looked brighter for the small confederation of kingdoms. Occupying a historically significant geographical location in the Persian Gulf along the Strait of Hormuz, over these last 40 years the UAE has seen an explosion of wealth with few parallels in world history. From the moment the first cargo container of exported crude oil left the dock at the port of Dubai in 1969, the UAE underwent a massive change in almost every respect. A small nation, almost unknown to the west became a centre of global finance, commerce, trade, and in the last decade, construction. The UAE has carved a niche for impressive engineering projects that seem to be constructed largely out of a sense of grandeur and a desire to reach the boundaries of what is or is not currently possible rather than for any specific requirement or purpose. Be it the construction of a miniature world map using artificially created islands off the coast of Dubai, or the world's tallest building, the world's most expensive and exclusive hotel, and even the world's largest shopping mall; Dubai in particular, and the United Arab Emirates in general, does not appear to believe in doing things on a small or gradual scale. Thus, when it was announced in October 2013 that the emirate of Dubai plans to cut its power and water usage by 30 per cent over the next 15 years, it must have come as something of a shock to the denizens of a city who think it normal to keep their air conditioners running on full blast 24 hours a day. This is a significant statement to come from the United Arab Emirates, which in 2005 became one of the first large oil-producing nations to ratify the Kyoto Protocol to the UN Convention on Climate Change, as it shows that even to nations whose extraordinary (and some might say exorbitantly displayed) wealth comes from its unique geographical fortune to sit on one of the largest deposits of crude oil anywhere in the world, climate change, and specifically a post-Peak Oil world is becoming an important priority. To give one an indication of how important crude oil is to the economy (and perhaps, even the identity) of the United Arab Emirates, consider the fact that the UAE, as a nation, occupies an area of land that is slightly smaller than the state of Arunachal Pradesh in India and has a population that is roughly equal to the population of the city of Bangalore. Yet, it is still the fourth largest exporter of crude oil in the world, beaten only by Saudi Arabia, Russia, and Iran. Every day, the United Arab Emirates exports three times as much oil as India manages to produce. This is a country that should, in theory, be very content with building its



mega-structures and spending the remainder of its wealth in one of the many vast shopping malls that dot its landscape. Furthermore, as Dubai is starting to emerge as a global financial hub to rival the likes of London, New York, Shanghai, and Tokyo, one would think it is safe to assume that the UAE of all nations would be unconcerned with the goings on of renewable energy and the trials and tribulations of nations suffering to meet their energy demands through any means necessary. And yet, the last few years have seen the emergence of dozens of renewable energy projects across the landscape of the UAE – specifically, the Emirates of Dubai and Abu Dhabi. The UAE is spending billions of dollars, and is trying to attract investments of hundreds of billions more, into the nation's numerous renewable energy projects, including the 100 MW Shams CSP solar power plant that went operational in March 2013. The UAE's flagship renewable energy project is Masdar City, a sustainable arcology (architecture + ecology) planned city that intends to be not only a zero carbon city but also a car-free zone. Covering an area of six square kilometres outside the city of Abu Dhabi, Masdar City was originally slated to be completed by 2017; however, the global financial recession has led to the cost of the project being reduced by 10 per cent and the deadline being pushed back to an unspecified date between 2020 and 2025. Nevertheless, the project with an estimated cost of $17 billion has been received positively by the international community, notably by such sustainable development advocacy organizations as the World Wildlife Fund for Nature (WWF), Greenpeace International, and BioRegional. The project has also garnered the support of the United States Government Department of Energy, with the USDEA entering a knowledge-sharing partnership with the developers of the project. The city intends to fulfil all of its energy requirements through a series of solar and wind energy power plants and is expected to house around 60,000 people. Some quarters of the international media have commented on whether this represents a serious commitment by the UAE on the issue of renewable energy and sustainable development or whether this is another high-end construction project intended to cater to an exclusive section of the world's wealthy and elite. At the end of October 2013, the Ruler of Dubai, Sheikh Mohammed Bin Rashid Al Maktoum formally opened the first stage of another ambitious venture in the realm of renewable energy in the UAE, a 1,000 MW solar power park outside Dubai, in Seih Al Dahal. The Mohammad Bin Rashid Al Maktoum Solar Park, constructed at a cost of US$3.2 billion, is intended to produce over 24 million kilowatt-hours (kWh) of electricity a year, which should be enough to provide electricity for 2,000 homes in the region. Sheikh Al Maktoum, who is also the Vice President of the UAE, is also the founder of Dubai Cares, a philanthropic venture that aims to provide education and access to drinking water to over 250 million children across the world is currently active in 31 countries.

Small nation with big aspirations

With the highest per capita GDP in the world, an unemployment rate of just below 1 per cent, and with exactly zero per cent of their population living under the poverty line, Qatar is widely regarded as the richest country in the world right now. Much like its Persian Gulf neighbours, the UAE and Kuwait, Qatar's extraordinary wealth is the product of its extraordinary mineral resources. The nation's two million inhabitants (of who only around an eighth are actual citizens of Qatar) sit on top of the world's third-largest

proven reserves of natural gas in the world. Much like the UAE, Qatar has in the past decade made definite attempts at diversifying their economy from one based solely on oil and natural gas. With the highest human development index in the region, Qatar is also seen as one of the most liberal and peaceful nations in the Middle East and is turning into a destination of choice for international conferences and, surprisingly, football, as the nation is slated to host the 2022 FIFA World Cup despite having never qualified for the tournament in 10 attempts. Qatar is increasingly being seen at the forefront of the global movement for sustainable development, with the 2001 World Trade Organization's ministerial conference at Doha giving rise to the Doha Declaration on Intellectual Property Rights and Public Health, and the current round of negotiations in the World Trade Organization having begun at Doha as well. Qatar has expressed its intention to ensure that the 2022 FIFA World Cup is a carbon neutral affair, which it says it will accomplish via on-site renewable energy resources at the various stadiums, efficient management of water use during the tournament, ensuring that the stadiums utilize recycled material and follow the principles of green architecture, and sustainably sourcing the elements for the construction of facilities required for the tournament.

On November 18th and 19th 2013, the Solar Qatar Summit saw the announcement of plans to meet 16 per cent of its electricity requirements through solar power by 2018. This would include the construction of an 1800 MW solar power plant, whose tender will be issued in the early months of 2014. These overtures towards renewable energy are part of a larger plan, as Qatar aims to build an inclusive, sustainable green economy, thus moving away from their current pattern of exorbitant energy usage that has led the nation to sit at pole position in the dubious list of the world's largest emitters of greenhouse gases per capita; Qatar emits over 55 tonnes of CO^2 equivalent per person every year, which is over twice the per capita GHG emissions of the US, Canada, and Australia, nearly 10 times as much as China, and nearly 30 times as much as India. Indeed, the top three largest per capita greenhouse gas emitters in the world are immediate neighbours, Kuwait and the United Arab Emirates, and with Bahrain in sixth place, there are four Gulf countries in the top 10. These small, wealthy, and oil-rich nations, along the southern coast of the Persian Gulf have per capita emissions which when combined are greater than that of all the others in the top 11 put together. Clearly, a greener, cleaner, and more sustainable path of further growth is no longer an option, but a necessity. The head of Qatar's ruling Al Thani royal family, Sheikh Hamad bin Khalifa Al Thani, who was the Emir of Qatar from 1995 to 2013, has outlined the long-term ambition of the nation as "Comprehensive development […] in striving for the progress and prosperity of our people." Qatar's National Vision 2030 describes the importance of a sustainable agenda for future development under the banner "Meeting the needs of this generation without compromising the needs of future generations" and lists 'Environmental Development' (in addition to Economic, Social, and Human Development) as one of the Four Pillars of Qatar's National Vision, an idea that in itself harks back to the Five Pillars of Islam and, thus appears to be a not-very-subtle attempt at making these development values as integral to the identity of the Qatari nation and people as their religion is. The Economic Development pillar outlines some of Qatar's goals in the

realm of green growth, highlighting the nation's intent at continuing to exploit its considerable hydrocarbon resources, particularly in the form of natural gas, and significantly diversifying its business interests to build a substantial knowledge base in high-end energy technology innovation such that Qatar can function as a global knowledge-based economy rather than one dependent on its bountiful oil and natural gas industry alone. However, it is in the Environmental Development goals that Qatar's true long-term objectives can be gleaned. The national vision speaks of "balancing the needs of economic growth and social development with the conditions for environmental protection", adding further that the environmental pillar of development is of critical importance to the local stability and prosperity of the region as the impact of international issues will be felt in the small coastal nation, with an emphasis on global warming and rising sea-levels.

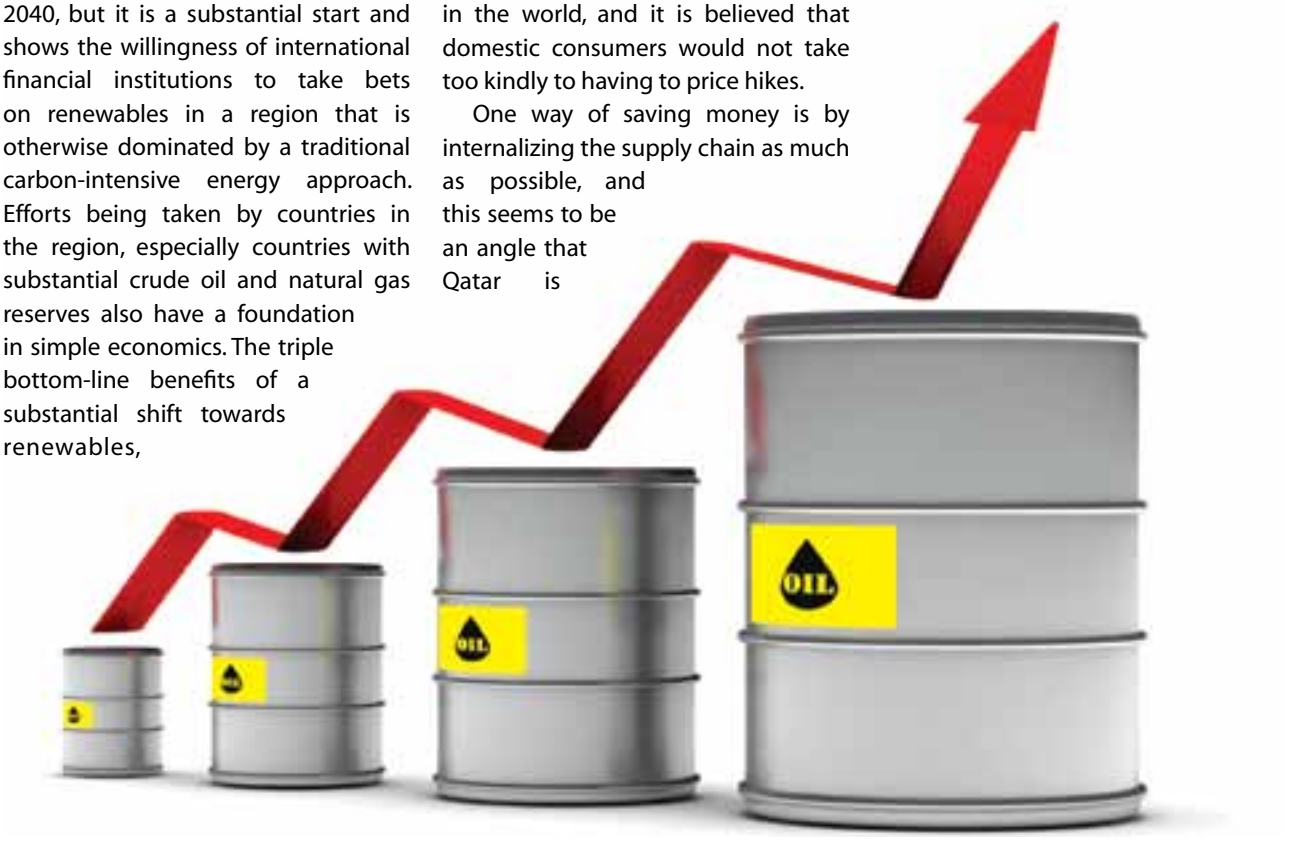
As a desert nation, Qatar's most precious commodity is fresh drinking water. Its energy wealth, coupled with the lack of any permanent or bountiful natural source within its borders, means that desalination is the only way in which the country receives almost all its fresh water. This highly energy-intensive process is the first target on the Qatar roadmap to renewable energy, with the aim that 80 per cent of the nation's substantial water desalination sector will be powered by solar resources, though at an unspecified date. An interesting project that was announced by representatives of the Qatari government at the recently concluded Solar Qatar Summit in Doha on November 18th and 19th, 2013 was the installation of rooftop solar panels on the roofs of dozens of the nation's water reservoirs. In a bid to generate more renewable energy, Qatar's state-run electricity and water company has announced plans to install solar panels atop dozens of water reservoirs across the country. The plan was announced by Saleh Hamad Al-Marri, Head of Renewable Energy at Kahramaa (the Qatar General Electricity and Water Corporation) at Doha and involves the public utility company installing solar panels on the roof of over 85 water storage facilities in Qatar. This project is part of the Qatari government's plan to try and meet its renewables target through small-scale decentralized renewable energy projects, something that has been described as the 'Scattered Model'. This approach by Qatar is in stark contrast to the approach by most other nations, not only across the world but in that region too. These water reservoirs are responsible for storing almost the entirety of Qatar's drinking water supply, are extremely large in size, with roofs whose surface areas run into hundreds of square metres, and are already connected to the nation's central electricity grid. As Kahramaa is Qatar's sole public utilities company for electricity and water, and owns both, the water storage facilities and the transmission lines that connect them to the central electricity grid of Qatar, there is no property cost involved and the installation would not be a financially intensive proposition. The project's tenders are expected to be

issued in the first few months of 2014, and are expected to see substantial bids from real estate developers from across the world.

The pragmatic economics of renewables

In addition to the nations mentioned in this article, viz. Saudi Arabia, the UAE, and Qatar, there are attempts afoot at shifting towards renewable energy across the MENA (Middle East and North Africa) region. The International Finance Corporation (IFC), a member of the World Bank Group that provides investment and asset management services to the private sector in developing countries, has pledged to invest US$300 million towards assisting nations in the MENA region through investments in renewable energy resources. This is merely 1 per cent of what the World Bank estimates will be required to fund the energy sector across the MENA region by the year 2040, but it is a substantial start and shows the willingness of international financial institutions to take bets on renewables in a region that is otherwise dominated by a traditional carbon-intensive energy approach. Efforts being taken by countries in the region, especially countries with substantial crude oil and natural gas reserves also have a foundation in simple economics. The triple bottom-line benefits of a substantial shift towards renewables, particularly in providing the energy used in domestic consumption in the region, are numerous, the most obvious being that it would allow these nations to free up more of their crude oil and natural gas reserves for sale at market rates in the global economy. In October 2013, the Minister of Oil and Gas in Oman touched upon the subject of artificially low prices for petrol and electricity among nations in the Middle East, specifically in the Gulf, describing the effect of such subsidies as encouraging wasteful consumption of resources. There is, however, an important counterpoint to this move to energy efficiency, which is that the removal of subsidies on carbon-based fuels and shifting the domestic energy supply chain to one that may not be entirely reliant on, but is substantially powered by renewables, is that selling this idea to consumers in the region would be a challenge. Prices for petrol and electricity in Gulf countries are much cheaper than anywhere else in the world, and it is believed that domestic consumers would not take too kindly to having to price hikes.

One way of saving money is by internalizing the supply chain as much as possible, and this seems to be an angle that Qatar is exploring. In addition to constructing solar power plants, Qatar also intends to become a leading regional, if not global, centre for the manufacture of solar equipment and has towards this end scaled up its manufacturing capabilities. This initiative would be headed by Qatar Solar Tech (QSTec), a company that is 70 per cent owned by Qatar Solar, a holdings company for the Qatar Foundation, which in itself is owned by the Al Thani royal family. Other investors in QSTec include the German-based SolarWorld Group and the Qatar Development Bank. In October 2011, QSTec began undertaking the construction of a US$1 billion plant for the production of poly-silicon (the fundamental ingredient in the manufacture of solar panels) and it is expected that the first commercial shipment of poly-silicon, expected to be in the region of several thousand tonnes, will take place during the second half of 2014.



Conclusion: Impacts beyond energy and money

In conclusion, it would be interesting to look at one of the peripheral impacts of the spurt of renewable energy projects across the Middle East and North Africa region. While the last few decades have seen astonishing growth in the per capita GDP, standard of living, and quality of life of people in the Middle East, there is one development index that has always lagged behind and it is an index that concerns the freedom and well-being of half the human population in that region. Until a couple of centuries ago, women in the Middle East exercised greater rights and control and were accorded greater liberty than their compatriots in the West. The suffragette movement spearheaded the cause of women's liberation across traditionally conservative boundaries in the late 19th and early 20th centuries in Europe and the Americas, which was further bolstered by the sexual revolution of the 1960s that saw women independently assert themselves in the public sphere in the West. Women in the Middle East, however, have not had a similar emancipatory era and are thus subject to the same kinds of societal pressures that they have had to face for hundreds of years and even with the advent of new riches in the Middle East, women's rights remained woefully behind development in other avenues. For example, women in Saudi Arabia have yet to win the right to vote or even drive. Yemen, which is the most economically and socially backward country in the Middle East, legally counts the testimony of a woman as being worth half of that of a man and does not allow women to leave their homes without their husband's permission. And even in the supposedly liberal and enlightened atmosphere of Dubai, a victim of rape was shockingly sentenced for violating

a law on premarital sex, even though it was violently against her will, to make an understatement. However, Amnesty International has indicated that the atmosphere in the region is making very gradual improvements in this regard, and a movement that could see it make more substantial strides is the Middle East Solar Power Association's 'Women in Solar' initiative. The initiative aims to bridge the gap between investments and skilled workers needed for the burgeoning renewable energy sector in Middle East nations by encouraging greater participation from women and aim to help by recruiting and mentoring young women in the Middle East to get involved in the renewables sector. With more educated and intelligent women forming a part of Middle East society, it is hoped that this initiative would lead to reforms across the board on women's rights and bring women in the gulf to something closer to a truly egalitarian society. The advancements being made in the renewable energy industry in the Middle East are a harbinger for greater investments in renewables across the world and should serve as a wake-up call for nations that continue to pump massive amounts of greenhouse gases into the atmosphere while living in a bubble of denial about the impacts of these emissions. The 2013 IPCC report stating that there is a 95-100 per cent chance that human beings are responsible for warming events in the last century on the planet and with nations that are currently the largest per capita emitters of GHG taking constructive steps to limit their carbon footprint and move towards a greener, cleaner, and more sustainable path of economic and social development, one can only hope that there is a chance, however remote, that humanity as single entity can if not avoid, at least mitigate and minimize the detrimental impacts of rampant climate change and resource abuse that will define our future over the course of the next century. ■

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The views expressed by the author are of own and do not reflect those of TERI.

PLENTIFUL, YET UNDERUTILIZED

Despite the National Waste Management Council recommending incentives for fly ash utilization and banning the use of top soil around thermal power plants, people are shying away from using it, given that it is available almost for free. **Jency Samuel** finds out why.

Question: Is fly ash, a plentiful resource, popular in the construction industry? Answers: "Fly ash is very popular in the construction industry. Your question of why it is not popular may have been valid some 10 years back"; "Fly ash is not popular in the construction industry because of the highly variable quality"; "When only 50 per cent of fly ash produced is utilized, will you say it is popular?" All the opinions are as varied as the colour of fly ash – grey, black, brown, green, and white. So is fly ash really being utilized to its potential, given that it is available almost for free?

Source of fly ash

In coal-based thermal power stations, pulverized coal is burnt to convert water into steam. The steam turns a turbine and a connected generator generates electricity to power homes and industries. As simple as it may sound, an important environmental implication is the generation of residues when coal is fired. When coal is burnt, it produces fine ash that goes up along with the flue gases. This fine ash extracted using electrostatic precipitators (ESP) or any other device is called fly ash. In India 60 per cent of the power is produced by coal-based thermal power stations. With the rapid electrification of the country, coal consumption has increased and the Indian coal is of low grade with low calorific value. All these factors have contributed in generation of a huge quantity of ash.

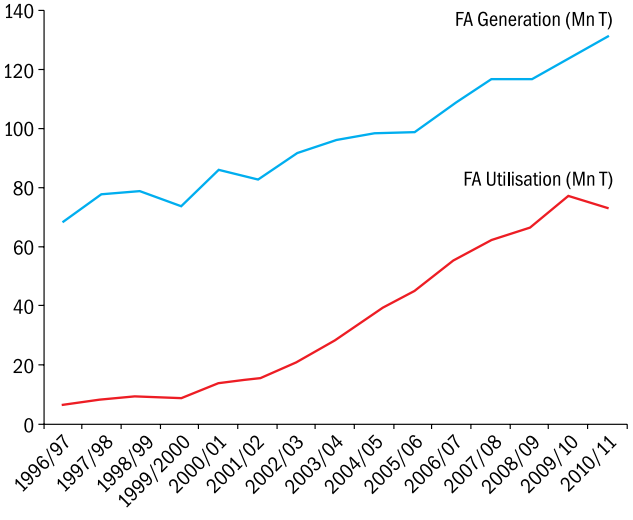
As per the 2010-11 report of Central Electricity Authority (CEA), 131 million tonne of fly ash was generated in 2011, which has increased from 1 million tonne per annum in 1947. The volume would be more as the statistics are based on data only from 88 power stations, whereas there are 102 thermal power plants in India.

Present use

Since 1996, CEA has been monitoring the generation of fly ash in coal and lignite-based thermal power plants and its utilization. Of the total fly ash generated in 2011, only 55.79 per cent was utilized. Practitioners in the industry point out that the actual figure of fly ash used is likely to be lesser.

As per the CEA report, Rajasthan tops the list of states that utilized fly ash at 95.13 per cent, followed closely by Tamil Nadu utilizing 92.98 per cent. Of the 35 states (including the six union territories), CEA had received data only from 16 states. Among these, 10 states had utilized more than 50 per cent of the ash generated.

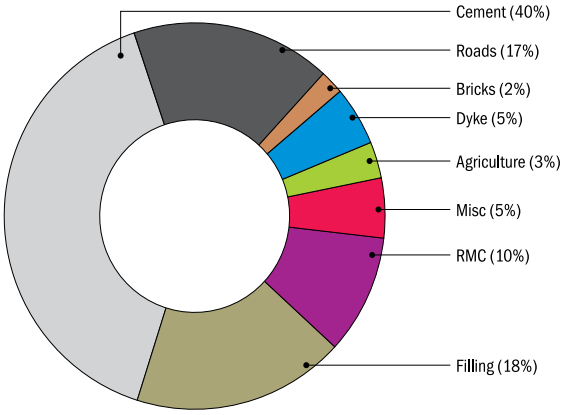
An interesting fact is that the Tamil Nadu Electricity Board's thermal plant in Mettur, Damodar Valley Corporation's plant in Durgapur, and West Bengal's Bandel Thermal Plant utilized far more fly ash than they generated by utilizing the fly ash



Fly ash generation & utilization over the years (CEA Report, 2011)

stored in the ash ponds. Kanti Bijlee Utpadan Nigam Ltd in Muzaffarpur utilized a whopping 913.69 per cent fly ash.

Consumption of fly ash by the cement industry grew from 2.45 million tonne in 1998-99 to 35.47 million tonne in 2010-11. By adding fly ash and producing Portland Pozzolana Cement (PPC) or blended cement, conventional Ordinary Portland Cement (OPC) is being phased out. Production of PPC has increased from 18 per cent in 1989 to 70 per cent in 2011-12. Though the maximum utilization of fly ash is by the cement industry, including Ready-Mixed Concrete (RMC) sector, it accounts for only 48.50 per cent. While looking at sector-wise use, fly ash brick manufacturing accounted for a meager 6.30 per cent.



Sector-wise utilization of fly ash

Government's initiatives in fly ash management

Fly ash management efforts were initiated by the government in the early '90s. In 1990, National Waste Management Council recommended incentives for fly ash utilization and banning the use of topsoil around thermal power plants. In 1991, Ministry of Finance offered exemption from excise duty for construction products made of 25 per cent fly ash. It also announced exemption of custom duty (up to 100 per cent) on machinery imported for making fly ash products. The Central Government commissioned Fly Ash Mission in 1994, which was a collaborative effort of the Ministry of Power, Ministry of Environment & Forests, and the Department of Science & Technology. From 'mission mode', the Mission went to 'programme mode' in 2002, called Fly Ash Utilization Programme. From being categorized as a 'hazardous industrial waste', it was changed to a 'waste material' in 2000 and in 2009 it was further changed to a 'saleable commodity'.

As per the MoEF's amendment notification of November 2009, thermal power plants had to utilize 50 per cent of fly ash generated within one year from the notification date and 60 per cent, 75 per cent, and 90 per cent in the subsequent years so that 100 per cent of the fly ash generated would be utilized within five years after the notification. BIS IS: 3812 – Parts 1 and 2 - 2004, pertaining to testing and certification of Pulverized Fuel Ash says that the IS Standard Mark can be put on the bag if the fly ash conforms to the specifications.

Potential use in the construction industry

Fly ash can be used to make bricks without using cement or clay and make PPC blended cements. It can also be used in concreting as a replacement material for cement and aggregate. However, using fly ash *in situ* concreting is not popular as handling the fine ash is cumbersome and proportions of cement and aggregates cannot be fixed

arbitrarily. PPC is manufactured by blending Portland cement clinker and fly ash. Hence, in concreting, fly ash-based PPC is preferred than a fly ash-OPC mix.

While making concrete, cement reacts with water in a process called 'hydration' and this reaction produces calcium-silicate-hydrate gel that binds cement and aggregates stone and sand together. During hydration some amount of free lime is released, which makes concrete porous, leading to cracks. But if fly ash is added, more C-S-H gel is produced. Mixing fly ash vastly reduces the risk of micro cracks, especially in mass concrete structures, says Prof. Manu Santhanam of IIT Madras.

When higher grade OPC came into the market, they were preferred as they produced high early strength but not necessarily high strength. Whereas fly ash reduces the rate at which concrete sets and rate of development of strength. According to Prof. Santhanam, "It takes longer for the concrete to gain strength when fly ash is used. If siliceous Type F fly ash is used, it takes the concrete 7 to 14 days more to reach the same strength as when OPC is used. Calcareous Type C fly ash needs additional 3 to 7 days." Concrete laid with fly ash continues to gain strength beyond 28 days and its durability is enhanced. The unreactive part of fly ash is similar to fine aggregate and, hence, enhances durability.

"Fly ash particles are more spherical than cement particles and, hence, need less water while mixing with the aggregates, thus increasing workability or the ease with which it can be laid. "Increased workability facilitates fly ash use in self-compacting concrete," says R Radhakrishnan, Secretary General of Indian Concrete Institute.

Mr N Kalidas and Dr Bhanumathidas of Institute for Solid Waste Research & Ecological Balance pioneered the FaL-G technology of making fly ash bricks using fly ash, lime, and gypsum without the autoclaving process. Despite a patent, they gave the technology to Housing and Urban Development Corporation (HUDCO) for wider dissemination and were referred to as FaL-G bricks. According to 2012 World Bank report, this resulted in over 16,000 FaL-G brick-making units, which accounts for one-sixth of the annual brick production, utilizing a minimum of 20 million tonne of fly ash annually. The duo have invented a No-Aggregate-Concrete or NAC, doing away with the use of both aggregates namely stone and sand.

Experts say that cement consumption is reduced by 20 per cent if fly ash bricks are used. Fly ash bricks are larger in size and, hence, the masonry mortar is reduced. Use of fly ash bricks would result in a minimum saving of 15 per cent, says Mr Rajendra Paul, a builder. It has still not become much popular in the construction industry as well as end-users.

Challenges in realizing potential

Availability and allocation

In Tamil Nadu, fly ash brick manufacturers have to register with the Tamil Nadu Electricity Board (TNEB) and depending on the manufacturers' infrastructure and production capacity, quota is allocated. But some manufacturers allege that many who have been allocated quota are fly ash traders in reality. Mr P Sivasankar of Agni Bricks registered with the TNEB 18 months ago but is yet to be allotted a quota. Mr Karthikeyan of Asian Fly Ash Bricks, who has been manufacturing FaL-G bricks for the past seven years, says he got his quota five years ago. Mr Sivasankar says that quite a few manufacturing units in Erode have shut down.

Inconsistent quality

Varying quality of the ash is a constant challenge that most users have to be content. Coal being a natural product, its quality varies. Naturally, the fly ash generated by burning this coal also varies. Mr J P S Gujral of TGS Impex, a fly ash supplier says, "Not only does the coal vary from plant from plant, but it also varies on subsequent days." Mr Radhakrishnan adds that combustion efficiency of the boiler and the system for collection of fly ash also contributes to the varying quality. Mr Rajan of AAA Traders says that particle size and colour

may vary. Prof. Santhanam says that much of the good quality fly ash is used by the cement manufacturers. The Ready- Mixed Concrete (RMC) industry gets fly ash of varying quality. Georg Dirk, a specialist in processing and handling of fly ash, cautions that fly ash that is not safe may be used as the RMC industry gets the unprocessed ash and do not control the ash quality at their end.

Mr R P S Mahendran of Iswarya Fly Ash Bricks has had to contend with varying qualities of fly ash, leading to producing sub-standard bricks and, ultimately, discarding them. Mr Radhakrishnan and Mr Kalidas aver that the problem of varying quality can be overcome with the use of admixtures. Prof. Santhanam adds that this problem could be addressed if fly ash can be processed to strict physical and chemical composition, such as Dirk Pozzocrete.

Transportation

As cement plants and fly ash brick manufacturing units are mostly not in the surrounds of power plants, transporting fly ash entails a huge amount. If the 'polluter pays' principle is adopted, manufacturers can be offered concessions in transportation charges, and the rest being borne by the power plants. Prof. Santhanam opines that selling fly ash as a commodity product will also address this issue.

Unequal pricing

Offered free initially, power plants now charge for fly ash. Charged as handling, administrative, or service charges, the rate varies from state to state and from government to private plants. Earlier, Mr Naidu used to pay Rs 50 per tonne for fly ash, but now he pays Rs 275 per tonne. In Tamil Nadu, while Mr Karthikeyan pays Rs 300 at the Ennore plant, Sivasankar buys it from a trader at Rs 1000 per tonne. Mr Tejas Shah of Conash Suppliers buys from private plants in Gujarat at Rs 100 to Rs 250 per tonne and at Rs 600 from government plants. States such as Rajasthan, Madhya Pradesh, and Maharashtra offer it for free.

"As per MoEF notification, dated December 14, 2008, fly ash has to be supplied free of cost. But it is sold at exorbitant prices, ranging between Rs 700 and Rs 800 per tonne," says Mr J P S Gujral of TSG Impex in New Delhi. Many allege that, given the demand, the rates are hiked. The MoEF notification, dated November 3, 2009 mentions that at least 20 per cent of dry ESP fly ash shall be made available free for units making fly ash bricks, blocks, and tiles and that the power plants could sell if the demand fell short of 20 per cent.

Underutilized performance potential

In cement manufacture as well as in fly ash admixed concrete, BIS limits the addition of fly ash to 35 per cent. Industry experts say that this can be raised up to 55 per cent. Kalidas explains, "The best Indian fly ash will have 35 per cent reactive and 65 per cent unreactive part, the latter working as micro-aggregate. While the 35 per cent fly ash works with the 25 per cent lime, if one tonne of fly ash is added to one tonne of OPC, 65 per cent unreactive part dilutes the strength of concrete. Though this can be offset by using admixtures, but its use is not yet popular in India, he adds. At INSWAREB, M60 to M80 grade of concrete (normal construction grades are M20 and M25) has been achieved by blending 80 per cent fly ash.

Technical standards

The standard body of the government ensured that it was equipped for the use of fly ash in the construction industry. Research in the USA in the 1930s had established that fly ash had pozzolanic property and because of this, in 1966, the Indian Standards Institute (now Bureau of Indian Standards) drew up IS: 3812 in three parts, each pertaining to using fly ash as pozzolana, admixture, and fine aggregate. As improvement in coal technology and methods of collection of fly ash led to improvement in the quality of fly ash, IS: 3812 was revised in 1981, 2003, and again in 2013.

But the construction industry feels that the standards for concrete, in general, do not reflect the technological advancements and changes. Industry practitioners refer or follow American or European standards to suit their needs. Hence the BIS has requested the IITs and Indian Concrete Institute to bring out an unified code in India.

Possible misinterpretation of terms

Besides the finer fly ash generated during coal combustion, the slightly coarser ash at the bottom of the furnace is called bottom ash. When these two ashes are mixed with water and discharged as slurry, it is called pond ash and when they are deposited in powder form as mounds, it is called mound ash. All these are termed as Pulverized Fuel Ash (PFA) in IS:

3812 (Part1). In general, only fly ash collected from ESP is termed as fly ash. In the MoEF notification, the term 'fly ash' encompasses all the four types, which may lead to problems where FBA can be used in place of fly ash.

Policy

Unlike the clay brick industry, Fal-G sector is considered an organized sector that entails big investment in infrastructure and attracts tax, besides having to wait for raw material.

Unutilized CDM potential

As per the World Bank report, from 2006 till 2012, registered FaL-G units have earned Rs 14.50 crore in carbon credit revenues. According to Georg Dirk, given the widespread use of fly ash, there is little room for improvement, which is one of the Clean Development Mechanism prerequisites.

Repercussions of non-utilization

As complete utilization of fly ash has not been realized, it is either deposited in dry form as ash mounds or in wet form in ash ponds. Dry deposits get airborne causing serious health problems. Either form of discharge needs vast tracts of land that could be put to other productive use; presently more than 125,000 acres of land is being used for this. Enormous quantity of water is needed in wet discharge. Presently 45 per cent of the approximately 150 million tonne is not utilized. For discharging 50 per cent of this, 2,250 million m^3 of water would be required, which could meet the water requirement of nearly 46 million people for a year, considering individual's requirement of 135 liters/day.

Making conventional clay bricks leads to depletion of the top soil. According to a World Bank report, 200 billion bricks were produced in coal-fired kilns in India in 2011, emitting 76 million tonne of CO_2. Calcium oxide is an important and fast depleting resource, which can be replaced with fly ash. Problems of illegal river sand mining and falling water tables can also be dealt with replacement of fly ash. Besides these, many power plants dump ash in nearby water bodies. Noted environmentalist Almitra Patel in her letter to the Quality Council of India in 2011, recorded that fly ash from the ash pond of Kanpur's Panki power plant was overflowing into the municipal drains of nearby residential neighbourhoods. This holds true for many other plants.

Concerns

Environmentalists say that fly ash is toxic as it has heavy metals and radioactive minerals. The chemical composition of fly ash is Silicon dioxide , Aluminium oxide (Al_2O_3), Ferric oxide (Fe_2O_3), Calcium oxide (CaO), Sulfur trioxide (SO_3), and Magnesium oxide (MgO). "But why are we not concerned about radioactive elements in cement and clay bricks?" counters Mr Kalidas. "When fly ash is used in concrete, toxic ingredients get immobilized in the hardened concrete, which do not leach out of the concrete," asserts Prof. Santhanam.

Steps for better utilization

- ISI mark should be made mandatory for fly ash, which would ensure processing and only quality products.
- Standards should be modified to reflect the technological advancements and fly ash constitution.
- Government should step up use of fly ash-based products in their infrastructure and building projects.
- The government should ensure spatial spread in availability of fly ash products for easy access.
- As RMC do not need space for raw materials, ensures quality, and uses fly ash, its use should be encouraged.
- Awareness needs to be created among the construction fraternity and consumers.
- A mechanism should be there to ensure that the recommendations and notifications of the government are implemented.
- More research efforts are needed for better and effective utilization of fly ash.

It is true that fly ash utilization has been increasing over the years, but so is its generation. As per the MoEF notification of 1999, 100 per cent utilization of fly ash should have been reached by August 31, 2007. But six years later, even 60 per cent utilization has not been achieved. Construction industry has not utilized the potential of fly ash in the cement industry. Pro-active measures on the part of government would hopefully encourage the industry into using this abundant resource, preventing pollution, and conserving valuable natural resources in the process. ■

Jency Samuel is a civil engineer and a freelance developmental journalist, with a focus on environmental issues.

Dr Vimal Kumar, an engineer with an MBA from IIM-Ahmedabad, is the Founder Mission Director of Fly Ash Mission of the Department of Science and Technology, Government of India. He conceived and implemented the project for 20 years in its different modes, namely, Fly Ash Mission, Fly Ash Utilization Programme, and Fly Ash Unit. He spearheaded the programmes whereby the utilization of fly ash increased from 1MnT/yr to 120 MnT/yr. After superannuation from DST in June 2013, **Dr Vimal Kumar** is working with the Centre for Fly Ash Research and Management (C-FARM), New Delhi as Adviser. He shares his views in an email interview.

It is 20 years since the government initiated the Fly Ash Utilization Programme (FAUP). Have we progressed in the desired direction?

Yes, we have not only progressed in the right direction, but have made significant achievements. The image of fly ash has transformed from 'a waste material' to 'a resource material' through various R&D initiatives. It has become a saleable and taxable commodity, which is also being exported. Standards, specifications, and guidelines have been prepared and issued by statutory bodies. Large scale utilization is taking place, conserving top soil, cement, coal, limestone, precious mineral clays, and sand resources, thus, reducing CO_2 generation. Fly ash industry employs more than 100 million people and generates more than Rs 300 billion per year. Stakeholder and potential user agencies of central and state governments are now sensitized and have initiated actions for its regular and large scale use. Russia has sought our expertize and technology in fly ash utilization.

What should be the government policy to ensure maximum utilization?

Facilitation, capacity building in terms of human resource, and implementation of MoEF notification through regular and strict monitoring.

What mechanism should be there to ensure that MoEF's plan for 100 per cent utilization is implemented?

Punitive measure alone is not appropriate for our socio-political setup. We need to educate, train, and undertake confidence building among agencies and regulatory bodies. Guidance needs to be given with strict implementation of MoEF notification, which requires environmental clearances as well as financial approvals for all infrastructure projects.

In spite of all steps, many government departments are using fly ash only in very small quantities. Why is that?

In-house procedures and systems of user agencies in all states spread over the country need to be addressed. Special efforts are required for bulk utilization at the locations where we have clusters of thermal power plants.

How is it that some states have fared better in using fly ash? Is it because of state policies?

The success is directly proportional to the desire, commitment, and efforts put in for implementation of MoEF notifications as well as the commitment for the betterment of the state in terms of conservation of environment, mineral resources, and generation of employment, economic growth as well as development of waste land and agriculture output.

Why aren't CDM projects involving fly ash much in demand?

A number of projects involving fly ash brick manufacturing as well as cement manufacturers have availed CDM benefits. It needs proper support and facilitation.

Industry people mention the need to modify IS codes to increase fly ash percentage to more than 35 per cent. What is your opinion?

This pertains to ash content in cement and concrete. I agree with the industry, because the quality of Indian fly ash is generally very good. Further, good facilities, systems, and procedures are in place to maintain and control the quality. Added benefits can be realized if the limit is raised to 50 per cent, in general, and for mass concreting up to 65 per cent.

Are ash ponds in India reclaimed for human settlement? Details please.

Not only human settlement, but a number of power plants have expanded on ash pond areas. Pragati Gas Power Plant as well as Millennium bus depot in Delhi are on an ash pond area.

Environmentalists talk about presence of heavy metals in fly ash. What is the percentage of heavy metals in fly ash in India?

The available (leachable) content of heavy materials as well as radio nuclides in most of Indian fly ash is within safe limits.

YET TO CREATE WAVES

Even as India is among the countries that offer the highest potential for tidal power generation, the Tidal Energy Programme in India has a long way to go, finds out **Suneel Deambi.**

Time and tide wait for none is an age old adage. Thus, pure wisdom lies in making the best possible use of both in a timely manner. Tide normally keeps its daily calendar showing up with waxing and waning of its might in a 24-hour cycle. That is where lies the scientific and engineering challenge of changing it to some useful power. The gravitational effect on the ocean water has another dimension. There are visible impacts created on a full moon day in some cases. Thus, tidal energy has several manifestations with the most important one being its potential of generating power.

Ocean energy potential

The ocean happens to be a giant and an unending source of energy. Humankind can put to use waves, tides, and currents to produce power. In actual terms, oceans can be regarded as our global heat buffer. In totality, the prospects of kinetic, potential, and heat energy are huge. Ocean energy can occupy a niche position in any region that is rich in currents, tides, and waves.

Underlying concept

Tides give rise to different water levels. These are a result of the changing gravitational pull from the sun and the moon. Such a change between high and low tide can be utilized to produce some useful power. Tides occur due to the periodical rise and fall of sea water level. Water level increases with high tide in comparison to the period of low tide level. This implies a higher value of potential energy during the high tide than the low tide. In simple words, the difference between the potential energy during high tide and low tide is the tidal energy. India possesses good potential for tidal power generation in the states of Gujarat and some parts of Sunderbans in West Bengal.

In a way, the technology is similar to the traditional hydropower stations. A dam is built at a suitable point between land and sea containing gates with turbines. The gates are opened when there is sufficient difference between the height of the ocean and the area inside the dam. The water flow to the lower level drives the turbine.

A holistic perspective

A significant objective of the tidal energy programme is to study, test, and assess the potential of tidal energy within the country accompanied by its use for power generation. In contrast to other forms of ocean energy, tidal energy is distinctly available on a commercial scale. To put this in perspective, India has a long coastline of estuaries and gulfs, within which there is a strong presence of tides. For instance, the Gulf of Cambay and the Gulf of Kutch in Gujarat have the maximum tidal range of 11 m and 8 m with an average tidal range of 6.77 m and 5.23 m, respectively. On the other hand, the Ganges Delta in the Sunderbans region is nearly 5 m with an average tidal range of 2.97 m.

RE programme in India

The Renewable Energy (RE) sector in India has continued its imprints of progress catalyzed more so in the backdrop of well-defined policy-cum-regulatory framework. No less important are the innovative measures taken in technology, financing segments in tandem with some of the readily acceptable business models. The share of RE power-based capacity has steadily gone up from around 10 per cent in November 2010 to nearly 12.2 per cent in October 2013.

The total, all India installed capacity stands at 229,251.174 MW as on October 31, 2013. The largest share is expected from the thermal energy sources (coal, gas, and diesel) of around 156,468.99 MW followed by hydro power (39,818.40 MW), renewable energy power (28,184.32 MW), and nuclear power (4,780 MW). Wind power (19,881.43 MW) and solar power (2,097. 34 MW) account for two most dominant RE power-based capacities. As evident, there is no contribution from tidal energy. This points out that tidal energy is yet to make any noticeable beginning in India.

Let us now take a close look at the comparative evaluation of RE technologies mainly in the financial terms to assess the market worthiness of tidal energy-driven power in terms of estimated per unit cost of generation.

Table 1 (next page) indicates that tidal energy source is the most expensive of all, both in terms of capital investment and cost of production.

Solar PV vs tidal energy

Solar PV technology is historically regarded as an expensive technology. It has caught the fascination of policy planners, scientists, and engineers for several reasons. Solar cell productivity, efficiency, and reliability have shown a remarkable increase during the last few years. As a result, cost per MW of installed PV is taking a plunge from Rs 180 million in 2008 to Rs 80 million currently. The moot question is whether something of this sort is expected to occur in tidal energy?

Table 1

Source	Capital Cost (Rs in million)	Cost of Fuel (Rs in tonne)	Plant Load Factor	Cost of Generation
Solar Photovoltaics (PV)	80	Nil	20	6.00 to 8.00
Wind Energy	60	Nil	25	3.00-4.00
Biomass	50	2500	90	3.80-4.00
Cogeneration	50	800	60	3.20-3.80
Small Hydro	80	Nil	55	2.50-3.00
Tidal Energy	170	Nil		15.00-17.00

Tidal energy potential is limited to just a few sites in the country. Further, solar PV is one of the best suited technologies for meeting various end-use applications like lighting, water pumping, and battery charging, especially in the remote rural areas. In contrast, tidal power does not score that high in fulfilling the various preferences of RE utilization.

Tidal energy potential in India

The Ministry of New and Renewable Energy (MNRE) encourages the resource assessment studies of various renewable energy technologies from time to time. As per which, there is a cumulative tidal energy potential of around 8,200 MW along the west coast. The Gulf of Cambay offers a potential of 7,000 MW as against a potential of 1,200 MW in the Gulf of Kutch. In addition, there is a possibility of developing small scale tidal power within the Ganges delta in the Sunderbans region that could offer a capacity of around 100 MW.

Initiatives in India

RE technologies based on solar and wind energy are leading to enhanced power generation. As against this, the number of tidal energy installations can be counted on the fingertips. Tidal energy projects are yet to see even an expanded phase of demonstration. MNRE has sanctioned a demonstration project for setting up a 3.75 MW capacity tidal energy plant at Durgaduani creek in Sunderbans, action on which is likely soon. The Government of Gujarat has also approved a 10 MW tidal energy plant proposed by Urja Global Ltd in association with a US firm — Ocean Energy Industries. However, nothing concrete seems to have moved further on this front so far.

India's first tidal energy plant

Gujarat is actively working towards the development of India's first tidal energy plant. Incidentally, the Gujarat government had altogether dropped its plan in 2009 of producing tidal wave power in the Gulf of Khambat due to its cost prohibitive nature. However, it later revived the plan due to a satisfactory technical study. As per the available information, it is possible to produce tidal power at the Gulf of Kutch near Mandva and the Gulf of Khambat near Hazira, which can lead to an estimated ouput of tidal power in the capacities of 200 MW and 300 MW, respectively.

For this, a budgetary outlay of around Rs 250 million has been earmarked under the patronage of Gujarat Power Corporation Ltd (GPCL). GPCL sought the services of National Institute of Oceanography, Goa, to undertake a full-fledged study related to marine environment impact assessment for tidal wave power. Besides soil investigation, topographical and geotechnical survey of the sea formed the other core activities of the pre-project commissioning stage. The larger purpose is to bring forward appropriate type of turbines well-suited to exploit tidal power.

The state government has already approved Rs 250 million for setting up the 50 MW tidal plant at the Gulf of Kutch. Regarding the availability of equipment, the government has signed an MoU with a UK-based developer of tidal current turbines, namely Atlantis Resource Corporation. The equipment has already been imported and the work is in progress.

CRC nod for 50-MW tidal plant

As per the available information, country's first 50-MW tidal energy-based power plant is still awaiting the coastal zone regulation clearance (CRC). The plant is near the Mandvi district, Kutch and will be taken up by GPCL, which has already submitted a report dealing with rapid environmental impact for the plant. This report has been prepared by the National Institute of Oceanography, CSIR institute in Goa.

Tidal power plant in Kerala

This low capacity tidal power plant is near the backwaters of Vizhinjam port which is around 20 km away from Thiruvananthapuram. The station began commercial operation in 1991. This Oscillating Water Column (OWC) produced around 150 kW power.

Gibrat ratio

Tidal power is generally a form of low head hydro-electricity and uses the more common low-head hydro-electric generating equipment. The technology needed for tidal power is well developed. However, construction cost is the key barrier to the enhanced use of the tides. There is a high capital cost for the tidal energy project with possibly a 10-year construction period. The major factors in determining the cost effectiveness of a tidal power site are the size of the barrage needed and the difference in height between high and low tide. These factors can be normally expressed in what is called a Gibrat site ratio. It is the ratio of the length of the barrage in meters to the annual energy production in kilowatt hours. The smaller the Gibrat site ratio, the more desirable the site is considered.

Economic considerations

The US-based Atlantis firm has worked out an estimated cost of Rs 170 million for the tidal power project of 1 MW capacity. This per MW cost estimate is based on the assumption of putting up a cumulative capacity of 50 MW project. However, the capital cost per MW could drop down to Rs 141 million for an aggregated power capacity of 250 MW implying the advantage of having "Economies of scale".

Investments in tidal energy

There are almost negligible levels of investment made in this new technology area. It was in January 2011 that Gujarat government made a major announcement to install Asia's first commercial scale tidal current power based plant of 50 MW capacity in the Gulf of Kutch with a financial outlay of Rs 250 million.

Subdued policy initiative

MNRE has been spearheading the fast-tracked development of RE programmes in the country. A slew of measures, including the financial and fiscal incentives, are being offered to the potential project developers for solar, wind, biomass, and small hydro energy-based programmes. However, the same cannot be said about tidal energy-based schemes. The reasons may range from exact mapping of the project zone, the high degree of complexity involved in setting up the project, and diminished interest of various stakeholders.

Sufficient scope exists for setting up some pilot scale projects. However, policy measures in this regard are not clearly defined. It is important for the developers to have clarity on its tariff and commercial development. A comprehensive policy document on an expanded implementation of tidal energy plan is needed. Failing which, the tidal energy resource capability may remain limited to theoretical demonstration only.

Key challenges

Several issues contribute to keep the tidal energy installations at very low ebb — for example, the Kolkata region. Following are a few reasons due to which tidal energy capacities have still remained at abysmally low levels:

- Technologies have remained at the development stage for decades, i.e., long development timescales.

- High initial capital costs.
- Lack of infrastructure for connection of the system to the grid.
- Environmental issues due to cable laying and construction work.
- Intermittent supply — tidal power plants provide power for just about 10 hours daily, i.e., when the tide is actually moving in or out.
- Tidal power needs a basin or gulf that has a mean tidal amplitude of 7 meters or above to ensure efficient mode of power generation.

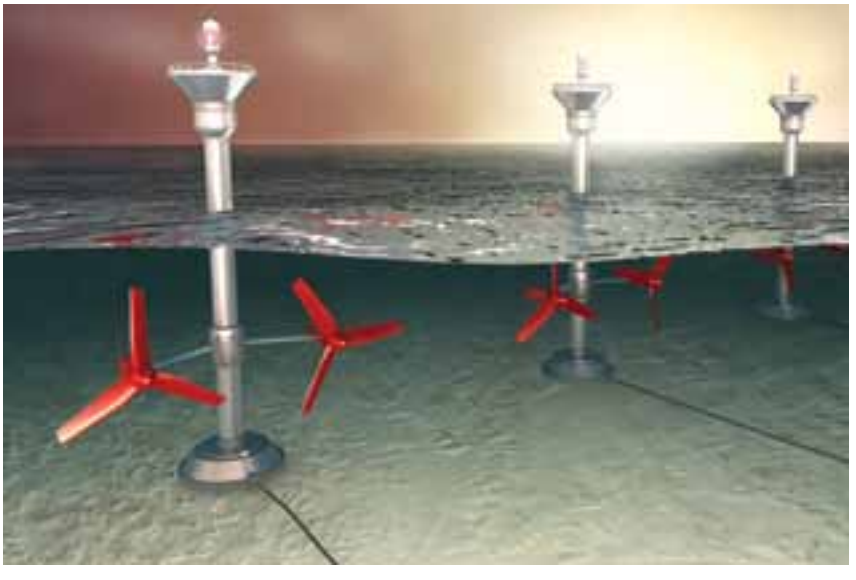
Global presence

The first tidal power station was built at La Rance, France. It was commissioned in 1966 with an installed capacity of 240 MW. The first such site in North America was Annapolis Royal Generating station, Nova Scotia, opened in 1984. The first in-stream tidal current generator in North America was positioned at Race Rocks on South Vancouver island in 2006. There are two main types of tidal energy, viz., tidal stream systems and barrages. Of these, the tidal stream systems use kinetic energy of the moving water and the barrages use potential energy in the difference between the height of high and low tides.

Factors against tidal power

There is a growing unanimity to the fact that RE sources can supplement the existing conventional power-based capacities to a sizable extent. Tidal power development has also got some inherent disadvantages, namely:

- Intermittent supply cost and environmental problems, particularly barrage systems are less attractive than some other forms of RE. Global estimates put the price of generation at 13-15 cents/kWh.
- The altering of the ecosystem at the bay — damages like reduced flushing, winter icing, and erosion can change the vegetation of the area and disrupt the balance. Like other ocean energies, tidal energy is available only in some regions.
- For a tidal power plant to produce electricity effectively, a basin or a gulf that has mean tidal amplitude of 7 meters or above is required. It is also desirable to have semi-diurnal tides where there are two high and low tides everyday.
- A barrage across an estuary is very expensive to build and it affects a wide area.
- Tides only provide power for around 10 hours every day.



- Present designs do not produce a lot of electricity. The barrages across river estuaries can change the flow of water, and consequently, the habitat for birds and other wildlife.
- Expensive to construct.
- Limited construction locations.
- Barrages may block outlets to open water.

Tiding over forward

The tidal energy programme in India continues to be moving at a slow pace for a variety of reasons. To match the high strength of a tide during a full moon day needs a Herculean effort. The vast expanse of sea is, in fact, a composite setting of prominent energy sources such as the high breezy winds and the setting sun. Exploitation of tidal energy is for sure going to be a new initiative worth trying on a large scale. Compared with solar and wind energy, tidal energy area is definitely less mature. However, it can go a long way in creating an ocean of power generating facilities in India provided wholesome thrust is accorded to it by the stakeholders. Research institutes need to team up with the industry enthusiasts to shape up the initiatives in a reliable and a cost-effective manner. Tidal power plants can benefit isolated communities to get electricity from this source.

In totality, the challenges faced by the emerging tidal stream power generation industry over the next decade are: i) to enhance the scale, ii) prove the reliability, and iii) showcase the environmental acceptability. These are needed to ensure that the cost of technology is reduced and it becomes comparable with the commercially competitive price regime. ■

The author is a consultant in the renewable energy area and a prolific writer on energy-environment issues.

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Going the Unconventional Way

Unconventional drilling techniques may have come a long way since the last two decades, but challenges such as rapidly increasing population as well as depleting resources are staring at us, reports **Viraj Desai.**

Energy has been the primary need of mankind since its discovery. Over two centuries ago, the discovery of petroleum extraction and subsequently natural gas, transformed the energy sector all over the world. But these conventional resources of energy such as coal, oil, and natural gas are being used up fast to meet the rapidly increasing demands for energy all over the world.

Even though extraction of oil and gas has been a challenging task, the current age of technology is heralding ways for unconventional exploration and production (E&P) techniques. This has allowed for an emergence of a revolutionary oil industry.

Very much like unconventional sources of energy, there are also unconventional forms of oil and gas reserves which are slowly being tapped by countries across the world for securing energy supplies. This includes shale, coal-bed methane, and tight gas. It is estimated that there are over 1,600 Gb of shale oil available worldwide. The reserves are huge but man has been finding ways to extract these precious reserves in an economical manner as costs pertaining to their extraction are quite high.

Shale is a kind of natural gas trapped within shale formations. Shales are fine-grained sedimentary rocks which can be rich sources of petroleum and natural gas. On the other hand, Coal Bed Methane (CBM) has methane held within the coal through a process called adsorption. CBM extraction works through releasing pressure in coal by pumping water or natural gas from the coal bed. Countries such as Australia, Canada, United Kingdom, and United States have started developing CBM quite early and have seen considerable success in their attempt. Besides this, China, Indonesia, and Russia are fast developing their CBM resources for meeting the energy demand.

Methane can be extracted by drilling wells into coal seam. The reduction in pressure allows methane to separate from coal and flow as a gap to the surface of the well. The gas is then compressed and piped to market. The aim is to avoid putting methane into water line. Another method to produce CBM is long dewatering of coal bed before production. This can be resolved by CO_2 sequestration technology. Due to greater adsorption affinity of CO_2 to coal surface, methane

would be forced to desorb from coal surface at comparatively high pressure and may reduce the dewatering time and even total project period.

About 95 per cent of the concentration level of methane is recovered through the techniques, making the gas a suitable replacement for conventional natural gas in pipeline networks. The gas can then be sent to businesses and homes for heating and cooking. The pipeline having natural gas needs to be easily accessible for addition of coal seam methane to be practical and economical. The existing networks may be extended to reach CBM projects if distances to be covered as well as geographical features make the project economically feasible.

Unconventional drilling, which means horizontal drilling and hydraulic fracturing, targets extraction of hydrocarbons from rock formations; whereas extraction through usage of conventional methods like vertical drilling was not economical. It is not economical as the hydrocarbons are found in tight rock formations, such as shale, which have porosity and low permeability. For extraction of hydrocarbons from tight formations, huge amount of water and sand is pumped into wells for breaking (also called fracking) these formations, allowing hydrocarbons to move easily through the wellbore to the surface.

The process is very expensive vis-a-vis conventional vertical drilling. With oil prices having surged significantly over the last decade or so, unconventional drilling techniques have been on the rise. The technologies are a marvel of scientific innovation and engineering. An innovation related to fracking involves the process of horsepower generation for accommodation of horizontal wells and not vertical wells.

In vertical drilling, an explorer's potential to explore oil or gas can be limited as drilling of 100 ft thick hole would only permit to find oil or gas through the length of that pipe. However, horizontal drilling allows operators not only to drill but also to set the pipe horizontally through same rock formation.

Horizontal drilling starts with a vertical shaft, like a typical well. As soon as it approaches the depth of the targeted oil or gas reservoir, the shaft bears off at an arc in order to ensure that it can intersect the reservoir at a near-horizontal angle. Horizontal wells are designed in such a manner that they can augment the well production by giving more contact with the productive layer of a reservoir. Even though the construction of such a well would cost over two to three times that of a conventional well, the initial production is about three to four times than a conventional one.

Hydraulic fracturing or fracking entails injecting millions of gallons of water as well as proppant (sand, etc.) and chemicals at high pressure into shale formation. The modern methods of hydraulic fracturing started in 1960's with the advent of water-based gels that were used to carry proppant into fractures. Proppants are natural or manufactured, and are used for opening fractures created during hydraulic fracturing. This leads to building up of pressure leading to fracture. The fractures are filled up with proppant for ensuring them from resealing. The natural gas in the formation can then be extracted. Almost all wells are repeatedly fractured during well operation as resealing of fractures happen naturally over a period of time.

The characteristics of target formation, that is, the rock from which gas is extracted, is what determines the specific technique used to extract gas. It has to be ensured that data must be gathered for every region developed for gas drilling. Larger fractures would result in higher natural gas but would also entail higher costs. The effectiveness of a hydraulic fracture treatment may be measured through combination of micro-seismic mapping in the field as well as measurements taken in the well including production, temperature etc., for supplying information on fractures that are near the well.

Hence, the process of fracking can help one explore oil and gas in over 5,000 ft of rock instead of 100 ft as it multiplies well recovery rates several times over. This advanced technology will aid drillers in hitting target at the end of drill string that lies below 10,000 ft, having a mile long horizontal

section. Sensors are also used for detection of promising rock intervals and the drill string can be utilized in any direction. These amazing technological improvements have resulted in better returns to operators through higher tax revenues for state authorities as well as higher royalty payments for mineral owners.

Vertical well operations are different from horizontal well drilling operations in scale. In a vertical well pad (the area at the surface, surrounding the well bore that is used to conduct the drilling and hydraulic fracture activities) is smaller vis-a-vis horizontal well pad — a fraction of an acre to about 3 acres for a vertical pad and about 3 to 6 acres for horizontal well pad.

The size of well pad in both vertical and horizontal drilling operations augments as the on-site storage needs rise for fluid and equipment. The amount of chemicals and water utilized in horizontal well which is hydraulically fractured increases by 100-fold as compared to vertical wells. While vertical wells normally use 20,000-80,000 gallons of water for hydraulic fracturing, horizontal wells, however, may use between two and nine million gallons of water.

Different kinds of chemicals are used for enhancing recovery of oil and gas, both in horizontal and vertical wells. Akin to drilling process, chemicals have undergone a change over time because of trial and error experimentation and also regulations.

Horizontal or vertical, hydraulically fractured or not, gas well drilling entails a series of complex steps. A well pad must be established before drilling takes place and it should be big enough for supporting equipment needed to drill and hydraulically fracture a well. For horizontal wells, special drill bit is used for turning the drill at an angle at a set depth, which is also called the "kickoff point." About 1,000 vertical ft drilling are needed for a well that is fully horizontal. The well would be lined with steel casing for preventing collapse of the hole while being drilled. The casings also ensure that gas and fluids do not escape from the sides of the wells while the drilling is done.

After this, a slimmer casing is hung in deeper well hole and put into place using cement. The cement is pumped down the well inside casing until it reaches the bottom of the hole.

While the monetary returns are a vital part of the process, technology results in producing sanguine results for environment as well. This is because a single well drilled horizontally can avoid the need to drill several vertical drills. This ensures less air emissions, lower impact as well as reduced water usage for producing a similar amount of oil and natural gas.

The GHG emissions in the US have witnessed a decline since the last two decades, which has not been matched by any industrialized nation. But for the past few years other countries are trying to catch up slowly. Since private firms are not able to take risks pertaining to unproductive exploration using experiments, the US government's R&D programmes have resulted in lowering exploration risks to industry and demonstrated market potential of unconventional gas. The government provided economic incentives for making contribution in this field.

The credit for this is provided to drill more wells and collect more data leading to contribution of knowledge for operators. The efforts led to catalyzed developments which would have taken more time to come into fruition. The increase in gas prices in the early 2000's changed the economics of unconventional gas production bringing new operators and augmenting drilling. The proven natural gas reserves have surged by 70 per cent, mostly due to shale gas resources. There are estimates that natural gas-fired power plants may account for over 60 per cent of new electric capacity additions between 2011 and 2035, largely due to sustained low gas prices from continued unconventional gas production. There are estimates suggesting that shale gas production may bring in $100 billion of gains to consumers every year. It was the spending of $220 million by the US government on R&D pertaining to unconventional gas between 1976 to 1992 which led to full-fledged development of the sector and which later set an example for other countries to emulate. In 2007, the first shale gas

production was recorded when the US natural gas production was just 7 per cent but in 2012, shale gas production accounted for over 30 per cent of US production.

Russia, a country having world's largest natural gas reserves, has been steadily ramping up horizontal drilling in the last few years. In fact, the CEO of Russia's biggest driller, Eurasia Drilling, had opined earlier that the use of horizontal drilling would grow faster in Russia than in the US, leading to boom in shale oil and gas. The company had doubled horizontal drilling in 2011 to 900,000 metres vis-a-vis 2010.

The CFO of the drilling company had stated in 2013 that horizontal drilling would witness a spike of 50 per cent in 2014. This is a clear indication that the adoption of this technology can bring energy comforts for a longer period of time.

China has also seen a surge in horizontal drilling due to tremendous requirement of energy. It has been estimated that the country has the highest shale gas reserves. The Chinese government and the state-run petroleum companies have already tied up with international companies for exploration of unconventional gas. The government is aiming to produce about 6.5 billion cubic metres of shale gas by 2015. China would be bringing out a policy for stringent measures pertaining to shale gas policy.

Its immediate neighbour, India, which meets 70 per cent of its oil needs through import, has also embarked on the journey of unconventional oil drilling. Technological knowhow may not be a bottleneck for Indian companies as firms such as OIL, GAIL, and RIL have invested heavily in shale in the US and the local staff is building technical capabilities onsite.

These companies are planning to use expertise of foreign firms for exploring shale gas and oil in India, where drilling of unconventional fuel was approved just a couple of months ago, for reducing dependence on oil imports. ONGC plans to approach the US-based energy firm Conoco Phillips for shale drilling. The firm would be taking up exploratory work in regions such as western Cambay, eastern Cauvery and Krishna-Godavari basins in India and commercial drilling is expected to start by 2014.

On the other hand, Oil India would be exploring regions of Rajasthan and Assam for initial shale drilling. It may work with US-based Carrizo Oil & Gas for the same. Last year, Indian Oil and Oil India had purchased a 30 per cent stake in Carrizo's Niobrara shale assets in Colarado.

According to the US Energy Information Administration, India may have about 96tcf of recoverable shale gas reserves that is about 26 years of its gas demand. Under the new policy, companies would be allowed three assessment phases having a maximum period of three years each. The taxes and royalties would be akin to conventional production in a particular area.

India has also started exploring CBM for meeting its rising coal demands. India has an estimated 4.6 million tcf of CBM resources but the government has made a strategy for awarding CBM blocks through a process of competitive bidding. Sourcing CBM entails lesser land than mining for petroleum or coal, reducing impact on environment and lowering land footprint. The development of CBM can be ideal for usage in Compressed Natural Gas (CNG), power generation, steel plants, industrial use as well as methanol production. Being the third largest coal producer in the world and the fourth largest in terms of proven reserves, the prospects of utilizing CBM in India are tremendous. Companies such as Essar Oil, Dart Energy, GEECL, and Coal India, etc., are already exploring options for CBM in various parts of the country. States such as Jharkhand, West Bengal, Orissa, and Chhattisgarh are considered to be excellent potential areas for CBM.

Most of the gas in coal is there on internal surfaces of organic matter and coal stores 6 to 7 times more gas than a conventional gas reservoir. With better coal rank, the gas content also increases. In order to ensure that the gas is released from coal, partial pressure should be reduced by removal of water from coal bed. Even though economical quantities of methane may be produced, water disposal is still a challenge. The gas recovered from unmined coal may also be suitable to replace conventional natural gas in power generation systems like gas engines and gas turbines.

India's present gas demand is limited due to access to gas supplies based on domestic production and imports availability. India should go for a policy allowing oil firms to drill for conventional oil and natural gas to investigate and produce shale gas and coal-bed methane along with natural gas.

The change may revive old wells that have been declared commercially unviable as well as augment energy capacity of the country. There needs to be also a market-driven gas pricing model. The government should also provide assistance to private as well as public sector firms for importing shale gas technology to India through incentives.

More than a shale gas policy, India has to manage resources such as water management as well as sustainable development. This means investment incentives for development of required supply chain as well as preventing ground water pollution for drilling horizontal wells in large tracts of populated land.

Like its European counterparts, the country will not have an easy time in dealing with the complexities involved.

The potential of shale gas can solve the impending energy crisis of the second-most populated country in the world. But, for this, it would have to understand the challenges and take learning from the US which has been the leader in the development of this precious commodity but is now revisiting some of its policies for aligning it with the environment.

For the European Union, development of shale gas may lead to addition of about 1 million jobs to the economy along with reducing dependence for energy imports. This was stated by the International Association of Oil and Gas.

But, the challenge that lies in drilling shale gas is that it entails injection of 10,000 cubic metres of water. Horizontal drilling is more expensive as well as technically more challenging than conventional drilling but ensures that the hydrocarbon reservoirs are tapped more effectively giving better yield.

In 2001, it was recorded that there were about 35,000 horizontal wells in 72 countries. Canada with over 18,000 and the US with over 11,300 wells were leading in horizontal drilling technique. There were over 5,000 horizontal drilling wells in countries such as Oman, Russia, Saudi Arabia, Nigeria, the UAE, and Indonesia.

On the other hand, before choosing a completion method for a CBM well, a number of factors should be considered. These include the investment required, expected production rate, reserves in the various coal intervals as well as future work requirements.

The cased-hole completion is another commonly used coal bed completion method and is used typically in the medium-to-low permeability coal beds.

The issues pertaining to using of unconventional drilling techniques includes usage of large amount of

water. The International Energy Agency (IEA) had estimated that fracking one well can consume anywhere from one to five million gallons of water. Besides the chemicals used by drilling companies and the flowback water may also have several heavy metals and salts along with naturally-occurring radioactive material found in the gas-bearing unit.

The difficulty is that water cannot be reused and this leaves the companies with the issue of disposing millions of toxic gallons of water. This disposal costs several million dollars. Besides, the disposal wells have been linked to earthquakes in some places. While some firms are trying to recycle water, some others are trying to use chemicals for treating frack water for reuse.

Air pollution is also another concern associated with unconventional oil and natural gas production. Air pollutants may be released during different stages of production of natural gas and oil. These include pad, road, and pipeline construction; flow back activities, well-drilling and completion and natural gas processing, storage as well as transmission equipment. The main pollutants include methane, volatile organic compounds, sulphur dioxide, nitrogen oxide, and a number of other air pollutants.

Oil giants like BP, ExxonMobil, Shell, and Chevron dominate the industry, but in view with oil industry's track record of environmental and health disaster, it will be more difficult for both public and policymakers to trust them with unconventional gas.

Unconventional drilling techniques may have come a long way since the last two decades but the challenges like the rapidly increasing population as well as depleting resources are staring at us.

The technologically superior and early movers should ensure that the technologies are shared with other countries for helping them meet their energy requirements. A systematic adoption and strategic planning can go a long way in solving the energy crisis prevailing in lot of countries. ■

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WIND ENERGY
At Dusk or Dawn?

Will wind power eventually become a crucial component of India's energy portfolio? **Mahazareen Dastur** takes a look at some of the most pressing issues for the wind power industry in India and compares the situation with the global wind industry today.

Since time immemorial, people have ascribed different powers to wind, a natural force that can be as benign as it can be malevolent. It can make trees sway; leaves rustle, determine the size of waves in oceans, and leave behind untold destruction in its wake as a hurricane. Time and again, man has made efforts to harness the energy of the wind for his use; historians have documented that between the 14th and the 19th centuries, wind energy provided a mind-boggling 20-25 per cent of Europe's total energy needs, while the water wheel, human and animal labour made up the shortfall. Cut to today, in the 21st century, we seem to be lagging behind our forebears.

Wind energy continues to play a vital role in the energy mix for countries today, albeit for different reasons. The need to cut back on carbon emissions and fostering independence from the traditional fossil fuels, or becoming "energy self-reliant", are the key drivers for countries to embrace wind energy. The technology for wind turbines has undoubtedly changed a great deal from its 19th century version, as have our requirements for energy. According to the International Energy Outlook (IEA) 2013, in today's fast-paced world of gadgets, gizmos and globalization, the world is likely to need 56 per cent more energy in 2040 than it did in 2010. Most of this demand will predictably come from countries like India, China, and Brazil, driven by strong economic growth. While the wind can more than make up for this requirement, the reality on the ground is different. In 2010, wind energy production was over 2.5 per cent of total worldwide electricity usage. It is expected that the industry will be able to supply 8 per cent of the world's total energy needs by 2018. The World Wind Energy Association reports that, today worldwide wind installed capacity is just shy of 300 GW (300,000 MW), of which 13,980 MW were added in the first six months of 2013 alone. The traditional big weights in the wind industry, in terms of the volume of installations as well as the size of the market, include China, the US, Germany, Spain, India, and the UK (see Figure 1).

Industry watchers keenly monitor the progress of continents, countries, and even states, in a bid to understand progress in this sector. Importantly, over the years, wind power has remained the highest contributor of energy from all renewable sources, including solar.

The Indian goal

Powered by onshore wind from Tamil Nadu, Karnataka, Maharashtra, Gujarat, Rajasthan, Madhya Pradesh, and Kerala, total wind installations during India's 11th Five Year Plan period (2007–2012) crossed 10.2 GW, exceeding the plan-period target of 9 GW. The Government of India has set a target of producing 15 GW of wind energy in new capacity additions during India's 12th Five Year Plan (2012–2017). This translates to roughly 10 per cent of India's total electricity requirement by 2017. Some countries have already achieved relatively high levels of grid penetration. An impressive 30 per cent of grid electricity production in Denmark was supplied by wind alone in 2012, followed by Portugal (19 per cent, 2011), Spain (16 per cent), Ireland (16 per cent, 2012), and Germany (8 per cent, 2011) setting good examples.

However, installation of wind energy does not guarantee grid penetration. This has been the case in India, where the total power penetration to the grid from the wind energy installations has been disappointing. According to the IEA, the actual electricity generated from wind energy was less than 1 per cent in 2009. Even today, it is difficult to fathom what proportion of nation-wide electricity generation can be attributed solely to wind power, as it continues to be clubbed with other renewable sources of energy. For this reason, it is difficult to estimate how much of India's present electricity is generated from wind energy alone.

Moreover, grid penetration rates are highly dependent on a number of factors, due to which wind energy in India continues to play a distant second fiddle to conventional forms of energy production, namely thermal power.

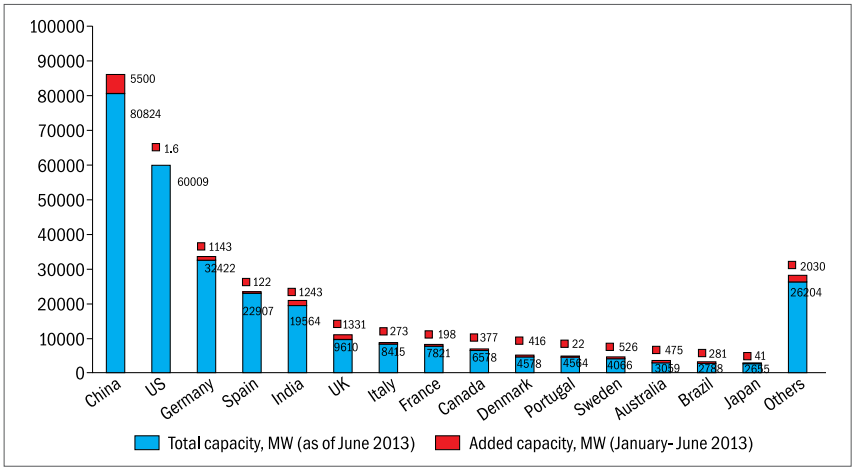


Figure 1: Country-wise total installed wind capacity as of June 2013
Courtesy: The World Wind Energy Association's half-year report, 2013.

When will the wind blow, and grid integration woes

Electricity generated from wind power can be highly variable on an hourly, daily and, even on seasonal basis. Consequently, instantaneous electrical generation and consumption must be balanced delicately so as to maintain grid stability. It is this variability that presents substantial challenges to incorporating large amounts of wind power into the grid. And the numbers can be quite extreme. In a report released in Denmark, it was noted that their wind power network provided less than 1 per cent of average demand on 54 days during 2002. Conversely, on April 16, 2012, wind power production in Spain reached the highest percentage of electricity production till then: wind farms covered a whopping 60.46 per cent of the total demand.

Such intermittency raises costs for regulation and the need for incremental operating reserves. While wind power proponents suggest that this issue can be resolved by having suitable standbys in place (either solar or thermal power), which would kick in on days of poor wind resource availability, critics contend that doing

so would entail considerable tinkering with the grid system; it could require an increase in the already existing energy demand management, load shedding and storage solutions.

Most of these are currently prickly issues for countries like India. According to a recent report by the Global Wind Energy Council, this variability has been creating problems for grids in maintaining a supply and demand balance. A majority of wind farms in India are located in remote areas that are quite far from load centres. Due to a weak transmission and distribution network, it is difficult to transmit the power from wind farms to the load dispatch centres. Moreover, the absence of reliable wind forecasting technology also leads to grid instability.

Grid connectability issues are not unique to India. In China too, traditionally, the bottleneck has been its transmission system, forcing wind power generators to curtail wind production at peak periods due to the grid companies' inability to manage the system effectively. About 20 TWh [1 TW = 1,000 GW = 106 MW] of electricity produced by wind power in China was lost due to curtailment in 2012. In fact, in 2012 China passed a regulation stipulating that new projects will not be approved in areas with over 20 per cent grid curtailments. Indian wind energy experts opine that "the remedy is more procedural than technical and requires administrative will rather than advanced technical understanding." Conversely, efficient grid handling can work wonders. Consider the state- and utility-level penetration of wind energy in the US. In 2012, while wind energy produced a mere 3.5 per cent of the total US electricity supply, it powered over 20 per cent of the electricity in the states of Iowa and South Dakota. Germany is planning to improve its grid transport capacity through "soft measures" such as temperature monitoring and high temperature conductors. Clearly, if India wishes to meet its 12th Five Year Plan goal, it needs to pay serious attention to this issue. An estimated Rs 420 billion is urgently needed to build a green energy corridor and boost India's transmission infrastructure.

Can improved turbine technology and wind assessment improve capacity factors

Somewhat esoterically titled, capacity factors muddy the waters further. Since wind speed is not constant, a wind farm's annual energy production does not equal the sum of the installed generator (nameplate) ratings multiplied by the total hours in a year. The ratio of actual electricity produced in a year to this theoretical maximum is called the "capacity factor" (see Box). Typical average capacity factors have been known to range from a dismal 3.27 per cent (Madhya Pradesh, 2011) to a more encouraging 20.96 (Tamil Nadu, 2010) to the state of the art 40-45 per cent (US, 2012).

Most parts of India, except certain pockets in Tamil Nadu, have low wind regimes. The lowest type wind class as

per the International Electrochemical Commission is Class 3, corresponding to a mean wind speed of 7.5 m/s. Close to 80 per cent of the wind turbine installations in India before 2009 were below 1 MW in rating. More recently, some Indian manufacturers, such as Suzlon, Gamesa, Global Wind Power, and GE Wind, have installed wind turbines with much higher ratings (exceeding 1.5 MW), the overall current installed capacity includes outdated turbine technology (less

What is "capacity factor"?

Capacity factor is the amount of electricity a power plant actually produces compared to how much it would produce if it is operated at full generator capacity of 100 per cent. For example, a 0.5 MW turbine with a capacity factor of 25 per cent will not produce 4,380 MWh per year ($0.5 \times 24 \times 365$), but only $0.5 \times 0.25 \times 24 \times 365 = 1,095$ MWh, averaging to 0.25 MW.

No power plant operates at 100 per cent capacity factor. The list below provides average capacity factors for different power plants:

- Natural gas combustion turbines: 80 per cent
- Natural gas combined cycle: 84.6 per cent
- Coal (pulverized and scrubbed): 84.6 per cent
- Nuclear: 90 per cent
- Hydropower: 50 per cent
- Solar photovoltaic: 21 per cent
- Offshore wind: 43 per cent
- Onshore wind: 40.35 per cent

Source: National Renewable Energy Laboratory (US), Transparent Cost Database

than 500 kW), which prevents a meaningful translation from installed capacity to production capacity. The World Institute of Sustainable Energy estimates that if wind turbines installed before 2002 are upgraded, Tamil Nadu's wind energy generation would rise by 50 per cent.

Financial constraints and delayed policy initiatives

Unfortunately, financial constraints currently prevent such upgradation as well as additional investments in India's case. Delayed policy initiatives and financial problems are the most severe issues faced by the Indian wind industry today. Says Mr Anand Pandey, Director of Business Development at EKI Energy Services Ltd, "Although India has massive wind energy potential, it continues to remain untapped due to poor financial incentives and lackadaisical policy planning."

In 2013, even new installations found it hard to get off the drawing board and onto the site. Poor planning by the government saw both the Accelerated Depreciation (AD) and the Generation-Based Incentive (GBI) lapse at the end of the 2012 fiscal year (see Box). The drastic reduction in the AD benefit from 80-15 per cent from April 2012 onwards has no doubt had a significant impact on wind installations in the country. Indeed, financial and regulatory surety can make or break a market. After setting a new record of 13 GW in 2012, the US experienced an unprecedented complete stop of wind turbine sales. The market came to an abrupt standstill—only 1.6 MW of new capacity was installed in 2012 compared to 2,883 MW in 2010. Experts blamed policy inertia for the fiasco.

Given that Indian wind projects require a capital expenditure of Rs 6 crore per MW (as opposed to Rs 4 – 4.5 crore for coal- and gas-based projects), industry watchers are keen that financial sops return and that innovative policies be implemented. The forthcoming reintroduction of the GBI will hopefully help (see Box).

Indeed, such sops, when played correctly, can power the renewable industry till grid parity is achieved. Take, for example, Germany. Germany's urgency in phasing out nuclear power after Fukushima is well known. Its amended Renewable Sources Energy Act targets a minimum of 35 per cent of renewable energy in final energy consumption by 2020, and 80 per cent by 2050. Interestingly, switching between the German fixed feed-in-

Accelerated Depreciation (AD) and the Generation-Based Incentive (GBI)

AD allowed firms investing in wind farms to write off about 80 per cent of invested capital in the first year, alongside a 10-year tax holiday. This led to setting up of a large number of wind farms, which were then neglected or not run efficiently. A 2008 study in a magazine reports that, "In April 2006, the IT department in Pune began investigating Suzlon's wind farms as part of a nationwide operation — spanning Gujarat, Rajasthan, Madhya Pradesh, Andhra Pradesh, Tamil Nadu, Daman and Diu, Pondicherry, Delhi, and Karnataka — to check for false depreciation claims, and ascertain if equipment suppliers and state electricity boards connived with equipment owners to manipulate such claims. IT authorities believe windmill owners make false depreciation claims to evade taxes; to the tune of Rs 700-1,000 crore." Generation-Based Incentives (GBI) was established by MNRE, whereby Rs 0.50 would be paid for every unit of electricity fed from a windmill to the grid over and above the feed-in-tariff (FIT) the utility would need to pay the power producer. The AD and GBI were mutually exclusive. In its first few years of operation, however, the incentive failed to attract as many independent power producers. Investors were of the view that the current rate of Rs 0.5/kWh was not at par with the fiscal benefit offered under the AD scheme. The government then decided to discontinue the GBI, believing that the FITs would compensate power developers adequately.

In its new form, the GBI will comprise an incentive of Rs 0.50 per kWh of electricity generated by wind projects registered under the scheme. The incentive will, however, stop once the payout reaches Rs 1 crore per MW of capacity. Producers will be allowed to draw this incentive of Rs 1 crore in no fewer and no more than four years and 10 years respectively.

tariff and the feed-in premium can be done on a monthly basis. The incentives for offshore installations originated with the view that offshore wind power will become the second most important renewable energy source for Germany by 2050. Clearly, planning incentives and policy measures is crucial for escalating growth in the wind power industry.

Planning their financials right: The case of Germany

The 2012 amendment of the EEG also created the conditions for direct sale of renewable electricity on the spot market with the introduction of a feed-in-premium (Marktprämie). The level of the feed-in-premium per kWh is flexible and calculated as the difference between the monthly average spot market price for electricity and the fixed feed-in tariff. Producers also receive a "management premium" amounting to EUR 1.2 cent per kWh with a gradual decrease to EUR 0.7 cent per kWh by 2015. By February 2012, more than 18,000 MW of renewable capacity including over 16,500 MW of wind had already opted for the feed-in-premium, exceeding 24,300 MW of wind by March 2013.

The good news

Notwithstanding the fact that there are other vital issues that also deserve attention (e.g. environmental concerns, delays in FIT payments, etc.), India continues to be a vital market for the wind industry. It presents substantial opportunities for both international and domestic players. In 2011, the Indian wind sector experienced its strongest annual growth ever, with over 3 GW of new installations, and although 2012 saw a slowdown due to poor policy planning, forecasts indicate that the Indian wind industry will be back on track in 2014. An assessment of the annual mean site conditions in terms

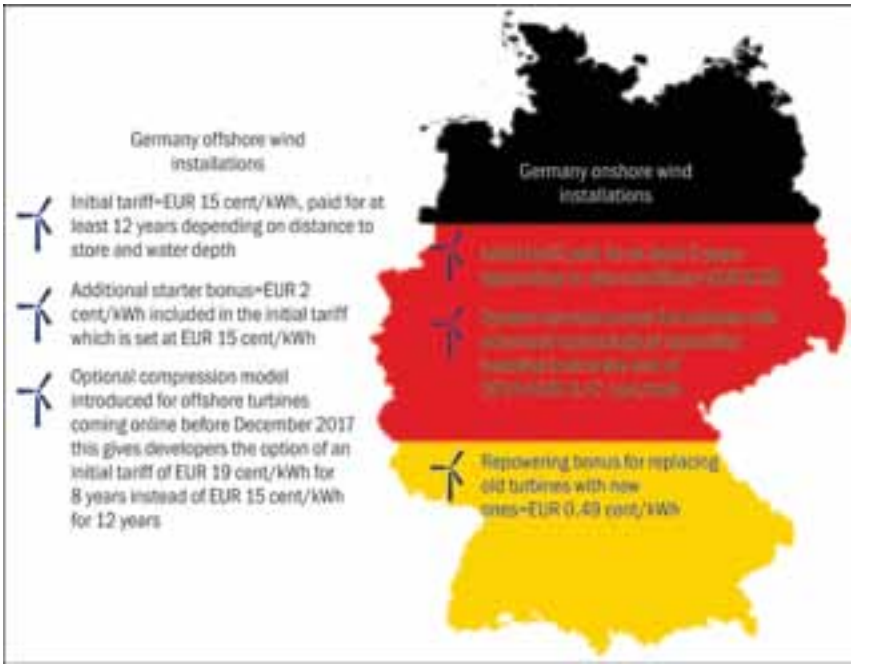


Figure 2: Planning their financials right: The Case of Germany

of the wind energy capture feasibility is crucial for economic justification of wind farm planning. The Centre for Wind Energy Technology (C-WET) recently revised the country's official wind potential figure to 102 GW at 80 m hub height (validation pending) from 49 GW at 50 m hub height (subject to certain assumptions). For example, in Gujarat alone, the total estimated wind potential was revised from 10,609 MW (50 m hub height) to 35,071 MW (80 m hub height). Such exercises help potential developers make a solid case for wind projects.

India is also home to about 20-odd wind turbine manufacturers, with an annual production capacity of close to 10,000 MW. With certain manufacturers now offering Class II and Class III machines with newer technologies and higher power capture capabilities, there is every hope that wind energy will expand and penetrate areas where it is most needed—rural India.

Further, India's 7,500 km long coastline will likely serve as a backdrop for future offshore wind energy development. The potential is immense, if only it is tapped right.

The Global Wind Energy Outlook sums it up best: "By 2020, India could have almost 89 GW of wind power in operation, supplying 219 TWh of electricity each year, while employing over 179,000 people in the sector and saving almost 131 million tonnes of carbon dioxide emissions each year. Investment would by then have reached a level of EUR 13 billion per year." The manner in which the industry and the government resolve outstanding issues will determine its future. ■

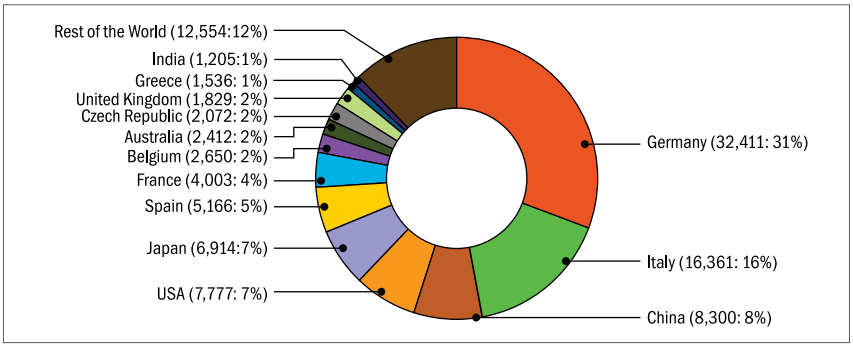
An environmental engineer by qualification, Mahazareen Dastur has worked in the area of environmental management for 12 years. She has provided advisory and review services on a myriad of topics, such as environmental economics, green products and services, World Bank environmental and social safeguards, environmental and social management frameworks, environmental due diligence for financial institutions, and urban environmental management. Currently, she researches and writes on a host of environmental issues for leading publications. An ardent believer in environmental education, Mahazareen also gives talks on environmental issues to students. She blogs at mahazareendastur.blogspot.com.

QUALITY OF PV MODULES IN LARGE GRID CONNECTED SYSTEMS

With the high stakes associated with PV (Photovoltaic) modules, it becomes extremely important to procure PV modules of high quality and great reliability, **Ravikumar Gurumurti** reports.

Electrical power generation using photovoltaic (PV) technology has grown remarkably in the world over the last five years. With the rapid scaling up of installation of large ground mounted and roof top grid connected systems, individual solar PV power plants of capacity 30 to 50 MW and roof systems of multiples of MWs are becoming a common site. The global installed solar PV capacity has now crossed the 100 GW mark in India, but the installed capacity has risen from a mere 2 MW in 2010 to 2 GW in 2013, driven by the Ministry of New and Renewable Energy Resource's Jawaharlal Nehru National Solar Mission (JNNSM) and the policies of state governments like Gujarat and Rajasthan. India is now listed amongst the leading PV markets in the world.

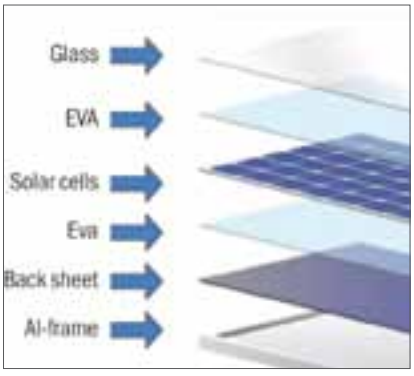
The energy generation data for the power plants installed under the JNNSM programme is now publicly accessible and even a cursory look at the data shows varying performance of power plants of same capacity for the same period of time in a given geography. Plant performance variation could be attributed to various factors such as the modules not delivering the rated power at STC due to errors in measurements, quality issues related to PV modules and inverters, quality of installation, and the maintenance schedule. The importance of module quality need not be over emphasized but a good understanding of the quality issues would help in sourcing the right quality of modules.



Global PV cumulative installed capacity share in 2012 (MW %) Courtesy: EPIA

The basic building block of a power plant is the solar PV module which is an assembly of interconnected solar cells. Solar cells are made of semiconductor materials and the most commonly used is silicon in crystalline form (both mono and multi). Since the solar cells are to be deployed in the open and, therefore, exposed to the sunlight, dust, and weather elements, there is a need to protect the solar cells.

Electrically matched and interconnected cells are encapsulated using the polymer Ethyl Vinyl Acetate (EVA) and sandwiched between high transmission (92–95 per cent) toughened glass and a weather-resistant back sheet of Poly Vinyl Fluoride (PVF) to form a laminate. When the laminate is fixed with a mounting



PV Module Construction
Courtesy: Microsystems Services

frame and terminal box to draw the electrical output, we have a PV module.

PV modules deliver DC electricity and are rated for its peak power output Wp, which is the maximum power the module will deliver under the standard test conditions (STC) of 1000 W/sq.m. of incident solar radiation (insolation) and 25°C cell temperature. The rated power has a measurement tolerance of +5 per cent. Thus, a module rated 100 Wp can deliver between 95 and 1005 Wp. It is evident that, higher the module output per unit area, lesser the size of the module for a given power output. Hence, modules constructed with higher efficiency solar cells like the silicon crystalline solar cells need lesser installation area.

Without exception, every module manufacturer extends both workmanship warranty and power warranty on the rated power. Workmanship warranty against manufacturing defects is usually for five years. As per the norm, the power warrantee is 10 years for lower-rated modules up to 20Wp and 25 years for higher-wattage modules. The power warranty assures the customer that the module will deliver 90 per cent of the rated power at the end of 10 years and 80 per cent of rated power by the end of 25 years. This is the reason the power plants are assigned a life of 25 years. There are very few products in the world that come with such a long warranty period. Implicit in this power warranty is the fact that there are processes which continuously degrade the module electrical performance.

The long-term performance as warranted by the manufacturer of module is very critical. The power plants installed in India have been in field for around two years and it is too early to notice degradation issues. Yet aging issues can start prematurely for various reasons discussed here.

Reduction in module power output greater than what has been specified by the manufacturer could lead to lower energy yield than predicted and, consequently, serious loss of revenue. Unlike all other components of a solar PV system, in PV modules, whose costs are very high, any defect/failure of

the encapsulated cell, EVA, and the back sheet cannot be repaired even though it is possible to fix defects in the components externally secured to the laminate like module frames, terminal box, and cables. Therefore, it is very important for Engineering, Procurement, Construction (EPC) companies, developers, and quality engineers to have a good understanding of the quality issues related to PV modules.

Silicon solar cell-based PV modules are most widely deployed in power plants around the world (> 85 per cent). In our country, however, thin film modules have been extensively deployed in the power plants installed so far, for reasons of lower cost, higher yield, and easier access to finance. Since the deployment of thin film modules are of recent origin, not much of data is available regarding the long-term performance of these modules, though it is known that their field performance can deteriorate faster than the silicon cell modules which have been in use for over three decades.

During the process of manufacturing and lamination, the silicon solar cells go through several physical handling. Silicon, being brittle, can break or develop visible and invisible cracks during the manufacturing processes. With cell thickness becoming lesser and lesser, 150 to 180µ, invisible micro cracks can be a serious issue.

When these modules with thin cells are deployed in the field, mechanical stresses introduced during installation and the thermal stresses introduced due to exposure to extreme climate conditions could damage the cells. Cell interconnect strips could also be subjected to thermal stresses and could result in potential high resistance path and consequent localized heating. Heating at the interconnect points would further aggravate the resistance problem and, in extreme cases could burn the cells and totally damage the module. Other problems that arise during manufacturing are trapped air bubbles and delamination in EVA.

When PV modules are deployed in the field, EVA, if it is not UV-stabilized could lead to problems. Some of the EVA formulations produce acetic acid when it is exposed to UV radiation and the consequent electrochemical reaction can lead to browning or yellowing of the encapsulant and corrosion of the solder bonding between the interconnect tabs and the cell bus bar. While the browning reduces drastically the amount of light reaching the active area of the solar cell, corrosion increases the series resistance; both of which in turn drastically reduce the electrical output. EVA degradation also results in reduced shear strength and adhesion

to the glass and the back sheet leading to moisture ingress.

Moisture ingress can cause deterioration of the anti-reflection coating and reduce the module efficiency. More importantly the insulation resistance between the module mounting frame from current flowing circuit will be reduced, which would be very dangerous as strings of modules connected together generate hundreds of volts.

Apart from the issues that arise during the manufacturing process and the subsequent weather induced deterioration of the material when deployed in the field, there could be a more basic issue that of relating to measurement of power output of modules. Usually module manufacturers specify a negative tolerance of 5 per cent. Measurement errors can result in the name plate power being marked higher than the lower limit specified.When modules with mismatched power outputs are used in the construction of power plants, it could result in module damage or premature failure of the module.

Problems with components fixed to the laminate like terminal box can also arise. In Europe as many as 15 fire accidents from roof-top systems were reported recently and the investigation traced the issue to design faults in the junction box that led to fretting corrosion at the tinned contact points and increased the contact resistance. With large current flowing through the contacts, fire accidents were an inevitable consequence. In addition to the modules, large parts of the roofs were destroyed in the fire accidents. As many as 650,000 modules installed across Europe during the period 2009 and 2011 have these junction boxes and the modules have been declared prone to fire hazard. The company which supplied these modules had filed for insolvency around the time the widespread fire accidents were reported. A reputed service provider has been assigned the repair programme. It should also be noted that when the insurance claim mounted, the insurance company, too, declined to make the payments after the insurance coverage limit was crossed. Now thousands of high risk modules may have to be repaired by the owners at their own expense.

All these problems could be traced to poor design, workmanship, poor choice of material, and lack of adherence to quality standards.

With the market growing rapidly, especially since 2008, module material suppliers and module manufacturers have mushroomed. All of them claim their product to be meeting international standards. All module manufacturers get their modules certified for IEC specification 61215, which incidentally is only a design qualification certification and not a certification for reliability. It cannot be said with certainty that the regular module manufacturing was carried out maintaining the same quality practices that were exercised during the manufacture of the test modules for certification process. Another important issue that cannot be overlooked is the fact that any time during the 25 long years, the manufacturer from whom the modules were procured may have, unknown to the purchaser, exited the business or business may have moved to another country where enforcing commercial commitments may be difficult, worst the company may have gone bust and vanished.

PV modules have to operate in extremes of climates and yet have to yield the predicted energy year after year for 25 years, in a safe manner, without which large-sized power plants do not make any economic sense. Therefore, purchase decision based purely on $/Wp could be disastrous. If we opt to pay less upfront, it is very likely that we will end up spending much more than what we would have spent in buying a good quality module at the beginning. The stakes associated with PV modules are indeed very high and there is no need to overemphasize the fact that due diligence must be exercised to ensure that the modules are sourced from manufacturers who have been in existence for long, have a history of demonstrated capabilities and earn a global reputation for the high quality and reliability of the modules they manufacture. ■

Ravikumar Gurumurti is associated with the PV industry for over 30 years, beginning his career in 1982 with the first PV company, Central Electronics Ltd. He was later associated with Siemens Solar, Shell Solar, Tata Power Solar and with the global industry association SEMI. Currently he is operating independently as a consultant offering technical services to the PV industry and is also engaged in conducting training programmes on PV technology and application, System Design, I&C, and O&M.

NEW CELLS FOR THE NEXT STAGE

Demand for solar is rising and the sector is recovering. Manufacturers are starting to invest in new product lines again – and since researchers and developers used the crisis to dream up cost-saving innovations, firms are spoiled for technological choice.

The Institute for Solar Energy Research Hamelin (ISFH) was never much into grand, publicity-grabbing announcements of its successful projects. The North German institute always favoured an understated approach. But now it looks like things are changing. At the EU PVSec conference and exhibition in Paris, one of the world's largest photovoltaic (PV) technology events, ISFH researchers stole the show with a new high-efficiency cell made of monocrystalline silicon. Thanks to a totally shade-free front, the cell can convert sunlight into electricity at 23 per cent efficiency - around four per cent more than standard mono crystalline cells can currently manage.

"We've found a way of manufacturing back-contact cells without any complicated structuring steps and at a reasonable cost," says Jan Schmidt, head of the PV division at ISFH. The cells use complex interdigitated back-contact (IBC) technology, which puts all electrical connections on the back of the cell to ensure that no metal pans stop light getting to the front. When it comes to the contacts, the electrical connections for both poles have to interlock, like fingers in clasped hands in order to prevent short circuits. Although developers began working on back-contact cells in the 1990s, the US company Sunpower was the only one to master the process. But now it looks as if the ISFH researchers have also managed to get to grips with it.

"At the moment, high-performance laboratory cells use photolithography to define the metallization. It's a complex optical process that is not suited to industrial production. We use lasers instead, and they work well in an industrial context," explains Schmidt. What's more, the contacts on the new cells are made of aluminium rather than silver. This reduces production costs.

The innovation has come at the right time, as the PV industry is about to be swept up in a wave of modernization. The crisis of the past two years meant that no money was available for new production lines. As funding dwindled and demand in key European markets faded fast, companies were forced to slash prices, and many fell into the red. Bur the global market is gradually gaining momentum, primarily because countries such as China and Japan are investing heavily in PV systems. US market-research company IHS estimates that annual PV growth will rise by about 50 per cent to a good 46 gigawatts between 2012 and 2015. New production lines will be crucial in filling this future demand for solar panels.

"Capital spending is starting to pick up, and we're already seeing some activity in South America, Mrica and the Middle East," says IHS analyst Stefan de Haan. Asia is also witnessing


RECHARGABLE

an upturn in the industry. Sales at Chinese panel manufacturers Yingli and Renesola are rising, which meant their losses in the second quarter of 2013 were down almost 50 per cent on the same period last year. Rising demand has led Canadian Solar to start planning a new factory in Indonesia. It will produce metal-wrap-through (MWT) panels and have an annual capacity of 80 megawatts (MW). MWT technology is relatively new and not unlike back-contact cells. The difference is that MWT cells don't put all the metal components (busbars and contacts) on the back, just the busbars. This means that MWT cells capture up to three percent more sunlight than standard cells.

China to boost efficiencies

Meanwhile, Japanese electronics giant Panasonic has ramped up production in its Malaysian panel factory, which opened in late 2012. The company says that the factory will now be working to its full capacity of 300 MW per year.

It produces heterojunction cells, which reach efficiencies of over 20 per cent. This means that they, along with Sunpower's back-contact cells, are currently leading the field in silicon PV Panasonic boosts electricity yields by combining crystalline with thin-film technology. Monocrystalline wafers are coated on both sides with amorphous (i.e., non-crystalline) silicon, which serves as a passivation layer and creates an impenetrable barrier for the photogenerated electrons. This prevents recombination occurring at the surface of the crystal and lowering electricity yields.

Solar institutes and mechanical engineers are hoping that more high-tech factories will be built. While manufacturers have largely avoided investments the past few years, researchers have been working flat out. Germany's federal government has so far pumped EUR 150 million into the Photovoltaics Innovation Alliance. Formed in 2010, the alliance brings together German solar firms and plant manufacturers with the aim of developing more efficient cells and corresponding production processes. Many of the projects are in their final stages or have already reached a successful conclusion. This means that manufacturers can draw on a whole range of new cell technologies and machines.

ISFH's back-contact cells are among the most interesting of the innovations, but they can't go into mass production until they've been tested on a pilot line. Mechanical engineering companies, however, already offer a variety of processes for producing PERC (passivated emitter and rear contact) cells. In these kinds of cells, a special coating reduces electricity losses between the semiconductor and the contacts on the back. This means the cells can use more of the light that hits them, which makes for more powerful panels. Singulus Technologies, a company from southern Germany, presented a new coating machine at EU PVSec that can improve cell efficiencies

by about one percent. Stefan Rinck, CEO of Singulus, says that China is very interested in the new technology. "The Chinese government will now only grant loans for the production of cells that reach an efficiency of 20 per cent or more, so companies are looking for ways to upgrade their lines."

Schmid, another German mechanical engineering company, also supplies equipment for producing PERC cells that get beyond the 20-per cent mark. What makes Schmid's solution unique is that, instead of producing the aluminium-oxide barrier layer (which increases electricity yields) in a vacuum, it does so under atmospheric pressure. The company says that this makes the step 40 to 50 per cent cheaper because it involves lower temperatures and uses less energy.

Researchers have also made significant progress with CIGS thin-film cells. These are produced by using coevaporation to deposit a layer of copper, indium, gallium and selenium onto glass — which means that there is no need for the complex process of slicing silicon blocks. Working within the Photovoltaics Innovation Alliance, German engineering company Manz and the Centre for Solar Energy and Hydrogen Research Baden-Wurttemberg (ZSW) have developed a complete turnkey production line for CIGS panels that deliver efficiencies of 14.6 per cent. To put that in perspective, when Manz took over the technology from Wurth Solar in 2012, it was working with about ll-per cent efficiency.The Manz-ZSW collaboration (the project is called CIGSfab) has also cut production costs for these kinds of panels. In 2012, they stood at around EUR 1 per kilowatt-hour, but now Manz says that figure has dropped to EUR 0.50, making them cheaper than crystalline panels. CEO Dieter Manz is, therefore, sure that the new thin-film production line will be a success. "The solar industry is going to experience a huge renaissance in countries such as the US, China and India, and in the Middle East. This is an enormous opportunity for German engineering firms, and the prospects for CIGS thin-film technology are especially bright," he says.

The new production lines are only just hitting the market, but researchers are already working on next-generation technologies. The greatest leaps in efficiency, for every type of cell, could still be to come. After five years of preparation, construction

work on Germany's EUR 19-million x-ray beamline EMIL (Energy In-situ Laboratory) began this summer. It will be connected to the BESSY II synchrotron radiation source at the Helmholtz-Zentrum Berlin. EMIL will make it possible to analyse cell layers precisely and observe processes on their surface.

These findings will allow us to produce tailor-made barrier layers, thus significantly increasing efficiencies," says Klaus Lips, one of the Helmholtz researchers.

But boosting efficiencies is just one of the aspects that researchers want to focus on. Increasingly, they are exploring cell designs that save on materials. This field has received relatively little attention to date and has yet to make much progress. The wafers used in solar cells are still 180 micrometres thick on average and account for about a third of the price of a finished panel. Researchers are now looking at ways of using much thinner wafers so as to radically reduce costs.

ISFH's MacPSi (macroporous silicon) process, for instance, uses electrochemical etching to separate ultra-thin layers from a mono crystalline wafer. The layers are used later as absorbers in thin-film panels (see diagram). "By etching electrochemical macropores into the silicon substrate, we create fixed breaking points that go between five and 20 micrometres into the wafer," explains ISFH's Schmidt.

When the absorber is removed, the side facing the main wafer has a rough sur face of tiny raised pyramids. This is used later as the front of the cell because the pyramids are good at directing sunlight into the cell and at reducing reflection tosses. Next, researchers "stick" the absorber onto a cheap substrate such as glass, thus making the cell stable enough to survive the next steps - such as applying the front contacts and passivating the cell with amorphous silicon. Aluminium is used to connect the absorber to the glass. A layer of the metal is put between them and then heated with a laser or halogen lamps in order to bind the two parts. The aluminium also functions as the back contract, which channels the photogenerated charge carried out of the cell. "We've already used this

> The Chinese government will now only grant loans for the production of high-efficiency cells.
>
> Stefan Rinck, Singulus Technologies

> The solar industry is going to experience a huge renaissance in countries such as the US, China, and India.
>
> Dieter Manz, Manz

production process to make cells that are 13.1 per cent efficient. It's almost ready for industrial use," says Schmidt.

Germany's Fraunhofer Institute for Solar Energy Systems (ISE) and the French start-up STile are also working on thin silicon cells that use a cheap substrate. Their solution, a wafer equivalent, uses a substrate of low-cost silicon powder and a photoactive silicon layer.

"We're already reaching 14 per cent efficiency in the lab," says Andreas Ben, deputy director of ISE. Tasks in the project are clearly defined. STile produces the substrate, which means that it lightly cleans the raw silicon, pulverizes it and compresses it at a high pressure until it forms a layer that is about 200 micro metres thick. The Fraunhofer researchers produce the absorber by depositing trichlorosilane from the gas phase onto the substrate to form a 20-micrometrethick layer of silicon. Trichlorosilane is produced when hydrogen chloride and silicon react at high temperatures. It exists as a liquid under normal conditions, but when it is thermally decomposed in the presence of hydrogen, it causes a film of ultrapure silicon to grow on the cell. Bett explains that the technology achieves similar efficiencies to standard monocrystalline cells, but reduces the manufacturing costs by about 40 per cent. He says that with continued development, industrial production will be possible in just two to three years' time. All this just goes to show that PV is far from reaching the limits of its technological potential. ■

The article is reproduced from the New Energy magazine.

“WE ARE ILL-PREPARED FOR PRESENT DAY EXTREMES”

Eddy Moors heads the Earth System Sciences and Climate Change group at Alterra Wageningen University and Research Center in The Netherlands. His key expertise is integrating different disciplines to tackle research questions that ask for an inter- and trans-disciplinary approach. His background in hydrology and climate change research, both on mitigation and on adaptation topics, makes him a key player in this field. He is and has been a coordinator of numerous national and international projects. Dr Moors has coordinated a study on the impact of climate change on the Ganga basin, where it was concluded that the Ganga basin temperatures will rise by 1-2°C by 2050. He also presented the Alterra research activities in India, such as the results from the EU High Noon project. In the backdrop of India Water Forum (IWF) 2013, Dr Moors discussed the water crisis in India and Asia with **Meenakshi Dwivedi**. Excerpts from the conversation follow.

As global water demand grows over the next two decades, India is likely to be among the most severely affected countries. Are we prepared to face such a crisis?

Although efforts are underway to improve water use efficiency and increase food productivity, I do not think India is ready to face an extreme drought. The floods in Uttarakhand are an indication that makes clear that action is needed to reduce the impacts of extreme drought events to come.

Do you foresee any importance in demonstrating new agricultural practices which will improve water efficiency and overall agricultural productivity for a country like India?

Agriculture has a large imprint on both — water quantity and water quality. Improvement of water use efficiency will not only help to reduce the water demand, but in general will also lead to improved management practices. From our experience, we can say that this will lead to reduced emissions to surface and groundwater bodies, sometimes to reduced GHG emissions to the air as well, and in almost all cases to increased production levels.

The world's water problems stem from our failure to meet basic human needs and our inability to balance human needs with the needs of the natural world. Where is the scope of improvement to ameliorate things?

Balancing human needs with the natural needs is one of the most important principles of sustainability. Strategies and solutions, that not just solve ad hoc problems and crises, but are a way forward to improve a robust way of the quality of life, are based on the principles of sustainability. Bringing in sustainability principles in our public and private objectives will greatly help to reduce the water crisis we are facing now and in the future.

"If you live in a slum in Manila, you pay more for your water than people living in London." That is the conclusion of a report from the United Nations Human

Development Programme. This is unfortunate. Why does this happen and what measures do you suggest to deal with the issue of irregular water pricing?

I haven't read the report yet. It is difficult to say if a higher water price in Manila than in London is bad for London or for Manila. Water pricing especially for domestic water use can be introduced to ensure good water treatment and distribution. Sometimes it is also used to stimulate sensible water use to ensure equity for all water users (including nature) in the present and in the future. Preventing contamination of water is the best way to reduce treatment costs at the intake and this puts the burden with the users who are the cause of the contamination of the water in the first place. However, introducing these measures require great commitment of people involved as well as substantial investments.

Success in addressing (water and sanitation challenges) through a concerted national and international response would act as a catalyst for progress in public health, education, and poverty reduction and as a source of economic dynamism. What do you have to say on this?

I agree and would like to add that addressing water and sanitation challenges as a part of education is a great way to overcome these challenges. These efforts will certainly help in reducing water consumption and decrease the prevalance of health issues such as diarrhoea, which is still one of the main causes of child mortality in India. Besides improving the quality of life, better health will also have a positive impact on the economy as it will increase the availability of the labour force.

In a country prone to floods, what is the significance of adaptive land use for flood alleviation?

Rethinking the way flood plains are developed is important. Creating flexibility in the land use to allow the river to expand during floods without causing major damage and loss of life is one such solution. Examples of such measures can be found in projects such as "Room for the River" in The Netherlands. For engineering purposes it is important to acknowledge that historical records are not representative for the future.

The United Nations-sponsored Warsaw Climate Change 2013 talks came to a close with a deal that failed to resolve contentious issues on addressing climate change. What do you have to say about the outcome?

Disappointing, but we expect some conclusion soon. However, can we allow ourselves to wait until an agreement has been reached? I personally do not think so!

To obtain common understanding and agreement is always difficult, especially if there is doubt over the urgency, or a question of who is going to be benefited. For example, when in a group it is difficult to have a common consensus on where to go for dinner, or what colour the walls of the school should be. An international agreement on climate adaptation and mitigation efforts is helpful; however, do we need it to prepare ourselves and take first steps? No! Taking those first steps towards adaptation and mitigation is already possible; however, an integrated approach remains important. To assure a coherent strategy that optimizes opportunities for all, a good integrated approach is of utmost importance. Therefore, individual or local initiatives are best complemented by cooperation at the national or regional level. We need to start doing things and not wait for an international agreement.

We knew global warming was going to make the weather more extreme. But it's becoming even more extreme than what anyone had predicted. Are we prepared to face this crisis?

No, at the moment we are ill-prepared for present day extremes, let alone more severe events. For me it is the most important part of climate change for which we should develop specific mitigation and adaptation strategies and measures. Historical extremes can be used as a proxy of what is to come and we can learn from these, but we should keep in the back of our minds that the frequency and severity of these extremes are likely to increase. ■

Invitation for applications to
Girish Sant Memorial Young Researcher Fellowship 2014

Girish Sant Memorial Young Researcher Fellowship has been set up in memory of Girish Sant to encourage young researchers to take up public interest oriented research and advocacy in the Indian energy sector, and to provide some financial and professional support to youngsters at an early stage of their career.

Applications are invited from interested candidates to avail of the fellowship for 2014. The fellowship is open to all Indians below the age of 35. The last date for submitting fellowship applications is January 31, 2014. Please visit http://tinyurl.com/yrf2014 or write to gsm-yrf@prayaspune.org for more details on the fellowship and how to apply for it. Please visit www.prayaspune.org/peg for more information about Prayas (Energy Group) and Girish Sant.

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TECHNOLOGY COULD LEAD TO MORE RELIABLE RENEWABLE ENERGY SYSTEMS

The patent, by the University of Alabama, claims an algorithm that 'when programmed into the turbine's power electronics' better controls the electric conversion.

Renewable energy sources such as wind-powered generators can be more reliable and efficient by better controlling the process of getting electricity onto the power grid, according to a United States patent-based on research by Dr Shuhui Li, associate professor of electrical and computer engineering at the University of Alabama.

Li, with assistance from Dr Tim Haskew, professor and head of the Electrical Engineering Department, found in their research that wind turbines often stop sending electricity to the grid because of competing processes in converting electricity into a form usable for power distribution. The patent, granted in November to UA, claims an algorithm that when programmed into the turbine's power electronics better controls the electric conversion.

"There are two different control tasks that fight to control each other's method," Li said. "When you compete, it's dangerous, and sometimes you compete wrong."

The patent and two other pending patents are part of Li's efforts to

enhance energy generation from renewable resources and improve the efficiency, reliability, stability, and power quality of integrated renewable and electric utility systems. For electric energy consumers, Li hopes to improve the power quality and uninterrupted energy supply to meet customers' needs and increase incentives for energy consumers to use less expensive, more reliable energy from renewable resources and electric vehicles.

Renewable energy such as wind or solar power produces electricity at varied rates, unlike electric generators powered by the consistent burning of fossil fuels such as coal or natural gas. The wind energy produced is alternating current, or AC, electricity, which is the form of electricity used to deliver power across the grid. However, it is near impossible for a wind turbine, for example, to produce AC electricity at the correct frequency needed for distribution.

To get the AC electricity at the right frequency, the generator converts it to direct current, or DC, power that can then be converted again into AC at a frequency needed for distribution on the power grid. The problem, though, is the active and reactive power control tasks of the conversion fight with each other, messing with the other's process, Li's research has shown. When the fluctuation or oscillation appears in the system -- as can happen with wind

turbines -- the generator could trip off until production ramped back up. This would interrupt the flow of electricity onto the grid, Li said.

If wind turbines and other renewable energy systems are to make up more of electricity production in the future, they need to be more reliable and with higher power quality, Li said. The technology behind the patent improves the energy coming from the wind turbine and makes it a more reliable and efficient contributor to the power grid.

The University of Alabama Office for Technology Transfer is working with Li to market the patent and related technology for commercial use. ■

The article has been sourced from Science Daily.

CURRENT R&D RENEWABLES

Modelling Renewable Energy Impact on the Electricity Market in India

Renewable and Sustainable Energy Reviews, Volume 31, March 2014, Pages 9-22

Deb Chattopadhyay

Renewable power generation development, in most cases for wind and solar, has taken off at a rapid pace in India, especially in the last four years. Though these developments have many positive aspects, there is a need to carefully assess a rapid shift in balance of baseload and intermittent generation to ensure that the share of renewable power generation increases without compromising system security and economics. Seasonal and spatial variability of wind, and to a certain extent that of solar can render these resources to have low availability for a significant part of the year, which leads to an increase in unserved energy, that is, deteriorate system reliability. The intermittency of generation also impacts inter-state power flows, which, in turn, leads to higher congestion in the grid. Climate model results provide a rich set of information on the nature of solar or wind variability that can be embedded in an electricity market simulation tool to assess these impacts on prices, generation dispatch, and power flows. We have developed a modelling analysis for the Indian national electricity market, which is informed by CSIRO climate model results. We have assessed the added costs arising from intermittency, which could be put in perspective of the true costs and benefits of renewable power. We have focused on the near-term developments in 2017 to show how some of the high renewable growth scenarios included in the Indian National Electricity Plan, which may imply significant pressure on inter-state/region transfer capability, and lead to a significant worsening of system reliability. Our modelling analysis suggests that there is a need for a more orderly and balanced development of renewable and conventional power generation capacity with a stronger focus on system economics and security.

Renewable Energy Certificate and Perform, Achieve, Trade Mechanisms to Enhance the Energy Security for India

Energy Policy, Volume 55, April 2013, Pages 669-676

Rajesh Kumar, Arun Agarwala

The Renewable Energy Certificate and Perform, Achieve, Trade mechanisms in India are designed to target energy generation and saving, respectively, in line with Clean Development Mechanism (CDM) implemented by United Nations Framework Convention on Climate Change (UNFCCC). The Renewable Energy Certificate System is a voluntary regulation for renewable energy generators in India and is designed for effective implementation of inter-state transactions by introducing the Renewable Purchase Obligation regulation for consumers and a flexible trading platform for transactions across the country. The Perform Achieve Trade scheme, another initiative, is an enhanced energy efficiency trading mechanism, which is based on consumption targets that require large energy user sectors

to improve efficiency by 1-2 per cent per year. The Perform Achieve Trade scheme has introduced mechanisms for the identification of industry sector, designated customer, specific energy consumption, and target setting. The Perform Achieve Trade design issues are in test phase in the first cycle of the scheme, which will run from 2012 till 2015. This paper discusses key design issues about boundary and target setting for Renewable Energy Certificate and Perform Achieve Trade energy saving certificate (ESCert). A data-sharing and trading mechanism for Perform Achieve Trade is also proposed for review and coordination among regulator, designated consumers, and traders in the market.

Off-grid Electricity Generation with Renewable Energy Technologies in India: An Application of HOMER

Renewable Energy, Volume 62, February 2014, Pages 388-398

Rohit Sen, Subhes C Bhattacharyya

Traditionally, renewable energy-based off-grid or decentralized electricity supply has considered a single technology-based limited level of supply to meet the basic needs, without considering reliable energy provision to rural consumers. This paper proposes the best hybrid technology combination for electricity generation from a mix of renewable energy resources to satisfy the electrical needs in a reliable manner of an off-grid remote village, Palari in Chhattisgarh state, India. Four renewable resources, namely, small-scale hydropower, solar photovoltaic systems, wind turbines, and bio-diesel generators are considered. The paper estimates the residential, institutional, commercial, agricultural, and small-scale industrial demand in the pre-HOMER analysis. Using HOMER, the paper identifies the optimal off-grid option and compares it with conventional grid extension. The solution obtained shows that a hybrid combination of renewable energy generators at an off-grid location can be a cost-effective alternative to grid extension and it is sustainable, techno-economically viable, and environmentally sound. The paper also presents a post-HOMER analysis and discusses issues that are likely to affect/influence the realization of the optimal solution.

Renewable Deployment in India: Financing Costs and Implications for Policy

Energy Policy, Volume 62, November 2013, Pages 28-43

Gireesh Shrimali, David Nelson, Shobhit Goel, Charith Konda, Raj Kumar

India's ambitious goals for renewable energy raise many questions regarding the nature of investment required. We conduct financial modelling of actual renewable projects in India; and derive the following insights. First, the high cost of debt is the most pressing problem: higher cost and inferior terms of debt in India may raise the cost of renewable energy by 24-32 per cent as compared with the US. Second, even if cost of debt goes down, loan terms, including short tenors and variable interest rates, will become significant impediments, given that they add 13-14 per cent to the cost of renewable energy in India as compared with the US. Finally, due to the high cost of debt, policy lessons from the US and Europe that focus on finer instruments such as duration of revenue-support, revenue-certainty, investor-risk-perception, and completion/cost-certainty are not likely to be as effective, with potential impacts on the cost of renewable energy in the range of 3-11 per cent. In fact, we find that an interest rate subsidy, which reduces the cost of debt, also reduces the overall subsidy burden by 13-16 per cent. This suggests that Indian policymakers need to prioritize the provision of low-cost and long-term debt and should have a closer look at the successful efforts by China and Brazil.

Critique of Offshore Wind Energy Policies of the UK and Germany: What are the Lessons for India?

Energy Policy, Volume 63, December 2013, Pages 900-909

Swaminathan Mani, Tarun Dhingra

Indian economy is growing at a rapid pace during the last few years. Seeing this, the power sector needs to build additional generation capacity to support this growth. Currently, India has an installed power generation capacity of over 210,000 MW, of which, barely 12 per cent of these are from renewable energy sources. The majority of remaining 88 per cent are from non-renewable sources. However continued dependence on fossil fuels to power the growth of electricity generation capacity is hardly sustainable. There is a need for renewable energy sources to step up and start contributing to the energy basket of India in a substantial manner. Though onshore wind energy and, to a lesser extent, solar power are picking up, the contribution from offshore wind energy sector is nil. India needs a policy framework to encourage the development of offshore wind farms. Several European countries, especially the UK and Germany, have effective offshore wind energy policies that have helped them to accelerate the growth of their offshore wind energy sector. This paper reviews the offshore wind energy policies of the UK and Germany on consent procedures, financial incentives, and grid connectivity and recommends best of breed policies for India to grow the offshore wind energy sector in the country.

Use of Renewable Energy to Enhance Sustainability of the Mid-day Meal Program in Schools
Energy for Sustainable Development, Volume 17, Issue 5, October 2013, Pages 451-457
Lasya Gopal, Y Nagaraju

Children in government schools in Karnataka, India are provided with cooked mid-day meals under the 'Akshara Dasoha' scheme. This initiative aims at providing a nutritious meal to school children (who mostly come from the lower economic strata) to enhance their nutritional status. This also acts as an incentive to minimize dropouts. However, the process of cooking these meals have numerous bottlenecks, including irregular supply of cooking fuel, that is, liquid petroleum gas (LPG) resulting in widespread use of firewood, which is burnt inefficiently. Along with that, due to frequent price fluctuations, a single variety of vegetable is used.

A comprehensive and replicable concept that was aimed at demonstrating the use of environmentally sustainable renewable energy device for cooking, raising an energy plantation and growing a bio-intensive school garden to address the above issues was pilot tested in three rural primary schools in the semi-arid area of Ramdurg taluk, Belgaum district, Karnataka, with active participation of children and local communities. The concept focused on a decentralized community approach to enhance the use of local resources in an environmentally sustainable manner. The pilot test proved that the concept could be replicated and customized to the needs of any community where similar issues exist.

The Effect of Renewable Energy Application on Taiwan Buildings: What are the Challenges and Strategies for Solar Energy Exploitation? Renewable and Sustainable Energy Reviews, Volume 28, December 2013, Pages 92-106
Shih-Yuan Liu, Yeng-Horng Perng, Yu-Feng Ho

Global warming or environmental issues in countries with effective energy applications and management of environmental resources have become key concerns. Energy is an important factor for countries to achieve sustainable development. Therefore, we need to actively seek renewable energy technology innovations, assess for optimization of resource inputs and strategize to proceed with effective energy strategic planning. Presently, international renewable energy technologies have been undergoing gradual and steady development. Taiwan is highly vulnerable in energy security, but geographic conditions for the development of solar energy applications have created a considerable advantage. However, the total installed solar energy capacity is far less than might be expected. Consequently, this study proceeds to explore the main resistance and key factors that affect renewable energy application concerning Taiwan buildings. Through the evaluation decision-making system model and expert decision-making groups giving evaluation values and feedback, the study found the main influences and key factors, and propose strategies for energy development in the future to improve the quality and quantity of renewable energy applications and competitiveness of national energy. This research, in addition to providing references to relevant environmental energy systems for deployment and technological research and development, also provides developing and underdeveloped countries access to applications of solar energy technology assessment and forecasts for the future.

The Impact of Different Grid Regulatory Scenarios on the Development of Renewable Energy on Islands: A Comparative Study and Improvement Proposals
Renewable Energy, Volume 60, December 2013, Pages 302-312
Antonio Colmenar-Santos, Oscar Monzón-Alejandro, David Borge-Diez, Manuel Castro-Gil

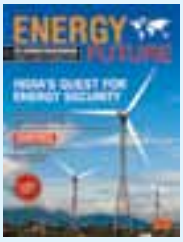
Electricity generation costs are typically higher on islands than in mainland regions, primarily due to the costs associated with conventional primary energy transportation. However, at the same time, islands are commonly granted with significant renewable energy potential in terms of wind, solar radiation and marine energy, among others, varying by case.

This article is focused on the impact that the grid regulatory framework has had on several islands from both the technical and economical points of view, with respect to renewable energy development. A comparison among the studied islands is carried out. Additionally, the possible differences between each island (or archipelago) and the rest of the corresponding country on the mainland are analysed to determine to what extent the peculiarities of the islands have been taken into account in the regulations.

Our objective is to analyse whether the renewable energy developments on certain islands have taken place because of certain favourable scenarios or by promoting specific actuations, which could be applicable on other islands to promote similar developments. As a result of the study, strategic key ideas are identified to increase the renewable energy percentage of the electricity generation and energy consumption mix on islands. ■

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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Danfoss introduces its new VLT® Automation Drive FC 360

Compact, flexible, reliable, and energy efficient drive solution dedicated for industrial applications for the future

Danfoss, a leading Danish multinational corporation and world leader in offering dedicated AC drives, unveiled its new VLT® Automation Drive FC 360 in the city in November. The user-friendly and energy efficient drive is built on the success of the renowned VLT® name, created when Danfoss introduced the world's first mass-produced variable frequency drives in 1968.

The VLT® Automation Drive FC 360 is a dedicated industry drive that provides precise and efficient motor control in a wide range of industrial applications. Due to the fact that all Danfoss frequency converters follow the standard design and operating principle, existing owners, and users of VLT® drives will feel instantly at home when operating the VLT® Automation Drive FC 360.

Built-in features help owners save space in installations, time in setup, and effort in daily maintenance. The result is a powerful and versatile solution that increases process efficiency and quality in a cost efficient package.

Featuring a basic yet comprehensive feature set, the drive provides precise and energy efficient motor control. Available in five frame sizes, the VLT® Automation Drive FC 360 can control electrical motors from 0.37-75kW.

Designed to work in harsh and humid environments, the drive provides reliable operation in industries such as textile, pharma and chemical, plastic and rubber, metal work, material handling, food and beverage, and building materials. The drive enables precise and efficient motor control of a wide range of industrial applications such as extruders, winders, conveyors, drawing benches, ring frame, texturizing, air compressors, mixer coolers, cranes, escalators, pumps, and fans. The efficient cooling concept ensures there is no forced air over the printed circuit board, which improves reliability. Also, a removable fan makes it possible to clean the inside of the drive quickly and easily, thereby reducing the risk of downtime. Special coated PPCBs used in the drive are standard to handle aggressive environment and reliable performance.

FC 360 also reduces initial costs and effort with a wide range of built-in features that simplify installation and commissioning, including an EMC filter, built-in brake chopper up to 22 KW and a user-friendly numeric display. As standard Danfoss VLTs are

designed with built in DC harmonic filters, it eliminates the need for installing external AC line chokes.

Mr Kamal K Singh, Director for Power Electronics, Danfoss India commented, "India is one of the key markets for variable frequency drives (VFD) in Asia. Nearly all the top global companies have expanded their presence in India; this has led to a demand for industrial automation control systems such as AC drives in the country. Danfoss is already a leader and a preferred drives supplier in many sub segments and with energy efficient drive solutions like the VLT® Automation Drive FC 360, Danfoss hopes to cater to the emerging and growing economy and help drive the long-term growth of the power drives market in India."

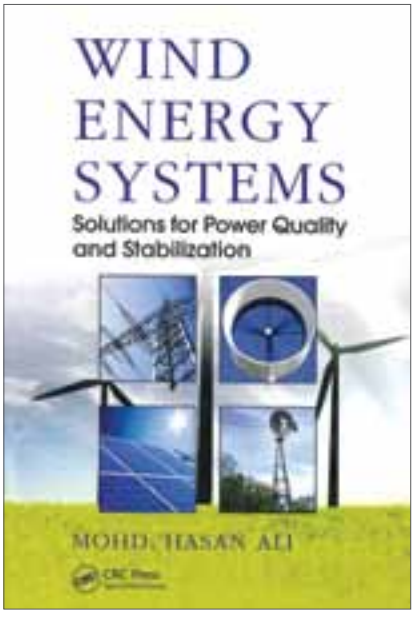
The VLT® Automation Drive FC 360 does not contain lead, cadmium, hexavalent chrome, mercury or flame retardant PBB AND PBDE and is very environment friendly. The VLT® Automation Drive FC 360 is designed according to the EU Directive no Waste Electrical and Electronic Equipment (WEEE).

One year's energy savings from Danfoss' annual production of VLT® Drives will save the energy equivalent to the energy production from a major power plant. Better process controls at the same time improves product quality, reduces waste and wear on equipment and also improves productivity. Danfoss Industries Pvt. Ltd, an industry leader focused on climate and energy efficient solutions, is a 100-per cent owned subsidiary of Danfoss Group Danfoss India serves a wide range of industries that rely on Danfoss products for their component and sub-system needs state-of-art refrigeration, air conditioning components and controls, VLT® Drives and a range of heating valves, controls & solutions for HVAC, district cooling & under floor heating applications.

Established in 1998, Danfoss is headquartered in Chennai with a nation-wide sales and support network comprising 10 offices, a manufacturing unit, a Panel Engineering facility, R&D centre, strong network of channel partners and employs over 440 people. ■

Due to the fact that all Danfoss frequency converters follow the standard design and operating principle, existing owners, and users of VLT® drives will feel instantly at home when operating the VLT® Automation Drive FC 360.

Wind Energy Systems: Solutions for Power Quality and Stabilization



Author: Mohd Hasan Ali

Unlike conventional power plants, wind plants emit no air pollutants or greenhouse gases—and wind energy is a free and renewable resource. However, the induction machines commonly used as wind generators have stability problems similar to the transient stability of synchronous machines. Control mechanisms are necessary to minimize power, frequency, and voltage fluctuations caused by network faults or random wind speed variations. The book, *Wind Energy Systems: Solutions for Power Quality and Stabilization*, clearly explains how to solve stability and power quality issues of wind generator systems.

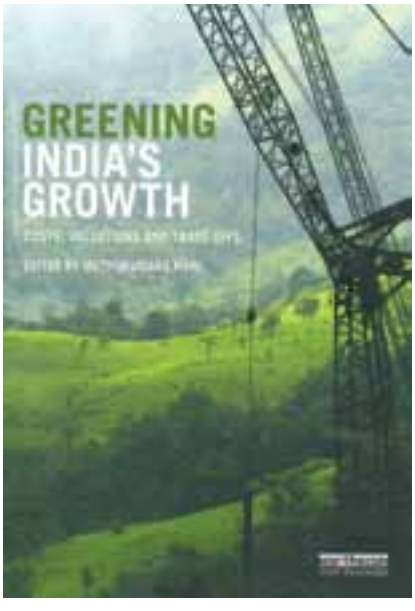
The book discusses several means to enhance the transient stability of wind generator systems, covering fundamental concepts of wind energy conversion systems. The book also explains the methodologies for minimizing fluctuations of power, frequency, and voltage.

Topics covered include:

- An overview of wind energy and wind energy conversion systems
- Fundamentals of electric machines and power electronics
- Types of wind generator systems
- Challenges in integrating wind power into electricity grids
- Solutions for power quality problems
- Methods for improving transient stability during network faults
- Methods for minimizing power fluctuations of variable-speed wind generator systems

This book is helpful for researchers and engineers in understanding the relative effectiveness of each method and selects a suitable tool for wind generator stabilization. Providing insights into important grid integration and stability issues, it also offers students an introduction to wind energy conversion systems.■

Greening India's Growth: Costs, Valuations, and Trade-offs



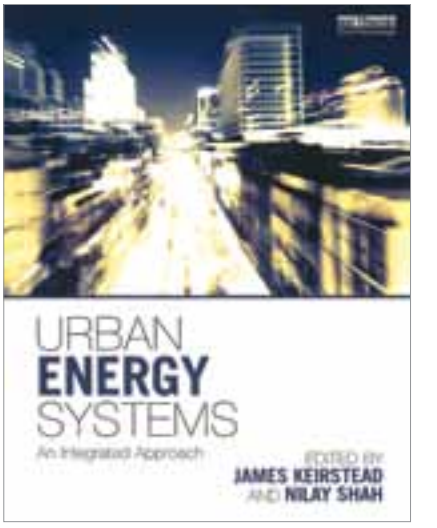
Author: Muthukumara Mani

India's sustained and rapid economic growth provides an opportunity to lift millions out of poverty. But this may come at a steep cost to its environment and natural resources. India's growth from an economic perspective is analysed in this insightful book. It also assesses whether India can grow in a "green" and sustainable manner. Three key issues have been addressed.

- The first is the physical and monetary costs and losses of environmental health and natural resources driven by economic growth. Using techniques that have been developed to better understand and quantify preferences and values of individuals and communities in the context of environmental quality, conservation of natural resources, and environmental health risks, the authors undertake a monetary valuation and quantification of environmental damage.
- The second part estimates the value of ecosystem services from the major biomes in India using state-of-the art methods with a view to preserve them for the future.
- The third section provides a menu of policy instruments to explore trade-offs between economic growth and environmental sustainability using a Computable General Equilibrium approach with particular attention to air pollution.

The book concludes with a focus on the way forward in terms of policies, measures, and instruments as India has to balance the twin challenges of maintaining economic prosperity while managing its environmental resources.■

Urban Energy Systems: An Integrated Approach



Energy demands of cities need to be met more sustainably. This book analyses the technical and social systems that satisfy these needs and asks how methods can be put into practice to achieve this.

Drawing on analytical tools and case studies developed at Imperial College London, the book presents state-of-the-art techniques for examining urban energy systems as integrated systems of technologies, resources, and people.

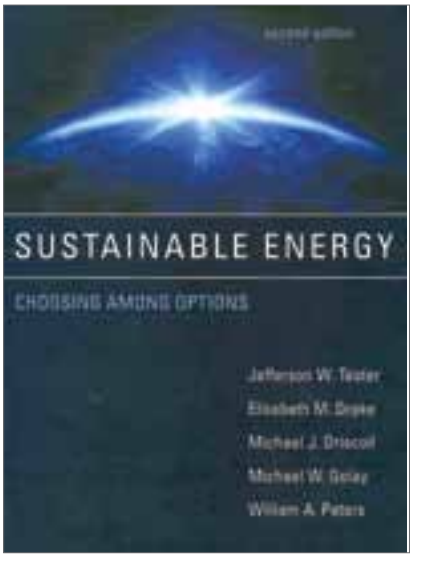
Case studies include:

- A history of the evolution of London's urban energy system, from pre-history to present day
- A history of the growth of district heating and cogeneration in Copenhagen, one of the world's most energy efficient cities
- An analysis of changing energy consumption and environmental impacts in the Kenyan city of Nakuru over a thirty year period
- An application of uncertainty and sensitivity analysis techniques to show how Newcastle-upon-Tyne can reach its 2050 carbon emission targets
- Designing an optimized low-carbon energy system for a new UK eco-town, showing how it would meet ever more stringent emissions targets.

For students, researchers, planners, engineers, policymakers and all those looking to make a contribution to urban sustainability.■

Author: JJames Keirstead, Nilay Shah

Sustainable Energy: Choosing Among Options



Human survival depends on a continuing supply of energy, but the need for ever-increasing amounts of it poses a dilemma: How can we find energy sources that are sustainable and ways to convert and utilize energy that are more efficient? This widely used textbook is designed for advanced undergraduate and graduate students as well as others who have an interest in exploring energy resource options and technologies with a view towards achieving sustainability on local, national, and global scales. It clearly presents the tradeoffs and uncertainties inherent in evaluating and choosing sound energy portfolios and provides a framework for assessing policy solutions.

The second edition examines the broader aspects of energy use, including resource estimation, environmental effects, and economic evaluations; reviews the main energy sources of today and tomorrow, from fossil fuels and nuclear power to biomass, hydropower, and solar energy; treats energy carriers and energy storage, transmission, and distribution; addresses end-use patterns in the transportation, industrial, and building sectors; and considers synergistic complex systems. This new edition also offers updated statistical data and references; a new chapter on the complex interactions among energy, water, and land use; expanded coverage of renewable energy; and new color illustrations. Sustainable Energy addresses the challenges of making responsible energy choices for a more sustainable future.■

Author: Jefferson W Tester, Elisabeth M Drake, Michael J Driscoll, Michael W Golay, William A Peters

RENEWABLE ENERGY TECHNOLOGY DEVELOPMENT

Innovation in renewable-energy technologies is booming

A new study shows that research investments and growing markets have fueled a huge rise in new patents. The number of patents issued for renewable-energy technologies have risen sharply over the last decade, according to new research from MIT and the Santa Fe Institute (SFI). The study shows that investments in R&D, as well as in the growth of markets for these products, have helped to spur this dramatic growth in innovation.

Luís Bettencourt of SFI and a graduate student Jasleen Kaur from Indiana University created a database of energy-related patents issued in more than 100 countries between 1970 and 2009, using keyword searches of the patents themselves, rather than the classifications assigned by patent offices. In all, the team examined more than 73,000 patents issued for energy-related technologies. This database "gives you a view into innovation activity — who's doing it, and where" . Further statistical analysis, Kaur says, showed a clear correlation between this rise in patents and prior investments in R&D, along with growth in the markets for such renewable technologies. The increase was most dramatic in patents related to renewable energy, chiefly solar energy and wind. Patents in fossil-fuel technologies showed a more modest increase, while those in nuclear technology were flat.

For example, between 2004 and 2009, the number of patents issued annually for solar energy increased by 13 per cent per year, while those for wind energy increased 19 per cent per year, on an average; these growth rates approach or exceed the rates for technologies such as semiconductors and digital communications. Overall, RE patents in the US increased from fewer than 200 per year in the period from 1975 to 2000 to more than 1,000 annually by 2009. By comparison, there were about 300 fossil-fuel-related patents in 2009, up from about 100 a year in earlier decades.

http://web.mit.edu/newsoffice/2013/innovation-in-renewable-energy-technologies-booming-1010.html

Technology could lead to more reliable renewable energy systems

Renewable energy sources such as wind-powered generators can be more reliable and efficient by better controlling the process of getting electricity onto the power grid, according to a United States patent based on research by Dr Shuhui Li, associate professor of electrical and computer engineering at the University of Alabama. He along with assistance from Dr Tim Haskew found in their research that wind turbines often stop sending electricity to the grid because of competing processes in converting electricity into a form usable for power distribution. The patent and two other pending patents are part of Dr Li's efforts to enhance energy generation from renewable resources and improve the efficiency, reliability, stability, and power quality of integrated renewable and electric utility systems. For electric energy consumers, Li hopes to improve the power quality and uninterrupted energy supply to meet customers' needs and increase incentives for energy consumers to use less expensive, more reliable energy from renewable resources and electric vehicles.

Renewable energy such as wind or solar power produces electricity at varied rates, unlike electric generators powered by the consistent burning of fossil fuels such as coal or natural gas. The wind energy produced is alternating current, or AC, electricity, which is the form of electricity used to deliver power across the grid. However, it is near impossible for a wind turbine, for example, to produce AC electricity at the correct frequency needed for distribution.

To get the AC electricity at the right frequency, the generator converts it to direct current, or DC, power that can then be converted again into AC at a frequency needed for distribution on the power grid. The problem, though, is the active and reactive power control tasks of the conversion fight with each other, messing with the other's process, Li's research has shown. If wind turbines and other RE systems are to make up more of electricity production in the future, they need to be more reliable and with higher power quality, Li said. The technology behind the patent improves the energy coming from the wind turbine and makes it a more reliable and efficient contributor to the power grid.

http://www.sciencedaily.com/releases/2013/12/131203124532.htm

Wind and solar power paired with storage could power grid

Renewable energy could fully power a large electric grid 99.9 per cent of the time by 2030 at costs comparable to today's electricity expenses, according to a new research by the University of Delaware and Delaware Technical Community College. A well-designed combination of wind power, solar power, and storage in batteries and fuel cells would nearly always exceed electricity demands while keeping costs low, the scientists found.

The authors developed a computer model to consider 28 billion combinations of RE sources and storage mechanisms, each tested over four years of historical hourly weather data and electricity demands. The model incorporated data from within a large regional grid called PJM Interconnection, which includes 13 states from New Jersey to Illinois and represents one-fifth of the United States' total electric grid.

Unlike other studies, the model focused on minimizing costs instead of the traditional approach of matching generation to electricity use. The researchers found that generating more electricity than needed during average hours -- in order to meet needs on high-demand but low-wind power hours -- would be cheaper than storing excess power for high demand later. Storage is relatively costly because the storage medium, batteries or hydrogen tanks, must be larger for each additional hour stored. One of the several new findings is that a very large electric system can be run almost entirely on renewable energy.

The study sheds light on what an electric system might look like with heavy reliance on renewable energy sources. Wind speeds and sun exposure vary with weather and seasons, requiring ways to improve reliability. In this study, reliability was achieved by expanding the geographic area of renewable generation, using diverse sources, employing storage systems, and for the last few percentage of the time, burning fossil fuels as a backup. The study used estimates of technology costs in 2030 without government subsidies, comparing them to costs of fossil fuel generation in wide use today. The cost of fossil fuels includes both the fuel cost itself and the documented external costs such as human health effects caused by power plant air pollution. The projected capital costs for wind and solar in 2030 are about half of today's wind and solar costs, whereas maintenance costs are projected to be approximately the same.

http://www.sciencedaily.com/releases/2012/12/121210133507.htm

Toward a 'green grid' for delivering solar and wind-based electricity

After years of neglect, scientists and policymakers are focusing more attention on developing technologies needed to make the so-called "green grid". That's the much-needed future electrical grid, an interconnected network for delivering solar and wind-based electricity to consumers.

Zhenguo (Gary) Yang and colleagues point out that concerns over the use of coal, oil, and other fuels that contribute to global warming and are in limited supply, have spurred interest in generating electrical energy from clean, renewable resources such as solar and wind power. But solar and wind are not constant and reliable sources of power, since wind power fluctuates from moment to moment and solar power is generated only in the daytime.

This situation poses a significant challenge for electrical grid operators because other power plants need to compensate for this variability and the US power grid currently has little energy storage capability. To enable a significant level of penetration and effective use of renewable energy sources amid growing energy demands, electrical grids of the future will need a low-cost, efficient way to integrate and store this electrical energy, the scientists note. The scientists analysed the conclusions of more than 300 scientific studies and identified several technologies that can be used for energy storage for the green grid. These include high-tech batteries now in development that can efficiently store electricity in the form of chemicals and reversible release it on demand. Among the promising technologies are so-called redox flow and sodium-ion batteries, which could provide a low cost, high efficiency way to store energy. In addition to the United States, several other countries such as China and countries in Europe are planning to increase research activities related to energy storage and development. ■

http://www.sciencedaily.com/releases/2011/04/110413121006.htm

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American Economic Association 2014 Annual Meeting

January 3rd - 5th, 2014
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Website: http://www.aeaweb.org/Annual_Meeting/

4th International Conference on Future Environment and Energy - ICFEE 2014

January 4th to 5th, 2014
Melbourne, Australia
Website: http://www.icfee.org/

Building Innovation 2014: The National Institute of Building Sciences second annual Conference and Expo

January 6th - 10th, 2014
Washington, DC

2nd International Conference on Electrical Energy and Networks (ICEEN 2014)

January 12th to 13th, 2014
Phuket, Thailand
Website: http://www.iceen.org/

World Future Energy Summit 2014

January 20th – 22nd, 2014
Abu Dhabi, UAE
Website: http://www.worldfutureenergysummit.com

11th International Specialist Conference on Biofuels: Fuels of the Future 2014

January 20nd – 21st, 2014
Berlin, Germany
Website: http://www.fuels-of-the-future.com

Onshore and Offshore Wind Operations and Maintenance Forum

January 27th – 28nd, 2014
Hamburg, Germany
Website: http://www.windenergyupdate.com/operations-maintenance/?utm_source=shannonssignature&utm_medium=signature+&utm_campaign=2406

EU StackTest Project Workshop on Progress in PEMFC Stack Testing Procedures

January 28th – 29th, 2014
Oldenburg, Germany
Website: http://stacktest.zsw-bw.de

2014 1st International Congress on Environmental, Biotechnology, and Chemistry Engineering (CEBCE 2014)

February 21st - 23rd, 2014
Pune, India
Website: http://www.saise.org/cebce2014

EWEA 2014 Annual Event

March 10th – 13th, 2014
Barcelona, Spain
Website: http://www.ewea.org/annual2014/

2014 International Conference on Mechanical Engineering (ICME 2014)

March 17th - 18th, 2014
Chennai, India
Website: http://www.saise.org/icme2014

The 2nd Biennial Conference on Sustainable Business, Energy and Development in Asia (COSA 2014)

March 17th -19th, 2014
Hiroshima, Japan
Website: http://www.presdafoundation.org/sustainable-business-conference/proposals

European Hydrogen Energy Conference, EHEC 2014

March 12th – 14th, 2014
Seville, Spain
Website: http://www.ehec.info

ExpoPlaza Latina

March 24th - 25th, 2014
Vancouver, British Columbia, Canada
Website: http://www.expoplazalatina.com/

GLOBE Series

March 26th - 28th, 2014
Vancouver, British Columbia, Canada
Website: http://2014.globeseries.com/

Intersolar China

March 25th – 28th, 2014
Beijing, China
Website: http://www.intersolarchina.com/en/intersolar-china.html

Globe 2014

March 26th – 28th, 2014
Vancouver, Canada
Website: http://2014.globeseries.com/

Wind Energy Summit South Africa

April 9th -10th, 2014
Cape Town, South Africa
Website: http://goo.gl/jbG8XX

RENEWABLE ENERGY AT A GLANCE

New and Renewable Energy Cumulative deployment of various Renewable Energy Systems/Devices in the country as on 31/10/2013				
Renewable Energy Programme Systems	Target for 2013-14	Deployment during October, 2013	Total Deployment in 2013-14	Cumulative achievement up to 31.10.2013
I. POWER FROM RENEWABLES				
A. GRID-INTERACTIVE POWER (CAPACITIES IN MW)				
Wind Power	2500	52.25	880.73	19933.68
Small Hydro Power	300	20.00	114.50	3746.75
Biomass Power	105			
300	-	20.00	1284.80	
Bagasse Cogeneration		-	55.05	2392.48
Waste to Power -Urban	20	-	3.00	99.08
-Industrial		-	-	
Solar Power (SPV)	1100		395.13	2079.97
Total	4325.00	72.25	1468.41	29536.76
B. OFF-GRID/ CAPTIVE POWER (CAPACITIES IN MWEQ)				
Waste to Energy-Urban-Industrial	10.00			
		3.00	3.00	118.57
Biomass(non-bagasse) Cogeneration	80.00	2.85	22.54	493.69
Biomass Gasifiers-Rural- Industrial	1.00	-		16.924
	9.00	-	4.74	146.32
Aero-Generators/Hybrid systems	1.00	-	0.03	2.14
SPV Systems (>1kW)	40.00	-	14.32	138.99
Water mills/micro hydel	500 nos.	-	-	10.65 (2131 nos.)
Bio-gas based energy system	2	-	-	-
Total	143.00	5.85	44.63	927.28
II. REMOTE VILLAGE ELECTRIFICATION				
No. of Remote Village/Hamlets provided with RE Systems	-	-	-	-
III. OTHER RENEWABLE ENERGY SYSTEMS				
Family Biogas Plants (No. in lakhs)	1.10	-	0.15	46.83
Solar Water Heating - Coll. Areas (Million m^2)	0.60	0.04	0.31	7.31

Source: www.mnre.gov.in

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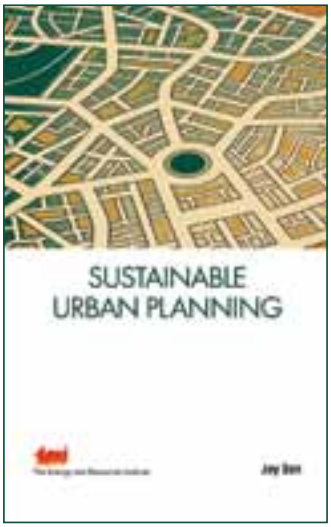

Sustainable Urban Planning

Joy Sen

2013 • ISBN: 9788179933244
Pages: 344 • Binding: Hardback
Size: 160 × 240 mm • Price: ₹950.00

The present book clarifies the planning process to students, who are trying to work in the Indian context. It presents in three sections a set of interwoven discussions. Section one operates on the corpus of planning reality to disentangle the sutras of fundamental dimensions of sustainability and the interrelationship between these sutras to re-explain a working framework of the dynamics of sustainable planning in India. Section two expands on each of the dimensions, explaining their divergent parameters and their indispensable roles in the making of such a framework. Section three synthesizes all of them to form the framework itself.

Key features

- Provides a framework of sustainable planning in India
- Integrates the concepts of livability and affordability
- Compares inequality and sustainability in the Indian planning context
- Explains the impact of facility design and management on the future of sustainable planning in India

Table of contents

Section 1: Initiating a Framework

- Sustainable development in Indian Urban and Metropolitan Contexts: Constituent Dimensions

Section 2: Dimensions of the Framework

- Assessment of Livability Variations in the Indian Context
- Impact of Affordability Thresholds on Indian Urban and Regional Planning Context
- Applicability of Inequality Variations in Understanding Indian Urban and Regional Agglomerations

Section 3: Proposing the Framework

- Towards a Framework of Sustainable Development in the Indian Context

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