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ENERGY FUTURE

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THE HUNGRY DRAGON

RENEWABLES AND CHINA'S ENERGY FUTURE

Fractured Hopes?
A Look at the Shale Gas Revolution

Coal:
Unravelling the Energy Logjam

VIEWPOINT

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From the editor's desk...

China is central to any discourse on the future of energy, whether from the point of view of consumption or from the point of view of its foray into the new and renewable energy industry. Indeed, in the last few years China has taken a quantum leap in this field and become a `renewable energy superpower' as well. It provides a concrete example of what can be achieved through a combination of government's vision and private sector's entrepreneurial skills. Here is a case where the state is helping promote the domestic manufacturing sector. Their vision is to not only serve the domestic markets, but also, to have an industrial base that can compete and capture the global markets.

At the other end of the spectrum, shale gas and oil are being touted as game-changers. These have certainly changed the complexion of energy supply in the US. However, whether the same can happen in water-stressed countries such as India is yet to be established given that fracking has a huge appetite for water. There are also questions about its environmental impacts. Likewise, in the post-Fukushima period, people's perception of nuclear energy has changed completely. In India, therefore, cleaner utilization of its coal through technological interventions such as ultra-supercritical power plants, carbon capture and storage, and coal washing are critical to drive socio-economic growth. On the economic front, doubts are being raised about its sustainability. However, it would be premature to conclude that India's phenomenal economic growth is all but over. These are difficult times with a need to focus on the inherent strong fundamentals of the Indian economy before reaching any hasty conclusion. The important role of energy is evident for the country's social and economic development. But just like future-gazing in any other field, forecasting the contours of energy future too is very complex and there lies the challenge!

Amit Kumar

Amit Kumar
Director, TERI

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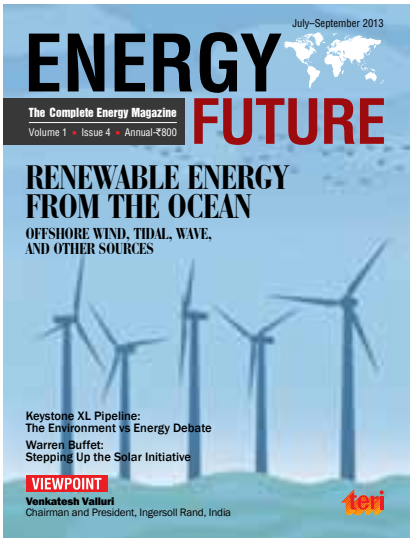

It was good to see *Energy Future* cover the intense issue on tar sands mining its July issue. I find it incredible that with the set aim of keeping global temperatures below 2 °C which requires an increasingly suppressed CO_2 diet today, we are still witnessing activities such as these which are only condemning the world and future generations to catastrophic climate change. One can only hope that the environment lobby would be able to factor in change this time, and as rightly pointed out by the author, target oil companies where it would hurt most – their wallets!

Dhairya Mittal
Agra

I enjoyed reading the cover story on Renewable Energy from Ocean as it gives a look into the various aspects of harnessing energy from ocean and how Government can make a difference in this regard. In the current issue, I found the article on Energy Crisis especially insightful. Both, energy crisis and global economy are inversely proportional 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*.

Suparna Das
Orissa

The danger seems imminent. The trend of frequent global natural disasters continues, highlighting the environment-related crisis. The article 'Sink or Swim' clearly brings out the worries of top leaders around the world and have made them tighten their seat belts to prepare a concrete plan to cope up with the fast-approaching danger. The piece has hit right on target to point out the failure of businesses to plan and prepare for the forthcoming dangers. Along with devastating human life, these massive earthquakes, floods and storms cripple a country's economy also. The need of the hour is that the issue to deal climate change should top the agenda of every country. There have been century spanning multi-billion plans to protect the cities as they are at a greater risk from natural disasters. Accurate and timely warning system would also be able to reduce damages up to a greater extent. Pumping in huge amount of money has not been able to produce fruitful results. More than preventive measures, work on the core issues would be beneficial.

Kamakshi Prasad
Coimabatore

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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ATOMIC ENERGY DEPARTMENT ALLAYS FEARS OVER NUCLEAR LIABILITY LAW

Days ahead of the Prime Minister's visit to the US, a controversy erupted when an American company bypassing the atomic regulator even as the department of atomic energy (DAE) asserted that any contract signed will be fully consistent with Indian law.

DAE also said NPCIL, the Indian operator, will enter into a preliminary contract with America's Westinghouse only with the approval of Atomic Energy Commission (AEC) and the government here. The statement by the DAE came after a note for Cabinet committee on security.

According to the note, there is a proposal to sign a "preliminary contract" between NPCIL and WEC to buy six 1,000MW nuclear reactors at a cost of $15.16 million for a power plant to be set up at Chayya-Mithivirdi in Gujarat.

The CCS note comes following an opinion rendered by the attorney general in which he is learnt to have said that it is up to the NPCIL — to invoke section 17 of the Civil Liability for Nuclear Disaster Act regarding liability of suppliers in case of an accident.

This was met with a sharp reaction from political parties with BJP saying reports of India compromising on crucial clauses in the Nuclear Liability Act regarding fixing of liability is "worrisome."

However, the government sought to downplay the controversy saying there will be no dilution on the issue and the country's interest will be protected.

External affairs minister Salman Khurshid said while India needs energy, it will get it at its "own terms and conditions". ■

Source: www.timesofindia.indiatimes.com

EIB TO SUPPORT INDIAN RENEWABLE ENERGY PROJECTS WITH EUR 80 MILLION LOAN

The European Investment Bank (EIB), supported by Italian export credit agency SACE S.p.A, signs EUR 40 million loan as first installment to SREI Infrastructure Finance Limited (SREI) to finance renewable energy projects in India.

The EIB and Italy's SACE S.p.A have signed a €40 million long-term loan agreement with India's SREI to help finance a series of investments intended to mitigate climate change in the country.

This tripartate cooperation is the first action of an 80 million pledge, and has been designed to promote Italian exports, assist India's renewable energy objectives, and benefit economies in the EU.

Funds from the loan will be ploughed into renewable energy projects in India. Specifically, the financing will target electricity and heat generation schemes, most notably photovoltaic energy and wind power.

The deal is an attempt to meet India's surging demand for environmentally sustainable electricity, and will also help to stimulate portions of the Indian economy.

SREI will manage the funding, identifying projects it believes are worthy of further financing. The EIB will carry out due diligence to ensure that the money is being used wisely, efficiently, and effectively, and that the initiatives also comply with the Bank's environmental and social requirement.

The loan is part of the EIB's wider ESF fund, which so far has provided more than €4.9 billion for long-term investment projects in Asia, €2.2 billion of which has been ploughed into the energy sector. ■

Source: www.pv-magazine.com

INDIA–CHILE TO ENHANCE COOPERATION IN RENEWABLE ENERGY

India and Chile have agreed to enhance their cooperation in the field of Renewable Energy. This was decided at a meeting held between the Chilean Energy Minister, Jorge Bunster and Dr Farooq Abdullah, Minister of New and Renewable Energy at Santiago.

Dr Abdullah stated that India plans to add over 30GW of renewable energy to its energy mix in the next 5 years alone. He also dwelt on the success of the wind programme as well as the significant cost reductions in solar energy through the JNNSM.

Bunster informed the Indian Minister that Chile is almost entirely dependent on imports for its energy needs and is therefore extremely keen to diversify its energy mix by introducing a large component of renewables. It has considerable potential in wind, hydro, solar, and geothermal energy. Mr Bunster expressed his government's desire to set up a 50MW solar thermal generating capacity in the north of the country.

Dr Abdullah offered the services of Indian experts and institutions like Centre for Wind Energy, Solar Energy Centre, Alternate Hydro Energy Centre for resource assessment of renewable energy sources, training of personnel, and also preparation of projects for exploiting these technologies in Chile.

He also offered training slots in India to Chilean scientists, engineers, and technicians through the Indian Technical And Economic Cooperation (ITEC) Programme.

The Minister also addressed a meeting of the UN ECLAC in Santiago where he offered India's fullest support to the entire region in development of renewable energy. ■

Source: www.ciol.com

INDIA'S UNTAPPED POTENTIAL IN OIL AND GAS SECTOR

The rapid surge in demand for hydrocarbons in India has not translated proportionately toward the growth of domestic E&P in the oil and gas industry. A case-in-point is that of the 11th Five-Year plan period, for which India committed to produce 206.8MT of crude oil but the actual production was 176.9MT, equating to an incremental import burden of over $20 billion for the period at today's prices.

Ensuring long-term energy self-sufficiency appears to be a formidable task for India, given the magnitude of the country's energy needs, complexity of technologies involved, large investments required, and obstacles in the political landscape to overcome.

Despite these challenges, India has large possibilities for growth in the oil and gas sector. Only half of the country's potential basins have been explored, and large blocks offshore remain untested, especially in deep waters. India's total hydrocarbon reserves are estimated to be around 2 BMTOE (Billion Metric Tonne of Oil Equivalent). With the current oil production level of around 815,000 barrels per day, on estimated reserves of 1.2 BMT (Billion Metric Tonne), the reserves-to-production ratio is 25 years. The potential for gas seems brighter; at the current production level of around 40 BCM (billion cubic meters) per year on an estimated reserves base of around 1,500 BCM, translating to a reserves-to-production ratio of more than 30 years. The nine rounds of NELPs have seen 247 blocks being awarded, but only 16 of those have been developed so far. ■

Source: www.moneycontrol.com

TAMIL NADU SEEKS PM'S INTERVENTION FOR TWO WIND ENERGY PROJECTS

Tamil Nadu Chief Minister J Jayalalithaa has sought Prime Minister Manmohan Singh's intervention for obtaining approval for two of its wind energy projects and grant of Rs 1,500 crore from the National Clean Energy Fund (NCEF).

"It is distressing to find that the IMG is going against the Government of India's guidelines to deny Tamil Nadu, which is a flagship state in harnessing clean renewable energy, the much needed support for a project which has for long been a felt need," she said.

The Chief Minister said she completely failed to see the justification for the IMGs stand and referred to Ministry of New and Renewable Energy's letter to the Finance Ministry seeking to reconsider its stance.

Ministry of New and Renewable Energy validated two of the three proposals sent by the state at a total cost of Rs 3,758 crore and recommended approval of a grant of Rs 1,500 crore from the NCEF in accordance with the guidelines which limit assistance from the Fund to 40 per cent of the project cost.

"The third proposal for setting up 400 KV substations with associated transmission lines at Karaikudi and other places in the State is being executed with Tamil Nadu's own resources," Jayalalithaa said.

Tamil Nadu plans to increase its capacity by another 5,000 MW in the next five years. It has also announced a Solar Policy aiming to install 3,000 MW of solar power in the next three years. ■

Source: www.zeenews.india.com

NUCLEAR ENERGY TO FUEL INDIAN RAILWAYS IN THE FUTURE?

The members from Railway Board, headed by Member Electrical Kul Bhushan, had a meeting with DAE officials. Sources in the railways said that they are keen on setting up a nuclear power plant in the future. "We want to look at the option of using nuclear power for our railway system and so discussed with DAE the construction of an exclusive nuclear plant in the future," said a senior railway official.

The DAE has the authority to set up nuclear plants for the railways to generate power for its trains. Railway officials added that the nuclear plant could be set up in any state of India. In Mumbai, the Bhabha Atomic Research Centre (BARC) operates nuclear plants.

For nuclear energy to fuel trains, a separate grid has to be set up especially for the railways. "Once the power is generated, it can be distributed through substations of Indian Railways which would then feed overhead cables that supplies electricity to trains," explained a senior railway official, admitting that the cost of setting up these nuclear power plants and establishing an isolated, independent system would incur heavy costs.

SK Malhotra, head of the public awareness in DAE, said, "The railways has shown interest in a dedicated power plant. There have been meetings but no Memorandum of Understanding has been signed yet. Sources claimed that they are presently checking the possibility of an in-principal agreement between the two and are identifying a suitable location for the plant. ■

Source: www.daijiworld.com

PLANNING COMMISSION SETS UP TASK FORCE TO PROMOTE SOLAR ENERGY

The Planning Commission has set up a task force, headed by member (energy) BK Chaturvedi, to oversee efforts to boost production of solar energy. The panel is composed of officials from the Ministry of New and Renewable Energy, the ministry of power and the CERC, among others.

The 12-member committee also has members from industry bodies like the CII and the FICCI.

Solar power contributes less than 0.5 per cent of India's energy mix, a figure the government hopes to raise to 5–7 per cent by 2022. According to a firm Bridge to India, the country had 1,700 megawatts (MW) of photovoltaic capacity installed by May 2013. It estimates that the figure will jump to 12,800 MW by 2016.

The terms of reference of the committee say that it is supposed to suggest policy interventions for improving domestic manufacturing solar energy products, as well as suggest measures to enhance availability of cost-effective finance for solar manufacturers and developers. The committee will also ensure effective implementation/strengthening of the renewable energy certificates mechanism and seek involvement of state governments for solar capacity development.

"The task force will also talk to states as the demand for power is going up" Chaturvedi said on the sidelines of a conference organized by Ficci.

Vivek Chaturvedi, Chief Marketing Officer at Moser Baer Solar Ltd, said the formation of the committee is a timely initiative. "We need to have a thriving domestic manufacturing industry to achieve energy security and help save on foreign exchange," he said. ■

Source: www.livemint.com

PUSH TO SEAL INDO–JAPAN N-ENERGY DEAL SOON

India and Japan have pledged for an early conclusion of the agreement. In a meeting in Tokyo with Prime Minister's special envoy for Japan, Ashwani Kumar, Japanese foreign minister Fumio Kishida expressed confidence that the proposed agreement can be concluded soon with the support of the people of both the countries.

"The meeting with foreign minister Kishida also provided an opportunity for a high-level review of the India–Japan strategic and global partnership as the two countries prepare for the visit of Their Imperial Majesties and the subsequent visit of Prime Minister Abe for the annual summit," it said.

Both sides agreed that closer economic cooperation between India and Japan was essential for Asia's continuing growth. In this context, they welcomed the recent decision to expand the bilateral currency swap arrangement to $50 billion, the continuing progress on the Delhi–Mumbai Freight Corridor and Delhi–Mumbai Industrial Corridor projects and the discussions on introducing a high-speed railway system in India. Kumar also referred to the progress in bilateral defence and security cooperation, including in areas of maritime security, anti-piracy, and counter-terrorism.■

Source: www.timesofindia.indiatimes.com

INTERNATIONAL ENERGY AGENCY PREDICTS GLOBAL OIL DEMAND GROWTH AT 1.1 BPD IN 2014

The International Energy Agency (IEA) predicts global oil demand growth at 1.1 million barrels per day (bpd) in 2014. According to the IEA's report on oil markets, the forecast of global demand growth remains flat at 895,000 bpd for 2013, as stronger-than-expected deliveries in July offset concerns about the demand impact of currency fluctuations in emerging market economies.

IEA's estimates show that global oil supply decreased by 770,000 bpd in August 2013 to 91.59 million bpd, with both non-OPEC and OPEC registering monthly declines.

The agency expects non-OPEC production to rise by 520,000 bpd in the third quarter of 2013.

OPEC oil supplies, according to the IEA' estimates, fell by 260,000 bpd to 30.51 bpd in August 2013 as near-record Saudi Arabia's output only partly offset a collapse in Libyan production. ■

Source: www.en.trend.az

UN NUCLEAR ASSEMBLY REJECTS ARAB PUSH ON ISRAEL

Member states of the UN nuclear agency rejected an Iranian-backed Arab bid to single out Israel for criticism over its assumed atomic arsenal, in a diplomatic victory for Western powers that opposed the initiative.

The debate and vote at an annual meeting of the 159-nation International Atomic Energy Agency (IAEA) underlined divisions at a time when the United States and its allies are hoping for progress in a separate, decade-old nuclear dispute with Iran.

Arab states had submitted a non-binding resolution on Israel to the gathering in Vienna for the first time since 2010 to signal their frustration at the lack of movement in efforts to create a Middle East zone free of weapons of mass destruction.

Fifty-one countries voted against the text, which called on Israel to join the nuclear Non-Proliferation Treaty (NPT), and 43 states voted for. Others abstained or were absent.

The United States said earlier that targeting its close ally would only hurt broader steps aimed at banning nuclear and other weapons of mass destruction in the tinderbox region.

Israel is widely believed to possess the Middle East's only nuclear arsenal, drawing frequent condemnation by Arab countries and Iran which say it threatens peace and security.

US and Israeli officials — who see Iran's atomic activity as the main proliferation threat — have said a nuclear arms-free zone in the Middle East could not be a reality until there was broad Arab–Israeli peace and Iran curbed its programme. ■

Source: www.euronews.com

ENERGY SECURITY: A MAJOR FACTOR IN INTERNATIONAL SECURITY

Energy has several security-related aspects. Supply lines and increasingly interconnected critical infrastructure are frequently targeted by terrorists, computer hackers, and pirates. Deployed forces need to become more energy-efficient in order to save money and reduce the environmental impact. And the growing global demand for energy and other scarce resources could lead to disputes. Highlighting the increasing importance of energy security for the Alliance, NATO's Secretary General formally inaugurated the NATO Energy Security Centre of Excellence in Vilnius, Lithuania.

The Alliance has a role to play in meeting these challenges. NATO's counter-piracy mission is helping to protect maritime supply lines. NATO also provides a platform for intelligence-sharing, training, and education, and the exchange of best practices on the protection of critical energy infrastructure with partner countries, other institutions, and the private sector.

The Allies are also taking steps to reduce the dependence of their armed forces on fossil fuels by developing alternative fuel sources and "smart energy" projects. Becoming more

energy-efficient is a necessity given rising fuel costs and financial austerity. Since the Second World War, the average fuel consumption per soldier has increased more than ten-fold. During recent years, more than four million litres of fuel have been used per day by NATO forces in Afghanistan. Most of the fuel is transported over land, through areas of a high risk of deadly insurgent attacks. ■

Source: www.nato.int

THERMAL ENERGY INTERNATIONAL RECEIVES $1.7 MILLION IN HEAT RECOVERY AND GEM(TM) ORDERS FROM A FORTUNE 500 FOOD AND BEVERAGE COMPANY

Thermal Energy International Inc. (TSXV: TMG) announced that it has received two heat recovery system orders and one GEM(R) steam trap system order from a Fortune 500 food and beverage company. The three orders total, in aggregate, approximately $1.7 million and represent the second, third and fourth orders from this customer.

On December 14, 2012 Thermal Energy announced it had received a $300,000 order for a heat recovery system at the same Fortune 500 food and beverage company and further that Thermal Energy was working on a number of additional sites developing both heat recovery systems and steam trap solutions for this Fortune 500 company. These orders are a result of the previously announced development work for this client, and Thermal Energy continues to develop additional heat recovery and GEM(R) steam trap projects at multiple additional sites for this global food and beverage customer. This company has revenues of approximately $50 billion and more than 200,000 employees.

The heat recovery and GEM(R) steam trap projects announced are calculated by Thermal Energy to reduce the annual fuel consumption at each site by between 10 per cent and 14 per cent, reduce carbon emissions by approximately 4,000 tonnes annually (equivalent to removing 833 cars from the road) and recover approximately 4 million US gallons of water annually. These projects, which have an expected life of 20 years, are projected by Thermal Energy to provide the customer approximately $400,000 in annual savings from reduced fuel use alone. ■

Source: www.4-traders.com

RUSSIA AWARDS FIRST RENEWABLE ENERGY TENDER TO BOOST THE INDUSTRY

Russia, the world's biggest oil producer, offered its first state support for renewable energy by awarding subsidies to 39 clean power ventures. Russia selected projects with a combined capacity of 504 megawatts, the industry regulator said on its website. Solar bidders had the most success, gaining support for 399 megawatts; wind developers won less than a 10th of the capacity offered.

President Vladimir Putin approved a subsidy programme to boost clean-energy generation in a bid to curb reliance on oil, gas, and coal for power while cutting emissions. The country plans to expand the share of renewables to 2.5 per cent of power output by the end of the decade from 0.8 per cent now. The country, which has only a handful of wind and solar plants operating, offered 1,100 megawatts in wind capacity and 710 megawatts of solar to be built from 2014 to 2017, as well as some hydropower. ■

Source: www.renewableenergyworld.com

RENEWABLE ENERGY IS AMERICA'S CHEAPEST OPTION, STUDY FINDS

According to a new study that aims for a more holistic count of energy costs, a switch to renewables by the US wouldn't only be good for the planet -- it would actually make better sense financially.

The study notes that most of the pollution generated in the US today comes from coal-fired power plants, accounting for 40 per cent of the nation's carbon footprint. But in addition to electricity, burning coal leads to countless unintended, yet pricey consequences, like increased rates of heart disease, respiratory illnesses, and premature death —as well as many environmental impacts associated with climate change.

It's cheaper to replace a typical existing coal-fired power plant with a wind turbine than to keep the old plant running. And new electricity generation from wind could be more economically efficient than natural gas.

The findings show the nation can cut carbon pollution from power plants in a cost-effective way, by replacing coal-fired generation with cleaner options like wind, solar, and natural gas.

Given the state of decision making and infighting in Washington, making the switch will undoubtedly be an uphill battle on a federal level. But from a purely pragmatic standpoint, it's looking more and more like a no-brainer.

"Burning coal is a very costly way to make electricity," Johnson concludes."There are more efficient and sustainable ways to get power." ■

Source: www.treehugger.com

SAUDI ARABIA FOCUSES ON ALTERNATIVE ENERGY

Saudi Arabia hopes to get up to 50 per cent of its power from nuclear and other renewable sources within 20 years, the president of the King Abdullah City for Atomic and Renewables Energy, or KA-CARE, says.

"Nuclear energy and renewables have an active role and can contribute up to 50 per cent of electricity production," Hashim Yamani said in remarks published by the official Saudi Press Agency.

The Arab world's largest economy plans to build 16 nuclear reactors by 2030 with 17 gigawatts capacity at a total cost of around $100 billion. The plants will take 9 to 11 years to complete and the first will start operations by 2020.

If Saudi Arabia's current energy-consumption growth rate of 7 per cent a year continues the kingdom within 20 years will burn the equivalent of around two-thirds of its total current crude production capacity of 12.5 million barrels a day, some economists say.

The UAE, Egypt and Jordan are seeking to develop nuclear energy, too. Saudi Arabia has signed nuclear cooperation pacts with China, France, Argentina, and South Korea and is in discussions with the US, UK, Russia, and the Czech Republic. ■

Source: www.gulfnews.com

THE NEED FOR CLEAN ENERGY FUEL CELL BUSES IN CHINA

China's rapid economic expansion over the past decade has resulted in a public concern regarding deteriorating levels of air quality. The China State Council is investing 1.8T Yuan (US$288 billion) in the renewable energy industry over the period 2010–15, along with 2.3T Yuan (US$368 billion) on actions designed to save energy and reduce emissions.

The growth of China has resulted in high levels of automotive emissions, with the International Council on Clean Transportation reporting that auto emissions contribute more than 33 per cent of the air pollution in Beijing, Shanghai, and Pearl River Delta Region.

Beijing's city government wants to expand public transit while also reducing the number of vehicles in the city. As a result, it unveiled new measures this month that place tougher restrictions on the number of new vehicles allowed on the roads each year going forward. By the end of 2017, the government will cap the number of cars on the road at 6 million. Beijing also aims to reduce total vehicle fuel consumption by promoting the sale of new energy vehicles — including the use of subsidies — while also encouraging people to drive less frequently.

Azure Hydrogen Corporation of Beijing plans to develop fuel cell bus capabilities in China with Ballard's technical support and funding from Chinese sources, including both private investors and various levels of Government. ■

Source: www.altenergymag.com

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RENEWABLES AND CHINA'S ENERGY FUTURE

China's exponential growth and industrial development have meant that its energy needs are also growing day by day, and it is turning to renewable sources to satiate this hunger for energy on its way to becoming a superpower. **Karthikeya Ramesh** examines the evidence and looks at how renewable energy is playing a substantial role in China's final push for global economic dominance.

China is now on the cusp of becoming the biggest and most powerful economy in the world. It is an accomplishment that rides on the back of an extraordinary concentrated thirty-year effort, which saw the Middle Kingdom abandon its millennia-old agrarian ways and transform itself into the manufacturing hub of the world. However, the last decade has seen China's hunger for energy resources grow exponentially, which might have a severe impact on its aspirations to become the next world superpower. China has responded to this challenge by investing heavily in renewable energy technology, leading to speculation that the day may come when the world's largest industrial economy will be powered in majority by wind and solar resources.

From Farms to Factories

December 1978. The third plenary session of the eleventh committee meeting of the Communist Party of China was underway. The nation, still recovering from the institutionalized violence and purges of the Cultural Revolution, was at its lowest ebb. Millions of people had died due to the arbitrary and unsustainable economic policies of Mao Zedong. Many others had suffered horrifically at the hands of the roving government hit squads that terrorized the countryside ensuring each man, woman, and child was doing what was required of them, with the apparent aim of ridding China of its cumbersome past and bringing the nation into a new age of prosperity. Following the precepts of Mao to the letter was clearly not the answer. The fate of the most populous nation in the world was hanging in the balance, and one of the most important decisions in the history of the modern world was about to be taken.

Four years ago, Deng Xiaoping was a pariah. The once-protégé of Mao himself was worried for his life, and that of his son, as an aging Mao distanced himself from a man who many in the central committee feared was becoming too powerful for his own good. His academically brilliant son, Deng Pufang, had become paralysed as a consequence of a suspicious fall from the third floor of a building on the campus of Beijing University. Discredited, excommunicated, and shunned, it appeared that Deng Xiaoping would be little more than a footnote in the pages of history, another name to be added to the list of dissidents who had been systematically targeted and destroyed by the feared Gang of Four, led by Mao's wife, Jiang Qing. In September 1976, Mao Zedong, the Paramount Leader who had ruled China for the last 27 years, died. A month later, the Gang of Four had been arrested. In 1977, Deng Xiaoping was welcomed back into the central committee. In addition, in December 1978, he took over the reins of power to become the new paramount leader of the People's Republic, despite not holding the official post of Chairman of the Communist Party of China until

1981. Deng advocated sweeping reforms with the aim to "make China a modern, powerful socialist country before the end of this century". It was the first step in a social and economic revolution that would take the world by storm, and has defined the geopolitical balance of power so far in the twenty-first century.

From 1980, China began to grow into an industrial powerhouse, and its energy consumption pattern showed a gradual and steady increase until around 2004, when it began to grow rapidly. By the end of the decade, China overtook the United States to become the largest consumer of energy in the world. In comparison, in 2000, China consumed approximately half as much as energy as the US. Deng Xiaoping's goal, it appears, has been achieved. However, the cost of being the largest industrial economy in the world is also evident in China today. China leads the world in total greenhouse gas emissions, though it is still significantly behind the United States and many other developed countries in terms of per capita emissions. The quality of air in Beijing was a serious concern among international athletes during the 2008 Olympic Games, and citizens living in China's large urban metropolises such as Beijing, Shanghai, and Guangzhou are starting to feel the health impacts of such rampant pollution. Additionally, China is the second largest importer of crude oil and coal in the world. China's coal imports in particular have been extraordinary, increasing by a staggering 875 per cent over six years from 20 million tonnes a year in 2004 to 195 million tonnes a year in 2010. The International Energy Agency warned China (and India) that their sudden increase in fossil fuel imports could have potentially catastrophic consequences not only in terms of emissions but also in terms of global trade. While China is close to achieving success at the target it set itself in 1978,

the process leading to this success has led to far bigger challenges, the implications of which could shape the future of the planet for centuries.

Renewable Energy and Energy Efficiency

Aware of the dangers that such energy dependency imposes on an economy in overdrive, China has sought to rectify the situation by investing heavily in renewable energy generation. As the third largest country in the world by area (after Russia and Canada), China certainly has an advantage in terms of resources and is attempting to leverage every last one of them in its effort to generate as much energy as possible. China's 2005 Renewable Energy Law set some ambitious targets to ensure that the nation achieves a certain degree of energy security by trying to ensure that 15 per cent of its energy supply will come from renewable sources such as solar, wind, biomass, and hydropower by 2020. Two years later, in 2007, China's National Development and Reform Commission (NDRC) announced a Medium to Long-term Renewable Energy Development Plan. According to this plan, China's installed capacity for solar power was assigned a target of 1.8 Gigawatts (GW), wind and biomass were assigned targets of 30 GW each, while small hydro was assigned a target of 75 GW. Achieving these targets would require an investment of around US$ 270 billion, it was estimated. These targets were later revised in 2009, and a proposal is in the works that might see them revised once again. The growth of China's renewable energy industry has been nothing short of spectacular, even by the standards of sudden, extraordinary growth that China has set in the last two decades.

Solar Power

China's initial target of 1.8 GW of installed capacity from solar power by 2020 was first revised in May 2009 after it became obvious that not only was China going to achieve this target, but it would also exceed it several times over much before 2020. In May 2009, a new target of 10 GW was revealed, and in 2011, that target too was overhauled and revised to 20–30 GW. China already had an installed capacity of 8.3 GW by 2012, and according to the European Photovoltaic Industry Association's publication on the global market outlook for photovoltaic solar power, China could see an installed capacity of as much as 68 GW by as early as 2017, in a matter of a mere five years. While this may appear to be a ludicrous assumption on the surface, a little analysis reveals it to be a rather conservative estimate. Such an increase would require China's solar energy market to increase its installed capacity at a rate 52.3 per cent a year. In the five years before 2012, China's

total installed capacity for solar power grew from 100 MW to 8,300 MW; that was an average annual rate of growth of 142 per cent. In one year, from 2010 to 2011, China's installed capacity for solar power quadrupled. This incredible growth story is the consequence of China's newfound power as the manufacturing centre of the world. Nearly half of all the photovoltaic panels used around the world are manufactured in China. However, this economic surge has come at a deadly price. As the world's largest producer of polysilicon—a crucial ingredient utilized in making solar cells—China has been negligent in its responsibilities towards the environment. The Washington Post reported that Chinese manufacturing firms were dumping large quantities of silicon tetrachloride, a highly toxic by product of the polysilicon manufacturing process, into nearby fields, lakes, and rivers. Manufacturing firms in developed countries are obligated to process and recycle the poisonous chemical, which has the effect of adding an expensive overhead to the entire process and therefore increasing the final price of the cell. Chinese firms were thus able to sell their products at a fraction of the cost. This led to the anti-dumping legislation crisis of earlier this year, where the United States, Europe, and China faced off over allegations of Chinese companies flooding the European and American market with cheap solar cells to garner a disproportionately high market share and destroying the indigenous solar manufacturing industries of the developed world. A compromise was reached in late July 2013, when the EU decided against imposing anti-dumping duties as high as 68 per cent against Chinese companies, in favour of limiting the import of Chinese photovoltaic cells and setting a minimum price on such imports. This agreement is meant to last until 2015, by when it is assumed a parallel probe by the EU will be able to shed more light on the matter.

Wind Power

The People's Republic of China is the third largest country on earth by area and is ranked tenth among countries with the longest coastline. Both these factors are clear evidence of the very large potential for wind energy in China which, according to a study conducted by researchers from Harvard University in the United States and the Beijing Tsinghua University in China, could be enough to do away with China's reliance on coal by as early as 2030. Estimates of China's potential

for wind power vary, none more than estimates that come from China itself —which is notorious for changing facts and misrepresenting data — but some have estimated that the People's Republic has around 2,500 GW, or 2.5 Terawatts (TW), of exploitable wind generation capacity on land and sea. In 2008, China was the fourth largest producer of wind power in the world, with an installed wind power capacity of 2.5 GW. In a story that we have grown to become familiar with as far as China is concerned, by the end of 2012, China became the largest producer of wind power in the world, its installed capacity growing at an average of 66 per cent a year to exceed the likes of the United States, Germany, and Spain. Currently, China has an installed capacity of over 75 GW, 15 GW higher than the United States, which is now the second largest producer of wind power in the world, with a capacity of 60 GW. In 2009, China had set itself the target of achieving an installed wind power capacity of 30 GW by 2020. Eight years before the deadline, it has already exceeded its intended target by 150 per cent. The revised target set by the Chinese government is an indicator of the kind of focus, drive, and determination China is intending to lay on the wind energy sector. After first revising its target to 100 GW which, based on previous history, China is expected to achieve in the next three or four years, the target for 2020 now stands at 150 GW of installed wind power capacity. The Global Wind Energy Council described this unprecedented surge of growth in wind power as "absolutely unparalleled" and many believe that China's focus on generating as much power as possible from this renewable resource could see a drop of nearly 17 per cent in its greenhouse gas emissions, which must come as a breath of fresh air for the people living in the Beijing smog.

A problem that has affected the bottom line of Chinese wind turbine and equipment manufacturers has been the problem of connecting the vast onshore and offshore wind farms with the nation's electricity grid. Despite an excellent feed-in-tariff scheme that has been in place since 2006, China has seen substantial problems in ensuring that the power generated on wind farms reaches the people it is intended to reach. Chinese policy on wind power helped instigate large scale investments in wind energy in the People's Republic, but bureaucratic and infrastructure related blockages are severely affecting the profitability of Chinese wind turbine manufacturers. Nevertheless, the percentage of non-connected capacity has seen a substantial drop from its peak at around 35 per cent in 2010 to

being closer to 20 per cent currently. Nevertheless this 20 per cent poses a severe problem to Chinese renewables as it implies that 15 GW of installed power is essentially being wasted and not utilized by Chinese industries and homes, both of which are hungrier than ever for energy. How China manages to ensure that this gap is closed and that connection delays are negated quickly will set the tone for the future of wind power in that country.

Nevertheless, the overall outlook for wind power in China appears to be extremely positive. A study by Bloomberg New Energy Finance indicates that wind and solar alone could constitute more of China's future energy mix than coal by 2030. What the rest of the world is particularly fascinated by when it comes to China's intense focus on wind power in particular, and renewable energy in general, is the impact it can have globally as a lesson. Currently, there have been a few successful examples of implementing renewable energy as a method of decentralized energy production in and around communities that utilize the natural resources of solar, wind, ocean, or biomass energy to generate power for their towns or villages. Following the July 2012 blackout across north India, stories abounded of how small rural hamlets that had been selected as pilot projects on creating decentralized energy solutions were enjoying the benefits of electricity while major Indian cities such as New Delhi, Chandigarh, Kanpur, and Gurgaon were plunged into the past. This seemed to give a positive sense of reinforcement to the idea that renewable energy can be best utilized through small scale adoption in communities through the idea of decentralization. The Indian government as well as the governments of countries such as the United States and Spain have heavily

incentivized small scale renewable energy production with the option of selling off extra electricity produced to the utilities grid at an attractive rate. This model has recently faced problems in California and Spain which, as a consequence of the economic recession and empty coffers, have found that this plan has become a bit too successful. As entire communities in both nations have become almost completely energy independent and are selling off large amounts of surplus generated power to their respective grids, utility companies in both nations are finding themselves at a loss, with fewer and fewer consumers to whom they can sell electricity, and more and more people from whom they are mandated by law to buy electricity at a price that they would find detrimental. This has led to unfortunate legislation arguments that could see the removal of subsidies for renewables and could de-incentivize the use of power generated by renewable sources for individuals and corporations alike. The electricity grid, which was first created in the era of oligarchical corporate empires in the nineteenth century, is designed on a large scale. It is not a design of economy — or as many people would argue, of sense — rather, it is intended to provide power to a large number of people in a top-down approach. The dichotomy between building a bottom-up model for generating power while keeping a top-down approach for transmitting it could severely influence the adoption and utilization of renewable energy in many countries which would face similar issues.

China, on the other hand, is staying true to its communist roots in its attempts to integrate renewable energy into its ever growing demand for power (electricity and otherwise). As 90 per cent of all wind power installed capacity is in the hands of entities that are directly or indirectly owned by the state, a large amount even for China, the approach that China is taking is to scale up its wind power generation to match the vast scale of its electricity grid. This could have significant repercussions around the world as China is in a unique position to showcase the way to integrate renewable energy, wind energy in particular, into its energy mix on a large scale. This lesson on large scale renewable energy production and distribution could then be replicated in countries around the world. In any case, just the fact that it can be done is a major victory for the renewable energy lobby who have for too long seen their ideas dismissed as impractical, and financially or logistically unfeasible. In many ways, China could be a paragon for large scale renewable energy in a

manner similar to how Japan showed the world that energy efficient, reliable, well-engineered, cheap cars are a possibility, a system that was then replicated in Germany, the UK, the United States, and most recently in China and India. What Toyota or Nissan did for the car, it is possible for China to do for renewable energy.

Hydroelectric Power

China's oldest and most substantial form of renewable energy is hydroelectric power generated by the streams of the many mighty rivers that flow in that country. Hydroelectric power already constitutes 22 per cent of the total installed capacity for electricity in China, and this figure is intended to be pushed up in the coming years. The May 2009 plan had first set a target of 380 GW of installed hydroelectric capacity by 2020, which was later revised to 430 GW. China added a further 16 GW of hydroelectric capacity in 2012 to increase its installed hydroelectric capacity of 240 GW, ensuring its dominant position as the leading producer of hydroelectric power in the world. China's overarching need for energy security and the concentrated efforts being made by the nation to ensure its independence from having to rely on fossil fuel imports make hydroelectricity a very attractive option for the Chinese. The reliability offered by hydroelectric power as compared to solar and wind also implies that it will be the preferred method of providing the people and industries of China with clean, renewable energy. The former Premier of the PRC, Wen Jiabao expressed this concern in early 2012, believing that China's energy needs could be served by investing in nuclear and hydroelectric power in addition to traditional renewables such as solar or wind. Six of the 20 largest hydroelectric power stations in the world are in China, including the massively controversial Three Gorges Dam, undisputedly the single largest hydroelectric power project ever undertaken, with an installed capacity of 22.5 GW in itself. In addition, China is currently undertaking a series of hydroelectric projects that will further entrench the country as the home of the large scale hydroelectric power project. The 12.6 GW Xiluodu Dam, the 6.4 GW Xiangjiaba Dam, the 5.9 GW Nuozhadu Dam, and the two Jinping Hydropower Stations with a combined projected capacity of 8.4 GW are a few of the numerous hydroelectric power stations that are expected to become operational between 2014 and 2018, making China's target of 430 GW in installed hydroelectric capacity by 2020 appear to be a done deal. The total potential capacity for hydroelectric power in China is estimated to be close to 600 GW, implying that despite being the largest hydroelectric power producer in the world, the PRC has still only utilized around 40 per cent of its potential. In comparison, in developed nations such as the United States, hydro utilization stands at 80

per cent, while Scandinavian countries have utilized as much as 90 per cent of their potential.

However, a major criticism of China's seemingly unstoppable hydroelectric expansion has been the callousness displayed towards the local environment. The Three Gorges Dam has been blamed for erosion, flooding otherwise fertile agricultural land, and destroying natural fishing areas and breeding grounds, as well as leading to the extinction of the Yangtze River Dolphin. Growing media attention and pressure from environmental groups and non-governmental organizations about the destruction these immense projects can cause to the natural habitat, and the issues being faced by refugees displaced by these large scale projects in urban resettlement areas have led the Chinese government to reflect more carefully on these issues in the construction of new projects. Or at least, so they claim.

Conclusion

China is currently the largest producer of renewable energy in the world, with a total installed capacity of over 800 GW, nearly 250 GW higher than the next highest ranked nation. Renewables constitute around 25 per cent of China's total installed capacity, up from 17 per cent in 2007, indicating a clear intent among the Chinese authorities to utilize their renewable resources as much as they possibly can. China's emergence as the dominant global superpower of the twenty-first century is not accidental; rather, it is the culmination of decades of meticulous planning and the execution of these plans. They have repeatedly fulfilled and exceeded expectations, surpassed their own targets, and have come to dominate the global economic landscape. The Twelfth Five-Year Plan for 2011 to 2015 is also significant as it highlights goals to prevent the escalation of climate change and to limit the emission of greenhouse gases, which China aims to do by revolutionizing the renewable energy landscape. The rest of the world waits expectantly to see what one of history's oldest civilizations, which gave us such inventions as paper, gunpowder, and silk, can do with solar and wind power. At the same time, it is essential for the Chinese authorities to understand that development comes at a price. It is critical for them to ensure that the damage done by constructing large scale projects — that would undoubtedly aid their economy and figuratively and literally enlighten the homes of many rural and urban Chinese — does not cause an equal amount of ecological destruction or come at the cost of ruining the lives of the people who are displaced by these projects. China is on the verge of a major renewable revolution. The Asian dragon is hungry for energy and is changing the way we view renewable resources in its effort to satiate itself. ■

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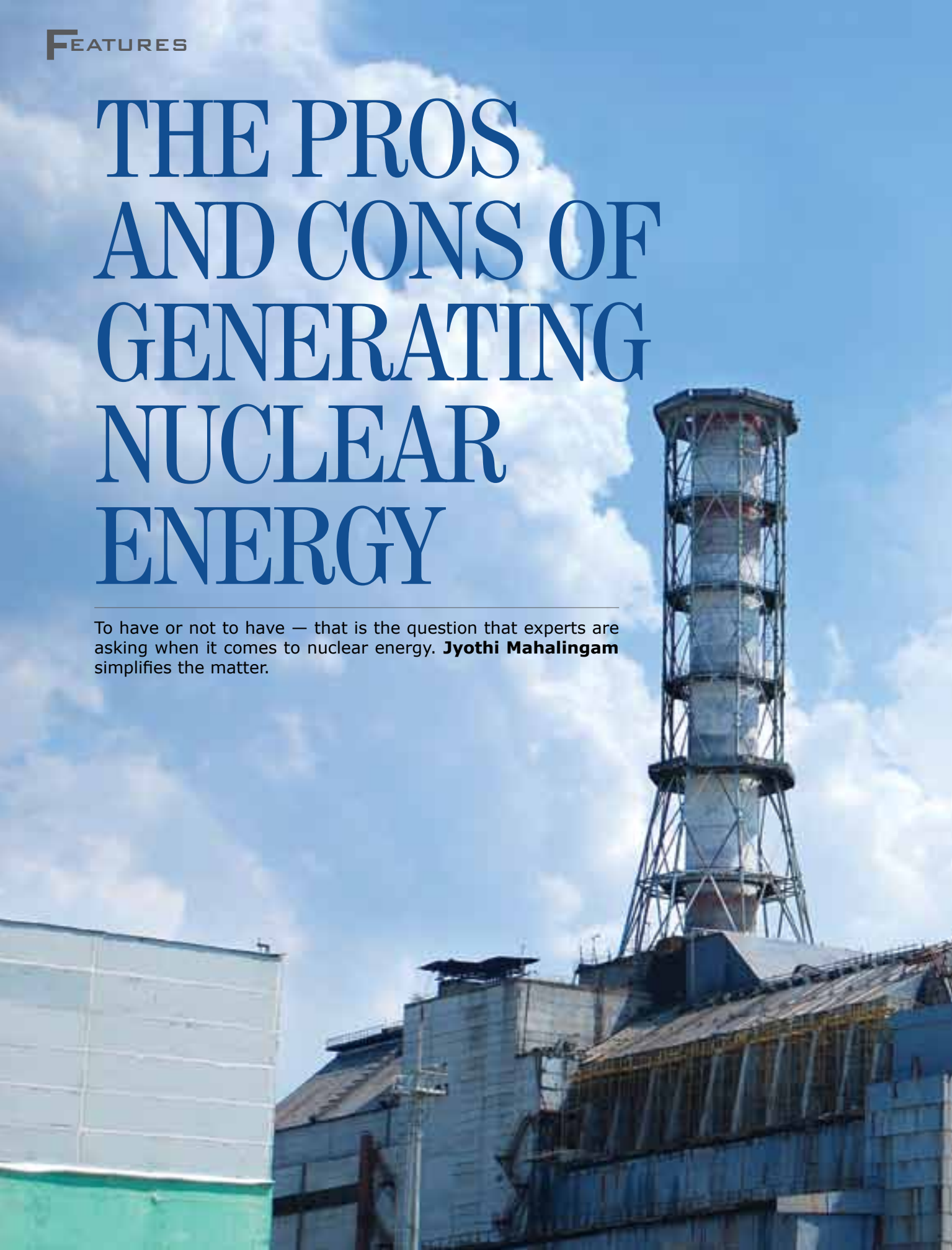
THE PROS AND CONS OF GENERATING NUCLEAR ENERGY

To have or not to have — that is the question that experts are asking when it comes to nuclear energy. **Jyothi Mahalingam** simplifies the matter.



The steady rise in global temperatures, which started in the last decade, continues to have an impact over the world. The Arctic Sea ice has shrunk to its lowest level when compared to the satellite records compiled in 1979. According to reports, about 3.4 million sq. km of ice-covered area was lost in this period. Reports warn that if we do not contain the present rate of global warming, we may soon face ice-free Arctic summers. The rise in global warming levels and changes in climate have also resulted in unexpected floods in India and Pakistan, droughts in East Africa, Australia, and Amazon, tropical cyclones in South East Asian countries, destructive hurricanes such as Katrina in the USA, and unprecedented heat waves in Russia and Europe. Increase in the levels of worldwide energy use and the consequent release of carbon dioxide is the main reason for such events.

The International Energy Outlook 2013 (IEO2013) report of the US Energy Information Administration (EIA) cautions that despite the worldwide laws and policies to curtail the use of fossil fuels such as oil, coal, and natural gas, our carbon dioxide discharges will rise by 46 per cent, from around 31 billion metric tonnes in 2010 to 45 billion metric tonnes in 2040. The report indicates that worldwide energy use will grow by 56 per cent between 2010 and 2040. In terms of British thermal units (Btu), it will rise from 524 quadrillion Btu in 2010 to 820 quadrillion Btu in 2040. The report quotes that fossil fuel alone will meet 80 per cent of the world's power generation needs by 2040. It also warns that the use of coal, especially by Asian countries led by China and India, will increase. According to the paper, the industrial sector will consume almost 50 per cent of such generated energy.

The report also predicts that renewable energy generation using wind and solar energy sources will go up by 2040. It estimates that wind energy alone will contribute 28 per cent of it. It forecasts that nuclear power generation will go up from the present 2.6 trillion kWh to 5.5 trillion kWh by the year 2040.

Nuclear Energy: How It Works

Nuclear energy is defined as a nuclear reaction, using a fission or fusion process, where the atoms of processed uranium or any other fuel will either split (fission) or combine (fusion) to generate a greater amount of heat energy. Einstein's equation $E=mc^2$ (E = energy, m = mass, c = speed of light) explains how the chain of a nuclear reaction produces large quantities of energy.

Unlike the usual thermal power generating facilities, which use fossil fuels to obtain the required thermo energy to produce steam and run power plants, nuclear power facilities use the heat energy released from atoms by means of nuclear fission.

In a nuclear power facility, uranium-235 or plutonium-239 is deployed as the atomic nucleus to undergo the nuclear fission process. When such an atomic nucleus ingests a neutron, due to fission, the atom splits into two or more smaller sized nuclei; this is accompanied by the release of a huge amount of mechanical energy. Such a process liberates the neutrons and produces gamma radiation. Some of these liberated neutrons join other fissile atoms to build a fission process to continue the release of more neutrons, thus creating a chain reaction.

Neutron moderators or neutron destroyers use heavy water, paraffin, and deuterium to control the chain reaction of atom splitting or the fission process. When such a reaction increases and becomes risky, to absorb the excess neutrons and prevent an explosion, control rods made of cadmium and boron are inserted

into the reactor core. The level of insertion of such rods is controlled from outside using either manual or automatic systems.

Thermal energy released during the fission process is transferred from the reactor to the water kept in the heat exchangers using coolants such as liquid sodium. The steam generated in the process is then utilized to run the turbines and produce electric power. A very thick concrete shield fully encloses the reactor to prevent possible harmful radiation going outside.

Types of Reactors

In nuclear power generation, the type of reactor and its construction design is normally decided by the type of fuel pellets to be used, moderator material, control rods, coolant fluid, pressure vessel or pressure tubes, and the steam generator.

- ***Pressurized Water Reactor (PWR)***: The reactor, deployed in countries such as the US, France, Japan, Russia, and China, uses enriched UO_2 as fuel and water for both coolant and moderator purposes.
- ***Boiling Water Reactor (BWR)***: Countries such as the US, Japan, Sweden, and India use BWR reactors. Enriched UO_2 is used as fuel in the reactor while water is deployed both as a coolant and moderator.
- ***Pressurized Heavy Water Reactor 'CANDU' (PHWR)***: Canada and India have deployed PHWR reactors. The reactor uses natural UO_2 as fuel and heavy water for cooling and moderation purposes.
- ***Gas-cooled Reactor (AGR and Magnox)***: This reactor, that uses either natural uranium metal or enriched UO_2 as fuel, is found in the UK. The reactor uses CO_2 as coolant and graphite as moderator.
- ***Light Water Graphite Reactor (RBMK and EGP)***: The reactor, deployed in Russia, uses enriched UO_2 for fuel, water as coolant, and graphite as moderator.
- ***Fast Neutron Reactor (FBR)***: The reactor, commonly found in Russia, uses both PuO_2 and UO_2 as fuel, liquid sodium as coolant, and does not use any moderator.

Refuelling a Nuclear Reactor

Most of the reactors shut down the power generation process for refuelling purposes once every one or two years. Up to one-third of the fuel fabrications (rods) are substituted by fresh ones. Most of the reactors use enriched ceramic uranium oxide (UO_2) as fuel. The fuel pellets, measuring 1.5 cm in length and 1 cm in diametre, are fixed up in an orderly manner in a long zirconium alloy (zircaloy) tube known as the fuel rod. Zirconium is used for its robust, corrosion resistant, and neutron diffusive qualities. In BWR reactors, nuclear 'poisons' such as gadolinium are used in the coolant or fuel to neutralize the performance of the reactor during the refuelling process.

Lifetime of Nuclear Reactors

Nuclear reactors working in most countries were designed to generate power for a period of 30 to 40 years. However, considering the huge investment and the years needed to build and commission new reactors, the life span of the existing reactors is being extended.

For extending the working lives of the reactors by another 20 years, the worn-out, degraded, and corroded components are regularly replaced. According to the type of reactor, the steam generators or pressure tubes are put back with new parts with a considerable level of investment after 30 years. Wherever possible, the old analogue instruments and

control systems are upgraded to the latest digital monitoring to improve functional safety.

Every reactor maintains a complete database of all records, right from the design, construction, commissioning, and regular safety reviews. It also updates its plant design records even for small modifications in the design of the plant. The engineers working at the reactor sites share and update their knowledge for the efficient, economical, and safe working of the reactor.

Present Scenario

Global Outlook about Nuclear Energy

Prior to the Fukushima Accident

The partial nuclear meltdown which took place in one of the nuclear reactors at the Three Mile Island site in the USA on 28 March 1979 was the first widely known nuclear reactor accident. The escape of a large amount of nuclear reactor coolant caused the problem, but the problem was brought under control soon. The submitted report did not find alarming levels of radiation which could cause cancer.

The disaster that occurred at the Chernobyl nuclear plant in Russia on 26 April 1986 was one of the worst accidents in nuclear power generation. Fire and explosion took place at the reactor, which used a graphite moderator. A large amount of radioactive particles escaped into the air. The number of deaths reported and the quantity of radioactive materials released into the air still remains a disputed fact.

Despite its known ominous attributes and the incidents which occurred, power generation using nuclear energy was growing at an even pace. The increasing level of climate change and dwindling energy resources had prompted more countries to look at nuclear power generation along with renewable energy sources as a viable alternative to fossil fuels. In fact, the generation of nuclear energy was considered the cheapest, fastest, and most complete solution to end our dependency on oil, gas, and coal power generation.

A number of countries unveiled plans to build nuclear reactors and generate power. Even Japan, which suffered a fire accident due to a magnitude 6.6 earthquake on 16 July 2007 at its Kashiwazaki-Kariwa reactor, announced plans to build eight more reactors on 30 March 2010. The Country wanted to increase its nuclear power generation from 49 GW to 60 GW by the year 2020. China and India also announced their plans for nuclear power generation expansion, thus making Asia the nuclear powerhouse of the future.

After the Fukushima Mishap

The 9.0 Mw Richter scale earthquake which occurred off the coast of Japan on 11 March 2011 set off very powerful tsunami waves measuring up to 14.5 metres in height and moving up to 10 km inland. The waves enveloped Japan's Fukushima Daiichi Nuclear Power Plant and submerged it in 43 feet high walls of water, pulling down its cooling system which resulted in reactor meltdowns. Unlike the Chernobyl reactor that suffered an accident due to human as well as reactor construction errors, the Fukushima reactors, which suffered a natural calamity, were advanced and their design was widely used all over the world.

Though most countries considered the Fukushima accident to be a very rare natural case, it has certainly been a setback to the global nuclear power generation programme which was being revived after the Three Mile Island and Chernobyl accidents. Germany was the first to announce its decision to phase out its nuclear power generation facilities. Switzerland wants to put an end to its nuclear expansion programme and Italy voted against its usage. The other countries though did not withdraw their support for the use of nuclear power; instead they slowed down the execution.

The nuclear reactors in countries under the European Union (EU) underwent stress tests after the Fukushima incident. The authorities tested the reactors' capability to deal with no power and no coolant conditions and submitted reports for immediate improvement.

Nuclear Reactor Power Rating

The power output in a nuclear reactor is measured in three modes:

- ***Thermal MWt***: Depending on the design of the nuclear reactor, the amount of steam released and its quality is rated in thermal MWt
- ***Gross Electrical MWe***: The power generated by the connected steam turbine and generator under cooler and warmer conditions and their average is known as gross electrical MWe
- ***Net Electrical MWe***: The final output of power that goes to the grid after deducting the electrical power used in running facilities at the reactor such as coolers, feeder water pumps, and the other plant works

Disadvantages

The Fukushima reactor meltdown gave enough ammunition to those who oppose nuclear power generation. The news on more radiation leaks

at the site increased the intensity of the argument. Environmental groups also argued that more support for nuclear energy by the lobbyists would divert much-needed investment from renewable energy generation.

Nuclear Radiation: The nuclear power reactors or breeders use uranium for generating power. During the chain reaction process, they release plutonium — a harmful byproduct not found naturally on earth. The atoms of plutonium take thousands of years to decay and keep emitting radiation till it becomes a non-radioactive element. Though external exposure to plutonium or eating plutonium contaminated food does not create a serious health risk, its inhalation poses all the risks. The lungs absorb the chemical form of plutonium and send it into the bloodstream. The blood, passing all through the body, exposes tender tissues to radiation, leading to cancer. Nuclear reactor meltdowns are found to release most of the nuclear radiation present in the atmosphere.

Radioactive Waste: The burnt out fuel rods of nuclear reactors are highly dangerous to handle and require a specific type of storage to prevent radiation leaks. The spent rods that contain radio isotopes release radiation for thousands of years and make the water and earth highly polluted. The rods are thus stored in thick concrete chambers constructed at a high cost to prevent any pollution. The plutonium waste available in such stored rods also creates a scare about their misuse for making nuclear weapons. It is also feared that the mining of uranium exposes the workers to radiation.

Nuclear Accident: Despite the fact that a number of safety measures were introduced after the Chernobyl incident to prevent such accidents, the recent Fukushima reactor meltdown due to the tsunami has eroded public confidence. Even a low-level radiation leak can result in damaging effects and cause fatigue, diarrhoea, vomiting, and nausea. In extreme cases, evacuation of people from their living places is required, and damage to crops and contamination of drinking water can occur. In some cases the increased level of radiation during such accidents makes more people suffer from radiation related cancer.

High Cost and Long Years of Construction: Nuclear reactors act as high level reservoirs of centralized power generation. Setting up a nuclear power reactor needs very big infrastructure and a high level of investment. The construction of a nuclear power plant normally requires 5–10 years for completing and commissioning the facility. Most of the existing nuclear power generation facilities were completed after winning long legal battles against public opinion. The high cost often prevents developing countries from opting for nuclear power generation.

Availability of Nuclear Fuel: Though uranium is mined in a number of countries, good quality uranium is available only in a few countries of the world. Its scarce availability and increased costs of mining and purifying make the process all the more complicated and expensive. Australia and Canada lead the uranium production table, followed by the countries from the former Soviet Union and China. Unlike fossil fuels, the countries that produce uranium do not part with it unless they are satisfied that it will be used for peaceful purposes.

Advantages

Extraordinary Energy Output: The Uranium-235 used in nuclear power reactors offers phenomenal energy output. It is estimated that one kilogram of uranium-235 generates the same level of energy produced by 1,500,000 kilograms of coal. The power generated from nuclear energy is said to be a million times more than a fossil fuel facility of the same size. The remarkable energy generation quantum of nuclear power makes it fit to use in aircraft carriers, submarines, and space shuttles. Even the Mars rover Curiosity uses nuclear power to probe the red planet.

Environmentally Friendly Power Generation: Nuclear power generation, unlike fossil fuels, emits very negligible levels of greenhouse gases such as chlorofluorocarbons, methane, and carbon dioxide. A research result released by the National University of Singapore discovered that nuclear power generation during its lifecycle

emits only 66 grams of carbon dioxide equivalent per kilowatt hour (gCO_2), while the gas powered plants release 443 grams and coal plants emit 960 grams of gCO_2.

Controlling CO_2 Emissions: According to a NASA report, nuclear power generation forestalled the entry of around 64 Giga tonnes of carbon dioxide from entering into the environment from 1971 to 2009. Such power generation also stopped the construction of a number of power plants that use coal power. It is estimated that halting nuclear power generation will increase CO_2 emissions by 370 million tonnes by the year 2020.

Energy Security: Nuclear facilities use only a small measure of uranium fuel. The available uranium reserves are estimated to last for another 100 years or more. The available technology processes to purify the uranium available are improving in most of the countries. Such an improvement is anticipated to assure continuous availability of fuel, thus making nuclear power generation a secure and lasting option.

Fewer Tragedies: While the cancer death toll of both the Chernobyl meltdown and the Fukushima disaster was within 15,000, a report released in 2010 by the Clean Air Task Force, a Boston, USA based agency, indicates that around 13,200 Americans die of coal pollution every year. Coal mine related accidents and pollution related deaths from other countries are not known or recorded.

The Future of Nuclear Energy

Deep rooted feelings about the risks of nuclear power generation and fear of the long term effects of radiation have affected the growth of nuclear energy. The fewer number of reported deaths and the news about reducing levels of radiation contamination at the Fukushima site have brought cheer to the nuclear lobbyists. The industry

is also moving in the right direction by improving reactor designs to make nuclear energy production a viable alternative. The issue of radio waste disposal is receiving priority attention and long term disposal ideas are at various levels of implementation.

The International Thermonuclear Experimental Reactor (ITER) research being conducted in France is trying to use fusion power instead of fission. A number of countries such as the United States, Russia, the European Union, India, China, Japan, and South Korea have shown interest in the project and given consent to make the required investment. In the fusion process, two atomic nuclei are joined together to make a new nucleus. The process uses deuterium, which is commonly found in sea water, as a fuel. It is anticipated that the success of the fusion power generation experiment minus the effects of radiation will give the much needed thrust to nuclear power generation.

Even the countries that have announced their intention to stop nuclear power generation after Fukushima are giving a second thought to nuclear energy considering the long-term effects of using fossil fuel generated power and the resulting pollution. ■

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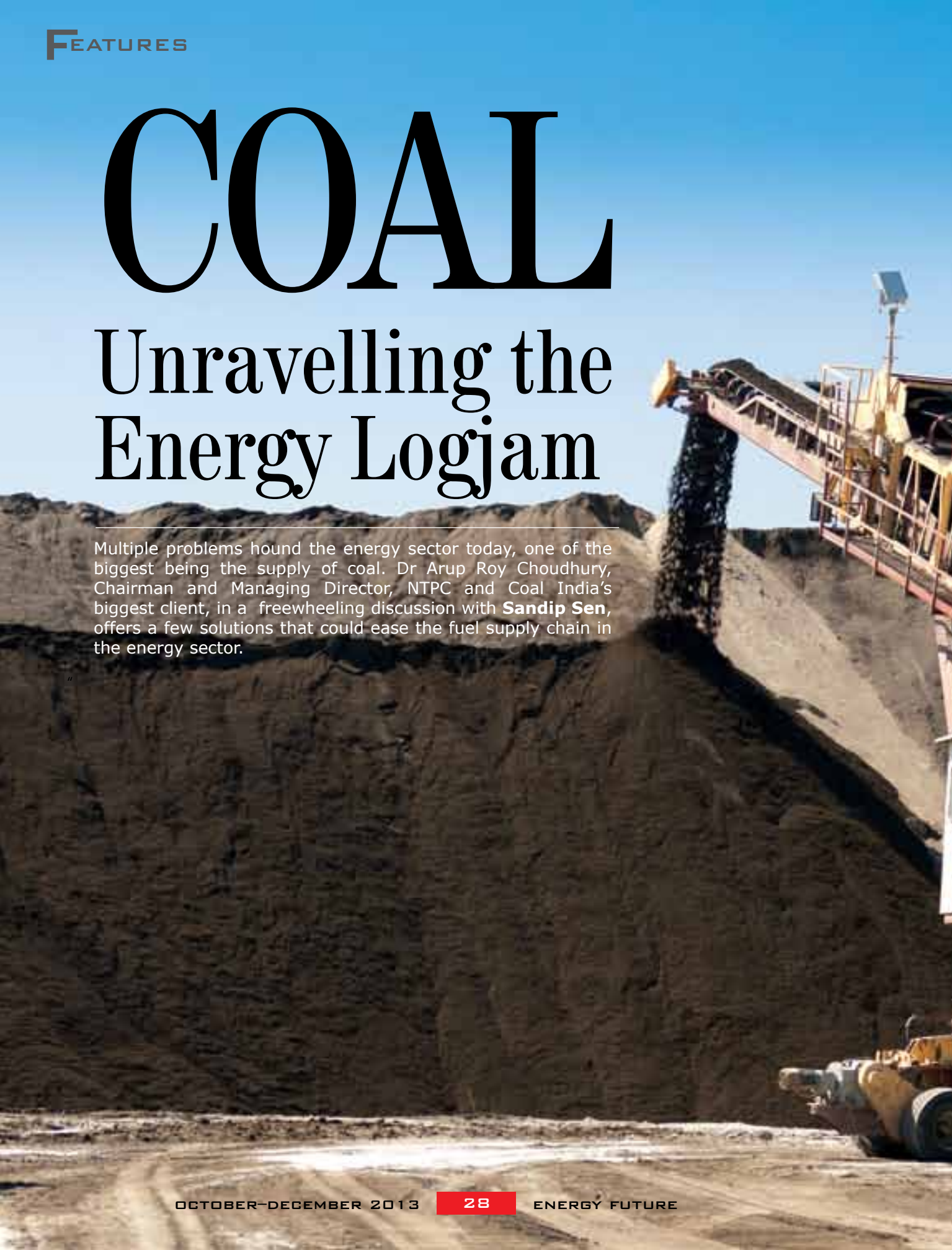
COAL

Unravelling the Energy Logjam

Multiple problems hound the energy sector today, one of the biggest being the supply of coal. Dr Arup Roy Choudhury, Chairman and Managing Director, NTPC and Coal India's biggest client, in a freewheeling discussion with **Sandip Sen**, offers a few solutions that could ease the fuel supply chain in the energy sector.



We are all for an independent coal regulator, one that operates outside the jurisdiction of the Ministry of Coal, responded Dr Arup Roy Choudhury, Chairman and Managing Director of NTPC, when confronted with the fact that a coal controller already exists in the Ministry since 1916. "We want coal to be priced as per its quality and that can only happen if an independent certifying authority exists that checks the various grades of coal coming out from the different mines and prices them according to the calorific value, giving due credit to the mine developer for capital invested."

The power major has possibly a valid grouse, for Coal India Limited (CIL) has revised prices once again on 28 May 2013, at a time when international coal prices have fallen. The move gives CIL a revenue boost of over Rs 2,500 crore (Rs 25 billion), and hits power producers who buy lower calorific value coal, where the increase is over 11 per cent. The coal monopoly has raised prices despite its very high post tax profit margin of 25 per cent, at Rs 17,356 crore (Rs 173.56 billion) on net sales of Rs 68,302 crore (Rs 683.02 billion). Though mine output rose by just 3.8 per cent last year, its net profit jumped by 9.4 per cent, largely due to a previous price hike in February 2011. "Volatility in coal prices ultimately affects the consumers who need to be protected. This apart, private sector mining leases too may soon be a reality. India has been talking about pricing coal correctly for more than a decade and a third party regulator is needed now as a solution to the problem", said the NTPC Chief.

CIL Fails to Deliver to Both Power and Steel Sectors

Quality, quantity, and the fair pricing of coal have become major issues that are now affecting both India's energy

security and Forex reserves. Coal shortage has led to the current crisis that has forced generating plants across India to cut back on production. On the issue of quality, the major offenders are Bharat Coking Coal Limited (BCCL) and Eastern Coalfields Limited (ECL), both fully owned subsidiaries of CIL. BCCL is mandated to produce and supply high gross calorific value (GCV) metallurgical coking coal to the steel producers and low GCV coal to the power producers. It has failed to raise its output of washed coking coal, as a result of which almost two-fifths of the coking coal used by steel plants in India is imported. In its revised draft National Steel Policy 2012, the Ministry of Steel has proposed that BCCL should be de-merged from parent firm CIL and its idle mines should be offered to home-grown integrated steel plants for commercial exploitation, with suitable terms and conditions.

The problem is equally severe with BCCL supplies in the low GCV coal bracket for the power plants. When coal quality became extremely poor, NTPC had refused to take delivery of poor quality coal citing very low calorific value and high stone content as the major issues. Later they made payment to BCCL as per GCV analysed at the power station. "We are fairly certain that NTPC's demand of having coal with GCV 3,100 as a minimum benchmark will be adhered to and third party testing will be agreed on", said Dr Roy Choudhury. "We are only asserting our rights on ethical issues as we must get the quality promised at the right cost. After all, we pass on the costs to the discoms and ultimately the consumer bears the brunt." CIL, after initial resistance, has finally offered corrections for oversized stones in the revised Fuel Supply Agreement (FSA) which has been now signed after NTPC took the tough stand to ensure quality supplies.

Politically Supported Mafias Make BCCL Sick

BCCL operates 81 coal mines; half of them being underground and the balance a combination of open cast and mixed mines. They recorded an output of 30 million metric monnes (MMT) in 2012. It is in the coal fields of Raniganj and Jharia that the Dhanbad based mining mafia operates, controlling the BCCL unions and transport systems, bribing the officials, the police, the politicians, manipulating coal auctions, stealing from mined output, and even replacing the stolen coal with stones and non-combustibles. Workers pay the mafia bosses to enter the unions run by them that control the jobs, and are then manipulated into stealing coal both from inside the mines and during transportation. Mafia-run coal depots within BCCL premises procure coal from the poor workers who shovel up bagfuls of coal from the open abandoned mines. These are then sent outside the mines by trucks right under the noses of CIL officials and armed guards.

Gang wars for turf control usually hit the headlines when high profile shootouts take place, such as the killing of mafia don Suresh Singh in December 2011 by Sashi, the son of Dhanbad Mayor Indu Singh belonging to a rival family called the 'Singh Mansion'. Suresh Singh, who fought and lost

elections twice on a ticket of the Indian National Congress to Kunti Singh of the BJP, Sashi Singh's aunt, had broken into the stronghold of the Singh Mansion, wresting control of some unions and auctions at BCCL. Dhulu Mahto is another powerful tribal mafia don who today controls the unions of contract workers and unorganized labour and rules over nearly a third of the BCCL mines where flash strikes have become a growing trend. Over the years the coal mafia with the help of politicians and leaders of the workers' unions have bled BCCL dry. It is estimated that a third of the BCCL output is pilfered and stolen and sold in cash by the mafia to the hundreds of boilers, foundries, and forging units that operate furnaces in Bihar, Jharkhand, Bengal, and Uttar Pradesh. Not surprisingly, BCCL, the only company which has enough mines to produce high value metallurgical coal that could make it India's most profitable mining company, was ironically declared sick in 2009.

CIL Goes Back on Commitment of Washeries

CIL wants to get the benefit of high prices but not by investing in washeries that improve quality, say clients. During the 11th Five-Year Plan, BCCL and CIL proposed to set up seven washeries for coking coal and 13 for non-coking coal to improve coal quality based on the public–private partnership programme. None of them have been set up even though private bids from McNally Bharat, TRF, and others were received well in time. Minister of State for Coal Mr PP Patil blamed environmental clearance for the delay in a written reply to Rajya Sabha last year. The truth could be just the opposite as the Ministry of Environment and Forests (MoEF) has restricted the use of coal containing more than 34 per cent ash content in power stations located 1,000 km away from pit heads, and only washeries can prevent that.

Confronted with proof of non-performance on setting up washeries, CIL Chairman and Managing Director Mr S Narsing Rao said at a Mumbai press meet during May 2013, "Academicians, technology suppliers, and contractors are talking about it but I can frankly say [that] since I became chairman, no consumer has demanded washed coal. We are a consumer-centric and not [a] supplier-centric company. We treat this as a business proposition; if it makes sense from the business point of view, then yes; otherwise, we are not wedded to anybody's idiosyncrasy." The NTPC Chief confirmed that they had on several occasions asked CIL in writing for supply of washed coal for their Badarpur and Dadri plants.

Imports are Hurting the Economy

Low output from CIL mines has caused large scale import of coal, resulting in a huge outflow of foreign exchange. The International Energy Agency (IEA) says that India's coal imports have trebled during the last decade leading to imports of over US$ 1.5 billion annually in a country that boasts of reserves of 286 Billion Metric Tonnes of coal, the fifth largest in the world. NTPC, CIL's largest customer, got a delivery of 130 million metric tonnes (MMT) against its requirement of 175 million metric tonnes at 90 per cent plant load factor last year. "We need to produce more coal than we can consume instead of importing coal", opined Dr Arup Roy Choudhury, a doctorate in Performance Assessment of Infrastructure Development Projects from IIT Delhi. In coal we have a resource that may lose its relevance in the next twenty years as the fuel consumed by energy plants could change. There is no point in sitting on over fifty years' reserves and importing coal today.

Mining Approvals Take a Decade

NTPC has had to import coal and may have to keep doing so in the future as the CIL mining output is growing at just 3 to 4 per cent. "We want Coal India to increase supplies at least for the next five years till our own captive mining and other private sector mining bear fruit. Both captive mining and private sector mining needs to be encouraged", said Dr Roy Choudhury, explaining that the gestation period of captive mining projects is too long due to capability assessment and regulatory clearance. NTPC has been allotted six coal blocks, namely, Pakri-Barwadih, Chatti-Bariatu, Chatti-Bariatu (South), Kerandari, Dulanga, and Talaipalli. These coal blocks have a production potential of 53 Million Tonnes Per Annum (MTPA) which can cater to around 10,840 MW, a quarter of NTPC's current coal-based generation capacity. The first of these captive mines at Pakri-Barwadih will start production from next year, said Dr Roy Choudhury, and confirmed that the coal output to be provided by the mine development operator Thiess of Australia would be washed and crushed coal at 50 mm size. The approval process for mines is long today and could be reduced if there are more professional agencies involved in the investigation stage, he said, citing that the Central Mine Planning and Design Institute (CMPDI) is the only agency today that handles that job. From exploration to mining plan approval, the process takes more than three years today depending on the site. The next step is the environment and forest clearance that also takes over three years after the mining plan is finalized. The land acquisition process takes another three to five years, including various notifications, land rate finalization, conducting Gram Sabha, rehabilitation plan approval, and so on. The appointment of the Mine Development Operator through competitive bidding takes another two years after the mining plan is approved and cost estimates for the project worked out. Thus the time span before the start of a mining project today is a good 10 years plus that

needs to be rationalized. "Although mining is not our core business, we are willing to do it only to find solutions to supply problems", said the NTPC Chief, "and we even have a joint venture company with CIL to take us through the learning curve."

Poor Output: Over 24,000 MW of thermal generation capacity has already been added during the last five years that is yet to get coal linkages or supplies. Existing clients including the PSUs SAIL and NTPC are also not being given full supplies. Production at CIL has stagnated during the last five years leading to a sharp rise in imports. In the financial year ended March 2010 the total coal output from CIL was 431.26 MMT that marginally increased to 431.32 MMT next year and 435.84 MMT in FY 2012. As per the IEA, nearly 130 MMT of coal is being imported to India annually and imports could rise to 500 MMT by 2015 when 60,000 MW of capacity is due to be added.

Quality and Environment Norms Ignored: There have been consistent complaints from the power and steel sectors about poor quality of coal with low calorific value, excess moisture, and high non-combustibles. Private sector clients say that CIL treats them as second class citizens. The mining done at CIL is crude and unscientific, and with little regard to the environment. Around 239 mines out of the total 470 operate without environmental clearance, but nobody can stop the monopoly producer because there is an acute shortage of coal.

Inadequate Investment: Despite sitting on a huge pile of cash exceeding Rs 100,000 crore (Rs 1,000 billion), there is no effort to mechanize coal production, screen supplies or wash coal before deliveries. Indian coal has a high percentage of shale, rock, and non-combustibles, in some mines up to 45 per cent. In absence of benefaction of coal, this non-combustible portion is also carried by the railways resulting in higher transport costs that could be reduced by at least 20 per cent. Apart from this, unwashed coal produces higher bottom ash as well as fly ash content that raises the operational costs of power plants. Even the PPP projects for coal washeries have not been implemented by CIL.

Low Efficiency: CIL, which employs 355,608 people and has 302,293 blue collar workers in its staff, has one of the highest manpower to coal output ratios in the world, almost five times that of a mechanized mine in Australia. Coal is still carried in open trucks and open trains out of the mines resulting in high pilferage. An efficient leak proof supply chain needs to be developed but the CIL, being a monopoly, washes its hands of the problem by saying that coal outside the mines is not CIL's responsibility. As a result over 15 per cent of the coal produced is lost in transit due to pilferage alone and customers foot the bill.

Coal Mafia and Corruption: The coal mafia rules with the connivance of CIL officials and political parties in every mine, though its effect in BCCL is most highlighted. Ever since nationalization of coal mines in 1973, things have gone from bad to worse, with output falling behind demand and pilferage from mines increasing each year.

Solution: One of the easiest solutions is to break up the eight CIL subsidiaries into independent entities and make them compete against each year. Instead of doing this the Government sets up an expert committee whenever they come under pressure and waits infinitely for the report. Since the reports arrive after months of investigations and consultation by which time the crisis has moved out of the lime light, the findings of the expert committees are shelved and it is back to business as usual. The Government needs to quickly take the first step of making each subsidiary autonomous, something that is simple from the administrative point of view. ■

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FRACTURED HOPES?

A Look at the Shale Gas Revolution

What lies beneath has long been the mantra of private and government oil and gas production companies all over the world. Ever since the industrial revolution, human beings have exploited the earth's resources to fuel and sustain the idea of human development. The primitive humans relied on food and sunlight for energy. The age of the agricultural humans saw the use of wood and animals in addition to food and sunlight to create energy. With the advent of the steam engine, the industrial age was heralded, and humans discovered the potential of coal, gas, and oil. It is these three sources of energy that have primarily fuelled the development of human civilization to the level at which it exists now.

However, growing environmental concerns about the use of these fossil fuels have pushed humanity to look for other more sustainable sources of energy. In the last two decades or so, there has been an increase in the application of renewable energy sources, such as wind, solar, geothermal, and nuclear energy. Though these resources substantially reduce CO_2 emissions worldwide, they haven't been able to meet the increase in energy demand. There is a need to find an energy resource that can support the growing global trend for energy consumption. According to the International Energy Agency (IEA), the global energy use increased by 23 per cent between 1990 and 2005 (Worldwide Trends in Energy Use and Efficiency, 2008). The report also goes on to indicate that the increase in consumption was most notable in the transport and service sectors. To feed the current global economy, which relies heavily on transport, there is a need to find an energy resource that lets the big players have their cake and eat it too.

Natural gas has recently taken centre stage as probably being the sustainable energy source that will let business go on as usual. According to a joint report by Eurogas and the International Gas Union, "With its low carbon emissions compared to other available fossil fuels, natural gas provides a solution to the world's economic and environmental challenges in a secure and sustainable way" (The Role of Natural Gas in a Sustainable Energy Market). The report goes on to indicate that natural gas leaves a substantially lower carbon footprint when compared with oil and coal, and results in less air pollution. Global support for natural gas has increased over the course of the last decade, and, as of 2010, this energy resource makes up about 23.8 per cent of worldwide energy consumption.

Lauded by oil and gas corporations as well as governments being the answer to the dilemma of industrial growth and environmental safety, the use of natural gas is set to rise, according to the US Energy Information Administration. However, there have been several environmental concerns raised by activists and organizations as to the sustainability of the production of natural gas.

What is Natural Gas?

Natural gas is defined as a flammable gas that comprises mainly methane and other hydrocarbons and occurs naturally under the earth's crust. It is classified as a fossil fuel because it is made from the remains of animals and plants that were exposed to intense heat and pressure for thousands of years. There are different types of natural gas, but it is mainly divided into two categories: conventional gas and unconventional gas.

Conventional gas is found in permeable geological formations, usually sandstone or limestone, under the earth's surface. This type of gas is normally found along with petroleum or oil, and has been extracted by oil and gas companies ever since such explorations began. It is easier and more economical to obtain.

Unconventional natural gas is tougher to extract. It is generally found deeper under the earth's surface and is trapped under impermeable rock, such as shale. There are different kinds of unconventional gas, including shale gas, tight gas, and deep natural gas. To access this type of naturally occurring gas, techniques such as hydraulic fracturing, or 'fracking', and acidizing are required. These processes are typically expensive.

In the recent years, unconventional natural gas explorations have been encouraged around the world, with governments and oil and gas companies seeking to dig deeper (pardon the pun!) to solve the global energy crisis. Shale gas has emerged as the new focus of such efforts, with several shale deposits discovered around the world.

Shale Gas

Shale gas is natural gas that is found in shale rock formations. One of the toughest geological formations, shale is a fine grained rock that is formed by the accumulation of sediments at the earth's surface or under water. This type of sedimentary rock is highly impermeable, and the natural gas can be trapped between layers of shale. The gas can be accessed either by the process of horizontal drilling or hydraulic fracturing known as 'fracking'.

What is Fracking?

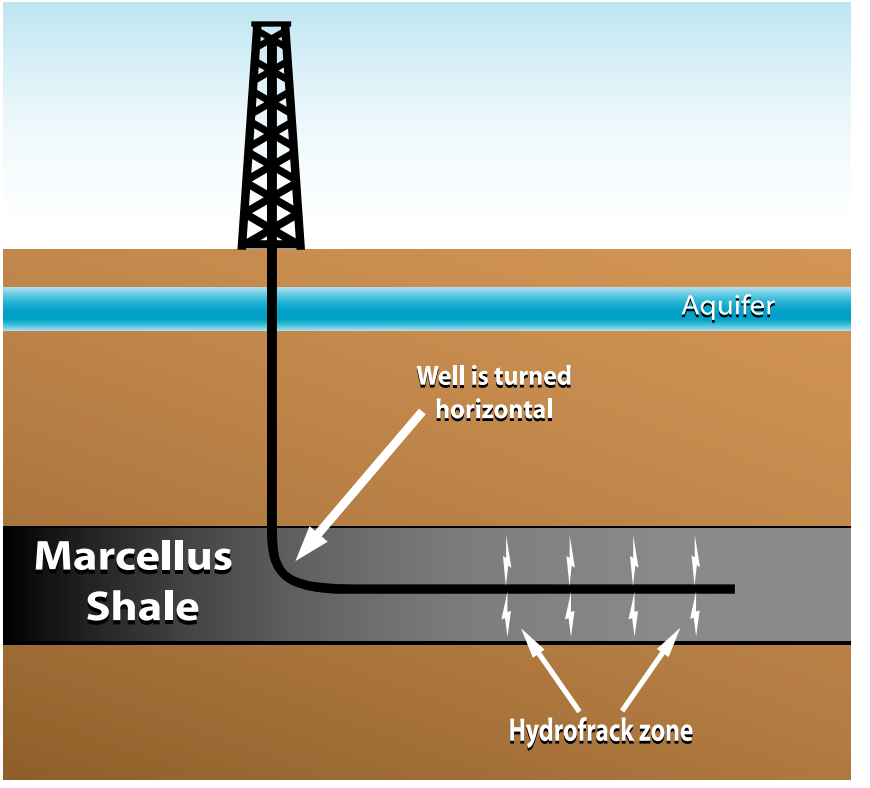
Hydraulic fracturing or fracking is a process that allows gas companies to create fissures or 'fractures' in shale formations that allow natural gas to flow to the surface, where it is captured. First, a vertical well is drilled into the earth, which is then expanded horizontally along the gas-rich shale rock. After this, a mixture of water, sand, and chemicals is inserted through the well at high pressure, which creates cracks or fissures in the rock. The gas, which is released by the fracturing, flows into the pipes and is collected in the well at the surface. The chemicals used in this process differ from country to country, depending on the regulations. In the United States, where this method of extraction has received publicized scrutiny, some of the chemicals used are hydrochloric acid, methanol, ethylene glycol, benzene, and lead.

The United States of America is leading the cause for shale gas exploration. Last year, President Barack Obama claimed that the country had a supply of natural gas that "can last

America nearly 100 years." He also said that the process of fracking could "create more than 600,000 jobs by the end of the decade."

Besides the US, fracking has been explored in numerous other countries, including the United Kingdom, New Zealand, the Netherlands, Canada, Australia, and Argentina.

In the last few months, there have been protests that have erupted across the world against fracking. Recently, the UK saw protests against drilling explorations by the company Cuadrilla Resources in the town of Balcombe over issues of environmental safety. The result: the company stopped its exploratory fracking. Similar uprisings have been reported across the world, including in Argentina, New Zealand, and the United States. But why is hydraulic fracturing considered environmentally unsafe?



Fracking and the Environment

According to a report published by the Environmental Protection Agency (EPA) of Ireland, among the environmental concerns of fracking are "earthquakes induced by slip on nearby faults; contamination of groundwater, and possibly of drinking water, with natural gas and other chemicals; emissions of volatile components, such as CO_2 and methane, into the atmosphere; and the leakage of drilling waste fluid from storage ponds" (*Hydraulic Fracturing or 'Fracking': A Short Summary of Current Knowledge and Potential Environmental Impacts*, July 2012).

One of the key issues that have received public attention is that of groundwater and drinking water contamination due to fracking. This can happen either due to contamination by the injected fluid or the out-flowing natural gas. The EPA Ireland report further goes on to say that most documented studies show that the contamination is due mostly to "poor well casings and their cements, or from leakages of fluid at the surface." Another source of contamination, the report states, can be a 'blow out', which is the consequence if the inserted, high pressure chemical-water fluid does not fracture the intended rock bottom, but instead blows out into other 'boreholes', such as drinking water wells. There have been reported cases of blow outs in the US states of Texas, Louisiana, Ohio, Pennsylvania, and Colorado. The Environmental Protection Agency of the United States is in the process of reviewing the impact of fracking on drinking water resources. Its study, according to its website, will be released in 2014.

Another important issue that environmental groups have raised is the sourcing of water for the hydraulic fracturing process. According to a study by the Massachusetts Institute of Technology, a shale gas well can use between 90,000 and 13,500,000 litres of water over its lifetime. This vast variation is partly because any particular well may be drilled or explored numerous times, depending on the reserves of natural gas underneath. These statistics are limited to the operation of gas wells in the United States, which is a country that, for the most part, does not suffer from large scale water scarcity. However, this number can have different significance for countries such as India which face the issue of water scarcity.

India and Shale Gas

With an increasing population and limited natural resources, India faces the challenge of meeting its energy demand. According to the figures released by the Ministry of Petroleum and Natural Gas, the country's energy demand is set to reach around 140 billion cubic metres (bcm) in 2013–14, while the production of natural gas for the same year is set to be around 40 bcm. To meet its energy requirement, India primarily relies on coal, which accounts for 37 per cent of its supply. However, since the 1970s, the Government of India

has been harnessing the natural gas deposits that were discovered off the western coast.

Till the late 1990s, natural gas exploration and production was mainly the prerogative of government owned companies, such as the Oil and Natural Gas Corporation (ONGC) and Oil India Limited (OIL). In 1997–98, the government introduced the New Exploration Licensing Policy (NELP) that allowed private and foreign companies to participate. This permitted companies such as Reliance Industries to become involved in the production of natural gas.

Now, with the success of shale gas explorations and production in the United States, the Indian government is keen on getting started with the same. According to the US Energy Information Administration, India has about 96 trillion cubic feet (tcf) of recoverable shale gas. This has prompted the Indian government to start exploring the possibilities of using shale gas to fill the increasing gap between demand and supply. A report by Ernst & Young revealed that for the financial year 2012, the Indian government had to rely on liquefied natural gas (LNG) imports to meet these demands (Shale Gas: Key Considerations for India). The study also states that the dip in production at the Krishna-Godavari D6 block, which had the biggest discovered natural gas reserves so far, means that there will probably be an increase in imports that will affect India's developing economy. Factors like this are encouraging the government to look at domestic shale gas production as a viable alternative for energy supply.

However, even with the presence of shale gas deposits, there is doubt over whether India could replicate the United States' perceived 'shale gas revolution'. One of the main reasons for this doubt is the technology that is required for extracting this natural gas. The process of fracking involves highly sophisticated mechanisms and technological know-how that India would need to import, most likely from the United States. Indeed, Indian oil companies, such as GAIL, have started investing in American oil explorations. GAIL has reportedly bought a 20 per cent stake in the Eagle Ford shale, while Reliance Industries has acquired substantial shares in two Marcellus shale explorations and one Eagle Ford exploration. This would enable Indian companies to gain the expertise and technology for future shale gas explorations on Indian soil.

Another major concern is the treatment of wastewater from shale gas explorations. The water that is produced as a byproduct of hydraulic fracturing contains chemicals and probably natural gas, and care must be taken to ensure it does not contaminate groundwater or drinking

water sources. In the United States, there have been concerns raised about this issue. A study done by Duke University revealed contamination of drinking water by methane and ethane in homes that were close to exploration and drilling operations.

India has a poor track record of wastewater treatment, with several major rivers showing high levels of unhealthy pathogens and waste. There is the question of whether the country has the capability of ensuring that drinking water sources would remain uncontaminated from shale gas produced water. In a notice issued by the Directorate General of Hydrocarbons (DGH) for a draft policy for exploration of shale gas, this concern is addressed, and the report states that "the treatment of this water before discharge to surface/subsurface water needs to be in line with the Central/State Groundwater Authority regulations." The report goes on to say that to prevent contamination of aquifers from fracking "fluid disposal", there has to be a compulsory "multiple casing programme (at least 2 casings)".

With these points in mind, the government needs to have a policy in place that safeguards its citizens' right to clean drinking water and right to land. The draft policy that the Indian government — mainly the Ministry of Petroleum and Natural Gas — is in the process of formulating aims to address the environmental and fiscal concerns of shale gas explorations. The draft states that rainwater harvesting in an exploration area should be made compulsory, "non-potable groundwater" should be used for hydraulic fracturing, and recycling of water should be the "preferred method of water management." It also goes on to refer to the Water (Prevention and Control of Pollution) Act and addresses the issues of air and water pollution.

However, there is still the major issue of lack of freshwater availability and fears of more pressure on the already stressed water sources of the country. In a study done by UNICEF and FAO, it is observed that India "faces a large gap between current supply and projected demand". Studies have also revealed that by 2030, shale gas-rich areas such as Cambay, Gondwana, Krishna-Godavari, and the Indo-Gangetic plains will witness major water stress (Shale Gas in India: Look Before You Leap, TERI).

The Way Forward

From these concerns and issues, it is clear that India really needs to thoroughly evaluate its shale gas situation before allowing exploration or production. The American shale gas 'miracle' may have been possible because of favourable geological, economic, and social conditions that India may not have the capability to replicate. In the rush to meet its ever-increasing energy demand, India needs to slow down and proceed with caution to ensure that its population's welfare is not traded for industrial prosperity.

The global reception of shale gas exploration and production, mainly via fracking, varies from eager acceptance to a complete ban on such activities. Among the countries in which fracking has been banned or put on hold are France, Bulgaria, Germany, the Czech Republic, South Africa, Romania, Argentina, and Ireland. While it is a fact that natural gas has a lower carbon output and releases less pollutants into the atmosphere upon burning, there is a need to discover a more sustainable way of acquiring this gas. This is a relatively new discovery and there is an urgent requirement for research on methods of exploration and production that do not put more stress on the planet's resources. For now, perhaps, the wiser thing to do is to wait and see whether America's shale 'revolution' fulfils its promises in the long run.

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IS THE INDIAN ECONOMIC SUCCESS STORY OVER?

India has been the darling of the economic world for nearly two decades as a series of revolutionary reforms in the early 1990s paved the way for extraordinary economic growth. This led to numerous predictions that the 21st century was going to be the Indian century. Now, however, there are fears that predictions of India's impending economic dominance were premature as the Indian economy is tottering close to the brink of failing. While corruption and governance issues are the obvious culprits in the mind of the public, **Harish Alagappa** tries to find a deeper cause. Was the reason India looks to be a false dawn that India's original growth was unsustainable, resource-intensive, and not conducive to innovation?

Throughout the first decade of the 21st century, India was constantly heralded as the world's next big economic superpower. After coming to the brink of economic collapse towards the end of the 1980s, India's hand was forced, quite literally, at the last moment and the Indian government implemented a series of economic reforms that liberated the economy of the second most populous nation on Earth. Regardless of how much credit subsequent economists and governments have tried to take by claiming to be the architect of the reforms or at the real brains behind the operation, the fact remains that economic liberalization was a last ditch effort, a final throw of the dice that fortunately for the nation and it's over 1 billion residents paid off spectacular dividends. In the years following the economic reforms, India's GDP grew at an astounding 8.79 per cent per annum on average. The nation's (purchasing power parity) GDP increased from US$751.3 billion in 1990 to over $4,051 billion in 2010, moving from being the world's tenth largest economy by GDP (PPP) to fourth. India became the toast of the world. Numerous books were written on India's incredible economic success story; some of them focused on the policy decisions that unleashed this otherwise dormant economic tiger while others looked at historic,

cultural, and social factors that were responsible for India's extraordinary economic success. Millions of jobs were created in the service sector and hitherto little-known Indian IT firms like Infosys Technologies or Wipro or Satyam ended up being traded on the prestigious NASDAQ stock exchange in New York along with such blue chip companies as Apple, Microsoft, and IBM. India's population millionaires and billionaires grew to rival nations such as China and the United States, and large-scale luxury brands in sectors ranging from automobiles to home furnishings opened shop in cities such as Delhi, Mumbai, Hyderabad, and Bangalore. Sleepy suburban towns like Gurgaon, just outside Delhi, and Whitefield, near Bangalore were, almost overnight, converted into special economic zones with attractive incentives to coax large foreign corporations to invest in the idea of India. Engineering and management colleges seemed to spontaneously erupt from all corners to cater to the demand for skilled Indian labour in the information and communications technology spheres. The 21st century, said articles in Time,

Newsweek, and the Wall Street Journal, was destined to be an Asian Century, to be led by the robust manufacturing sector of China and India's service industry.

However, the story was far from perfect. As the economy grew, so did prices. The resources that Indians had struggled to obtain in the decades following independence in 1947 were still limited and now there was a bigger rush for them than ever. Even among members of the nation's growing nouveau riche and bulging democratic middle-class, the story was far from perfect. There was a constant battle between inflating prices for food, fuel, electricity, and housing, along with the associated problems of rampant and unregulated industrial growth, viz. crowded cities, pollution, and climate change. For the nation's 400 million poor, though, things seemed to only get worse. While a few lucky villagers grew suddenly wealthy as their land was bought up by the government and private contractors in order to build malls and business parks, most of India's rural population saw little change from the situation that had existed in their lives for the preceding decades. The story of India's economic growth was thus lacking in the sense that the benefits of this economic had not been transferred uniformly across all sections of Indian society. The growth itself was not sustainable and required large investments in not only capital buy resources such as energy, land, and water, which further exacerbated an already strained situation in the country. Nevertheless, economists and opportunistic writers continued to speculate unabated with more predictions of India's impending global dominance. The global recession hit, but India seemed largely unaffected by such problems, at first and continued to grow, albeit more slowly than in the years before the recession. The first signs for trouble only began to crop up in the late 2000s and early 2010s. In 2010, India rose to fourth in the list of the world's largest importers of oil, with over 3 billion barrels of oil imported per day. Whereas roughly 50 per cent of the oil consumed in nations such as the United States or China is produced within that nation, almost all of India's oil consumed is imported.

In the last 20 years, India's total energy consumption has grown by 91 per cent. We are the fourth largest consumer of energy in the world, and a very large proportion of it has to be imported in the form of coal or oil. Nevertheless, India's per capita energy consumption is in the bottom 10 per cent of the world, lower than countries like Zimbabwe, Nigeria, and even North Korea. Clearly India's much-vaunted economic success story was

hyped far too much and far too soon. Sure, there had been tremendous growth, but it had been unsustainable and far from uniform. Recently, the Indian economy is in the midst of a crisis as the value of the nation's currency is falling at an alarming rate. This is far from surprising; a currency is only worth what goods, services, or resources one can get in exchange for it. India has been importing raw materials and finished products at an alarming rate while not providing much in exchange. A nation such as Japan, which scarcely has any substantial natural resources and has to import almost all of the coal and oil used in their substantial manufacturing industry nevertheless converts those raw materials into exquisite, sophisticated, and highly prized finished goods in factories famous the world over for their efficiency and minimal use of energy and other resources. It is this balance that helps keep the Japanese economy in check. India's major claim to fame in the modern globalized world over the last two decades has been a service industry that is known more for being a cheap alternative rather than being a place of high quality. Sure, there are numerous Indian companies that have been praised for the quality of their service, but what kicked off India's service industry growth was that a multinational corporation could hire five call center employees or software developers in India for the cost of the salary of one in a developed nation like the United States. The quality deficit between an Indian and American was negligible and many times the Indian employee far outperformed his or her peers from developed nations. However, with inflation, economic uncertainty, and the constant fear of social or political unrest under India's deceivingly docile exterior, the costs may soon outweigh the benefits.

Perhaps the biggest reason behind why India's initial economic success could not be translated into consistent economic growth that not only made India's rich richer was that while many of the restrictions on the Indian economy were freed by the reforms of the 1990s, India's infrastructure is still following a model of copying and reverse-engineering rather than innovating and experimenting. India takes a lot of pride in its ability to adapt and use all the resources at its disposal to solve a problem, a technique that is evident in methods by which cars are kept running for decades using ingenuous and slightly dangerous home-brewed technologies or by how electricity is routinely stolen in neighbourhoods across the nation. This adaptability is not innovation, regardless of how many Indian writers and analysts try to plug it as such. Innovation requires technical aptitude, the willingness to experiment and fail repeatedly, and

the commitment to persist in the face of repeated failure. India cannot hope to replicate the development model followed by the United States and China, the two nations that are most commonly looked at as targets to be achieved, and in the overestimation of some, to be overtaken. The reason for this boils down to a single word: resources. China and the United States are the third and fourth largest nations in the world by area respectively, each of them nearly three times larger than India. Thus, China, despite its substantial population — which India is projected to overtake in the next few decades — nevertheless has a greater pool of resources to reach from in their efforts to industrialize the middle kingdom. The United States, which while three times India's land area only has a quarter of the population is replete with mineral, fuel, and agricultural resources that would be the envy of any nation. The development models of both these nations are not examples that India can realistically hope to emulate. A better option would be to try to learn from successful societies that we share our limitations with. Japan, for example, is a nation with a population quite close to our own (337 people per square kilometer to our 368 people per square kilometer), surrounded by hostile neighbors and with few natural resources to their name. The secret behind Japan's extraordinary success was hard work and an environment where technological tinkering and innovation was encouraged as essential to the nation's survival. Japan, like India, began by reverse-engineering technology they received from the United States and Europe. Critically, however, Japan was aware of resource scarcity at a time when American cars offered a mileage of 6 kilometers a liter on average. Thus, Japan's entire post Second World War industrial economy was designed on the principle of efficiency in design and execution. Thus, despite being one of the largest importers of coal and oil in the world, Japan's economy grew exponentially and is one of the most powerful industrial economies in the world.

India should similarly look at opportunities accorded to us by our limitations. If India's economic success story from the 1990s is to continue into the 21st century, it is critical that the a development model must be arrived at that looks at the limitations on the country in terms of infrastructure to stimulate technological innovation and expertise and focus on finding ways in which the restrictions on our national growth can be turned into advantages. India's success story is in the midst of a critical juncture and requires not just a quick fix like the 1991 reforms truly were, but a solution that addresses the issues of spreading the benefits of economic growth across the board, building a strong economy in the face of resource scarcity, and achieving social and political cohesion. It is not going to be easy, but it is necessary that these issues be addressed, lest the so-called Indian success story turns into a cautionary tale against hubris in the face of starting successes. ■

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MAKING SOLAR ELECTRICITY LAST

Efforts to expand photovoltaics will only work if storage solutions are available that can offset fluctuations in solar energy. No cost-effective technologies exist as yet, but researchers are exploring some extremely promising avenues, find **Jurgen Heup** and **Sascha Rentzing**.

If you invest in a photovoltaic system today, you will also have to weigh up whether or not to purchase a storage solution. If your system is small, then batteries are a good idea because they can help you consume more of the lucrative electricity that you produce. In Germany, one kilowatt-hour (kWh) of solar energy costs EUR 0.15 to produce, while mains electricity from the plug socket costs an average of EUR 0.25. So clearly, it makes sense for homeowners to supply themselves with as much energy from their photovoltaic systems as possible.

As for operators of large solar farms, acquiring storage technology makes sense because energy suppliers are likely to reduce the output of farms more often in the future. Solar electricity fluctuates heavily. Grids are flooded with it at midday, but there is none available at night. As more photovoltaic systems get connected to the grid, the balance between generation and consumption will become increasingly skewed. Storage technologies can keep grids stable by holding onto excess energy until it is needed. However, researchers still need to work out which kind of storage is best for which application. The technologies available range from small and large batteries and hydrogen to thermal energy storage.

Lithium versus Lead

About 50 companies in Germany now sell systems that combine solar panels and batteries. Most use modern lithium batteries, which are preferable to standard lead batteries since they take up less space, can store more solar electricity, and because their electrodes are more electrochemically stable, have a longer service life. "Lithium-ion batteries can last for up to 10,000 charge cycles, but lead batteries only manage about 3,000," explains Matthias Vetter, Head of the Electric Storage Systems department at the Fraunhofer Institute for Solar Energy Systems ISE in Freiburg, Germany. But lithium technology is also significantly more expensive. Vetter says that it currently costs about EUR 0.35 per kWh to store solar electricity in a lithium-ion battery. Of that, EUR 0.20 is down to storage costs alone. These kinds of figures are likely to scare off many potential investors.

But he also thinks that bigger production runs and advances in

technology could cut storage costs in half over the next three to four years. "If that is coupled with household electricity prices continuing to rise by five per cent each year, using lithium-ion batteries will start to make financial sense as early as 2015." Some manufacturers, among them Leclanche in Switzerland and Varta in Hanover, are already increasing production. Companies are also developing electrode materials that are more robust and more powerful. In most standard batteries, the anode is made of graphite and the cathode of lithium metal. The metal and the graphite are partners in the chemical reaction that occurs in the battery. Leclanche is now planning to use anodes made of lithium titanate, as they are quicker to charge than graphite and can withstand more charge cycles.

Batteries are not the only way to go if you have your own photovoltaic system and want to use more of the electricity it produces. You could choose a much simpler route and store the excess energy in water. In theory, all you need to do is put an immersion heater in your hot water cylinder. At midday, when your panels are producing electricity at full capacity and little is being used in the house, the excess energy will be stored up, which means you can use it later and the grid will get a little respite. The advantage of this solution over batteries is that most homes already have a water tank, so there is no need to purchase a special container. Not everyone thinks this is a good idea, though. Critics say that using solar electricity as heating is a waste, and that solar thermal collectors, which convert sunlight into heat directly, are a much better option. The trouble is, the cost of collectors has not fallen as much as it has for solar electricity systems in the past. Feed-in-tariffs and the security they offer investors mean that photovoltaics have enjoyed much more growth than solar thermal technology has.

Volker Quaschning, a professor of renewable energy systems at HTW Berlin — University of Applied Sciences, thinks that heating with photovoltaics could increase the solar share of Germany's overall energy consumption. It would only take a few years before we reached what Quaschning calls "oil parity" — when it costs less to heat with solar electricity than it does with heating oil.

High-Temperature Batteries for Solar Farms

In fact, many companies (among them Centrosolar and Schuco, and

heating-system manufacturers such as Viessmann, Stiebel Eltron, Junkers and Buderus) are already offering these kinds of solutions. Most of the systems include a detour, whereby the solar electricity drives a heat pump that increases the electricity's thermal output. This boosts efficiency and means that one kilowatt-hour of electricity can, in the best-case scenario, generate over three kilowatt-hours of heat. Researchers at the Centre for Solar Energy and Hydrogen Research Baden-Wurttemberg (ZSW) also found that heat pumps allow owners of smaller solar systems to use 45 per cent of the electricity they produce, rather than the 30 per cent they use without them.

These days, lithium-ion batteries are a well-known storage solution. But Michael Stelter, a battery expert from the Fraunhofer Institute for Ceramic Technologies and Systems IKTS in the state of Thuringia, is keen to draw attention to another kind of battery. He says that although high-temperature batteries (either sodium-sulphur or sodium-nickel chloride) are often overlooked, they make good sense, especially for the large-scale applications that will become increasingly relevant as the switch to renewables progresses. Why do they make good sense? Because German companies such as AEG and ABB already had this kind of battery ready for series production back in the 1980s and 1990s.

These batteries are very different to the kinds most of us are familiar with, which usually have two solid electrodes separated by a liquid electrolyte that transports the ions.

In high-temperature batteries, the electrodes are liquid once operating temperatures exceed 200 °C, and the electrolyte is a solid ceramic. During charging and discharging, the ceramic becomes permeable to sodium ions, but isolates the electrons. These

batteries were originally developed for use in electric vehicles, but the high operating temperatures called for such complex insulation and heating systems that the projects were shelved in the early 1990s. Some Japanese companies later picked up the idea and used it for large stationary batteries. NGK, for example, is now the leading manufacturer of megawatt-sized sodium-sulphur batteries. The US is on board too, with General Electric having recently invested in a new factory for large sodium-nickel chloride batteries. Over in Italy, Fiamm is producing sodium-nickel chloride batteries at the kilowatt (kW) scale for smaller solar power plants.

Stelter summarises the pros and cons of high-temperature fuel cells as follows: At 150 watt-hours per kilogram, they have a relatively high energy density. Compared to lithium-ion batteries they are quite sluggish in terms of output, but they have more storage capacity. "That makes them ideal for storing electricity generated by solar plants or wind turbines," says Stelter, adding that the biggest advantage lies in their cost, since the raw materials they use (e.g., sodium, sulphur, aluminium oxide) are inexpensive and much more readily available than lithium. He estimates the costs for mass-producing the batteries at EUR 150 per kWh, and thinks that a ten-year service life is perfectly realistic. Some of these batteries are said to have already put in 15,000 charge cycles. So with a usable capacity of 80 per cent, storage costs could theoretically be as low as one or two eurocents per kWh.

Redox flow batteries are just as suitable for wind and solar farms as high-temperature batteries are, since they can also store large amounts of energy at comparatively low costs. Unlike standard batteries, the redox Bow variety keeps electricity storage and production separate. The electrical energy is stored in liquids contained in two separate tanks. The tanks can be easily adapted to suit different capacities and are relatively cheap to produce. Only when the battery is charged or discharged do the electrolytes begin to flow slowly through the cells, which then either supply electricity or store it as ion solution. Redox flow batteries have the advantage of being able to handle deep discharge and are only subject to minimal losses when not in use — two things that are often major problems in normal batteries. "The electrolytes do not wear out, and we can reprocess

them at the end of the battery's service life," says Stefan Schauss, a battery expert from Gildemeister Energy Solutions, a subsidiary of the German mechanical engineering firm Gildemeister.

Gildemeister Energy Solutions already offers combinable redox Bow batteries with capacities of up to 400 kWh. Its Cellcubes are a good option for helping renewable power plants to achieve a smooth energy output and offset fluctuations. But the technology is only being used on a small scale in Germany at the moment. At a multistorey car park and on the site of the company Teamtechnik, for instance, it is ensuring that charging stations for electric cars have a permanent supply of solar electricity.

Hydrogen, the Good All-Rounder

Many people think that hydrogen is the way to a climate-neutral future. They imagine hydrogen fuel cells providing households with electricity and heating, and cars that drive along emitting only water vapour from their exhaust pipes. But the problem is that hydrogen is an energy carrier, not an energy source. So just like electricity, it has to be produced from other energy sources. "Hydrogen research petered out in the late 1990s," says Andreas Brinner from the Centre for Solar Energy and Hydrogen Research Baden-Wurttemberg (ZSW). "But we started seeing a renaissance about three years ago." ZSW developed a power-to-gas system in collaboration with Etogas (formerly SolarFuel) and the Fraunhofer Institute for Wind Energy and Energy Systems Technology IWES. The first step uses alkaline electrolysers, which can currently get up to about 15 MW in size and so produce hydrogen on a large scale. Next, the hydrogen is reacted with carbon dioxide to produce methane, which can then be fed directly into Germany's natural gas system.

Innovations are also happening in two other kinds of electrolysis. Siemens is currently producing 300-kW polymer electrolyte membrane (PEM) electrolysers, which remove the need for caustic lyes. The technology uses a proton exchange membrane and electricity to split distilled water into hydrogen and oxygen. Siemens says that this kind of electrolysis is especially well suited to renewable energy systems because, unlike conventional technologies, it can react to energy fluctuations within milliseconds. At the moment, though, the process is limited by the size of the electrolyser. In March, Siemens put a prototype into operation at the Niederaussem power station to the west of Cologne. The 300-kW system should produce two to six kilograms of hydrogen per hour. The company hopes that it will be able to offer modular systems of up to 10 MW in a few years' time.

Another German firm, HTec, is building PEM electrolysers for its parent company, the project developer GP Joule, which combines the technology with large solar and biogas plants. The solar planes provide the electricity, and the biogas helps when it comes to turning the hydrogen back into electrical energy. With pure hydrogen, the combustion temperatures in the power plant would be much too high. Mixing it with biogas brings down the heat and so minimizes the technical complexity of the process. GP Joule has thus achieved a seamless, renewable way of supplying electricity. Company founder Heiner Gartner says that the model will be ready for market, and affordable, in just a few years.

ZSW's Brinner says that the third technology, high-temperature electrolysis (using solid polymer electrolytes), is still at the research stage. Since the process happens at temperatures of about 900 °C, it needs less electricity and thus uses primary energy more efficiently than the two other technologies. This is good, because efficiency is the issue that makes many people sceptical

	Lead Batteries		Lithium-ion Batteries		High-temperature Batteries		Redox Flow Batteries		Hydrogen		Heat Pumps	
	2013	2020 +	2013	2020 +	2013	2020 +	2013	2020 +	2013	2020 +	2013	2020 +
Efficiency in per cent	80	90	92	95	90	90	75	80	<50[1]	>60[1]	3[2]	5[2]
Investment costs/kW	500	150	750	200	800	150	800	250	800-2,000	300-500	500-1,500[3]	<500[3]
Service life	7	12	10	20	<10	>15	10	20	20-30	>30	20	>20
Storage costs/kW	0.20	0.08	0.30	0.05	0.28	<0.08	0.37	0.11	0.20 -0.50	0.08[4]	0.05[5]	>0.02[6]
Maturity	Advanced		Ready for use		Midway		Midway		Early stages		Ready for use	
Applications	• Storage for small to medium systems • Emergency power • Load balancing • Grid stabilisation		• Storage for small to medium systems • Emergency power • Load balancing • Electric vehicles • Grid stabilisation		• Storage for small to medium systems • Load balancing • Temporary storage for renewables		• Storage for small to medium systems • Emergency power • Load balancing • Temporary storage for renewables • Seasonal storage		• Seasonal storage • Temporary storage for renewables		• Seasonal storage	

Source: DLR, own research

of electrolysis. Fifty per cent of the electricity is lost in the process of converting electricity to hydrogen and then hydrogen back to electricity — so only half of the electricity that goes in at the start is available at the end.

But Brinner believes there is a good chance that future households will produce hydrogen, store it, use it for heating, and convert it into electricity. He says ZSW is working on combining electrolysers and fuel cells to develop a one-stop energy solution.

The speed with which these technologies reach the market will depend heavily on the German government's next moves. It needs to issue concrete statements on building storage solutions and to develop a master plan that details which technology should be available when. But politics aside, with so many highly promising storage options in development, the ambitious vision of rapidly expanding photovoltaics and of renewables supplying all our energy needs is inching closer to reality.

The table shows that there is no single "best" technology that can be used in all situations. It is also difficult to compare the solutions. A funding scheme that is open to all technologies therefore makes the most sense.

(i) Only electrical efficiency; (ii) Average annual coefficient of performance (COP) of heat pumps (ratio of 1 kWh of heat to 1 kWh of electricity in a year); (iii) Average investment costs for one heat pump. The investment costs for a full system (heat pump and heating infrastructure) currently stand at about EUR 4,000 per kW; (iv) Hydrogen production costs; (v) Based on solar-electricity production costs of EUR 0.15 / COP = 3; (vi) Based on solar-electricity production costs of EUR 0.10 / COP = 5 ■

The article is reproduced from the New Energy magazine.

WORST OVER FOR RENEWABLES?

Stabilizing equipment costs and growing opportunities in emerging markets have brightened the outlook for manufacturers. Solar shares have a following wind behind them after a long period in the doldrums, while wind-turbine manufacturers are starting to reap the rewards of painful cost-cutting, reports **Rohan Boyle**.

After a prolonged period of abstinence, investors returned to solar stocks earlier this year with renewed vigour. The NYSE Bloomberg Global Solar Energy Index, which tracks the performance of 103 solar companies globally, gained 23 per cent in May alone and stood some 64 per cent higher on 30 May than at its low point, reached on 3 December 2012. The rehabilitation of this sector's stocks, complete with characteristic volatility, would appear to be complete. Investors are eager to jump back on the solar bandwagon as demand for photovoltaic modules is forecast to gain momentum this year and prices are expected to stabilize. By 30 May, shares of JA Solar Holdings, a China-based cell maker, were up 85 per cent since the start of the year, a modest increase compared with the 250-per cent jump in the share price of US module manufacturer Sunpower. Rooftop developer Solarcity trumped even this with an increase of more

than 300 per cent since the start of January. Solarcity, which is chaired by billionaire Elon Musk, recently signed a lease-financing agreement with Goldman Sachs Group that will help the company build about 110 megawatts (MW) of solar power systems for homes and businesses. "We hope it sends a signal that solar is a stable and reliable asset to invest in," Solarcity CEO Lyndon Rive said in an interview. "These are not luxury yachts we're talking about, it is your energy, and the default rates are lower than mortgages."

The deal, which is the largest single financing agreement for rooftop systems in the US (some 66 per cent larger than the USD 300 million deal between Morgan Stanley and Clean Power Finance), demonstrates that banks are becoming more comfortable committing sums to the distributed solar sector. Solarcity hinted that lenders are willing to finance systems for homeowners with credit scores below top-tier, which would dramatically expand the market of residential solar customers in the US.

Utility-scale solar projects are also attracting more interest. In early April, for example, Dutch Infrastructure Fund, a fund manager, bought 35-per cent stakes in four French photovoltaic plants operated by Solaitedirect, while later that month, Southern Co, the second-largest US power company by market value, acquired its fifth US solar project — First Solar's 139-MW Campo Verde project in California — in partnership with billionaire Ted Turner's renewable energy company.

Such is the widespread appeal of solar assets that even the public markets are being tapped for investment. Fund manager Bluefield Partners is seeking to raise GBP 150 million (USD 226 million) by selling shares in a new solar power fund. The money raised from the initial public offering, which is scheduled for mid-June, will finance solar plants in the UK, the company said in a statement. Bluefield hopes to emulate the success of Greencoat UK Wind, which raised GBP 260 million (USD 396 million) in an initial public offering for investment in UK wind assets in March.

Enthusiasm for downstream solar investments — whether rooftop installers or utility-scale assets — and recovering share prices, partly predicated on the somewhat tenuous hope that a rise in demand for equipment this year will soon alleviate some of the pressure on manufacturers, cannot disguise the fact that these are still very tough times for most players along the value chain. There are likely to be more bankruptcies and consolidation ahead.

The latest casualty is Isofoton, Spain's second-largest solar panel maker, which announced that it would file for voluntary insolvency in early June after failing to reach an agreement with creditors. The company, which has manufacturing plants in Malaga and Ohio, started proceedings on 4 June with the aim of reaching a deal to secure its future. The decision came after lenders declined to refinance its loans and its discovery of additional debt from before 2010.

As the bankruptcy of former market leader Suntech Power Holdings clearly showed, the Chinese government will not step in to save even the biggest players. Although some firms such as Trina Solar and Jinko Solar are still getting money, the China Development Bank and other lenders are being more cautious about which companies they support, and this will surely hasten consolidation in the coming months.

The EU's threat to impose punitive tariffs on imports of Chinese solar modules has also weighed heavily on investors in recent months. A tense showdown between two of the world's chief trading partners culminated in an agreement at the end of July that puts a minimum price (EUR 0.56 per watt) and quantity limit (seven gigawatts) on EU imports of solar hardware from China, in exchange for exempting the shipments from punitive tariffs.

While preventing an escalation in the trade feud, the accord threatens to hurt developers of ground-mounted plants and reduce the number of installations, said Bloomberg New Energy Finance analysts. The pledged price will allow Chinese companies to continue exporting to the EU and "keep a reasonable market share", according to a statement on the website of the China New Energy Chamber of Commerce, which advises both the government and companies.

Japan's solar sector is still booming, despite a ten-per cent cut in the feed-in tariff for large photovoltaic systems on 1 April. The country is forecast to install between six gigawatts (GW) and 9.4 GW of solar capacity this year, according to Bloomberg New Energy Finance. This would make it the second-largest, or even largest, solar market. A number of major commitments have been announced in recent months, including promised investment of JPY 50 billion (USD 489 million) in renewable energy projects by Goldman Sachs over the next five years.

After 12 long years of detailed site surveys, contentious public hearings, political intrigue and creative law suits, development of the first offshore wind project in the US has entered what promises to be its final, decisive

phase. The 468-MW Cape Wind project off the coast of Massachusetts has managed to overcome opposition and is now fully permitted, but still faces the monumental task of securing an estimated USD 2.6 billion in the next few months to allow construction to start before the end of this year, when the federal Investment Tax Credit expires.

Bank of Tokyo-Mitsubishi UFJ was engaged as lead arranger for the debt financing in March this year, and power purchase agreements have been struck with utilities Nstar and National Grid for 78 per cent of the project's output. The developer will have to attract approximately USD 1 billion in tax equity investment, according to Bloomberg New Energy Finance estimates, which will be a challenge considering the entire tax equity market was about USD 6 billion last year and that investors require a risk premium where tax equity is subordinated to debt and where there is a significant technology risk.

US opposition to an offshore wind project on the other side of the Atlantic has set the scene for yet another epic battle. In March, the Scottish government approved a plan to build an eleven-turbine wind farm off the coast of Aberdeen, much to the disapproval of New York real estate billionaire Donald Trump, who responded by pulling the plug on GBP 750 million (USD 1.1 billion) of proposed investment in a nearby golf resort. He vowed to "spend whatever monies are necessary to see to it that these huge and unsightly industrial wind turbines are never constructed". The approval of this project, the European Offshore Wind Deployment Centre, a venture between Vattenfall, Technip and Aberdeen Renewable Energy Group, will allow offshore wind farm developers and associated supply chain companies to test new designs, prove existing products and receive independent validation and accreditation before commercial deployment. The green light is seen as an important step for the Scottish offshore wind market, where installed capacity currently only amounts to 10 MW but could expand to 1.4 GW of commissioned capacity by 2020.

Earlier this year, offshore policy in Europe took two steps forward and one step back. The UK government introduced an energy bill to parliament that helps clarify the upcoming Electricity Market Reform, while Germany passed a law that helps protect generators from loss of revenues due to delayed connection to the electricity grid or interrupted transmission. On the minus side, Berlin has proposed subsidy cuts, which prompted Bloomberg New Energy Finance to downgrade its forecast for new European offshore installations this year by 946 MW.

Opposition to wind projects is by no means limited to groups in richer countries. Danish wind-turbine maker Vestas Wind Systems said recently that the 396-MW Marena Renovables project in Mexico has been significantly delayed by members of an indigenous community, who have partially blocked access to the sites as they fear the development will wreck local fishing and farming. The project developer, meanwhile, entered into forbearance agreements with lenders until 30 July (at press time it was unclear whether or not this had been extended as expected) and with Vestas until the end of November.

The scale of the Marena project highlights the importance of this and other emerging markets to major manufacturers. In May, for instance, Vestas announced a 155-MW order for turbines to be installed at the Energia Sierra Juarez plant in Baja California, northern Mexico, while Spanish infrastructure company Acciona has agreed to provide 210 MW of turbines for projects in northeast Brazil. Africa is also looming larger — Germany's Siemens recently won a 100-MW order from Eskom Holdings in South Africa, and Gamesa will supply 14 MW of turbines to a wind farm in Kenya.

Between 2017 and 2020, Latin America, Africa, and Australasia together will account for more new installed capacity than China, Europe, or the US individually, according to Bloomberg New Energy Finance. These new markets are in contrast to the slowing growth in more established markets that helped push many manufacturers' margins into negative territory last year.

To remain viable, many manufacturers are trimming production in existing markets and moving to where there is growth. Vestas, for instance, has closed, sold or reduced output capacity at six facilities in the US and Spain, merged two in Denmark and moved another from Denmark to China.

Gamesa too is shifting its focus. The Spanish company, which recently dismissed 394 workers at a turbine blade plant in Spain, has established a nacelle and hub assembly plant in Bahia state, Brazil, in order to meet new local content rules. Projects that use its turbines are now eligible for lower cost loans from local development bank Banco Nacional de Desenvolvimento Economico e Social.

Connecticut-based General Electric has also said it will invest in a supply chain in Brazil in order to satisfy the local content requirements.

Turbine manufacturers are looking beyond mere survival tactics this year. As well as reducing costs and scaling back production, many are taking steps to strengthen their balance sheets and develop low-cost products in anticipation of a market recovery. While a jump in global demand over the next three years seems unlikely, certain markets will see a rebound. New installations in the US, for instance, are expected to jump from just 2.8 GW this year to 8 GW in 2014, but the Chinese market will remain relatively stable at 16 to 17 GW of new installations per year between now and 2016.

One big-name buyer will certainly be on the lookout for turbines. Warren Buffett's Midamerican Energy Holdings announced in early May that it has plans to invest USD 1.9 billion in additional wind-generation capacity. Midamerican expects to add slightly more than 1 GW of wind capacity in Iowa, consisting of up to 656 turbines, by the end of 2015, according to the company's website.

The EU is fighting anti-dumping battles on more than one front. In addition to the investigation into Chinese solar cell, module and wafer makers, it has decided to levy duties on biodiesel imports from Argentina and Indonesia. EU producers including Verbio in Germany, Diester Industrie in France and Novaol in Italy suffered "material injury" as a result of dumped imports from Argentina and Indonesia, the European Commission said. The levies are for six months and may be prolonged for five years.

The duties are the preliminary outcome of an inquiry opened last August after a dumping complaint by the European Biodiesel Board on behalf of manufacturers that account for more than 60 percent of EU production of biodiesel. Argentinian and Indonesian exporters increased their combined share of the EU biodiesel market to 19.3 per cent in the 12 months through to June 2012, from 9.1 per cent in 2009, the Commission said.

The bloc has also started investigating possible trade-distorting government aid for Argentinian and Indonesian exporters and has until August to decide on the imposition of any provisional anti-subsidy levies. In 2009, the EU hit the US with five-year anti-dumping duties on biodiesel, bringing trade valued at USD 1 billion a year to a halt. It also applied separate anti-subsidy levies on American manufacturers such as Archer-Daniels-Midland and Cargill.

Government intervention has become a central part of Brazil's ethanol market, although there is no suggestion that Brasilia is about to fall foul of international trade watchdogs with its latest raft of supportive measures. In April, the state granted BRL 970 million (USD 480 million) in tax deductions (to help offset a BRL 0.12 per litre tax on ethanol) and made available BRL 4 billion (USD 1.9 billion) in loans for crop renewal this year. It also raised the mandatory amount of ethanol blended into gasoline to 25 per cent from 20 per cent on 1 May.

These measures are designed to boost investment, increase production and partially replace demand for gasoline. As they coincide with what promises to be a good harvest this year, the prospects are looking better for an industry that has been hurt by domestic government policies that have kept petrol prices artificially low to fight inflation. However, considering that a new sugarcane mill can cost up to USD 400 million, developers are likely to shrug at these policies as

being insufficient to bring confidence back to the industry.

Progress in the development of next-generation biofuels is proving more challenging than some players initially bargained. Bio Architecture Lab, a US biotechnology company that sought to turn seaweed into ethanol in Chile, has given up on the technology after deciding it made more sense to sell the raw material than process it into fuel. "Seaweed is worth USD 1.30 a kilogram without doing anything to it, so why would you harvest it and produce ethanol, which costs USD 0.75 a kilogram?" CEO Ric Lucien asks.

Even Exxon Mobil, the world's biggest maker of gasoline and diesel, has decided to redirect the focus of its efforts to develop algae-derived biofuel. After four years of research together with Synthetic Genomics and investment of more than USD 100 million, it has concluded that "simple modifications of natural algae would not provide a level of performance that we believed would be economical or viable for a commercial solution". Exxon CEO Rex Tillerson recently said that its investments in algae biofuel may not succeed for at least another 25 years.

Australian algae-to-fuel company Algaetec has as-yet-unfulfilled ambitions. Last September, it announced plans to build as many as six factories by 2015 at a cost of about USD 100 million each. In the same month, it agreed to work with airline Deutsche Lufthansa to build a European plant that uses algae to make jet fuel. Then in January this year, it said it planned to sell USD 200 million of bonds in Europe to fund the expansion. In the most recent development, it said it hopes to raise about AUD 1 million (USD 958,000) in a share sale, some of which will be used to validate the company's plant in Australia.

The biomass and waste-to-energy sectors seem to be attracting growing interest in Europe as subsidies for wind and solar are pared back. For instance, Milan-based Falck Renewables is selling its UK wind assets and will invest EUR 250 million (USD 322 million) in non-intermittent sources of renewable power such as biomass, waste-to-energy and anaerobic digestion by 2017. Spanish paper pulp producer Ence Energia y Celulosa is also looking to boost its presence in biomass in Europe as regulatory changes in Spain have deterred it from investing at home.

Moves by certain power producers in Europe to convert a portion of their coal-fired generating portfolio to biomass seldom seem straightforward. Dong Energy, Denmark's largest utility, has postponed switching a power plant unit to burn biomass instead of coal, citing rules on the tax it will have to pay for producing heat from the renewable fuel. The project faces a delay of one year while Dong waits for the Danish government to set the fees, Carsten Birkeland Kjaer, a company spokesman, said. ■

The article is reproduced from the New Energy magazine.

"I AM OPTIMISTIC THAT BY THE MIDDLE OF THIS CENTURY, THE WORLD COULD BE DERIVING NEARLY ALL OF ITS ENERGY FROM RENEWABLES"

Godfrey Boyle is Professor of Renewable Energy at the UK Open University, where he has chaired various courses on renewable and sustainable energy and directed the Energy and Environment Research. *Harish Alagappa* catches up with him during his visit to India where he participated in the Delhi Sustainable Development Summit 2013.

Prof. Boyle, you are an expert in the sphere of renewable energy and new and unconventional sources of energy. I'd like your opinion on where you think the energy future of the world stands today, mainly in terms of energy sources and in terms of transmission of that energy to the common man.

In terms of energy sources, opinions differ. I tend to veer to towards the very optimistic view that by the middle of this century this world could be deriving all or nearly all of its energy from renewables, i.e., if there is a fair assessment, if there is support from governments and the cooperations (which is coming, but not quite there yet) as well as support from the public. However, other people take more pessimistic views. The International Energy Agency sees a third or maybe a half come from renewables by 2050. They do have, what they call, I think, the blue map, which pens down several energy scenarios — some of which are more optimistic towards renewables than others. So, it depends really; all scenarios depend on the assumptions that you make. But, I think that if we really want to, it may well happen that renewables provide the majority of the world's energy in a very low or zero carbon way.

In an emerging economy such as India, there are a lot of questions being asked about whether or not renewables are capable of powering the economic growth that we have

been seeing the past decade or so. Some people have come to agree that economic growth and Green growth are mutually incompatible. For one to move forward, the other one has to take a back seat. Do you think this is the case or do you think they can co-exist?

Well, it depends on what kind of growth you mean. I think if you mean growth in a rather gross and old-fashioned sense that is reflected in an endless increase in material goods and endless increases in consumerism without recycling, then it would be hard for any source of energy – renewable or otherwise – to keep up with it! With fossil fuels, it is not so much that we are running out but that we are having to aim for more and more inaccessible and expensive sources of fossil fuels. Even nuclear would have trouble keeping with an endlessly increasing consumption of material. But certainly all the studies I have seen shows that renewables, particularly if you see the gross overall potential of renewables, exceed about 7,000–8,000 times, the world's present requirements of energy; for instance, energy from the sun. So in principal renewables not only vastly exceed our present requirements but also would never run out. And, since, they don't disappear when you use them, we just need to reorient our economy in a considerably different way; and I think this would still ensure prosperity — probably calculated on measures other than the GDP. If we had different measures, we could have an extremely happy life, a much more equitable and ecological if we based it mostly or entirely on renewables.

The Department of Energy and Climate Change in the UK has an excellent resource available online that helps you try and find the right energy mix so that you can reach your target by reducing carbon emissions by 80 per cent by 2050. What in your opinion would be the ideal energy mix for the UK to reach such a goal?

These are very good and I think anyone with a bit of perseverance would be able to make their own energy scenarios. Again, the studies I have seen are by the WWF, not only the world as a whole which shall be my graph of representation here, but also study for the UK showing that it could derive – I think the exact percentage is quite high – something like 80 or 90 per cent from renewables in the UK. I think that particular study didn't study overall energy use in other forms than electricity but it should be pointed out that regarding electricity, many forecasts foresee electricity not only being used for the things it is used now but also for cars and for heating in the form of heat pumps, and so on and so forth. Electricity would become more of a dominant carrier than it is presently prevalent.

What are the biggest challenges that you feel are being faced by the renewable energy sector?

Well, I hate to say this but I think a lot of the challenges [in the renewable energy sector] are to do with the opposition of vested interests in the fossil fuel industry. I mean understandably enough it is difficult for corporations, large oil corporations, fossil fuel corporations, etc., to change from the existing profit mechanisms that they already have, but they

tend to muddy the waters a bit and make it more difficult by lobbying governments and pushing their vested interests. They make it more difficult to make the transition to a largely renewable future of the country that people like me would like to see. But it may seem a little bit paranoid to say that but I am afraid that is a major obstacle. It also maybe that people find it difficult to adjust to anything new; new paradigms always take a bit of adjusting to, not just in corporations but also among the public, and amongst politicians as a whole.

You had a very long and distinguished career in many different fields. So based on your experiences, how do you view the current sustainable development and energy scenario across the world as it is?

Well, coming to an events such as this, one can get a very optimistic view. One gets to see so many committed people led by Dr Pachauri and others, campaigning and agitating, building alliances and corporations, creating change in a very encouraging way. So, to come to this event, one becomes very optimistic, or fairly optimistic one should say perhaps, for the prospects for a sustainable future not just in terms of energy but agriculture, water, etc. So I think if the initiatives that we talked about in these sorts of events were to be pursued with the dedication and energy that everyone here seems to exhibit then the future could be bright. But of course when you step outside these environments, the prospects don't quite seem so good. I tend to veer on the optimistic side myself given the progress since the past 40 years since I went to the Stockholm Conference in 1972 and Lo! we haven't created utopia yet. There has been quite a bit of movement towards to consciousness of environment; there is legislation, renewables are building up; we are not by any means there yet but progress has been made in the last 40 years. Maybe in the next 40 years, we will make a bit more progress.

In order to see progress, we would obviously have to spread the word; people should be made aware of the kind of problems we will face, that we are currently facing, and get them to make the sacrifices that are necessary. This means to educate people. The Open University has in a sense changed the paradigm of how higher education is done in the UK. So, what can we learn, not just in the renewable energy sector but in general from the precedence set by the Open University?

I am glad you mentioned that because certainly the Open University in the UK was indeed the first modern Open University. Your own Indira Gandhi National Open University has successfully reached out to very large audiences. I think the next iteration in open education will come from these MOOKS or Massive Open Online Course which are being started by Harvard and MIT and others. And we at the Open University have realized that we are also going to get into this business as well. Its early days, but certainly I do see, given the challenge of sustainability the one way to get to very large audiences in very short time would be to have massive online open education. Furthermore, one of the studies we have done in the Open University shows that open online education is actually more resource frugal, thereby making it more sustainable than other forms of education.

It has been seen that most people who follow renewable energy in the country are those belonging in the 18–35 age bracket. What kind of message would you want to give them?

I think that if they want to put their efforts in finding out about the many dimensions of the sustainability challenge and trying to solve the problem or the many sub-problems, if I may say so, that this issue entails then I think they could make a difference. I don't think there should be pessimism. Yes the climate change issue and the other environmental issues are very serious but that doesn't mean that given sufficient will power and dedication a solution can not be reached at. The younger generation is therefore in a very good position to solve them. ■

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7TH REI EXPO GARNERS APPRECIATION FROM INDUSTRY

The Renewable Energy India Expo 2013 showcased India's renewable energy market and discussed mainstreaming sustainability through a conference. With exhibitors from over 27 countries and more than 10,000 visitors participating, **Meenakshi Dwivedi** reports that the event was a roaring success.

Recognized as Asia's largest Expo on renewable energy, the Renewable Energy India (REI) Expo 2013 was held between September 12 and 14 at the India Expo Centre, Greater Noida. The 7th REI 2013 Expo attracted more than 10,000 visitors from across the globe.

Showcasing products, services, and solutions, the annual exposition aims to serve the Indian renewable energy market in leading sustainable development globally, with a focus on up scaling and mainstreaming environment-friendly renewable energy resources, such as solar, wind, biomass, bio-fuel, small hydro, and geothermal energy and energy-efficiency through an international exhibition and conference platform.

The event is supported by the Centre for Wind Energy Technology (C-WET) set up by the Ministry of New and Renewable Energy (MNRE) and

the Ministry of Power, Government of India. The highlight of the show was participation by exhibitors from over 27 countries who expressed their faith in the Indian renewable energy market as an attractive investment destination. Leading international and domestic trade associations also participated in the Expo, magnifying its visibility.

Both exhibitors and visitors expressed their satisfaction at the approaches outlined for addressing the key challenges faced by the industry, and the outcomes of the Expo and the conference reaffirmed their confidence in the sector. Trade Associations such as the Global Solar Alliance, Panchabuta, Indian Biomass Power Association, Maharashtra Solar Manufacturers Association (MASMA), Wind Independent Power Producers Association (WIPPA), Solar Power Developers Association, Tamil Nadu Solar Energy Developers Association (TNSEDA), and Solar Thermal Federation of India (STFI) also made their presence felt.

Joji George, Managing Director, UBM India, organizer of the Expo, said, "REI 2013 Expo witnessed the crème-de-la-crème as far as industry participation is concerned. Powerful international participation by trade delegations such as JETRO and NEDO from Japan was another highlight wherein they unveiled industry reports. Apart from that, workshops by the Asian Development Bank (ADB), BASF, Sterling and Wilson, and KPMG were also conducted."

Being the country partner, Japan attracted 29 companies under its pavilion which showcased cutting edge technologies and innovative products in the sector. JETRO acted as a catalyst for creating business matching opportunities in all sectors for an inclusive and scalable growth. The Japanese support has taken the Indo–Japan energy dialogue to new heights.

A series of high-power conferences and workshops ran parallel to the Expo. The conference on 'Jawaharlal Nehru National Solar Mission (JNNSM) Phase II — Industry Wish List' chaired by Tarun Kapoor, Joint Secretary, Ministry of New and Renewable Energy (MNRE) and supported by key industry head honchos, stole the show.

Nitin Kasturi, Chief Strategy Officer, BORG Energy India said, "The Expo was a great launch pad for us to showcase our flagship solar brand the 'Astra Home Series' and the Tesla power station that garnered exponential interest levels pointing in the direction of increased business opportunities. The Expo has been quite instrumental in taking us much closer to our prospective customers, resulting in a flurry of enquiries about the products and their benefits. The Expo has been quite resourceful for us to develop new network groups while developing existing relationships with our clients and partners at the same time."

"It was a very heartening and encouraging experience for us at Inox, the fastest growing wind turbine manufacturer in India, as this was a perfect platform to showcase our latest technology best suited for Indian climatic conditions and also our best in class execution capabilities," said Kailash Tarachandani, CEO of Inox Wind Ltd.

The Expo provided an environment conducive to interactive discussions between policy-makers, manufacturers, and financing institutions. The show continues to attract footfalls, confirming its status as Asia's most talked about trade expo in the renewable energy space, with the number of visitors and exhibitors growing with each passing year. ■

CURRENT R&D RENEWABLES

Renewable Energy Certificate Markets in India: A Review
Renewable and Sustainable Energy Reviews, Volume 26, October 2013, Pages 702–716
Gireesh Shrimali, Sumala Tirumalachetty

In India, the National Action Policy on Climate Change (NAPCC) has set a target of 15 per cent of electricity via renewable energy sources by 2020. To reach these ambitious targets, in March 2011, the Government of India launched the Renewable Energy Certificates (REC) — a market based mechanism — to drive renewable energy development and spur further investments. However, a look into the actual performance of REC market trading during the first year of operation shows that, though volume of trading steadily increased, the number of accredited certificates issued was less than 2.5 per cent of the technical REC demand potential, indicating that the full potential of the REC markets was far from being realized. We critically examine the design and implementation of the REC market in India as well as its effectiveness in meeting the desired objectives in the context of international best practices. Our analysis of REC market best practices reveals that, though forward markets, banking and price bounds are recommended for stable markets, best-of-class methods for determining the optimal length of banking, the level of floor and forbearance prices, and the values of credit/vintage multipliers are not fully established. We then establish that the main issues with the Indian REC markets appear to be demand uncertainty resulting from lack of long-term targets, absence of clarity on compliance, and near-absence of long-term price signals to investors. Finally, we present an analysis of other important features of the Indian REC market in the context of well-functioning REC markets, such as credit-multipliers/set-asides, vintage multipliers, and voluntary markets.

Renewable Energy Certificates (RECs) in India: A Performance Analysis and Future Outlook
Renewable and Sustainable Energy Reviews, Volume 27, November 2013, Pages 654–663
Kapil Narula

Well-designed Renewable Energy (RE) policies and their effective regulation is the key to promote RE generation in the world. Renewable Energy Certificate (REC) mechanism is a market-based policy instrument which facilitates Renewable (Energy) Purchase Obligations (RPOs) in order to increase RE generation in a country. The recently conceived and implemented REC mechanism in India attempts to involve various stakeholders in an economically efficient manner and has been effective in its first year of operation. The paper commences with the background and the genesis of REC mechanism in India. It characterises the REC trading mechanism and analyses the performance of the REC market for the financial year 2011–12. Comparing the financial viability for sale of RE by project developers in certain key states, the paper shows that REC mechanism is more profitable than entering into a Power Purchase Agreement (PPA) for sale of RE at Preferential Tariff (feed-in-tariffs). Thus, the REC market which has attained a size of INR 2.3 billion in its first year of existence is forecasted to grow manifold

in the future and the paper attempts to forecast the market size in near term. Further, analysis of the REC market reveals that although there are inherent advantages of the REC mechanism over other methods of promoting growth of RE, the market is currently subject to various distortions and the paper suggests few steps for correcting these distortions by appropriate market re-design. The paper concludes that the REC market mechanism has gained momentum and can effectively promote RE generation in an economically efficient manner, with benefits to all stakeholders, provided it is strictly implemented and continuous corrections are given in the right direction by the market regulator.

Renewable Energy for Rural Communities in Maharashtra, India

Energy Policy, Volume 60, September 2013, Pages 192–199

T Blenkinsopp, SR Coles, K Kirwan

The desire for universal access to modern energy and the use of Renewable Energy Technologies (RETs) as a means of delivering low carbon solutions are driven by several local and global factors, including climate change, population increase and future energy security. Social attitudes are a major challenge to overcome in order to successfully introduce low carbon technologies as a sustainable alternative to more traditional means of energy provision. It becomes a challenge to educate the target population in order to counteract any negative preconceptions or scepticisms in using these technologies which can have adverse effect upon their viability and long-term success. This work presents the results of a rural energy survey conducted in the Indian state of Maharashtra. The survey highlights the opportunities and attitudes of these rural communities towards sustainable modern energy services and the technologies used to deliver them. Results from the survey show that there is interest in using sustainable or renewable technologies for energy provision and suggest that cost, reliability, and ease of use are more important factors than the environmental benefits. A suggestion for a way to improve RET adoption in rural communities is also presented based on the results of this study.

Role of renewable energy investment in India: An alternative to CO_2 mitigation

Renewable and Sustainable Energy Reviews, Volume 26, October 2013, Pages 414–424

A Mahesh, KS Shoba Jasmin

This paper discusses the potential of renewable energy, investment and CO_2 mitigation by renewable energy technologies. Currently, India's per-capita emissions are around one tonne of CO_2/year. The present energy scenario offers India a window of opportunity to invest in renewable energy. The annual turnover of renewable energy industry has reached $12.3 billion in 2011, which is 36 per cent higher than 2010 investment of $7.5 billion. Increasing the share of renewable energy in overall energy mix is an effective option to mitigate CO_2 emission. Presently, the share of renewable energy is around 12 per cent in the energy mix. The present study estimated CO_2 mitigation potential of Indian renewable energy sector about 203 million tonnes with an installed capacity of 24 GW in 2012. However, enormous potential identified in renewable energy sector with favourable CO_2 mitigation the government is compromising with limited financial resources. However, policy efforts need to be strengthened to encourage a massive scale-up of renewable technologies to build sustained low carbon economy.

Status of Solar Wind Renewable Energy in India

Renewable and Sustainable Energy Reviews, Volume 27, November 2013, Pages 1–10

Vikas Khare, Savita Nema, Prashant Baredar

There are some specific constraints that hinder the development of solar and wind energy system in India. However, India has adequate sunshine and balanced wind speed. Hence, there is greater opportunity for extension of solar and wind energy system in the Indian scenario along with enough future scope for these renewable sources through "Grid Parity". The aim of this paper is to present in a coherent and integrated way the major constraints hampering the development of renewable energy in India.

An Assessment of Renewable Energy Potential for Electricity Generation in Pakistan

Renewable and Sustainable Energy Reviews, Volume 20, April 2013, Pages 240–254

Muhammad Khalid Farooq, S Kumar

Renewable energy for power generation is gaining attention around the world, and for Pakistan, these resources can fulfill the present and future energy demands of the country. Though the potential of renewable energy resources has been assessed in earlier studies, their assessment did not consider the most promising technologies. Moreover, their estimation was static and the future renewable resource potential was not estimated. This study estimates the current and future potential of renewable energy sources for power generation by employing most promising technologies. The technical potential of solar energy from solar photovoltaic and parabolic trough thermal technologies for power

generation is estimated to be 149 GW in 2010 and 169 GW in 2050. The suitable area for wind energy generation is available for the capacity installation of 13 GW. The potential from biomass energy sources is 5 GW in 2010 and could be 15 GW in 2050. Small hydro installed capacity under current circumstances can reach 3 GW installed capacity. The current national plans are resulting in exploitation of wind and small hydro plants, but a large technical potential of solar and biomass technologies also exists. The study results clearly demonstrate that renewable energy sources can supplement the energy needs of Pakistan and can provide a sustainable energy base.

A Comprehensive Method to Find Rpo Trajectory and Incentive Scheme for Promotion of Renewable Energy in India with Study of Impact of RPO on Tariff

Energy Policy, Volume 61, October 2013, Pages 686–696

RM Shereef, SA Khaparde

Renewable Purchase Obligation (RPO) regime in India started in 2011 with the announcement of benchmark RPO (BRPO) of states for the Financial Year (FY) 2011 by respective State Electricity Regulatory Commissions (SERC), to promote Renewable Energy (RE). The report submitted to Forum of Regulators (FoR) in this regard has recommended uniform rate of increase of BRPO of states and studied the impact of RPO on tariff for FY 2011–15. However, more rigorous analysis is needed for fixing BRPO in a scientific manner and for fair allocation of incentives to promote RE. This paper attempts to evaluate all states on a common platform to find BRPO, giving due weightage to the state-wise energy demand and RE generation, ensuring minimum change in BRPO of consecutive years and hence less impact of RPO on tariff. To encourage the states to align their actual RPO with BRPO, a financial incentive scheme is proposed giving due weightage to RE consumption, RE capacity addition and RPO compliance of the states. The methods are illustrated for the Indian states using real system data. A study of RPO's impact on electricity tariff of Indian states is also conducted and reported for FY 2011–15, considering Renewable Energy Certificate (REC).

Renewable Electricity Generation in India: A Learning Rate Analysis

Energy Policy, Volume 60, September 2013, Pages 906–915

Ian Partridge

The cost of electricity generation using renewable technologies is widely assumed to be higher than the cost for conventional generation technologies, but likely to fall with growing experience of the technologies concerned. This paper tests the second part of that statement using learning rate analysis, based on large samples of wind and small hydro projects in India, and projects likely changes in these costs through 2020. It is the first study of learning rates for renewable generation technologies in India, and only the second in any developing country—it provides valuable input to the development of Indian energy policy and will be relevant to policy-makers in other developing countries. The paper considers some potential problems with learning rate analysis raised by Nordhaus in the National Bureau of Economic Research Working Paper Series (No. 14638) titled '*The Perils of the Learning Model for Modeling Endogenous Technological Change*' published in 2009. By taking account of these issues, it is possible to both improve the models used for making cost projections and to examine the potential impact of remaining forecasting problems.

Optimum estimation and forecasting of renewable energy consumption by artificial neural networks

Renewable and Sustainable Energy Reviews, Volume 27, November 2013, Pages 605–612

A Azadeh, R Babazadeh, SM Asadzadeh

Increasing energy consumption has led to release of pollutants, such as greenhouse gases that effect human health, agriculture, natural ecosystems, and earth temperature. Accurate estimation and forecasting of renewable energy is vital for policy-and decision-making process in energy sector. This paper presents an Artificial Neural Network (ANN) approach for optimum estimation and forecasting of renewable energy consumption by considering environmental and economic factors. The ANN trains and tests data with Multi Layer Perceptron (MLP) approach which has the lowest Mean Absolute Percentage Error (MAPE). The proposed approach is particularly useful for locations where there are no available measurement equipment. To show the applicability and superiority of the proposed ANN approach, monthly available data were collected for 11 years (1996–2006) in Iran. Complete sensitivity analysis is conducted to choose the best model for prediction of renewable energy consumption. The acquired results have shown high accuracy of about 99.9 per cent. The results of the proposed model have been compared with conventional and fuzzy regression models to show its advantages and superiority. The outcome of this paper provides policy-makers with an efficient tool for optimum prediction of renewable energy consumption. This study bypasses previous studies with respect to several distinct features. ■

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MANAGING FORESTS AS COMPLEX ADAPTIVE SYSTEMS

Building Resilience to the Challenge of Global Change

Author: Christian Messier, Klaus J Puettmann, and K David Coates
Year: 2013
Pages: 368
Publisher: Routledge

In times where global environmental changes occur most severely in large parts of the human society, there are fears of diminishing well-being, along with alteration and even extinction of entire ecosystems. There is a lack of understanding of the earth as a live supporting system that can cope with present and future challenges posed by environmental changes. The ecosystems as we see them today are "trained" in adapting to environmental changes of different magnitudes. This may lessen the fear of global changes and enable society to realise that we deal with complex adaptive systems that provide us with efficient tools to maintain our well-being, only if we are wise enough to understand and use them.

It is with this spirit that the book is edited by Christian Messier, Klaus Puettmann, and David Coats. It provides a profound and holistic overview of the major global forest biomes as complex systems that have a good potential to adapt to the future global changes. The book is not just a collection of articles, but is a result of a process of joint learning undertaken by the authors in a three-day workshop held in the initial phase of the book. In this workshop, the contributing authors have interacted with experts of complexity science and exchanged their concepts and ideas for the book. As a result, the outcome is an organised, informative and well-written piece of work.

The book raises an important that can complex science provide a useful framework for understanding the functioning of various forest biomes? It also aks if these can be useful in reconciling the variety of recently developing forest management and restoration approaches that are emerging in numerous regions?

To address this question the book is structured in three parts. The first part, "Setting the stage" sets the foundation by showing how forests are adaptive systems, clarifying terminologies used for complex adaptive systems. It also points out differences in the views on forests as complex adaptive systems and traditional forest management. The second chapter informs the reader about the characteristics of complex systems and key definitions used in complexity science. This makes the reader well-prepared to absorb the messages of the second part which apply the concepts of complexity science to three major forest biomes. In the third chapter, starts off with an excellent introduction into tropical forest as complex adaptive systems. The central finding of the chapter is that tropical forests are not fragile systems but "resilient to a range of natural and human large-scale disturbances". In the fourth chapter, Sybille Haeussler, Charles Canham, and David Coats merge forest dynamics of temperate forests and principles of complexity science together by comparing forest of the West and East coast in North America. They

conclude that "complexity science has become, de facto, our modern theory of succession" and this succession is lifted from a sequence of different plant communities to the core element of the new approach to forests as complex adaptive systems. The fifth chapter shows the reader that the principle of complexity systems not only applies to forests with a high diversity in species and structure like tropical forests, but also to forest ecosystems that are relatively poor in tree species. He points at the high diversity of boreal forest taxa that exists beside trees, mainly among soil biota, including an enormous variety in species and genomes of mycorrhizal fungi. It gets evident that these interactions drive a diversity that, to a large extent, lies in compositions of species that assemble in many different pathways of succession, acting as a set of tools of boreal forest systems to respond to disturbances.

Informed about the ecological basics of forests as complex adaptive systems through these illustrated examples, the reader gets into the third part of the book and gets introduced to the management of forest against the backdrop of complexity science. Chapters 6 and 8 elucidate the challenges in the practical application of the complexity science in the southern boreal transition zone at the Great Lakes region and tropical forest. In Chapter 8, after introducing ecological features important for silviculturists as well as the problems they face in Bornean Forests, Francis Puts points out that the knowledge and concepts for tropical forests remain mainly in the academic community and hardly reach on-the-ground managers. The seventh chapter illustrates the complexity of interaction between different elements of temperate Douglas fire forest in meta-networks connecting fungi, fauna and flora in a comprehensive manner and how the knowledge about these mutual interaction can aid in conceptualising forest management.

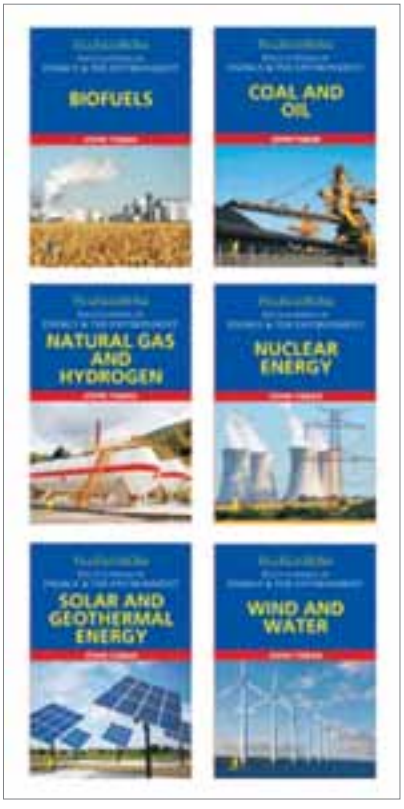
Chapter 9 asks if the close-to-nature forest management (CTNFM) in Europe leads to an enhanced complexity and adaptability of these forests. They find that CTNFM overlaps with principles of complexity science to some extent but fall short of some important aspects like permitting large scale disturbance that triggers diversity and capacity to adapt. In Chapter 10, the reader gains new insights in the complex topic of the severe alteration in the Mediterranean forests due to a long history of human land use. As a consequence, the forests act as complex adaptive systems and instead of avoiding them, a call to include changes in forest management framework has been made. Chapter 11 shows the complexity in species interaction in the boreal forests of Finland and the role the forest fire plays in building structure and resilience. They point out that it is time to utilize the capacity of as complex adaptive systems in order to enhance this capacity and not lose it. In Chapter 12, elaborates in length and maybe a bit too long , about fire as a natural agent of complexity of Tasmanian forests and expresses the need to further build this knowledge and apply it in forest management as a preparation measure for the unpredicted changes that can be expected in future. Finding of Chapter 13 are important as it shows that forest plantations do not need to be green deserts and they contribute to enhance ecosystem functions as "simplified complex adaptive forest ecosystems".

The final chapter on the history of this book is a pleasure to read. It summarises the main findings and provides space to the main authors of the chapters to express their learnings that emerged while writing their contributions. Messier et al. also answers the questions that they asked at the beginning. The answer to the first question is a clear yes and the answer to the second question leads to a statement that a new approach in forest management is needed that sees forests as a "network of interaction and strongly linked elements that compete and help one another at the same time". At the end of the different chapters of part III, they show that this new approach has already started to realise in several parts of the world.

The book provides new insights of ecology and forest science with practical relevance. Another example, that would have added value to the book, are of mangrove forests, that are also often perceived as fragile but are a very good example for complex adaptive forest ecosystem at the forefront of climate change. Some chapters could have been made more focussed in their approach to inform managers. For instance, Chapter 12 gives the impression of promoting the utilization of fire as a tool for forest management against the view of environmentalists. More space could have been given to the ecological role of fire in Tasmanian forest in the backdrop of a long history of fire as a management tool in this region. The best match may have been provided by Chapter 9 as it informs a well-establish forest administration in Europe which is likely to absorb some of the findings. However, the book is not thought to be a guideline in management, but is an excellent tool that could be used in higher education and research and as a base to develop means of communication to reach out to practitioners. It can only be hoped that this trend continues to benefit the society and the knowledge about forest as complex adaptive systems finds its way, not only to forest managers but also to environmentalist and conservationists and even further to larger parts of society. ■

The book was reviewed by Dr Joachim Schmerbeck.

Encyclopedia of Energy and the Environment (6 vols) (2013) set of 6 vols (2013) VIVA



The book examines the history, technology, science, environmental, and social implications (including issues of Environmental justice) associated with the acquisition and production of energy. Designed to complement science curricula, each volume describes comprehensively one or more sources of energy and the technology needed to make it useful. The books emphasize the science on which such technology is based, the limitations of each technology, the environmental effects of its use, questions of availability and cost, and the way in which government policies and energy markets interact. Each Volume contains more than 40 colour photographs and four-colour line illustrations, sidebars, a chronology, a list of acronyms, a glossary, a detailed list of print and Internet resources, and an index. Energy and the Environment is essential for high school students, teachers, and general readers who wish to learn about the effects of large-scale energy production and consumption on the society. ■

Author: Elvin Yuzugullu • **Year:** 2013 • **Pages:** 246 • **Publisher:** Artech House

Volume 1: Biofuels

Biofuels describes the principal fuels derived from recently decayed biological material, the methods by which they are produced, and their uses in transportation and in electricity production. The book also discusses the implications of large-scale biofuel use on the environment and on the economy, with special consideration given to its effects on the price of food. The book features an exclusive interview with economist Dr Amani Elobeid, a widely respected expert on ethanol, food security, trade policy, and the international sugar markets, who shares her thoughts on these subjects. The volume includes information on biodiesel, biomass, combustion, electricity production, environmental protection, ethanol, the nature and history of biofuels and policy, research, and legislation.■

Volume 2: Coal and Oil

Coal and Oil is a timely overview of the complex relationship that the world has with these primary sources of fuels. The book describes the characteristics of these energy sources, the ways in which they are used, and the technical, social, policy, and environmental consequences of large scale coal and oil consumption. The book also features an exclusive interview with Ms Charlene Marshall, a member of the West Virginia house of Delegates, who shares her thoughts on the safety and environmental hazards of coal and coal mining. The volume includes information on alternative uses for coal and oil, the chemistry and geology of oil, the environmental and social costs of mining, the global oil economy's impact on the environment, a historical overview of the coal and oil industries, obtaining and transporting oil, oil markets and governmental policies and power-production technologies. ■

Volume 3: Natural Gas and Hydrogen

Natural Gas and Hydrogen is a timely overview of the complex relationship that the world has with two significant sources of gaseous fuel. The book discusses the business of natural gas production and the energy futures markets that have evolved as vehicles for speculation and risk management. It also focuses on the possible advantages of adopting hydrogen as a viable source of energy, as well as on the inevitable obstacles that hamper large-scale fuel switching. The author includes an exclusive interview with Dr Ray Boswell of the US Department of Energy's National Energy Technology Laboratory in which Boswell discusses his work in identifying and characterizing methane hydrate reserves, one of the most promising fields of energy research today. The volume includes information on early gas technologies and policies, electricity generation, energy markets and energy politics, government policies, a hydrogen economy, the origin and nature of natural gas, the physical and chemical properties of hydrogen and the restructured natural gas market. ■

Volume 4: Nuclear Energy

Nuclear Energy is an objective discussion of commercial nuclear power, a hotly debated issue of worldwide significance for many decades and one of the most controversial power-generation technologies. The book covers not only the physics and technology of energy production, reactor design, and nuclear safety but also the relationship between commercial nuclear power and nuclear proliferation and the United States attempts to resolve the problem of nuclear waste disposal. The book also features an exclusive interview with Harold Denton, the Former Director of the Office of Nuclear Reactor Regulation at the US Nuclear Regulatory Commission, on the commercial nuclear industry. The volume includes information on the business of electricity production, nuclear energy and national policy, reactor fuel, nuclear reactor designs, the physics of nuclear fission, a prehistory of nuclear power, reactor safety, and spent fuel. ■

Volume 5: Solar and Geothermal Energy

Solar and Geothermal Energy describes two of the least environmentally disruptive sources of power by which electricity is generated today. In addition to an overview of both solar and geothermal energy and the processes by which they can be harnessed, the book details how these sources are used to supply electricity and discusses ways in which governmental policies affect the growth of these sectors of the power market. The book also features an exclusive interview with John Farison, director of process engineering for Calpine Corporation at the Geysers Geothermal Field, one of the world's largest and most productive geothermal facilities, in which he discusses the challenges of maintaining output at the facility, alternative geothermal technologies, economic and environmental consequences and energy, geology and heat, heat engines and solar power, photovoltaics, sunlight and geometry, government policies and energy, and solar power and geothermal energy use through history. ■

Volume 6: Wind and Water

Wind and Water describes conventional hydropower, or wind power, and some newer technologies (with less predictable futures) that are being introduced to harness the power of ocean currents, ocean waves, and the temperature difference between the upper and lower layers of the ocean. The book discusses the strengths and limitations of each technology, the mathematical models that articulate the maximum amount of energy that can be channeled through such devices, how these power producers benefit from government subsidies, and the economics of operating these types of generating stations. The book includes an exclusive interview with Dr Stan Bull, Associate Director for science and technology at the National Renewable Energy Laboratory, in which he shares views on how scientific research projects should be managed and evaluated. The volume includes information on costs and public policy considerations, 'creating' supply and demand, history of waterpower and wind power, government's role in promoting new technologies, hydroelectric power, heat engines, tidal and wave power, and wind energy. ■

RENEWABLE ENERGY TECHNOLOGY DEVELOPMENT

Table Lamps, Smart Phones: In With Antennas, Out With Electrical Cords

The pretty designer lamp on the table is meant to add charm to the room. If only the annoying cord wasn't there, then you could also put the lamp in the center of the table when it suited you. In future, you will be able to do just that thanks to SUPA Wireless technology. SUPA stands for Smart Universal Power Antenna, and the technology removes the need for electric cables, whether for lamps, laptops or smartphones. Researchers at the Fraunhofer Institute for Electronic Nano Systems ENAS have developed SUPA Wireless together with colleagues at the University of Paderborn and four medium-sized technology companies. "Without cables, you can put your lamps anywhere you like on the table — and they look better to boot," says Dr Christian Hedayat, Department Head at Fraunhofer ENAS in Paderborn.

http://www.sciencedaily.com/releases/2013/09/130904093303.htm

Generating Cool Energy from Low-Temp Geothermal Liquids

Recent Department of Energy awards for small Cleantech businesses included one to Cool Energy, a Boulder, Colorado, company that has developed a new Stirling engine that converts low temperature heat energy into electricity. The grant will support a demo programme to build the company's first 20kW prototype engine and use it to generate electricity from untapped heat from distributed geothermal sources.

http://blog.cleantechies.com/2013/09/06/generating-cool-energy-from-low-temp-geothermal-liquids/

New Technologies Aim to Save Energy—and Lives—with Better Air-Conditioning

As the heat of summer fades into the cool of fall in the US, air-conditioning becomes more luxury than necessity. Yet demand for cool, dry air during hot spells is on the rise—and not just because of global warming. The US expends roughly 185 billion kilowatt-hours of energy each year on home cooling, the most of any nation in the world. Plus, air-conditioner sales worldwide are growing by roughly 20 per cent per year, with the newly affluent in China and India leading the way.

http://www.scientificamerican.com/article.cfm

A Standardized Approach to Distributed Solar Studies

With distributed solar growing at a record pace, states nationwide are assessing the benefits and costs of this dynamic resource. The implications of these studies couldn't be greater, as cornerstone policies such as net metering are on the line. To help guide those critical efforts, Vote Solar, and the Solar Energy Industries Association hosted a webinar exploring the lessons learned and emerging best practices from the now substantial volume of studies evaluating the costs and benefits of distributed solar generation (DSG).
The webinar featured experts from Rocky Mountain Institute (RMI), Interstate Renewable Energy Council (IREC), and Rábago Energy Consulting. RMI shared finding from their recently released study entitled, 'A Review of Solar PV Benefit and Cost Studies', which reviews 16 DSG benefit/cost studies by utilities, national labs, and other organizations.

http://blog.cleantechies.com/2013/09/06/a-standardized-approach-to-distributed-solar-studies/

MAGAZINES ON ENERGY, ENVIRONMENT AND SUSTAINABLE DEVELOPMENT

TerraGreen

TerraGreen promotes the concept of **sustainable energy for all**. Launched in June 2004, this monthly flagship magazine of TERI acts as a platform for information and knowledge dissemination in the fields of **energy**, **environment**, and **sustainable development**. It brings to its readers in-depth coverage of environment-related issues—from energy options for the future to sustainable community development and climate change. With a communication style that is reader friendly and content that is broad-based, ***TerraGreen*** has emerged as a pioneer magazine in this field in India.

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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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NATIONAL AND INTERNATIONAL EVENTS

Portfolio.hu Energy Investment Forum 2013
3 October 2013
Budapest, Hungary
Website: http://www.portfolio.hu/en/events/reszletes.tdp?id=55

Energy and Environmental Protection in Sustainable
9–10 October 2013
Hebron, West Bank, Palestinian Territories
Website: http://conference.ppu.edu/iceep3/files/ICEEP13_%20Call%20for%20Paper_3_12_2012_Finalized.pdf

3rd International Conference on Petroleum and Sustainable Development (ICPSD 2013)
12–13 October 2013
Paris, France
Website: http://www.icpsd.org/

People in Energy Summit 2013
28–30 October 2013
Houston, TX, The United States of America
Website: http://the-tma.org/oilandenergy/

International Conference Industrial Engineering and Environment Protection
30 October 2013
Zrenjanin, Vojvodina, Serbia
Website: http://www.tfzr.uns.ac.rs/ieep/index.php

Target Energy 2013
31 October–1 November 2013
Washington DC, The United States of America
Website: http://www.targetenergy.org

POWER-GEN Africa
6–8 November 2013
Johannesburg, South Africa
Website: http://www.powergenafrica.com

Middle East Smart Lighting and Energy Summit
11–12 November 2013
Abu Dhabi, The United Arab Emirates
Website: http://www.lightingsummit.com

5th Annual Baltic Energy Summit
13–14 November 2013
Helsinki, Finland
Website: http://www.eelevents.co.uk/baltic_energy_summit_2013/

Solar Qatar Summit 2013
18–19 November 2013
Doha, Qatar
Website: http://www.solarqatarsummit.com

Nuclear New Build Forum 2013
19 November 2013
London, The United Kingdom
Website: http://marketforce.eu.com/events/nuclear/nuclear-new-build-forum?utm_source=conferencealerts.com&utm_medium=event_calendar&utm_campaign=newbuild13_conferencealerts.com_event_calendar&src=conferencealerts.com

5th MWT Workshop in Freiburg
20–21 November 2013
Freiburg, Germany
Website: http://www.mwt-workshop.com

3rd International Conference on Power and Energy Systems (ICPES 2013)
23–24 November 2013
Bangkok, Thailand
Website: http://www.icpes.org/

2nd International Conference on Cement Industry, Energy and Environment (CIEE)
24–25 November 2013
Tehran, Iran
Website: http://cie.ut.ac.ir/

Conference of Natural Resources and Development
25–28 November 2013
Viña del Mar, Valparaíso, Chile
Website: http://confnrd2013.info/

International Research Conference on Innovations in Engineering, Science and Technology
27–29 November 2013
Batangas City, Batangas, The Philippines
Website: http://www.irciest.com.ph

2014 1st International Conference on Non Conventional Energy (ICONCE 2014)
16–17 January 2014
Kalyani, India
http://www.iconce.in

RENEWABLE ENERGY AT A GLANCE

New and Renewable Energy : Cumulative deployment of various Renewable Energy Systems/ Devices in the country as on 31/07/2013				
Renewable Energy Programme/ Systems	***Target for 2013-14***	***Deployment during July, 2013***	***Total Deployment in 2013–14***	***Cumulative achievement up to 31.07.2013***
I. POWER FROM RENEWABLES:				
A. GRID-INTERACTIVE POWER (CAPACITIES IN MW)				
Wind Power	*2500*	*96.20*	*608.20*	*19661.15*
Small Hydro Power	*300*	*20.50*	*74.50*	*3706.75*
Biomass Power	*105*	*-*	*-*	
Bagasse Cogeneration	*300*	*-*	*-*	*2337.43*
Waste to Power -Urban	*20*	*-*	*-*	*96.08*
-Industrial		*-*	*-*	
Solar Power (SPV)	*1100*	*79.56*	*152.56*	*1839.00*
Total	*4325.00*	*196.26*	*835.26*	*28905.21*
B. OFFGRID/ CAPTIVE POWER (CAPACITIES IN MWEQ)				
Waste to Energy -Urban	*10.00*	*-*	*-*	*115.57*
-Industrial				
Biomass(non-bagasse) Cogeneration	*80.00*	*12.00*	*15.69*	*486.84*
Biomass Gasifiers -Rural	*1.00*		*0.10*	*16.892*
-Industrial	*9.00*		*1.30*	*142.88*
Aero-Genrators/Hybrid systems	*1.00*	*0.03*	*0.03*	*2.14*
SPV Systems (>1kW)	*40.00*	*-*	*7.19*	*131.86*
Water mills/micro hydel	*500 Nos.*	*-*	*-*	*10.65 (2131 nos)*
Bio-gas based energy system	*2*	*-*	*-*	*-*
Total	*143.00*	*12.03*	*24.31*	*906.83*
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*	*-*	*-*	*46.55*
Solar Water Heating - Coll. Areas (Million m2)	*0.60*	*0.07*	*0.07*	*7.07*

Source: www.mnre.gov.in