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From the editor's desk...

In our quest for exploring frontiers in clean energy solutions, our endeavour has always been not to tread the beaten path but to constantly evolve. This philosophy also reflects in the nature of knowledge products that we share with our readers. Against this background, it is my pleasure to put before you, the first issue of our new publication, namely, the **'Energy Future' – The Complete Energy Magazine**.

Given that the future of our planet is intricately entwined with the future choices of energy, it is only apt that we take a closer look at these options just after the recently concluded United Nations Conference on Sustainable Development, or the Rio+20 Summit. After all, for development to move on a sustainable path, future choices of energy – whether on the demand side or on the supply side – will have a major bearing on the final outcome. *Energy Future*, therefore, is not only about energy per se, but also about how energy can contribute to inclusive economic growth, social development, and environmental protection. Indeed, the Rio+20 declaration clearly states: "We recognize that improving energy efficiency, increasing the share of renewable energy, and cleaner and energy-efficient technologies are important for sustainable development, including in addressing climate change." In a sense, attainment of both, the Millennium Development Goals as well as Sustainable Development Goals hinges on the future energy pathways.

Through this publication, it is therefore aimed that the latest in the field of energy is brought to you in a simple yet comprehensive manner, covering all the key elements of future energy scenario; and their nexus with country's energy security and independence.

The current issue deals with very topical issues ranging from the need of energy storage for intermittent renewable energy resources like solar and wind to the future of fuel cell technology and thin-film solar PV technology, besides other upcoming solutions like solar air-conditioning and solar powered refuelling stations for electric vehicles.

The whole motive of dealing with disruptive ideas in the clean energy domain is to make such futuristic elements part of one's thought process, thereby facilitating their adoption sooner than later. Towards this, constructive feedback and new perspectives will help us in sharpening up this knowledge product even further.

Amit Kumar

Amit Kumar
Director, TERI

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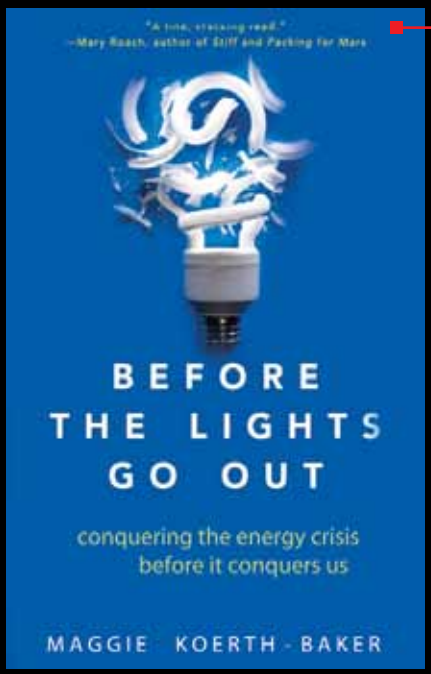


Siemens wins first solar receivers order for Indian solar power plant

Siemens Energy has been awarded an order to supply UVAC 2010 (Universal Vacuum Air Collector) solar receivers for a parabolic trough power plant to be built in Rajasthan, India. Purchaser is Shriram EPC Limited under contract to project developer Abhijeet (Corporate Ispat Alloys Ltd). Siemens will supply over 17,000 solar receivers, which will generate all of the heat for the 50MW facility. Start-up for the solar plant is scheduled for spring 2013. Siemens UVAC 2010 features extremely high solar absorption and reduced heat loss with outstanding product durability, offering solar field developers consistently high revenues and reduced operating costs. The Abhijeet power plant is being constructed as part of the Jawaharlal Nehru National Solar Mission (JNNSM), the Indian government's on-going program for promoting solar power. The programme envisages installing up to 20 gigawatts of solar power capacity in India by the year 2020."We view this first order from Shriram EPC Limited to be a demonstration of their trust in our know-how and technology," said Shmuel Fledel, CEO of Siemens Solar Thermal Energy Business Unit. "The Indian CSP market is rapidly developing, and with this step we strengthen our business for CSP technology." Siemens is in a position to offer highly efficient solar receivers and system solutions, such as solar fields or power blocks, as well as complete plant solutions for parabolic trough power plants.

Source: worldofsolarthermal.com

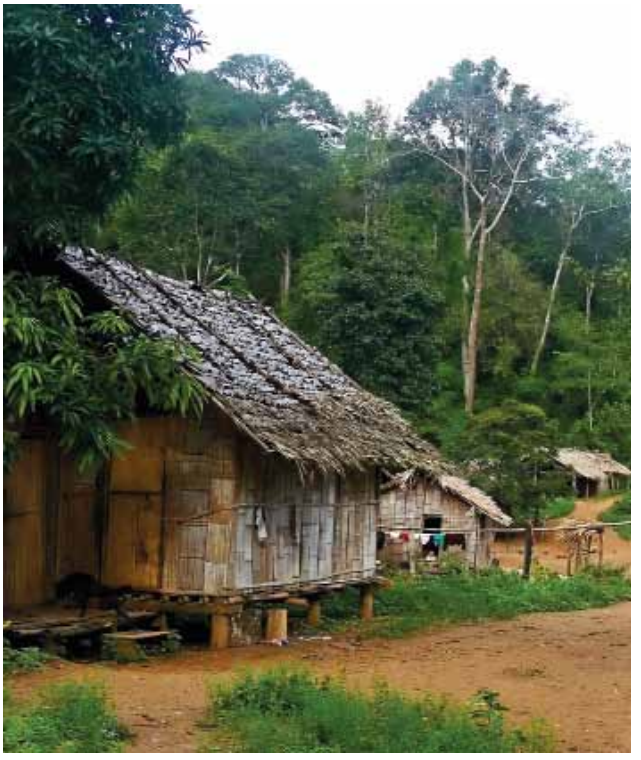
JINDAL STEEL & POWER

Jindal Power Limited to invest US$ 7.7 billion in hydroelectric projects

Spurred on by the crisis in coal reserves, utilities companies are now looking at renewable energy as a means to revive India's slowing economic growth patterns. Coal shortages have led to a substantial and significant increase in power outages, and with no respite in sight, many companies are starting to take renewable and clean energy technology far more seriously. Jindal Power, a subsidiary of Jindal Steel Pvt Ltd, and owned by noted businessperson and politician, Naveen Jindal, plans to invest over US$ 7 billion in hydroelectric projects in the northeastern state of Arunachal Pradesh.

Jindal and other major players in the Indian infrastructure sector, such as GMR Infrastructure Ltd and Lanco Infratech Ltd, are expanding into hydroelectric and renewable energy projects as a hedge against recent issues with inadequate fuel supplies. Over half of all the power generated in India is done using coal. In addition to Jindal Steel & Power Ltd, five other companies have announced plans, totalling to $16 billion in investment, to take advantage of the incentives in the clean energy sector offered by both central and state governments. The MD for Hydro and Renewables at Jindal Power said that the company expects to get government approvals for the first project by the end of 2012.

Source: Businessweek / Bloomberg



10,000 solar water systems in Maoist-affected areas

In a bid to make potable drinking water available to people living in Maoist-violence affected areas, the government is planning to install 10,000 solar powered water pumps in 78 districts. The move is also aimed at making convergence between two goals of the government-sustainable development using renewable energy and providing clean drinking water to rural people. "We have just prepared a proposal for 10,000 solar based water systems which supply drinking water to communities in rural areas," Rural Development Minister Jairam Ramesh, who also holds the charge of the Ministry of Drinking Water and Sanitation said. The cost of the project would be ₹540 crore.

"For the first time we have taken the programme and said that lets address this issue of renewable energy because there are villages and habitations which are not going to get electricity in the near future because of a variety of reasons... for remoteness, forest areas and so on," the minister said, while addressing an international workshop on "Towards Greening Rural Development Programmes in India." Later speaking to reporters, Ramesh said 200 such water systems had already been installed in Naxal affected Gadchiroli district of Maharashtra.

Source: Livemint.com

India setting up new cell to promote investments in clean energy

The Minister for New and Renewable Energy, Dr Farooq Abdullah, stated that the Government of India is setting up an Investment Promotion Cell to act as a single point of contact for investors in the Indian energy sector. "The cell will be our window for the potential investors to engage with us and bring their efforts and ideas to fruition", he said. Dr Abdullah expressed India's resolve to invest in clean energy as a means to ensure energy access for Indians across the board. In the next five years, the country plans to invest US$ 50 billion in renewable energy, including US$ 19 billion in wind, US$ 25 billion in solar and US$ 3 billion each in hydro and biomass projects, the Minister said.

While addressing journalists during an investor's meeting in London, Dr Abdullah was confident that investors from across the world would benefit from investing in India's energy market. "We strongly believe that it will be a win-win situation for all of us", Dr Abdullah said, "India has shown an impressive increase in installed power capacity, from about 1,350 MW at the time of independence 65 years ago to about 200,000 MW at present."

Despite these advances, however, most of India's burgeoning population suffers from a crippling lack of energy access. A third of India's population does not have access to any commercial energy source and is still reliant on burning

firewood and biomass. As part of the 12th five-year plan from 2012-17, the Government of India intends to increase India's installed capacity from renewable sources by 30,000 MW.

Source: PTI / The Economic Times

Former President Kalam advocates renewable energy

Scientist and Former President of India, Dr APJ Abdul Kalam advocated the use of renewable energy sources, specifically solar, biofuels, and hydro-energy as key to ensuring India achieves the target of universal energy access for all. Dr Kalam was present at the inauguration of the Centre for Innovation in Energy Research at the Central Electro Chemical Research Institute (CECRI) in Karaikudi, Tamil Nadu.

Dr Kalam spoke of the need for ensuring India's energy security in the face of an increasing population and greater requirements for electrical power. "With the population growing at its current rate, by 2030 India's energy requirement will double from 200,000 MW to 400,000 MW to sustain a population of over 1.4 billion." Discussing the need for India to address its energy security, Dr Kalam supported a concentrated effort on producing energy from renewable sources such as hydro-electricity, solar energy, wind power, and bio-fuel; suggesting that energy technologies could be matched to the geography and nature of a region's problems. In reference to the Energy Mission 2030, Dr Kalam said that affordability, minimisation of dependence on fossil fuel and ensuring the balance between energy generation and sustainable growth were to be considered seriously. Solar energy should be used for agricultural purpose. Advances in energy technology could allow for the harnessing of desalinated seawater in coastal areas to meet the shortage of drinking and irrigation water.

The Central Electro Chemical Research Institute (CECRI) was founded in 1948, under the Council for Scientific and Industrial Research (CSIR), and is currently one of South Asia's research laboratories for electrochemical science, electrometallurgy, and material sciences. The director of the institute, Dr Vijayamohanan K Pillai, said that the opening of the Centre for Innovation in Energy Research is indicative of the institute's efforts to ensure that Dr Kalam's vision can be actualized in the lives of millions of rural Indians.

Source: PTI / CNN-IBN

Sardar Patel University develops India's first solar tracker

It is like a sunflower that tracks the sun as it moves around the sky each day. Researchers at Sardar Patel University have designed, developed, and implemented an automated dual-axis sun-tracker system, which works on sunflower motion for a solar power plant. It also increases solar energy harnessing power by as much as 45%. The tracker has been installed at the terrace of SPU's Physics department, where it generates up to 1.5 kWh of electrical power through 20 crystalline silicon panels of 75 Wp each. The tracker has been designed to provide rotation angles as per the rotation path of the sun for the entire year for various regions of the country. The system has been designed in such a way that the batteries connected in the circuit store excess power that can be utilized during the periods of non-sunshine like early mornings or late nights. The device has a special feature whereby the tracker starts automatically at 5.45 a.m. and shuts down automatically at 6.45 p.m. The system has been designed on a sensor-based technology.

Source: EAI

Gurgaon aims to become a solar city

A Green Ring Project aims to convert the Delhi satellite city of Gurgaon into a solar campus, where all significant areas will be lit up through solar energy. The Union Ministry of New and Renewable Energy, along with the United States Department of Energy, and in association with the Times Group, are assisting the Advit foundation, a non-profit organization that aims to conserve the environment and empower communities through viable means of environment conservation and sustainable development, in this attempt.

The project will concentrate on the use of solar power for lighting common areas, adding greenery to the neighbourhood, waste management through composting, retrofitting existing structures, using green technology in new constructions, and energy-efficient water pumping. During a citizen's meet in early June, the Director of the Union Ministry of New and Renewable Energy, Dr A K Tripathi, said that, "Renewable energy is for households and new constructions. It is not confined to the government; rather it should be a part of the action plan of all builders and architects".

The idea was the consequence of a meeting featuring residential welfare associations, eminent residents of Gurgaon, NGOs, and government agencies, to discuss solutions to run various renewable energies successfully. The Green Ring project will first be tried out in the pilot sample areas, including the 1km stretch of road from HUDA City Centre to Golf Extension Road, and from Sohna Road to Golf Course Road.

Source: The Times of India

Apoorva Renewable Energy to make solar-electric buses for transport body

Buses in Bengaluru may soon be powered by solar energy. The Bangalore Metropolitan Transport Corporation (BMTC) has placed orders with Apoorva Renewable Energy Products to design solar-electric hybrid buses, the company CEO, Mr Suresh Babu, said on the sidelines of the Global Investors Meet 2012. "The BMTC has asked us to provide a sample hybrid vehicle and we have accepted the order and will start working on it," Mr Babu said. Several other government bodies such as the Bruhat Bengaluru Mahanagara Palike (BBMP) are in talks with the company too, he said. The company makes three-wheeled vehicles powered by electric and solar power, and customizes products for Indian conditions. "Using a common technology, we design products as per customer requirements and outsource the manufacturing", currently, the company's vehicles are used in Delhi and parts of Karnataka and it will start exporting in two months from now. "During the GIM expo, Ministers from Saudi Arabia, Latin America, Ghana, and Europe evinced interest in our products," Mr Babu said, adding that the company already has orders from Thailand for passenger vehicles to transport school children. The mini school bus will come equipped with GPS capability so that parents can

track their children en-route to the school and will be able to monitor movement of the vehicle real-time. All the vehicles are fitted with batteries and one can switch from solar power to the batteries. The batteries, once fully charged, can cover about 120 km at a speed of 60 kph, Mr Babu said. With an increase in demand for the products, the company is in talks with several banks to strike deals to provide loans and financial assistance for customers. Currently, the government offers a 20% subsidy on the products.

Source: The Hindu Business Line

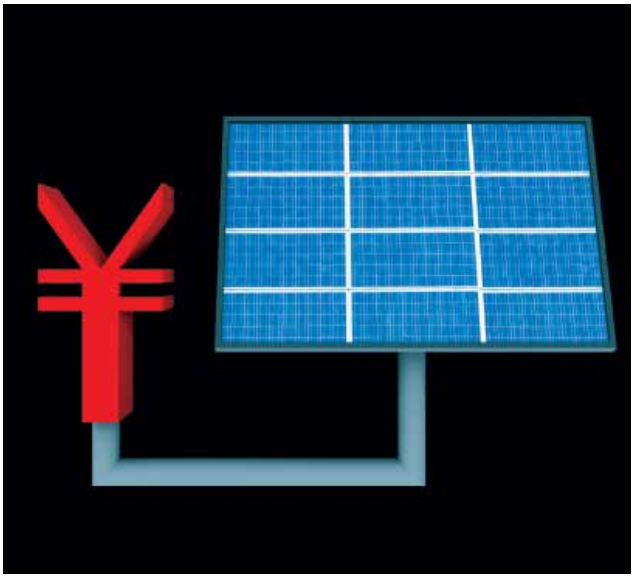
UK – South Korea collaborate on offshore wind / tidal energy

The United Kingdom and South Korea have decided to form an alliance to share their common interest with offshore wind development. Both nations have extensive plans for developing capabilities for exploiting the massive potential of their vast coastlines and strategic locations. South Korea has been the world's fastest adopter of renewable energy as a major source of their installed over the last decade, and the UK has expressed interest in launching economically viable tidal and wave energy industries.

Both South Korea and the UK are small nations with a vast coastline. The UK-Korea Ocean Energy Technology Cooperation Project will focus on collaborating at an academic and policy level to help generate technology that can harvest the immense ocean-based energy potential of these two nations. The UK is the world leader in offshore energy generation, with an installed capacity of 1,858 MW online, 2,359 MW currently under construction, and a 42,000 MW planned for future development. Similarly, South Korea has 2,500 MW of offshore wind power currently under development, and projects to develop over 2,000 MW by from offshore energy sources by 2019. South Korea is also home to the world's largest tidal power facility, the 254-MW Siwha Lake Station.

This latest collaboration follows an agreement signed earlier this year between RenewableUK and the Korean Wind Energy Industry Association, forging an alliance that may help each nation become the dominant presence in their respective regional renewable energy markets.

Source: United Press International (UPI)



Post-Fukushima Japan looks to solar energy

Government subsidies and incentives for Japanese solar companies that become effective from July 1 will help Japan overtake Germany and Italy to become the world's second biggest market for solar energy, behind only China in installed capacity. Changes in tariff and pricing were announced in late June by Japanese Industry Minister Yukio Edano, who set a premium price for solar electricity that is three times what industrial users pay for electricity from conventional energy sources. Bloomberg New Energy Finance forecasts an increase of close to US$ 10 billion in new installations that will add a cumulative installed capacity of 3,200 MW.

Mina Sekiguchi, Associate Partner and Head of Energy and Infrastructure at KPMG-Japan, described the new tariff as "very attractive", saying, "The [new] rate reflects the government's intention to set up many solar power stations very quickly."

Following the Fukushima nuclear meltdown in 2011, Japanese Prime Minister Yoshihiko Noda has shown a firm resolve to cut Japan's dependence on atomic energy, which was responsible for 30% of Japan's installed capacity before 2011.

Japanese utilities will now pay JPY 42 (US$ 0.53 / ₹30) per kilowatt-hour for twenty years to solar power producers, almost twice the rate in Germany – the world's biggest market by installations. This revised solar tariff is among a series of incentive rates for clean energy that was announced the Japanese Ministry of Economy, Trade, and Industry.

Source: Bloomberg

China's Titan Wind Energy buys Vestas' tower factory in Denmark

Coinciding ahead of a state visit by Chinese President, Hu Jintao, Danish wind turbine manufacturer Vestas sold a tower factory to the Chinese group, Titan Wind Energy. Founder and chief executive of Titan Wind Energy, Mr Yan Junxu said of the deal, "Our new towers facility here in Denmark increases our possibilities of servicing and expanding our global customer base. Europe is the region that offers the most promising outlook for the development of offshore wind energy."

Titan Wind Energy is China's largest manufacturer of wind turbine towers, with annual production capacity of 1,600 towers. On the other hand, Vestas has reported larger than expected first-quarter losses due to delayed deliveries and rising costs with the elimination of government subsidies as a consequence of European austerity measures.

Source: Reuters

Indonesia announces major investment in geothermal energy

Stressing the importance of energy security, and as part of the country's efforts towards diversifying its energy sources Indonesia's state investment agency (the Pusat Investasi Pemerintah or PIP) is willing to invest as much as US$ 370 million towards the construction of geothermal energy-based power infrastructure. Chairperson of the PIP, Soritaon Siregar, said that the agency would provide loans of up to 2 trillion Indonesian Rupiah (US$ 212 million) to private investors willing to build geothermal power facilities, with another 1.4 trillion Rupiah (US$ 148 million) earmarked for firms planning to construct micro-hydropower plants.

Indonesia is an archipelago of over 17,000 islands that is distributed along the Pacific Ring of Fire, a region of intense volcanic activity surrounds the Pacific Ocean from California and Alaska. Indonesia has been the site of some of the most devastating volcanic eruptions in the world, such as famous eruptions of Mt. Krakatoa in 1883, Mt. Tambora in 1815, and the Toba super-volcano. However, this also gives Indonesia immense opportunity to harvest geothermal energy as a clean, renewable, plentiful power source.

PIP Chairperson Soritaon Siregar signed a Memorandum of Understanding (MoU) with the Indonesian government-owned energy corporation, the Perusahaan Listrik Negara, or PLN, in Jakarta earlier in June. The government has been encouraging the PLN and independent power producers to invest in clean energy, and the deal appears to be the part of a series of concrete steps taken by the Indonesian government over the past few years towards building a renewable energy infrastructure in the country.

Pertamina Geothermal Energy (PGE), the geothermal unit of state oil and gas company Pertamina, plans to build two geothermal power plants with a combined capacity of 110 MW in Ulubelu, Lampung, on the island of Sumatra, this year. The construction of the plants, which started earlier this year, is due to be completed by 2014, said Slamet Riadhy, the president director of PGE. The two plants will cost $270 million combined.

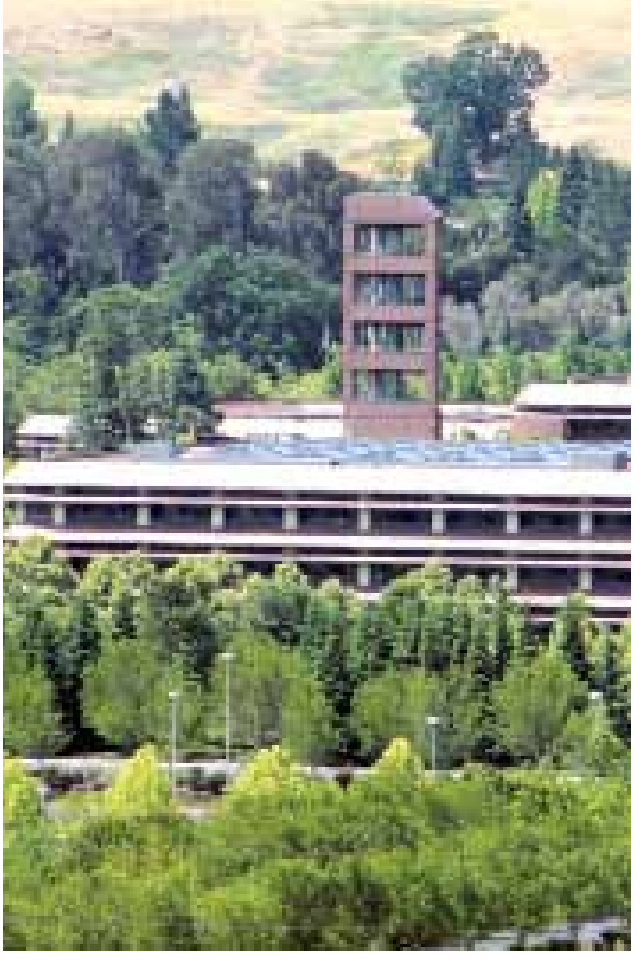
PGE's planned geothermal power plants form a model that will be rolled out across the country. PGE runs a geothermal power project in Muara Enim, South Sumatra and plans to construct a geothermal power plant in Karaha Bodas, West Java, among other projects.

Source: The Jakarta Globe / Investor Daily

Malaysian energy developer invests US$ 800 million in Vietnam's Wind Industry

Timar Wind Solar Sdn Bhd, a Malaysian alternative energy development firm announced its intention to invest US$ 800 million into Vietnam's wind energy industry. The firm stated that it aims to construct a wind-farm using Maglev (Magnetic Levitation) vertical axis turbines. Maglev Turbines are claimed to be 20% more efficient, have life spans of 50 years, and can save more than 50% in operational costs. Timar Wind Solar hopes that that their investment, which is inclusive of two assembly plants in Vietnam, will help decrease the price of Maglev turbines in Vietnam in the future. "With a capacity of 1,000MW, each group of Maglevs will have a capacity 20 per cent higher than traditional turbines capable of supplying electricity to 750,000 households at an estimated cost of $52 million, reducing pollution by eliminating the dependency on fossil fuelled power plants," said Nguyen Duc Thanh, chairman of the provincial People's Committee.

Source: BusinessWeek



Elders question Chevron's geothermal energy production in Philippines

Elders of the Balatoc, Colayo, and Guinaang communities in the province of Kalinga, Philippines have expressed fear of the environmental consequences of a proposed geothermal plant from US multinational energy corporation, Chevron. The local elders maintain that little information has been given about geothermal plants, and the people's questions go unanswered.

Despite compliance certificates that attest to the informed consent of the leaders of the villages that make up the municipality, as well as a Memorandum of Agreement (MoA) signed by community representatives with the Guidance Management Corporation – Aragorn Power and Energy Corporation (GMC-APEC), and the National Commission on Indigenous Peoples (NCIP).

Locals in the Philippines have been wary of geothermal energy extraction ever since the volcanic eruption of Mt. Pinatubo in 1991, which has been thought of as a dormant volcano until then. The cataclysmic eruption was so powerful it reduced global temperatures by around 0.5°C. Geothermal drilling operations that had been taking place there in the 80's were inaccurately blamed as being one of the causes in creating the disaster. One of the areas being considered for drilling in order to set up the geothermal plant has a dormant volcano. Elders of the communities fear the project might lead to environmental effects such as earth movements or volcanic eruptions.

Source: Bulatlat (Philippines) / Feed The Grid

GE, Fraunhofer building solar electronics lifetime prediction tool

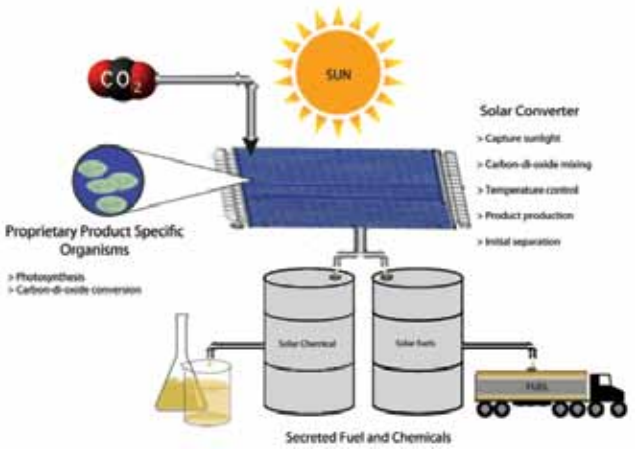
GE has collaborated with the Fraunhofer Institute for Reliability and Microintegration IZM to develop a new method to forecast the remaining lifetime of solar power electronics, such as insulated gate bipolar transistors (IGBTs). The first prototype of this measurement system will be presented in Berlin in September. Constant load fluctuations burden the power electronics of solar inverters in PV plants, which increases the risk of sudden plant failure. Up to now, it was almost impossible to safely predict the service life of power semiconductors, according to the companies. The joint project, known as Condition Monitoring für Leistungselektronik in der Fotovoltaik (CoMoLeFo) or Condition Monitoring for Power Electronics in Photovoltaics, has focused on the identification and detection of relevant aging mechanisms of insulated gate bipolar transistor power modules. IGBTs are switch elements designed for high-power levels and constitute the central component of modern inverters. Mathematical algorithms and measuring data are now able to make precise assessments concerning the condition of semiconductors during operation. This enables a forecast of the remaining lifetime of an IGBT and, therefore, conditions-based maintenance, according to the companies. CoMoLeFo is based on two complementary processes: One process indirectly determines the chip temperature by measuring relevant electrical parameters of the IGBT during operation. The other process monitors the parameter shift due to aging. In this way, the remaining lifetime of the IGBTs can be determined by a software-based remote diagnostic system.

Source: Solar Industry Magazine

Scientists investigate obtaining green fuel from carbon dioxide

Prof. Dr Ingo Krossing from the Freiburg Materials Research Centre (FMF) at the Albert Ludwig University of Freiburg is leading a team that claims to have developed a new system that uses CO2 and hydrogen to producing methanol (a cleaner alternative to gasoline). Dr Krossing's team combined the carbon dioxide with hydrogen in a high-pressure environment using a process known as hydrogenolysis. Their current goal is "to develop new catalyst systems and methods for accelerating the chemical reaction even more". The researchers at FMF used metal oxides of copper and zinc, and zirconium dioxide as catalysts, enabling the reaction to happen at lower temperatures. These catalysts then form a system of surface-rich porous solid matter with defined properties. If the catalysts consist of nanoparticles, their activity is increased even more.

Methanol is a less dangerous and cleaner alternative to conventional fuels. The team hopes to be able to produce methanol on a mass scale using this technique within the next two years. Interestingly, when methanol fuels a vehicle, CO2 is released again. Thus, by using the same carbon dioxide that is emitted from the fuel, it would theoretically be possible to use 50% less CO2 to create the same amount of energy. Methanol is also used as a chemical means of hydrogen storage, and could thus be used to power fuel cells. According to a team member, "There is enough energy out there, but it needs to be stored. As a sustainable means of energy storage, methanol has potential in a wide range of areas. We want to use that potential."



Source: Science Daily

Denmark aims at 100% renewable energy supply by 2050

Danish government has increased its clean energy and carbon reduction targets, describing the move as the "broadest, greenest, and most long-term energy agreement Denmark has ever reached". Denmark's Minister for Climate, Energy, and Building, Martin Lidegaard, described a series of steps and a new set of goals designed to eliminate their dependence on oil and gas.

As part of the agreement, Denmark aims to cut its Greenhouse Gas (GHG) emissions by 34% of its 1990 levels by the year 2020, and reduce energy consumption by more than 12% of the 2006 level. The Minister also described Denmark's aim of supplying 35% of its total energy requirement from renewable energy sources by 2020, with around 50% of its electricity demand being delivered by wind farms. The agreement also covers advances in renewable heat, smart grids, and biogas among other green technologies.

Minister Lidegaard was quoted as saying, "Denmark will be the global leader in the transition to green energy. This will prepare us for a future with increasing prices for oil and coal. Moreover, it will create some of the jobs that we need so desperately, now and in the coming years."

The agreement aims for Denmark to achieve a goal of obtaining 100% of its total energy requirements – including electricity, heating, industry, and transport – from

renewable energy sources by 2050. Lidegaard added that the commitments would prevent consumer energy bills from soaring by reducing the country's dependence on the volatile price of fossil fuels. The commitment could also provide a boost to efforts across the European Union to increase its carbon emissions reduction target to 30% from the current 20%.

Source: The Guardian Environment Network

US Naval Research Laboratory generates solar power underwater

Researchers at the US Naval Research Laboratory demonstrated a method for harvesting solar power underwater at depths of up to 30 feet. The research team's leader, Phillip Jenkins, described the technology as "a new tool in the toolbox", opening up further possibilities in renewable energy, and new options for powering underwater systems.

A renewable energy source underwater gives rise to the possibility of installing long-term underwater autonomous systems for communication and environmental monitoring. To date, the solar cells are capable of generating 7 W/m2 at depths of 9.1 meters, which is enough to demonstrate the technology's potential for use in shallow water near shorelines. (Normal, aboveground solar cells generate about 110–220 W/m2.)

To achieve this breakthrough in efficiency, researchers needed a solar cell that was optimized to absorb the narrow wavelength spectrum of visible light that is available underwater. Instead of crystalline silicon solar cells or amorphous silicon cells, the researchers opted for high-quality gallium indium phosphide (GaInP) cells. GaInP cells are better at absorbing wavelengths in the blue/green part of visible light spectrum, making them ideal for capturing light that has been filtered through water.

The researchers' next step is to test how the technology will fare during long-term deployment. This includes understanding how variations in water quality affect performance. In addition to understanding how water quality affects energy harvesting, the researchers need to test how the system will age and degrade. The team says there is no reason why the underwater solar cells should not last a long time, providing they can withstand potential sedimentation and the accumulation of microorganisms and algae on their surface.

Source: Ecomagination / Renewable Energy World

India highest in "pain-in-the-pump" petrol prices ranking

Bloomberg New Energy Finance's survey of petrol prices around the world, and the cost of one gallon of gasoline divided by average daily wage ranks India as the country where petrol prices are the highest for the greatest percentage of the population. Bloomberg New Energy Finance ranked nations on two categories, the first being the price of one gallon of premium gasoline. On this metric, India, where a gallon of premium gasoline costs US$ 6.06 (₹89.30 per litre), came in at 37th place. Norway – the 13th largest oil producing country in the world – has the highest fuel prices in the world; a gallon of premium gasoline in Norway would cost you US$ 9.69 (₹142.80 per litre). However, Norway is also the 5th largest exporter of oil in the world, thus, according to Bloomberg, "instead of subsidizing fuel at the pump, the country uses its oil profits for services such as offering free college education and saving for infrastructure improvements."

The second metric used was described by Bloomberg as the "Pain-In-The-Pump" ranking, a measure to normalize fuel prices by purchasing power. Countries were ranked based on the ratio of a gallon of premium gasoline by the average daily wage of the country, as an indicator of what percentage of the average daily wage would be required to buy a gallon of premium petrol. Based on metric, India was ranked first, as the only country where a gallon of premium gasoline was higher than the average daily wage. The average daily income in India is $4.50. The share of a day's wages needed to buy a gallon of gas is 135%. Describing the state of energy in India, Bloomberg says, "Low wages combine with costly gas prices to create widespread energy poverty, where quality of life is hampered by limited access to electricity and clean fuels."

Source: Bloomberg New Energy Finance

First solar and intermolecular start work on CdTe efficiency roadmap - PV-TechPV-TechPV-Tech

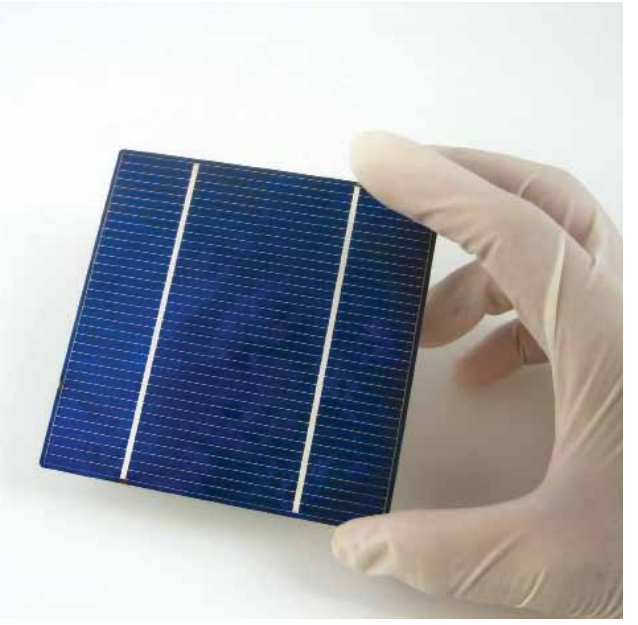
First Solar has teamed up with Intermolecular to establish collaboration and licensing agreement that is aiming to accelerate the efficiency roadmap for CdTe modules using Intermolecular's High Productivity Combinatorial (HPC) platform.The new programme will see First Solar use the HPC platform to carry out its CdTe efficiency experimentation at speeds up to 100 times faster than traditional methods. It is hoped that the programme will open up new opportunities in critical materials and processes that could well affect CdTe's conversion efficiency. The research work will be carried out at both Intermolecular's San Jose, California facility and in First Solar's research and development labs. "We are excited to engage in this on-going collaboration with Intermolecular," said Raffi Garabedian, First Solar's CTO. "Further improving our world-record CdTe conversion efficiencies remains a strong lever to reduce the cost of solar energy. We evaluated Intermolecular's HPC platform and technical team in trial collaboration, and this experience confirmed the suitability of the platform for our purposes.

Source: PV-Tech

Kaneka, imec's 6" heterojunction silicon solar cell reaches 22.68% conversion efficiency

Fraunhofer ISE confirmed that Kaneka and imec's six-inch, semi-square; heterojunction silicon solar cell has a certified power conversion efficiency of 22.68%. The solar cell has an electroplated copper contact grid on top of a transparent oxide layer, which essentially replaces the traditional silver screen printing and is said to lead to higher efficiencies with lower manufacturing costs. The silicon solar cell was developed at Kaneka's Osaka lab using its copper electroplating technology, which is based on imec's copper electroplating background. Jef Poortmans, director of PV technologies at imec, commented, "We are excited that we could support Kaneka in developing this breakthrough results. They prove the capabilities of copper metallization for next-generation solar cells and strengthen our belief that in the future copper will play an important role in high efficiency and sustainable solar cell technology.

Source: PV-Tech



Solar power leads as investment in renewables reaches record highs

Solar generation surged past wind power to become the renewable energy technology of choice for global investors in 2011, according to two new reports from the United Nations Environment Programme (UNEP) and the Renewable Energy Policy Network for the 21st Century (REN21). Solar attracted nearly twice as much investment as did wind, driving the renewable energy sector to yet another record-breaking year. However, challenges abound for all types of renewable energy, the reports added. The UNEP report shows that despite an increasingly tough competitive landscape for manufacturers, total investment in renewable power and fuels in 2011 increased by 17% to a record $257 billion - a six-fold increase on the 2004 figure and 94% higher than the total in 2007, the year before the world financial crisis. Although in 2011, 17% increase was significantly smaller than the 37% growth recorded in 2010, it was achieved at a time of rapidly falling prices for renewable energy equipment and severe pressure on fiscal budgets in the developed world. Renewable power, excluding large hydropower, accounted for 44% of all new generating capacity added worldwide in 2011 - up from 34% in 2010. This accounted for 31% of actual new power generated, due to lower capacity factors for solar and wind capacity. In 2011, renewable energy technologies continued to expand into new markets. For instance, solar PV capacity moved rapidly into new regions and countries, and solar hot water collectors are used by more than 200 million households as well as in many public and commercial buildings worldwide. Total investment in solar power jumped 52% to $147 billion, led by booming rooftop photovoltaic installations in Italy and Germany. The rapid spread of small-scale PV to countries such as China and the UK, as well as significant investments in large-scale concentrating solar power projects in Spain and the U.S., also helped investments grow. The US surged back to within an inch of the top of the renewables investment rankings, with a 57% leap to $51 billion, as developers rushed to cash in on three significant incentive programs before they expired during 2011 and 2012.

Source: Solar Industry magazine

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A BEGINNER'S GUIDE TO ENERGY SECURITY

Is India Secure?

Chetan S. Solanki
Associate Professor, Department of Energy Science and Engineering, IIT Bombay & Principle Investigator, National Center for Photovoltaic Research and Education (NCPRE), IIT Bombay, chetanss@iitb.ac.in

Energy as fuel is the key driver of world economies. Our reliance on energy sources is increasing every passing day.. Most of our activities including food production, transportation, telecommunication, building construction and operations, health services, etc., cannot run without energy. Access to various energy sources, which are adequately abundant and affordable, has, thereby, become an important factor to obtain and maintain economic growth of a country. Significant population of the world is either underdeveloped or in the developing stage and would need energy to fuel their growth.

What is energy security?

It is well known that the world energy resources, particularly based on fossil fuels; coal, oil, gas, are not evenly distributed across the countries. Some countries have surplus resources while some do not have any. And, therefore, there is urgent need to get access to affordable energy sources. In this way the energy security of a country is all about securing long-term adequately abundant and affordable energy resources. The cost of available energy source plays an important role in economically viable utilization of the source and therefore the affordability of available energy source is an important parameter from the perspective of energy security of a country. And, increasingly, energy security is becoming an issue for national security.

In the current world order, securing energy is not easy. There can be several threats to energy security of a country. These include; (a) political instability of energy surplus countries, (b) manipulation of energy supplies, (c) competition over energy sources, (d) attacks on supply infrastructure, and (e) accidents, natural disasters, rising terrorism, etc. These threats are real and their impact on global energy supply can be severe. The impact of geopolitical events on crude oil prices is a good example. Over the last four decades the crude oil prices has fluctuated between $15 to $100 (See Figure 1) and events like oil shock of 1972-73, Iran-Iraq war, the Gulf war have all played an important role in the price fluctuations.

In the context, the question that arises is: 'Is India energy secure?' Let us try to understand this by discussing India's current energy consumption and its future energy requirements, its in-house energy resources and their future prospects.

India's current energy consumption

India is a vast country with 1.2 billion people. More than 60% population still lives in rural areas. People rely on range of energy sources to fulfil their requirements. The energy sources that are being utilized in India includes conventional fuels like coal, oil, gas, renewable energy fuels like hydro, wind and solar, as well as nuclear fuel. All these fuels are commercially traded fuels. But a significant number of rural populace also uses non-commercial

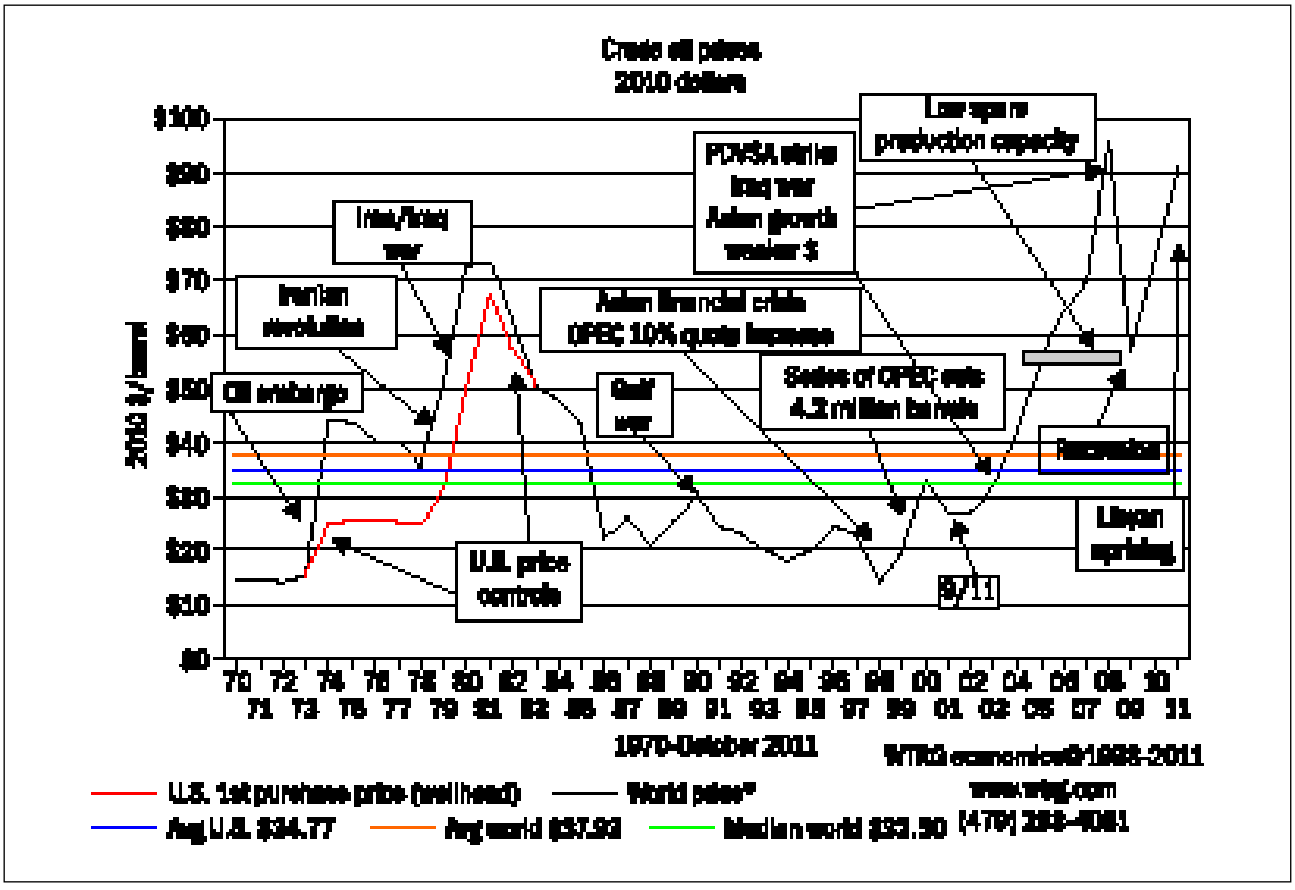


Figure 1 Fluctuations in crude oil prices with reference to geopolitical events

fuel like agricultural waste, cowdung cake, forest wood, etc., mainly for cooking purposes. As per the National Sample Survey Organization (NSSO), Government of India (2001), 85 million households spend 30 billion hours annually in gathering fuelwood and the economic cost of such biomass fuel was estimated at ₹299 billion using a wage rate of ₹ 60 per day. These non-commercial fuels are normally not accounted in national energy scenario.

India's total primary energy consumption or energy consumption from all commercial sources, in the year 2010-11 was about 530 million Tonnes of oil Equivalent (ToE) . This is equivalent to about 22 Exa Joules of total primary energy consumed. On per capita, per year basis this consumption is about 0.48 ToE, which is quite low when compared to many other developed countries wherein it is 10 times more than India. Figure 2 shows percentage share of various energy sources as of 2010. It is clear from this data that more than 90% of our primary energy comes from fossil fuels. Together with this the impact of the use of fossil fuel on climate change should be noted. However, the percentage share of various sources

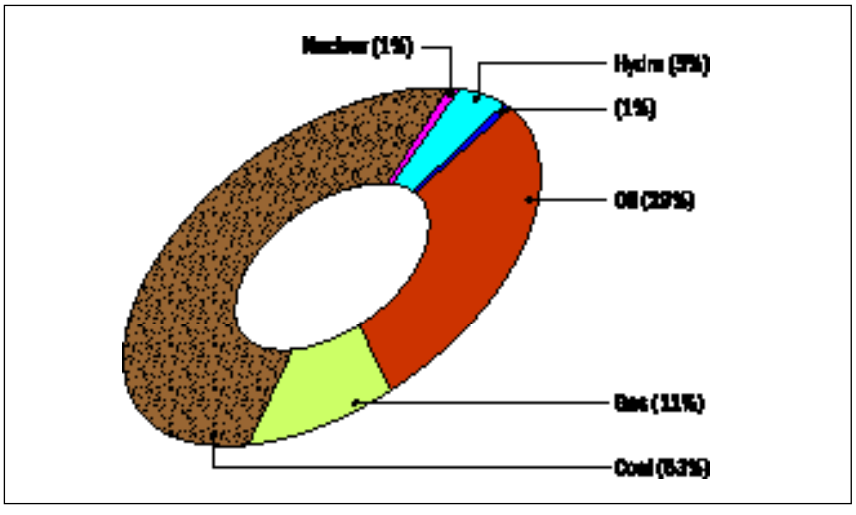


Figure 2 Primary energy consumption of India for 2010

Table 1 Installed electricity generation capacity of India (March 2012)

Fuel	Installed capacity (MW)	% of total capacity
Total Thermal	123758.98	65.98
Coal	104,816.36	55.88
Gas	17,742.85	9.46
Oil	1,199.75	0.63
Hydro (Renewable)	38,848.40	20.71
Nuclear	4,780.00	2.54
Renewable Energy (MNRE)	20,162.24	10.75
Total	187,549.60 MW	100.00

has been similar since long and it is unlikely to see a significant change in this pie chart in the near future. Is that a good sign for India's energy security, is a question that is debatable.

Consider the electricity scenario in India, an energy resource which has visible impact on our daily lives. As of March 2012 the total installed power generation capacity of India was about 187,000 MW (see Table 1), which can generate about 900 billion units of electricity in a year. In terms of per capita per year, this is corresponding to about 650 electricity units. On the other hand, the average consumption in the world is about 2,300 units per capita per year and the consumption of developed countries is over 10,000 units per capita per year.

Our future energy needs

India's energy consumption per capita is low as compared to world average and very low as compared to developed countries. The per capita energy consumption has direct impact on the health, literacy, economy, etc., and overall on the quality of life of people in a nation. Therefore, in order to increase the quality of life in India we must increase per capita energy consumption. There are two main parameters that govern the required growth in energy consumption. These are:

1. Economic growth of India
2. Population growth of India

Availability of affordable energy is a key fuel in economic growth of any country. India has been growing over 7% which is very much required in order to grow from developing country to a developed country. Maintaining this growth would require increased energy consumption. Secondly, our population is high and still growing. Our population growth rate is about 1.4%. A large increase in energy consumption is required to support this ever-increasing population.

Quality of a person in a country is presented by Human Development Index (HDI) having a value between zero (worst quality) to 1 (best quality).

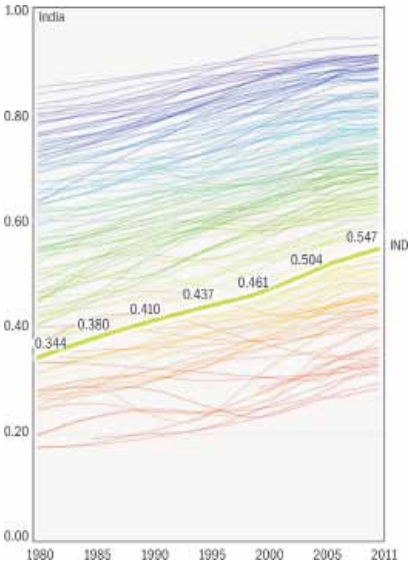


Figure 3 Human Development Index of India (other lines showing trends of HDI for other countries)

The HDI incorporates parameters like literacy level, health condition and income level. The index of India is currently just above 0.54 which indicates below average quality of life. A trend of HDI growth of India is shown in Figure 3. The HDI is strongly related to per capita energy consumption of a country. In order to increase our index from current value of 0.54 to above 0.75 for an average quality of life our per capita energy consumption must increase from current level of 0.48 ToE to about 2.0 ToE. This is corresponding to increasing our total primary energy consumption from current level of 530 million ToE to about 2400 million ToE, an increase of more than 350%. In the report "Integrated Energy Policy" of Planning Commission of India it is estimated that by 2030–31 India needs to increase its total primary energy supply by 3 to 4 times and its electricity generation capacity by 5 to 6 times. India's annual primary energy consumption must reach to 1850 million ToE and electricity generation capacity much reach to 800,000 MW by 2030–31.

Our available energy resources

Energy security of a country requires that available energy sources to the country should be adequately abundant and the exploration of available sources should be cheap. It is well known that coal, oil and gas, the naturally occurring fossil fuel based sources, can be extracted and used in economically viable manner. And, access to such resources holds key toward being energy secure. However, it is to be noted that with advancement in renewable energy technologies and threat of climate change looming the contribution of renewable energy resources will soon start to play, at least, some role in energy security of countries.

Let us now have a look at fossil fuel reserves of India and potential of other

energy sources. Are these resources available in enough quantity to fulfill current energy requirements of India and to maintain future growth rates?

Coal It is a product of natural process of decomposition of organic matters buried in swamps and has been out of contact with oxygen. Coal comes in various forms like peat, ignite, bituminous and anthracite (in the order of increasing carbon contents). Larger carbon content is equivalent to higher energy contents and high energy content coal is considered high quality coal. Thus both quantity and quality of coal is important. The Indian coal is known as high ash content coal. Coal power plants in India normally import high grade coal and mix it with Indian coal before burning in power plants. Coal in India is mainly found in Madhya Pradesh, Chhattisgarh, Jharkhand and Orissa. According Geological Survey of India (GSI) the estimated coal reserves in India is about 250 billion tones.

Oil Or the crude oil occurs in the form of liquid. It is complex mixture of hydrocarbon and some amount of inorganic elements like sulfur, oxygen and nitrogen. The crude oil in itself is not useful for consumption in appliances. Crude oil is refined to get various products like petrol, diesel, kerosene and some solid material like nylon, paints, plastics, etc. The crude oil reserves in India are found in Gujarat, Bombay High, eastern Assam, and Rajasthan. The crude oil reserve of India is estimated to abou 757 million tonnes.

Natural gas It comprises gases like methane, ethane, propane, etc. ,but the principle component is methane. It is mainly found along with crude oil but also there are some reserves where it is obtained in absence of crude oil. The natural gas reserves are found at places close to crude oil reserves. The natural gas reserve of India is estimated to about 1240 billion cubic meter.

Hydro The use of Earth's water cycle to generate electricity can be termed hydro resource of a country. The potential of resource is determined by the amount of rain, the geographical suitability to store water and its

feasibility to use for energy generation. India has a potential of about 150,000 MW of hydro power plant, of the power plants of about 38,000 MW has been installed , which generates about 20% of our total electricity consumed. It can be noticed that the potential is not very high as compared to our requirement of 800,000 MW power by 2030-31v. Also note that the power generation capacity depends on the rainfall. So far due to water shortage, on an average, the hydropower plants are operational only 60% to 70% time of year.

Nuclear This is resource where energy content of a nucleus of atoms is converted for electrical energy use. The process that is used currently is called fission reaction, in which a nucleus splits into smaller nucleus and results in release of energy. Currently the reactors that are used for fission reactions are called Burner reactors which uses uranium isotope U-235, which is less than 1% of the naturally occurring uranium. Since the uranium isotope U-235 is available only in short supply, the nuclear energy route cannot be sustained until new technologies like breeder reactors are developed, which uses uranium isotope U-238 and thorium isotope Th-232, which are available in large quantities in India.

India's current installed capacity of nuclear power plant is 4560 MW . All these power plants do not operate to their full capacity due to shortage of fuel. Since the beginning of 1990s, Russia has been the main supplier of nuclear fuel to India. Recently, after getting waiver from Nuclear Suppliers Group in September 2008 for nuclear trade, the country has signed contracts regarding nuclear power with countries like France, United Kingdom, United States, Canada, etc. Overall the current installed capacity is not very large and considering the fuel shortage, it may never become significant source of our energy needs.

Wind It is the resource in which flow of wind which originates due to temperature difference. The kinetic energy of wind flow is harnessed to get electrical energy. The wind power depends on the available wind velocity. And, the wind velocity increases as we go higher up from the ground. According to Center for Wind Energy Technologies (C-WET) there is potential for installation of 50,000 MW of wind power at the height of 50 meter from ground and more than 100,000 MW of wind power at the height of 80 meter from the ground. Till year 2011, wind turbines of over 14,500 MW have been installed in the country. It can be seen from the above number that the potential for wind energy technology is not very high as compared to our energy requirementsv.

Solar India is located in the equatorial sun belt of the earth and receives abundant solar radiation. Most parts of India experiences 250 to 300 clear sunny days in a year. The average daily global solar radiation received in India varies between 4 to 7 kWh/m2/day and corresponding annual global radiation varies from 1600 to 2200 kWh/m2/year. The equivalent energy potential is about 6,000 million GWh of energy per year. Our current total primary energy consumption is only about 6.1 million GWh. This reflects the enormous potential for solar energy harvesting in India. Under the Jawaharlal National Nehru Solar Mission (JNNSM), launched of Central government, there is plan to install 20,000 MW of solar power in India, of this more 1000 MW of solar power has been installed. Other than Central government, many state governments are also now taking initiatives to install solar power plants.

Though solar energy is abundant but economically it is not affordable right now. However, with advancement in solar photovoltaic (PV) technology and solar thermal technology, the cost of electricity is coming down rapidly. There are many regions in India and world where the solar energy is competing with fossil fuel based energy. Based on these facts, it appears that solar energy is one resource which can be very useful in obtaining energy security of India.

All resources are important In above paragraphs we have discussed various available energy resources and their potential to meet our demand. When we talk about energy security of the country, we should not just only

Table 2 Reserves, domestic production and total consumption of coal, oil and natural gas in India (data are for year 2010-11)

Fuel	Proved Reserves	Domestic Production	Actual consumption	Reserves/Consumption (years of fuel remaining)
Coal (Million Tonnes)	250,000	533	721.9	346.26
Oil (Million Tonnes)	757	38.4	141.8	5.34
Natural Gas Billion m^3	1240	52.2	64.9	19.11

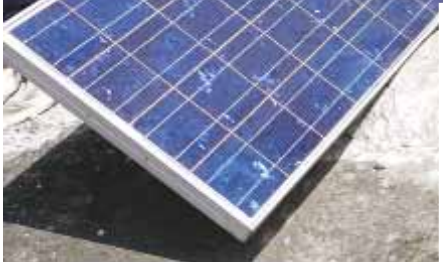
think about electricity generation. The primary energy requirement also includes energy for cooking, transportation, industrial heating, etc. And, therefore we need to use combination of fuels to achieve energy security, if at all it is possible. There is no doubt that among all the energy resources, energy resources based on fossil fuel plays and will play, at least in near and mid-term future, a very important role in obtaining energy security as they can be utilized in many ways for meeting our primary energy requirements.

How long we can use our fossil fuel reserves?

For the coal, oil and natural gas the total reserves of India, their domestic production and actual consumption is given in Table 2. It is clear from this Table that our consumption of the fossil fuel is higher than the domestic production. Interestingly, if we divide India's fuel reserves with corresponding annual consumption rates, we get the ratio which represents the number of years that particular fuel will last if only national reserves are to be utilized. In this way if we use only the oil produced in India, we will finish our oil in just over 5 years, and if we use only the gas produced in India we will finish all our natural gas resources in just over 19 years. We have large reserves of coal, but our consumption of coal is higher than the domestic production indicating that we are importing significant amount of coal as well.

Are we energy secure?

The data says NO, we are not. And, we should remember that energy security of a country very strongly affects the national security. The data presented in Table 2 clearly indicates that our fossil fuel based reserves are not very high. In current situation we are importing coal, oil as well as gas. Except the coal, if we do not import we will consume all our domestic oil and gas in no time. This indicates that we have no other option than to rely on fossil fuel



imports which greatly undermines the energy security of India. The reliance on fuel imports may harm the country in many ways; not only that it reduces our foreign currency reserves, but the worst thing to happen is complete stoppage of supply of these fuels to India. Geo-political events in oil-rich countries from where we import may result in, at least, temporary stoppage of oil and gas supply. This puts India in a very fragile situation; we must be aware of it and should keep ourselves preparing to deal with situation if at all it arises.

The crude oil prices have a history of fluctuation, steep rise and fall, which is affected by important events of that particular time (See Figure 1). The current crude oil prices are touching to nearly 100$ a barrel level. As per Michael Wesley (Power Plays: Energy and Australia's Security, 2007)i we are going through a period of oil shock, a third oil shock. There is increased demand of oil in fast growing India, China and some other countries. Due to this the decline in current oil prices are less likely. This means that we have to pay more and more to meet our current oil requirements and to fulfill our future needs. In future even if we find oil and gas deeper in earth, its extraction and refining is likely to be more expensive. So, are we energy secure? In this scenario the need for finding alternative sources for our energy security is more than ever. The energy sector requires careful thinking, planning and implementation of right policies to guarantee our citizen an energy safe future. Solar energy has great potential to be our secure source of energy. Appropriate investment in this sector with the suitable policies can not only ensure increase in electricity generation in India but it can create employment for people, it can help us to reduce greenhouse gas emission, it can provide almost instant solution to rural electricity (which is not possible by any other energy resource). Most importantly, use of solar energy can provide us energy security. ■

ENERGY STORAGE:
THE NEXT MAJOR CHALLENGE FOR RENEWABLE ENERGY

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Grid scale energy storage is currently being seen around the world as the missing link for successful implementation of smarter grids and integration of significant renewables in the existing grids. Recently, when Lux Research, an independent advisory firm which provides strategic advice on emerging technologies, predicted that the world over, the demand for grid scale energy storage by 2017, would touch a whopping US$113.5 billion, they were only voicing an indication of the times that lie ahead of us. Their report, "Grid Storage under the Microscope: Using Local Knowledge to Forecast Global Demand", reveals that the annual global demand for grid-scale energy storage will reach an astounding 185.4 gigawatt-hours (GWh) by 2017 and represent a $113.5 billion incremental revenue opportunity for an industry which presently generates sales of $50 to $60 billion a year.

These figures are probably now a reality in an era that is battling problems like coal shortage and depletion of natural resources, with emerging clean technologies that use renewable energy as an alternative. In such a scenario, one factor which assumes immense significance is energy storage. While there is no doubting that clean and renewable energy are the best bet when it comes to tapping our resources, unless there is a provision to store the excess energy produced and meet the shortfalls when the renewable resources are not available (i.e., wind is not blowing or the sun is not shining), renewable energy sources cannot replace fossil fuel based base load generation.

Ritesh Pothan, who leads a renewable energy advisory organization and advises clients in the wind, solar, biomass, and hydro domains on managing their macro ecosystems, feels that without energy storage, technologies like solar, wind and its ilk cannot replace base load generators like coal and hydro. "These current standard sources provide power continuously through the day and at night to consumers. However, varying peak power will limit the amount of energy which can be injected into the grid by solar PV and wind to uncertain times during the course of a day."

"Storing (converting) such energy into another medium will further reduce efficiency. Renewable energy, especially solar PV and wind in India are amongst the worst power generators, requiring eight times the equivalent capital investment to match that of a conventional power plant", he elucidates.

While Dr Rahul Walawalkar, who heads an emerging technologies practice for Customized Energy Solutions and is a board member for International Electricity Storage Association, agrees that "although it is true that energy storage systems add significant capital investments, the key to success is looking at the life cycle cost of ownership and for opportunities in order to optimize the grid or investments for particular industries / micro grids by utilising the flexibility provided by the emerging energy storage systems."

Merely comparing capital costs lead us to sub-optimal investment decisions, where we may end up paying significantly higher costs during the operational phase of the project, which typically accounts for 70 to 80% of the life cycle costs, he explains.

However, it is now being widely accepted that storage systems, be it for the wind or the solar sector, is financially lucrative. John Petersen, a US lawyer based in Switzerland and a partner in the law firm of Fefer Petersen & Ciem who also advises clients on energy, affirms that a storage system, be it for wind or for solar energy, "is economically very lucrative and viable."

Scenario in India

India's economic growth and the growth in the power sector are highly correlated. As on March 2012, India's installed capacity was over 199 GWs. India is likely to need capacity additions of 200 to 450 GW over the next 10 to 15 years to enable continued economic growth.

As per the India Energy Storage Alliance (IESA), the average power deficits in the country are around 8.3% with peak power deficits being over 12.1%. Peak power deficits are even higher among the industrial regions – 22% in Maharashtra and 17% in Punjab. Also, the Aggregate Technical and Commercial (AT&C) loss is believed to be over 30%, among the highest in the world.

Even though energy storage is still in its infancy in India, it is expected to grow at a rapid pace. Various drivers, including the restructuring of the electricity industry, growing penetration of renewable resources, along with increased requirements for power reliability and quality has made utility-scale EES more attractive, according to the IESA. In India there could be a huge demand for EES technologies for applications such as:

1. Optimizing the supply added demand imbalance

India's peak power shortages results in reliance on very expensive diesel power as backup for industries, commercial establishments as well as residential complexes. Various EES technologies can be deployed at Grid Scale projects for managing the gap between supply and demand.

2. Supporting the growth of intermittent RE sources

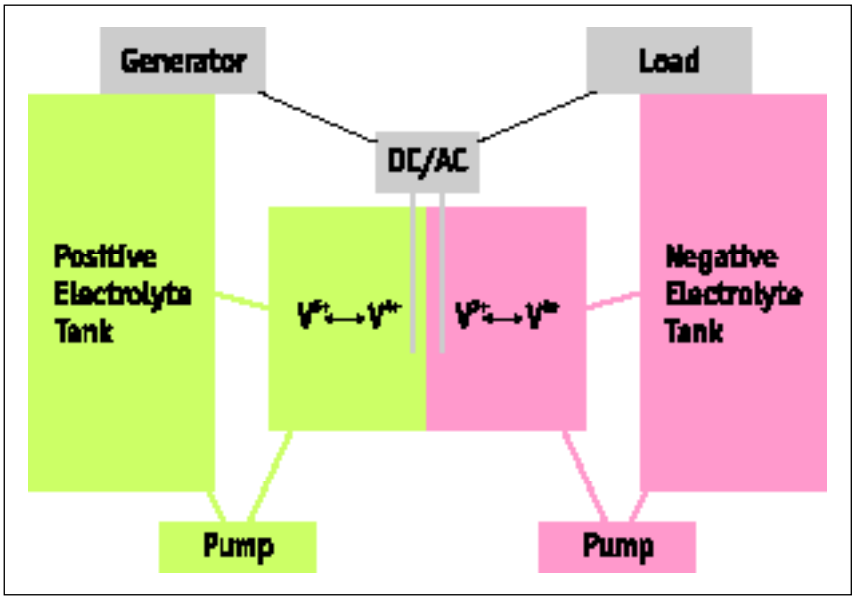
India now uses wind as the largest renewable resource with an installed capacity of ~18 GW. In addition, India's National Solar Mission aims to interconnect 20GW of solar power to the grid over the next 10 years. Recent studies have estimated the potential for wind in India at over 200 GWs, thus making it clear that the only major challenge for continued renewable growth will be the ability of the electricity grid to absorb the variable power.

3. Introduction of ancillary service markets

As of now, India does not have an efficient and robust market for ancillary services. However, the CERC is trying to work out a policy framework to introduce such ancillary markets in India. In this scenario, EES can play a crucial role in meeting the ancillary service requirements by replacing generation capacity.

4. T&D deferral

The Power Grid Corporation of India plans to invest $26 billion in the expansion of the transmission program for the next five to six years in India. There is increased attention for maximizing the transfer capabilities of existing lines and creating more efficient utilisation of the overall



transmission capacity. Large EES projects and fast response energy storage technologies will surely help in optimizing transmission capacity utilization.

5. Reduced congestion on transmission lines

India has opened up the electricity markets through national power exchanges and also allows open access to industries and generators. One of the challenges in managing the energy costs for open access customers is the transmission congestion on key transmission facilities. EES can reduce congestion.

While India has proved that it is very serious about adopting renewables, as a diverse geographical country, it comes with its own set of challenges. So while Petersen strongly believes that the benefits of storage in India are huge, he also adds that the technology needs to be cheap for the concept to work. "India has a much better opportunity, a terrifying economic force and a very good work ethic, which all work in its favour."

And, despite the positives, there are some real challenges and barriers to grid based energy storage. Ritesh concurs that the currently perceived cost as well as an indifferent government coupled with inefficient local technology are some of the factors which need to be looked at. "Off grid solar has to be paired with either lead acid or SMF batteries to be used in the nights, the Ministry of New and Renewable Energy (MNRE) does have some subsidies."

The focus on solar PV, he adds, which is ideally an off grid technology owing to its poor PLF's, has overshadowed the need to use the heat of the sun to augment traditional grid based technologies which efficiently use heat. Furthermore, he advocates that municipalities need to mandate the use of solar energy heating to reduce grid loads. Removal of subsidies on diesel will also push manufactures to be more efficient and innovative in their product lines.

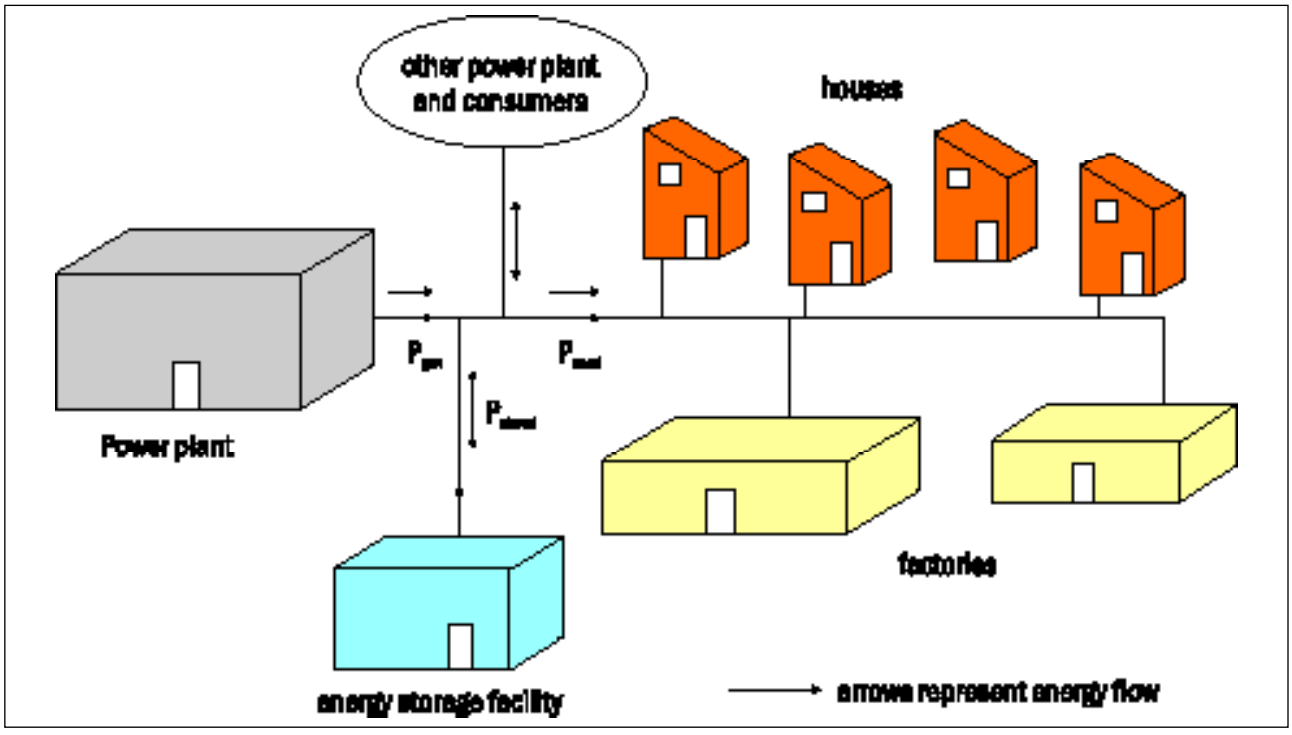
Revealing that energy storage is better used in thermal systems since they can replace or augment current conventional power plants, Ritesh elaborates that a much overlooked sister of solar PV is solar water heating. It uses heat (energy) storage to replace the need for higher consuming uses of the sun. Therefore, if 50 million Indian families use 1kWh unit to heat water daily, the power consumed would amount to:

50,000,000 kWh x 365 days

= 18,250,000,000 KWh units, reducing the need to add 3041MWs of conventional power generation and 4200+MW in a system which loses 40% of the energy pumped into the grid.

"Energy storage for grid plants running on solar PV and wind may be detrimental to the nation since they will only escalate power tariffs without actually being a viable solution," he feels.

According to Domula Chandrasekharan, professor and head of the department of Earth Sciences, Indian Institute of Technology, Bombay, and geothermal energy can directly generate electricity, since it is 97% online with a base load supply of electrical power. In the case of solar PV, at night, the systems cannot generate power and hence what is generated during the day is what needs to be stored for consumption at night. "Basically, you need batteries to store energy. Storage of large amount of electrical power needs several batteries which are not economical. This is true even with the case of wind energy. You generate power whenever



the wind velocity is sufficient to drive the turbine and when wind is not blowing, you cannot generate electrical power. Electricity generated while the wind blows needs to be stored again through batteries. This kind of secondary storage system adds to the cost of electricity supplied to the consumer." He adds that since the storage system cost has to be added when it is supplied to the consumer, the price increases. As the producers cannot absorb the cost simply because it will not be profitable for them, all hidden costs will have to be borne by the consumer.

Notwithstanding the flak which comes with energy storage, Aditya Jammi, Director of India Energy Storage Alliance (IESA), defends stating that some of the criticism is actually due to a lack of awareness about the advances in energy storage technologies in India. He goes on to clarify that there are, in fact, tremendous advances taking place in energy storage arena, both in terms of technological innovations as well as innovations in the business models and changes in the regulatory framework.

IESA was formed with the aim of bringing together expertise from around the world on implementation of economically viable energy storage technologies that can be adapted in the Indian context, within the regulatory and commercial landscape. Although most people think of energy storage as lead acid batteries, there are over 100 different technology companies which are developing various energy storage systems that cover an entire range of technologies from electrochemical batteries (advanced lead acid, li-ion, flow batteries, sodium sulphur, etc.) to mechanical systems including flywheels and Compressed Air Energy Storage systems. These companies include established industry giants such as Enersys, GE, United Technologies, Dresser Rand, and Siemens to new start-up technologies such as A123, Altairnano, Premium power, Aquion, SustainX, etc. Due to these advances, customers now have a wide range of choices wherein energy storage systems can be sized to meet the customer requirement based on power rating, energy storage duration, cycle life, efficiency, as well as capital costs. Additionally, there are a number of instances where a properly sized energy storage system can help optimize the grid infrastructure as well as reduce operational costs and emissions.

Dr Walawalkar cites one such example of optimizing capital expenditure using energy storage for transmission grids. Given the variability in renewable resources such as wind, if a project developer is trying to build a transmission network to evaluate 100% of the installed capacity of the wind farm, such a transmission system will get utilized to 80% of more capacity only for 10 to 15 per cent of the year. This results in significant stranded investment in transmission capacity. On the other hand, appropriate storage technology can be integrated at the wind farm for providing the wind firming / smoothing to reduce the capital cost for the grid

interconnection and transmission. Thus although the project developer is investing in additional capital cost for storage, it will get at least partially compensated by avoided cost for transmission. Moreover, under the new Indian Electric Grid Code, where wind farms above 10 MW have to forecast and schedule wind output with SLDCs, such storage capability can provide additional flexibility in case of deviations from the forecast, thus saving wind farms from potential financial penalties.

Another opportunity in India is for Commercial & Industrial (C&I) customers who are being affected by the regular power cuts as well as the lack of power quality in the distribution network. As a result most of the customers need to invest on backup systems that include UPS for short duration critical loads as well as Diesel Generators for medium to longer duration outages. With the growing prices of oil around the world, the cost of DG electricity is ~ 15 to 20 ₹ / kWh as compared to electricity available on national power exchanges like Indian Energy Exchange that can be purchased at night for fewer than 3 INR/ kWh. This provides tremendous opportunity in terms of energy arbitrage and also can result in additional savings by managing of the demand charges and addressing short duration outrages that can result in product stoppages for the industry.

The global picture

With this concept gaining credence, governments in most countries have realized the relevance of energy storage. Also, the numbers only go on to prove that this is now a serious business and is only going to gain further ground.

Dr Walawalkar points out that energy storage as a concept is not new to energy industry. Currently, there is over 80 GW of energy storage deployed around the world in form of pumped hydro energy storage. These pumped hydro facilities have contributed to grid stability and provided flexibility to systems around the world. One challenge faced in expansion of pumped hydro facilities is the long lead times to find and develop geologically suitable terrains and then obtaining the necessary environmental clearances for building the projects. That is where there is tremendous interest; in the distributed energy storage systems that can be deployed at the locations close to the need and also help optimize the generation and T&D investments.

He believes that the United States is expected to lead the world in the development of energy storage technologies as well as policy innovations that are enabling adoption of energy storage by various stake holders. At the same time, around the world there are number of locations where the value proposition of energy storage is much clearer due to presence of weak grids or need for developing cost effective ways for distributed micro grids. During its research, a comprehensive evaluation of various local factors, which include "utility market structure, generation technology compositions, peak power demand, demand growth rate, infrastructure growth rate, penetration and growth rate of intermittent renewable energy sources, grid reliability, (time of use) electricity rates, commercial demand charges, and outage costs", Lux concluded that Japan, China, the United Kingdom, Germany, and US (especially Arizona), will be the top five regions for grid storage and collectively account for about 58 per cent of global demand in 2017. While Japan and China will each account for about 18%; United Kingdom and Germany, will each account for about 9%; and the US will account for about 23%, with Arizona alone will account for 4% of global demand.

Speaking of energy storage, one cannot but cite the instance of Germany, a key energy storage player in Europe, due to its leading position in terms of installed capacity of fluctuating renewables. In 2011, generation from renewable sources in Germany are said to have accounted for 20% of total electricity generation. If the country is to meet its ambitious goals of getting a third of its electricity from renewable energy by 2020, at least 50% by 2030 and 80% by 2050,

it is believed that it must find a way to store huge quantities of electricity in order to make up for the intermittency of renewable energy.

Experts feel that the intermittency of wind and solar will make it almost impossible for German electric utilities to provide clean and affordable power to industry and consumers, at the high levels of penetration by intermittent renewables which the country is trying to achieve.

Utility-scale energy storage will be a key part of this future German energy plan.

As per the German Energy Agency (Dena), investments in the two-digit billion ranges will be needed if it intends to meet its stated objective, of getting a third of its electricity consumption from renewable resources in 2020.

Recently, Falkenhagen in northeast Germany made news when it was announced that it will use surplus renewable energy sources to produce hydrogen for storage in the country's existing natural gas pipeline network. Compared to current utility-scale solutions, power-to-gas offers unmatched energy storage capacities. Over a 24-hour period, the two-megawatt Falkenhagen facility is likely to be able to store over 30 MWh of energy.

Probably taking a cue from Germany, Mesa del Sol, Albuquerque's mixed-use, master planned community in the southern part of the city, unveiled its new smart grid system – the first of its kind in the USA. The smart grid system, in conjunction with the PNM Prosperity energy storage project, the country's first solar storage facility which is fully integrated into a utility's power grid, is a showcase for future smart grid projects. The project aims at innovating smart grid controls to overcome the challenges presented by the intermittency associated with renewable energy sources. The newly installed micro grid uses on-site solar, fuel cell, natural gas and back-up battery storage to power the 78,000 square foot Aperture Centre at Mesa del Sol.

Partnering with Mesa del Sol on the Smart Grid is Japan's New Energy and Industrial Technology Development Organisation (NEDO), PNM, Sandia National Laboratories, The University of New Mexico and nine major Japanese companies including Shimizu Corporation.

The smart grid will manage energy generation sources, the electrical grid and energy storage sources in a sustainable way. To meet the Aperture Centre's needs, NEDO installed a 50 kW solar photovoltaic system, an 80 kW fuel cell; a 240 kW natural gas powered generator and a 160 kW/h battery storage system as well as a building energy management system. "The new smart grid has a building management system that is automated and manages the electric supply and distribution between our on-site generation sources, energy storage and PNM's power grid", Manny Barerra, Mesa del Sol's director of engineering was quoted as saying.

Another example that came to light recently was that of a new Microgrid at Ft. Bliss, when Princeton Power Systems (PPS) announced its Energy Storage