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ENERGY FUTURE

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COVER STORY

ENERGY TRANSITION: AN ENABLER OF CHANGE

VIEWPOINT

RECYCLE YOUR THOUGHTS

FEATURE

ELECTRIC VEHICLE MOBILITY IN INDIA

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Head Office
TERI
Darbari Seth Block, IHC Complex
Lodhi Road, New Delhi – 110 003
Tel. +91 (11) 2468 2100 or 2468 2111
Fax +91 (11) 2468 2144 or 2468 2145

Regional Centres
Southern Regional Centre
TERI, CA Site No. 2
4th Main, 2nd Stage Domlur
Bengaluru – 560 071
Email: terisrc@teri.res.in

North-Eastern Regional Centre
TERI, Chachal Hengrabari
Express Highway, VIP Road
Guwahati – 781 036

Western Regional Centre
TERI, F-9, La Marvel Colony
Dona Paula, Panaji – 403 004 (Goa)
Email: teriwrc@goatelecom.com

Affiliate Institutes
TERI North America
1152 15th Street NW Suite 300
Washington, DC 20005
Email: terina@teri.res.in

TERI Europe
27 Albert Grove, London SW20 8PZ, UK
Email: ritukumar@aol.com

Overseas Representation
TERI Japan
C/o IGES
Nippon Press Centre Building (8th Floor)
2-2-1, Uchisaiwai-cho, Chiyodi-ku
Tokyo, Japan - 100-0011
Email: teris@iges.or.jp

TERI South-East Asia
Unit 503, 5th Floor, Menara Mutiara Majestic
15 Jalan Othman, Seksyen 3, 4600 Petaling Jaya,
Selagor Darul Ehsan, Malaysia
Email: nimtech@tm.net.my

TERI Gulf Centre
Flat No. 105, Dalal Building, Al Qusais,
Dubai, UAE

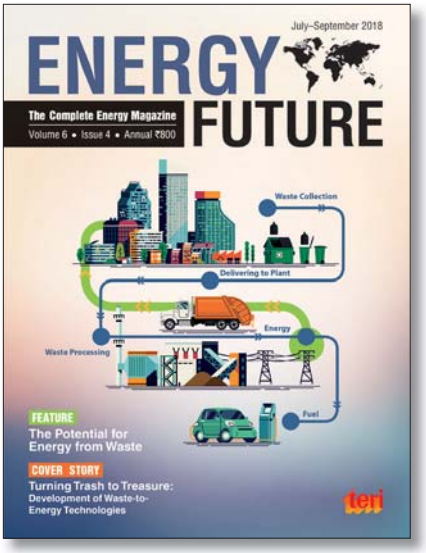
From the editor's desk...

What is 'transition'? According to Cambridge English dictionary, it is 'a change from one form or type to another, or the process by which this happens'. Thus, the 'energy transition' points to change from one form of energy to another. The background of `energy transition' can be traced back to Conference of the Parties (COP21) held in Paris in 2015. COP21 saw a global agreement to limit the global temperature increase – compared to pre-industrial levels – to 2 °C. Indeed, the ambition is to tame this increase to 1.5 °C. This translates in to reduction of energy-related CO_2 emissions by around 70% by 2050 as compared to 2010 levels. Essentially, the energy transition is all about decarbonization of energy system, at both the ends of spectrum: generation as well as consumption. Developing countries like India have twin challenges. While they require enormous amount of energy for their socio-economic development; they also have to provide universal energy access to millions of people who do not have access to electricity or clean cooking energy so far. It implies that this energy transition, from developing countries' perspective, must also be cost-efficient. Generally it is assumed that the energy transition or decarbonization of energy sector is all about replacing fossil fuels based energy supply to that relying on clean resources like renewable energy. While this is true, it gives only half of the narrative. Actually, the whole construct of this transition is built around two pillars, namely, energy conservation and clean energy supply. The first and foremost step of this process of change is reducing energy demands in all the sectors. This in turn implies obviating wasteful energy consumption and moving towards energy-efficient equipment and appliances. Actually, being simply energy-efficient is passé now because the energy transition is accelerated by 'super' efficient appliances. While energy demand reduction is being affected on one side, simultaneously the focus is also on how this demand can be met through clean energy sources such as renewables. Transport being one of the largest consumers of fossil fuel, and consequently a major contributor to GHG emissions, it is also a crucial part of this transition puzzle. Electric and hydrogen vehicles are the prime movers of that transition where charging is done not through dirty, fossil fuels based electricity but through solar or renewables–generated electricity. While technological solutions play their role, the real transition is contingent on our lifestyles; how far do we succeed in making our day-to-day life less energy-intensive.

Amit Kumar

Amit Kumar
Senior Director, Social Transformation, TERI

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



New Message

teripress@teri.res.in

Letter to the Editor

With reference to the cover story published in the July–September 2018 issue of *Energy Future*, I recently read in a newspaper report that nearly half of India's waste-to-energy (WTE) plants, meant to convert non-biodegradable waste, are defunct. Further, the country's inability to segregate waste has resulted in even the existing plants working below capacity. Since 1987, 15 WTE plants have been set up across the country. However, seven of these plants have since shut down. The key reasons for closure are the plants' inability to handle mixed solid waste and the high cost of electricity generated by them that renders it unattractive to power companies. We need to arrest the slide soon, hopefully.

Arvind Sawhney
New Delhi

Trebuch... | Send | Saved

"I liked reading the article on clean energy farming published in the latest issue of Energy Future. The authors have explained the role of RE sources in the agricultural sector, focussing in particular on how agriculturists can use renewables as a growing source of energy and rural income in India. It is also a means of enhancing sustainable food security in the country and presents the existing technologies and emerging opportunities in RE application in the agricultural sector. Thanks for such informative articles."

Madhavi Rai
Panchkula, Haryana

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

Email: teripress@teri.res.in

Editor
Energy Future

"Your magazine provides me with all the information that I need related to the energy sector. The article on MNRE's Solar Pumps Programme is very relevant for me. Evaluation on how farmers in the country fared with the MNRE-invested programme is useful. The author is correct as he says that the MNRE is proactively taking the right steps in the desired direction to deliver on national agricultural priorities. The solar pump programme can support the Ministry of Agriculture's efforts to achieve the PM's vision of "doubling farmer incomes by 2022".

T K Raghavan
Chennai, Tamil Nadu

"The article on energy from waste published in the July–September 2018 issue of your magazine is very apt. The increasing industrialization, development, and changes in the pattern of life, which accompany the process of economic growth, give rise to generation of increasing quantities of wastes leading to increased threats to the environment. In recent years, technologies have been developed that not only help in generating substantial quantity of decentralized energy but also in reducing the quantity of waste for its safe disposal. I read that the Indian government is promoting all the technology options available for setting up projects for recovery of energy from urban wastes. In developed countries, environmental concerns rather than energy recovery is the prime motivator for waste-to-energy facilities, which help in treating and disposing of wastes. Energy in the form of biogas, heat or power is seen as a bonus, which improves the viability of such projects.

Arunabha S Murthi
Hyderabad, Telangana

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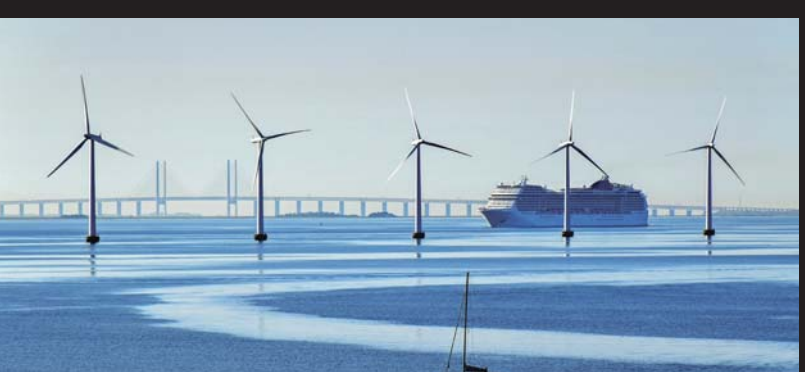


INDIA TARGETING 40% OF POWER GENERATION FROM NON-FOSSIL FUELS BY 2030

India is targeting 40% of electricity generation from non-fossil fuel-based resources by 2030 as it looks to tap vast solar and wind potential to replace reliance on polluting coal to meet its energy needs, according to Prime Minister Shri Narendra Modi.

Shri Modi said he saw the 121-country International Solar Alliance as the future OPEC for meeting energy needs of the world. Oil cartel OPEC led by Saudi Arabia currently meets close to half of the world's oil needs. Speaking at the first Assembly of the ISA, he said the solar power will play the same role that oil wells have played over the past few decades in meeting global energy needs. For a secure future, resources available above the ground like solar and wind energy need to be harnessed. EF

Source: The Times of India

INDIA, FRANCE SIGN TWO PACTS FOR RENEWABLE ENERGY INNOVATION

Two agreements have been signed between India and France to foster the development of renewable energy innovations in the country, such as high-efficiency solar panels, power storage, e-mobility, and smart grid management.

French Minister Brune Poirson signed two cooperation agreements between the French Development Agency (AFD), the French Alternative Energies and Atomic Energy Commission (CEA), Bollor lue-Solution and their Indian partner, Solar Energy Corporation of India (SECI), according to an official statement. These agreements will foster the development of renewable energy innovations in India, such as high-efficiency solar panels, power storage, e-mobility and smart grid management. EF

Source: The Hindu Business Line

UP GETS SEPARATE WASTE MANAGEMENT BODY

Modifying a previous order passed on the compliance of Municipal Solid Waste Management Rules, the National Green Tribunal (NGT) has constituted a separate committee to implement the rules in Uttar Pradesh. While constituting a committee to be headed by former Allahabad High Court judge, Justice Devi Prasad Singh, the Bench said, "Considering the fact that Uttar Pradesh has a large number of local bodies, it will be appropriate that a separate committee is constituted for the State." The green panel further said that the committees will ensure implementation of plastic waste management, construction and demolition waste and bio-medical waste rules. EF

Source: The Hindu

ANDHRA GOVERNMENT TO IMPLEMENT ENERGY CONSERVATION BUILDING CODE

In a first in the country, the State government is going to launch Energy Conservation Building Code (ECBC) for saving energy and reducing air pollution and power outages.

The groundbreaking ECBC implementation has been made mandatory by incorporation of the ECBC clause in online Development Permission Management System (DPMS) by the Directorate of Town and Country Planning (DTCP) of the Municipal Administration department from Monday (October 22, 2018). It will be formally launched soon. According to the chief secretary, the Chief Minister Shri N Chandrababu Naidu has directed them to implement water security, energy security and environmental protection for the overall economic development of the State. ECBC applies to any commercial building or complex that has plot area of 1,000 sq. m or more or built-up area of 2,000 sq. m or more buildings such as multiplexes, hospitals and hotels must comply with ECBC irrespective of built-up area. Administrative Staff College of India (ASCI) has been working with State government to develop and implement the code. EF

Source: The New Indian Express

IIT-KHARAGPUR DEVELOPS TECH TO FILTER FAKE NEWS ABOUT DISASTERS

Filtering out fake news about disasters on social media platforms such as WhatsApp, Twitter and Facebook is going to get simpler. The Indian Institute of Technology Kharagpur has come up with a solution that uses artificial intelligence to extract critical information from social media platforms that is difficult to obtain manually. This information can be used to determine the authenticity of posts and also pass on data to aid rescue and relief operations.

This is how it works: While one tweets about the situation of victims hit by an earthquake in English or Hindi, a computer programme can read through the empathetic post and send the relevant information to relief operators nearby. A person sitting in the control room can get live updates about what resources are needed and where they are available and coordinate relief operations accordingly. EF

Source: The Economic Times

UN SELECTS NOIDA TO PARTICIPATE IN GLOBAL SUSTAINABLE CITIES 2025 INITIATIVE

The United Nations officially invited Uttar Pradesh's Noida and Greater Noida to become a member of its initiative which aims to create 25 model cities across the world that will be fully compliant with the sustainable development goals by 2025, officials said. The twin-cities in Gautam Buddh Nagar district, adjoining the national capital, have been selected in the "University City" category ahead of Mumbai and Bengaluru, which were also under UN consideration for the initiative, as the only invitee from India, a senior UN official said.

"Noida (along with Greater Noida) has been formally invited to participate in this showcase 'Race to Sustainability' among 25 global cities to become fully compliant with the Sustainable Development Goals by 2025 under the UN Global Sustainable Development Goals (SDG) cities initiative," said Senior UN Advisor and CEO UN Global Sustainability Index Institute (UNGSII) Roland Schatz. EF

Source: The Economic Times

OVER 5,000 PEOPLE REGISTER TO USE DELHI CIVIC BODY'S SMART CYCLES

New Delhi Municipal Council's (NDMC) ambitious 'smart cycle' sharing project has received an encouraging response in its one-month trial with over 5,000 people registering to avail the facility, officials said. Seeing the tremendous response, NDMC chairman Naresh Kumar announced a plan to develop cycling tracks on major roads (starting on pilot basis at Barakhamba Road), 50 more cycling stands and hold a cycling carnival every month next year to promote the concept. He said these stands would be located close to residential areas, education institutes, and hospitals so that people can easily use them as a means of last-mile connectivity to neighbouring Metro stations and bus stands. People who wish to avail this facility can do so by registering on NDMC's app — 'NDMC-311'. "After registration, cyclists can use the touchpad on back of the cycle to unlock it through a one-time password (OTP). This app-based system records the time when the bike is unlocked and the user is charged the fee accordingly," he added. EF

Source: Hindustan Times

IIT HYDERABAD USES RECYCLED MATERIAL TO REDUCE VIRGIN ASPHALT FOR ROADS

Two IIT Hyderabad professors and their graduate students have come up with an innovative material to lay roads which reduces cost, is environmentally friendly and also stronger than asphalt roads. This material — reclaimed asphalt pavement (RAP) — uses a mix of fly ash (a coal-combustion by-product) with reclaimed asphalt concrete. It reduces use of virgin asphalt by about 30%. The team's findings have been published in journals such as *Construction and Building Materials* and *Journal of Materials in Civil Engineering*. Further, the material has also been tested on sections of the road built as "part of the State highway (SH 2213) connecting Nuzvid and Mylavaram [in Andhra Pradesh] designed for a traffic of 1,213 commercial vehicles per day," according to Sireesh Saride, the Principal Investigator of the project. Reclaimed asphalt concrete is by itself not strong enough to lay roads with. Amongst the several additives that have been tried out to bolster its strength are limestone and industrial waste such as fly ash. Fly ash consists of fine particles of ash that mix and escape from chimneys of coal-fired boilers and is now collected by using electrostatic precipitators before they escape. "India is producing lot of fly ash which has very low calcium content. Low calcium fly ashes would not produce high pozzolanic reactions, meaning they are not highly cementitious materials. They need some kind of additives/activators to enhance their reactivity and cementation," explains Prof. Saride. EF

Source: The Hindu

NEW BEIJING AIRPORT TO PROMOTE USE OF RENEWABLE ENERGY

Renewable energy will account for over 10% of the total energy consumption of Beijing's new international airport when it starts operation, according to local authorities. Beijing Daxing International Airport, set to start test runs at the end of September 2019, will combine the use of solar energy, earth energy with traditional energy sources, according to the Beijing Municipal Commission of Development and Reform. Solar photovoltaic systems will be installed on the roofs of the airport, including its car park buildings, business jet hangars and cargo areas. They are set to generate up to 6.1 million kilowatt hours of electricity each year. EF

Source: China Daily.com

TUNISIA PRODUCES 3% OF ELECTRICITY FROM RENEWABLE ENERGY

A total of 3% of the electricity is from renewable energy in Tunisia, according to President of Tunisian Association of Wind Energy (ATEE) Nafaa Bakari at an international forum on renewable energy, energy efficiency, and investment in energy infrastructure.

Bakari said that Tunisia was able to make the first steps towards energy transition in a carbon-free economy voicing hope to reach 20% by 2020 and 22% by 2030.

Since 2017, a series of international tenders were launched for the achievement of major energy projects by the production of 1,000 megawatts from renewable energy, including 500 megawatts from solar photovoltaic energy and 500 megawatts from wind energy. EF

Source: Tunisian Monitor Online

GUATEMALA TO USE BIO-FENCES TO REDUCE PLASTIC POLLUTION

Guatemala announced a commitment to reduce plastic pollution in the oceans as part of the UN Environment Programme's (UNEP, or UN Environment) Clean Seas Campaign. Guatemala will stop plastics from entering the ocean by installing bio-fences in its rivers to recover plastic debris.

Guatemala's Minister of Environment and Natural Resources Alfonso Alonzo announced his government's commitment at the 21st Meeting of the Forum of Ministers of Environment of Latin America and the Caribbean (LAC), which took place in Buenos Aires, Argentina, from 9–12 October 2018. He said Guatemala is "actively fighting plastic pollution through innovation and community participation" as part of an effort to preserve healthy oceans for future generations.

Guatemala pledged to increase waste collection in its rivers through deploying artisanal bio-fences that are made from recovered plastic debris and installed in rivers across the country to trap and collect plastic waste. The fence nets catch the plastic waste, making it easier for communities to recycle or dispose of it properly. The El Quetzalito community, located near the mouth of Guatemala's Motagua river, which flows to the Caribbean Sea, was a pioneer in using bio-fences. Through the deployment of bio-fences, community residents have generated additional income through recycling and upcycling. EF

Source: SDG Knowledge Hu

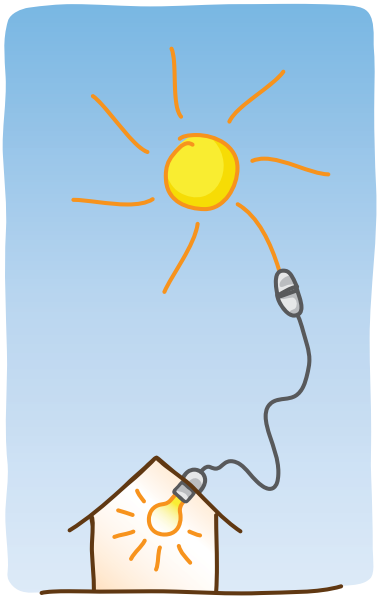
COCA-COLA GOES BETTER WITH SOLAR, GREENSYNC TUNES UP 'SMART GRID'

Coca-Cola Amatil has decided that things go better with rooftop solar at bottling plants all over Australia and software firm Greensync is set to launch the next stages of its deX Connect distributed energy platform – part of the smart grid solution to grid instability caused by rapid renewable energy uptake. The developments are the latest examples of the transition to clean, decentralized energy continuing in the face of federal government policy upheavals and attempts to subsidize "firm" generation such as coal power stations and browbeat power companies to cut their prices.

Coke will install 3.5 megawatts of solar panels on three bottling plants at Eastern Creek in western Sydney, Kewdale in Western Australia and Richlands-Titan in Queensland, enough to provide 14% of its energy needs and save $1.3 million in energy costs and 4163 tonnes of greenhouse gas each year.

It's part of a swelling wave of big corporate and government energy users switching to rooftop solar and power purchase agreements with wind and solar farms to lower energy bills and reduce carbon emissions in line with hardening consumer sentiment against planet-warming greenhouse gas and other pollution. EF

Source: Financial Review



FOR 300 DAYS, COSTA RICA GENERATED ELECTRICITY FROM RENEWABLE SOURCES ALONE

For the fourth consecutive year, Costa Rica has generated more than 98% of its electricity using only renewable sources. For 300 days, Costa Rica used no fossil fuels to create electricity, the Costa Rican Institute of Electricity announced. The last time the country had to use hydrocarbons to make electricity was May 17. Hydroelectric plants generated nearly 74% of Costa Rica's electricity in 2018, followed by wind at more than 15%, geothermal at just over 8%, and biomass and solar both at less than 1%.

Those five sources were responsible for 98.56% of the country's electricity this year, according to the electricity institute. It's the fourth consecutive year the figure has topped 98%. In 2015, it reached 98.99%; in 2016, it was 98.21%; and in 2017 it reached 99.67%. EF

Source: The Weather Channel

GREEN TRANSITION: POWER NOW IN THE HANDS OF DEVELOPING COUNTRIES, SAYS BNEF

A new report out from Bloomberg New Energy Finance (BNEF) reveals that developing nations are abandoning coal to switch their focus to rolling out renewable technology instead, a shift in market dynamic that puts non-OECD countries in the driving seat of the green energy transition for the first time.

According to the latest Climatescope report, which every year takes stock of clean energy activities across the world's developing nations, the majority of global clean energy activity is now taking place in non-OECD countries.

By comparison, in 2017 developing nations added 114 GW of zero-carbon generating capacity, including nuclear and hydro, with renewables accounting for the majority of all new power capacity added for the first time. Wind and solar alone accounted for 94 GW in these nations. Meanwhile, foreign direct investment in supporting clean energy rose to an all-time high of $21.4bn in 2017, compared to $13.9bn in 2016. The turnaround reflects the growing willingness of private investors to pump cash into clean energy in developing markets, according to BNEF, encouraged by the proliferation in clean energy auctions for government contracts. EF

Source: BusinessGreen.com

SOLAR, THERMAL… SPAIN'S HISTORIC HOTELS GO GREEN

Spain's state-owned chain of paradores, the grand hotels often housed in ancient castles and monasteries, has announced that all 97 of its establishments will use only electricity from renewable sources from 2019.

The 90-year-old chain said the decision to switch to green electricity had been made for both environmental and symbolic reasons."Natural gas is less polluting than some of the other sources that hotels have traditionally used," its head of communications, Sonia Sánchez Plaza, told the Observer. "But we are gradually eliminating our fuel oil consumption and we have an ambitious plan to bring renewable energies into Paradores, including biomass, solar and geothermal energies." Sánchez said biomass technology was already being used in two hotels, while solar panels had been

installed in other paradores, such as the one in Cádiz, Andalucía. The hotel chain is also looking into harnessing geothermal energy for its hotel on the volcanic island of Tenerife.

Spain is aiming to ensure that its electricity system uses entirely renewable sources by 2050 and then to decarbonize its economy. EF

Source: The Guardian

WINDY WEATHER CARRIES BRITAIN TO RENEWABLE ENERGY RECORD

Storm Diana brought travel chaos to road, rail and airports, but the clouds did have a silver lining: the strong winds helped set a renewable energy record. Wind farms supplied about a third of the UK's electricity between 6 pm and 6.30 pm on Wednesday, a time of peak energy demand. Output hit a high of 14.9GW, beating a previous record of 14.5GW.

The milestone coincides with the official opening on Friday of E.ON's Rampion wind farm off the coast near Brighton, which is the first in the Channel and can power about 350,000 homes.

Blustery weather has buoyed wind output in the past few days, with National Grid reporting thousands of wind turbines were the UK's No 1 source of power, at about 32% of generation. Gas power stations are usually top. Wind

farms have moved from a niche source of electricity generation a decade ago – when they supplied less than 2% – to a cornerstone of Britain's power mix, at nearly 15% of supply last year. EF

Source: The Guardian


Save

ENERGY TRANSITION

AN ENABLER OF CHANGE

The world saw total renewable installations of over 178 GW, the largest till date in 2017; this was greatly aided by the massive surge of 29% over the previous year at 98 GW. Clean energy is now being seen as the future of reliable energy supply to millions of people with investments and capacity enhancements set to continue for the next few years. The commitments made under COP 21 provide a thrust to countries globally for increasing renewable capacity to mitigate the effects of climate change. **Viraj Desai**, through this article, unravels the historical perspective of clean energy, the global scenario, in particular India's current status, the challenges, and the way forward.

Introduction

According to the research organization REN21, renewables in 2018 accounted for 70% of the global capacity addition. India, as one of the fastest growing economies and the powerhouse of Asia, saw almost 15 GW installations of renewables in 2017, boosted by foreign investments in the sector and a policy push by the government. Clean energy is, therefore, expected to not just outperform conventional power in terms of installations but also investments for the next few years. It is the age of renewable energy and it will not be wrong to say that the renewable power is silently bringing a revolution by surpassing installation of conventional power over the last two years.

Historical Perspective

Even though the industrial revolution was the beginning of the shift from renewables to coal-fired thermal plants, biomass has been in use for thousands of years. In the last five decades, the total renewable energy generated globally in 1965 was just a little over 10,000 TeraWatt hours (TWh); this has surged by almost 7,000 TWh in 2016. In simple terms, the world witnessed a 5 to 6 fold increase since the 1960s, with hydropower still accounting for 70% of the total share.

Investments in renewables globally rose at a whopping 600% during 2004 to 2015, to reach almost $300 billion. China accounted for one-third of the total investments with investments surging over 3000% in the Asian major.

While renewable energy technologies were known over three decades back, commercial deployment, stronger push for conventional sources of energy and lack of a strong reason did not allow these to flourish for many years. However, it was at the Earth Summit organized by the United Nations Framework for Climate Change 1992 in Rio de Janeiro, Brazil, also known as the first serious meeting of leaders from over 100 countries, wherein there was a discussion on conservation of biological diversity, sustainable use of components, and equitable distribution, where the first thought of clean energy came to the fore.

It is commendable that renewable energy growth has been stupendous since the 1990s with wind and solar installations accounting for 430,000 megawatts (MW) installed capacity between 2000 and 2010. However, during the same time frame, the global development and energy requirement surge led to installations of 475,000 MW of new coal-fired power plants leading to cumulative emissions of over 55 billion tonnes carbon over their lifetime. This shows that even though

renewables grew fast, it wasn't fast enough to support the growing needs of countries.

While wind power installations were primarily in Denmark, Spain, and Germany in the early 2000s, now over 70 countries globally have adopted the renewable source for their energy needs. In fact, the decade 2000–2010 witnessed over two-thirds of new power plant installations in either gas-based power plants or renewables. This decade can be safely called the start of a silent revolution towards clean energy. This can be substantiated by the fact that almost 85 countries had a policy target by 2009, up from 45 countries just four years before. Most countries also began setting targets towards clean energy, region and country wise.

The Bloomberg New Energy Finance (BNEF) Clean Energy Investment Trends, 2017, demonstrated that solar has moved from being the third biggest sector after wind and biofuels in 2006 to being the largest now.

Mechanisms Adopted to Push Renewable Growth

While the costs of renewables have fallen over time, thanks to the tremendous scale up in China and increasing demand in international markets, governments globally have resorted to offering subsidies and various incentives to push companies and citizens to use clean energy especially at the nascent stages. One of the most common mechanisms adopted to push renewable energy includes feed-in tariff, cost-based compensation providing price certainty, and long-term contracts helping finance renewable energy investments. Many governments also fixed renewable purchase obligations as a mandate for state distribution companies to procure green power. Policies were shaped in a manner to include direct capital investment subsidies, grants or event rebates in more than 45 countries. Tax incentives could include import duty reductions and tax credits.

Current Global Scenario

Perhaps the COP 21 Summit on December 12, 2015, can be considered the defining convention where countries globally reached a landmark agreement for combating climate change and accelerating efforts towards a sustainable low carbon future. The agreement's aim was to strengthen global response towards climate change by keeping temperatures below 2 °C above pre-industrial levels. Additionally, it aims to help countries deal with climate change by facilitating financial flows to enable low greenhouse gas emissions and climate-resilient path. All countries under the agreement had defined Intended Nationally Determined Contributions (INDCs), which was a roadmap for implementation of low-carbon goals and take stock every 5 years to check the progress.

Even though initially only 55 countries came forward accounting for 55% of the global emissions, over 125 countries totally joined by early 2017

defining their intent. Since renewable energy will play a significant role to achieve the targets set by 2030, it is imperative for countries to ramp up installations and technological transfers from the more industrialized nations.

As per the Renewable Energy Policy Network for the 21st century, a global renewable energy policy multi-stakeholder network with 60 members connecting a wide range of stakeholders based at the United Nations Environment in Paris, renewables contributed to about 20% of energy consumption and 25% of the total generation. In fact, about 10 million jobs are associated with the renewable energy industry, with solar photovoltaic being the largest and set to rise further in the future.

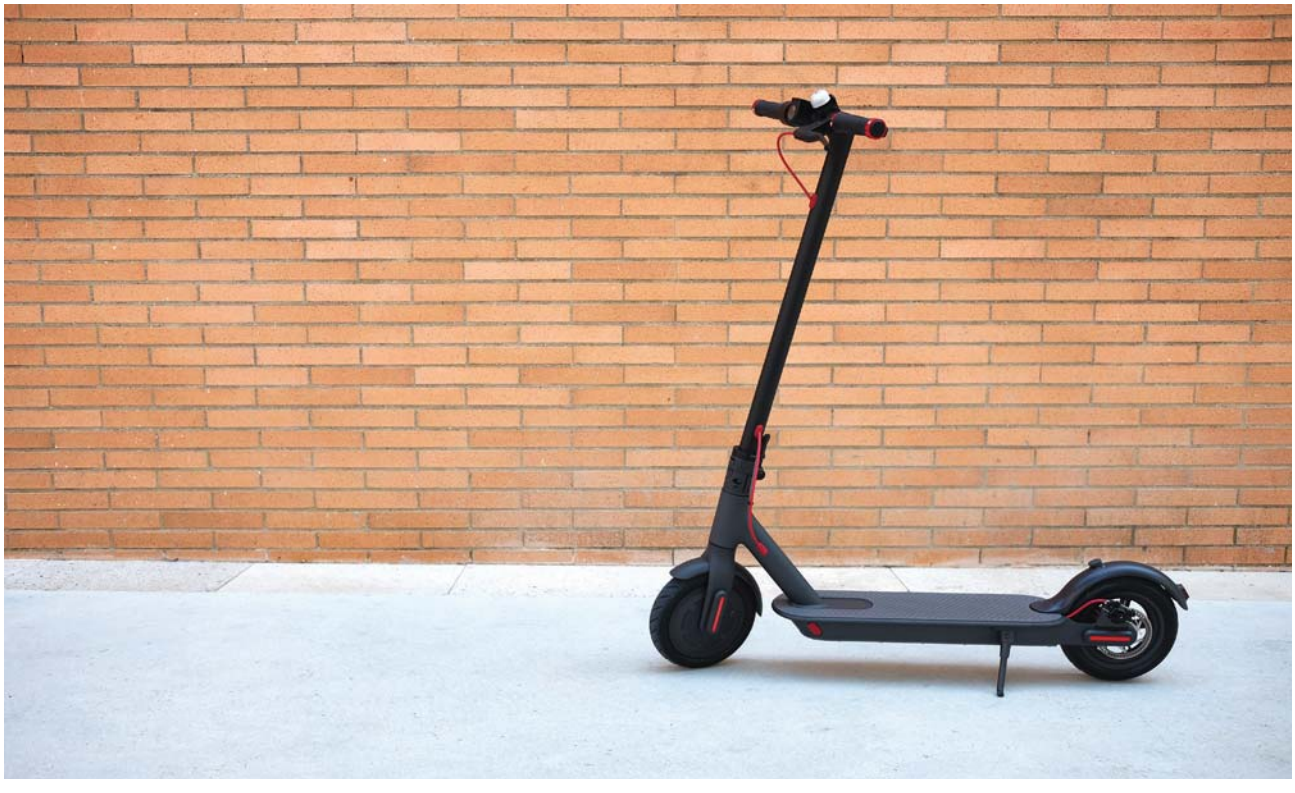
China, the USA, and India are clearly ahead of the rest, with the dragon nation expected to account for 40% of the global clean energy mix by 2022. China's rapid strides akin to its other industrial developments have been remarkable. To put it in perspective, the Asian giant had about 3 GW of solar and 61 GW wind energy installations in 2012, accounting for just 2% of the country's total consumption. Fast forward five years, the country's solar and wind power capacity stands at 130 GW and 168 GW, generating over 5.3% of its total electricity supply. This also demonstrates in earnest its ambition towards clean energy. Even though subsidies accounted for the massive leap, it has brought a revolution and investments have poured in thick and fast.

Some other emerging nations in renewable energy include Chile and its Atacama desert, largest in South America; Brazil with significant wind installations; Egypt, and Taiwan.

Concentrated solar thermal power, touted as one of the potential ones for large-scale solar installations, had just a little over 5 GW installations by 2016. According to Bloomberg New Energy and Finance, the total geothermal installations were slow but reached 13 GW. More countries are now exploring offshore wind installations to utilize the wind intensity over waters for generating electricity.

The International Energy Agency, a Paris-based autonomous intergovernmental organization, working towards clean energy adoption globally, has estimated that renewable energy capacity expansion will witness a surge of 43% to reach 920 GW by 2022.

European countries are clearly ahead of the pack as they are set to achieve maximum renewable energy as a percentage of its GDP and population. For instance, Scandinavian country Denmark will be producing almost 70% of energy from renewables by 2022, according to the International Renewable Energy Agency, an intergovernmental organization supporting countries in their transition to a sustainable energy future. Other European Union countries that have ambitious targets include Ireland, which expects to generate over one-third of its energy from renewables and Spain, United Kingdom, Germany having 25% of total generation from non-conventional sources of energy. Sweden became the first country in 2015 to announce its intent to switch



over to 100% renewables. Scotland achieved the feat of running entirely on wind power in 2015. Another European country that has achieved a remarkable feat is Uruguay running almost 95% on non-conventional energy, barely within ten years of decision making and no subsidies. It is commendable that renewables accounted for almost 28% of EU's power in 2015 which is expected to surge to 50% by 2030.

However, it is not just the European countries taking a lead. Smaller countries, such as Nicaragua reached 54% of its electricity production from renewables in 2015.

Off-grid energy or small-scale installations are expected to nearly triple to 3,000 MW in Asia and Sub-saharan African countries, helping provide 70 million people with clean and affordable electricity. Off-grid solar devices, such as solar lanterns and solar home systems, experienced 60% annual growth rates between 2010 and 2017. In fact, the pay-as-you-go (PAYG) model, enabled by mobile technology, saw tremendous progress in East and West Africa with pay-as-you-go (PAYG) companies raising $263 million in capital—up 19% from 2016 serving 700,000 customers.

Distributed renewable systems are playing a vital role in providing cost-effective alternatives for improving access as it served an estimated 300 million people by 2016.

If the optimism seems exaggerated, it should be viewed with the investor confidence which can be gauged by $42.8 billion merger and acquisition (M&A) deals in 2017, an increase of 57% over the previous year, according to the Ernst and Young's *Power Transactions and Trends: 2017 Review and 2018 Outlook*. Asia Pacific accounted for $13.5 billion of the same, a growth of 72% over the previous year, thanks to the favourable policies laid by various governments.

Since industries are a major carbon emitter, the RE100 initiative, a network of corporations committed to using 100% renewable power, has over 130 signatories vis-à-vis just 87 in 2016. This shows that awareness is on the rise and companies realize their responsibility towards sustainability.

On the other hand, utilities across countries are planning to disengage from fossil fuel generation and move into large-scale renewable energy generation. Examples include utilities, such as China, Australia, India, Africa, and the USA. An instance of this is the French major, Engie selling off coal and gas assets amounting to $18 billion and aiming to reinvest the same towards energy efficiency and renewables.

Renewables in Transport

Since transport contributes to significant carbon emissions globally, electrification is being explored in the transport sector. It is no surprise that Tesla, a US electric car company, is being looked at keenly by everyone globally. Though Tesla car prices are high, they present a superb alternative to good luxury fossil fuel vehicles. Electric scooters are common in

countries such as Norway and China. It was estimated that there were over 200 million two- and three-wheeled EVs the world's roads in 2016, with almost 15% growth each year. On the other hand, cars passed the 3 million mark in 2017 (up by an estimated 1.2 million since 2016).

In fact, as many as five countries have announced their intention to ban sales of new diesel and petrol cars by 2030 (India, the Netherlands, and Slovenia) and 2040 (France and the United Kingdom). Another part that may push renewable energy further is the EV100, a new campaign to accelerate uptake of EVs and associated infrastructure comprising 16 global corporations from China, Europe, and the USA.

Although aviation fuel contributes to just 10% of the total energy utilized in transport but it is expected to grow fast due to surging tourism and globalization. Hence, International Civil Aviation Organization's landmark agreement in October 2016 to mitigate greenhouse gas emissions in the aviation sector which may see increased deployment of renewables. By early 2018, over 100 countries representing 90% of the air traffic submitted State Action Plans under the agreement and progress has begun as five renewable jet fuels were certified for blending with traditional petroleum jet fuels.

On the other hand, maritime transport contributing 9% of the global energy in transport and 2% of global greenhouse gas emissions is also witnessing some action to move towards a clean future. The International Maritime Organisation's Marine Environment Protection Committee approved a roadmap (2017–2023) to develop strategy for reducing emissions from ships. China has taken the first step in this by launching world's first all-electric cargo ship in 2017, whereas Sweden saw two large ferries being converted from diesel to electricity.

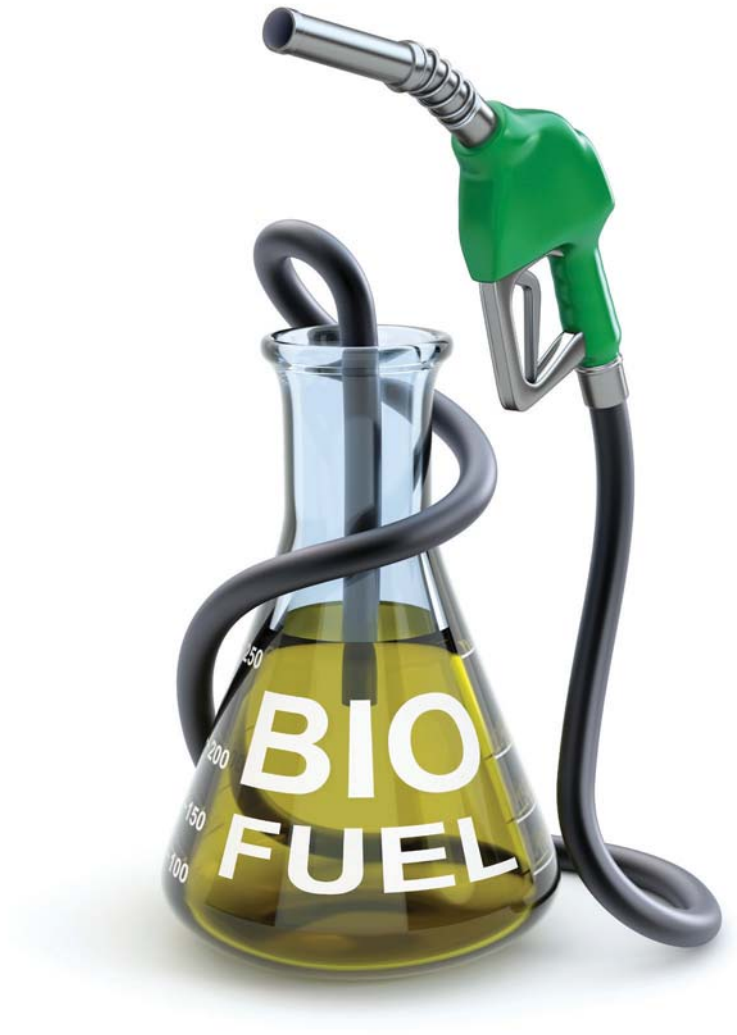
India taking lead

With about one-fifth of the world's population and yet a quarter of the same still lacking access to electricity, India has a long way to go in being self-reliable for energy requirements. However, its progress to provide clean and affordable energy to millions of citizens can be termed steady, though it continues to be dependent on thermal power for meeting 80% of its energy needs.

Renewable energy, including large hydropower plants, now account for one-third of the total installed power capacity in the country. Large hydro installed capacity was 45.29 GW early in 2018, contributing to 13% of the total power capacity.

The trigger was the Jawarharlal Nehru Solar Mission (JNNSM) or The National Solar Mission was announced in 2009, which aimed at 20,000 MW installations by 2020. This eventually increased fivefold in 2014 by the new government setting a herculean task. While the progress was slow in the initial years due to different reasons, a number of factors, such as plummeting solar prices internationally, encouraging domestic manufacturing under Make in India, and a policy thrust have kicked off abundant investments in the sector. Until June 2018, the total installed capacity crossed 25 GW. In fact, the country is also home to the single largest solar power plant at a site of over 700 MW with another mega solar power plant of 2GW under construction in Pavagada, Karnataka. Additionally, the world's largest solar power plant, Bhadla Solar Park is being constructed in Rajasthan with a capacity of 2255 MW. This demonstrates the appetite for large-scale renewable projects in India.

India was in fact one of the founding members of the International Solar Alliance, an alliance of more than 121



countries initiated by India, most of them being solar-rich countries, which lie either completely or partly between the Tropic of Cancer and the Tropic of Capricorn. The Alliance has seen active participation of many countries and is being supported by all major economies of the world with the recent announcement of its vision, 'One World, One Sun, One Grid' at ISA's meet in New Delhi.

On the other hand, India's wind energy installations picked up pace over a decade back, with the help of home-grown companies such as Suzlon Energy. Despite consistent additions of almost 2 GW a year, it was the new government's announcement of having 60,000 MW by 2022, almost a three-fold jump from about 23 GW installations in 2014, which has given it a new lease of life. As of June 2018, the country has managed to have installations of about 35 GW and has become the fourth largest globally in wind installations. In fact, wind energy now accounts for 10% of the total installed power generation capacity, with states such as Tamil Nadu, Gujarat, Maharashtra, Rajasthan, and Karnataka having 70% of the total installed capacity in the country.

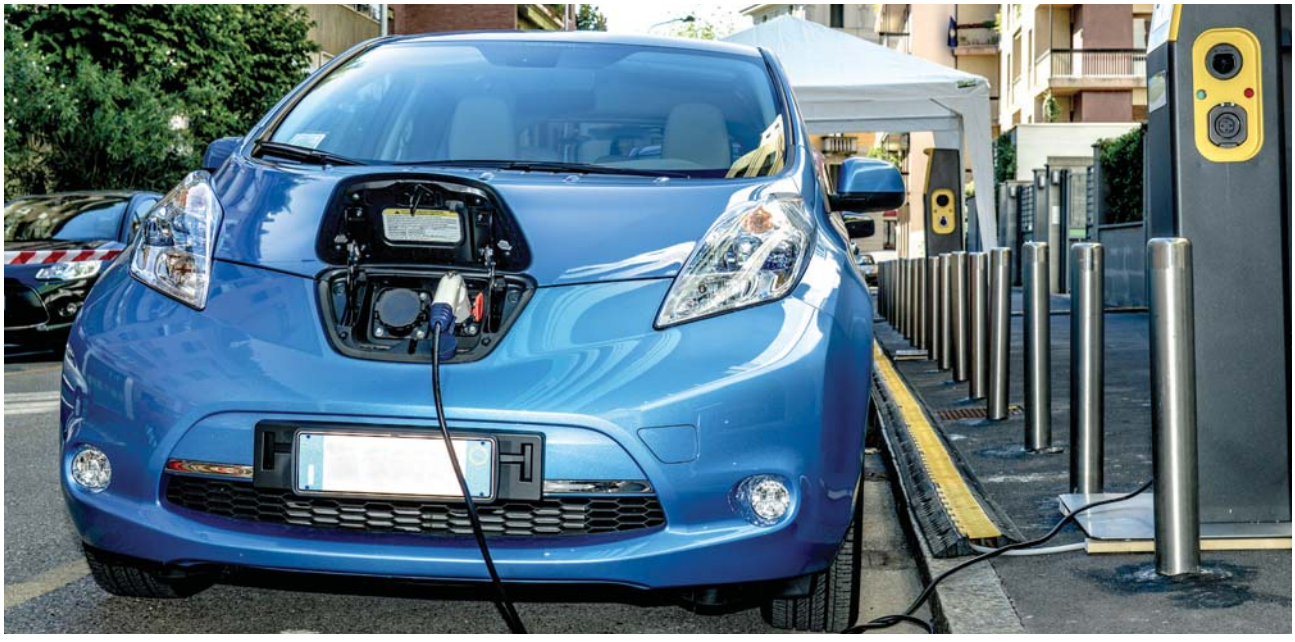
A blueprint draft published by the Central Electricity Authority estimates that 57% of the total electricity capacity would be through renewables by 2027. Furthermore, India aims to have a renewable energy installed capacity of 275 GW, in addition to 72 GW of hydro-energy, 15 GW of nuclear energy, and nearly 100 GW from "other zero emission" sources.

Challenges

Despite the impressive progress, one must remember that over 1 billion people globally, 14% of the population, does not have access to electricity. Though this is a marginal improvement over 2014 when 1.2 billion lacked access to electricity, there is much to do. In fact, experts suggest that the energy transition may not still result in global temperature levels 2 °C below the pre-industrial levels, and 1.5 °C also be hard to achieve.

Sanguinity in the renewable sector is accompanied by skepticism on whether the momentum can be maintained for the next two decades. In addition, there are issues of energy storage which are at a nascent stage and high costs which act as a deterrent. Grid stability and aligning renewable usage with conventional power for the foreseeable future are challenges that power developers, governments, and distribution companies continue to face, affecting the uptick in its usage. Transport sector continues to be almost entirely dependent on oil globally. The augmenting global trade also resulted in rapid freight movement with growth of over 250% during 2000–2016 in emerging economies and almost 10% in the IEA countries.

The next big growth in renewables will be driven with the possibility of energy storage, which would help in utilizing power generated during those hours when the sun doesn't shine or the wind doesn't blow. BNEF estimated that the global battery storage market may reach over 900 GW with the spur in electric mobility in the future. This will attract investments of $620 billion over the next two decades. According to the new report, *Energy Access Outlook: From Poverty to Prosperity*, part of the *World Energy Outlook 2017* series, providing first-of-its-kind historical analysis for 140 countries, the world will require investments of $31 billion to ensure access of energy



for all. A gargantuan task, this will entail significant investment by banks, pension funds, private equity, and multilateral institutions. In 2017, global clean energy investments were estimated to be $333 million, 3% higher than the previous year but 7% lower than the all-time high of $360 billion of 2015. While investments have been stepped up by all, a lot more will need to be done for achieving the ambitious targets.

A major part that is still being seen in electricity systems globally is the curtailment of renewables, as some countries globally do not have the requisite transmission capacity at times of excess supply. This factor results in impeding the advancement of renewables, augments overall system costs, and is a sign that more flexibility is needed in power systems. Countries like China saw this issue but government policies in transmission infrastructure have aided in reducing the problem. Average curtailment in China in 2017 was lower both for solar PV and wind power as compared to 2016. Germany, another major renewable power, with 3.7 TWh of renewable electricity (about 2.3% of annual renewable generation) saw curtailment in 2016 and even experienced congestion on its grids due to rising renewables output.

What the Future Holds

It will not be an understatement that renewable usage will witness a manifold growth in the times to come. According to BNEF 2017 report, the share of renewable power usage in transport is just 3%, despite contributing to 32% of the total emissions. This is expected to significantly rise with the evolution of EVs leading to a reduction in emissions. With energy efficiency and smarter heating and cooling needs being spoken, it won't be surprising to see renewable share in heating and cooling rise from the current level of 10%.

The usage of biofuels in transport has been acknowledged in many countries but has been moving slowly due to policy uncertainty and concentration in small number of regions: the US, Brazil, the EU and China. Apart from road transport, strong interest continued in the development of aviation biofuels but the quantities produced are abysmally small and only for demonstration purposes.

There is a greater need to phase out subsidies for fossil fuels which stood at over $300 billion as compared to renewable subsidies accounting to less than $40 billion.

According to the IEA's *World Energy Outlook 2017* ('Sustainable Development Scenario'), to avoid global temperatures rise below 2 °C would entail $12 trillion investment in renewable power supply itself until 2040, translating to $500 billion per year. This shows that financial institutions and investors globally would need to work actively towards universal energy access in the years to come. Political ambition will be a major determinant for achieving this. EF

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Viraj Desai currently works with an NGO and likes reading and writing on energy, environment and science & technology. He may be reached at <viraj29@gmail.com>.

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ELECTRIC VEHICLE MOBILITY IN INDIA

Understanding Consumer Perceptions in Delhi

Electric vehicles insofar as they help arrest the alarming levels of pollution indices present an enormous opportunity for India. They can also save a lot of fuel and the financial cost borne by India for annual crude oil imports. The Government of India is working hard to give a strong push to electric mobility over the last few years and has already announced Electric Mission 2030 to provide an impetus to the entire e-mobility ecosystem, including vehicle manufacturers, charging infrastructure companies, fleet operators, service providers, etc. In this article, **Abhishek Sharma** and **M Vijay Kumar** analyse the growing importance of electric vehicles, their potential, and the challenges ahead.

In this study, a survey was conducted to understand the perceptions of the potential users of electric vehicles in Delhi. As per the results, around 92% of the people are ready to shift to electric vehicles albeit they are highly sensitive to the price of these vehicles as well as the maintenance cost and charging infrastructure. Potential e-vehicle users preferred swappable batteries over the charging stations. The study recommends that subsidy should be provided to the buyers for electric vehicles. The option of swappable batteries should also be provided to avoid the long waiting queues at charging stations. In fact, the e-vehicle ecosystem also has the potential to create livelihood opportunities.

Introduction

Environmental sustainability is one of the biggest global challenges of the present times. With increasing population and higher consumption levels, the natural resource stress[1] levels, on the one hand, and carbon emissions on the other hand, have been on the rise. It is crucial for the all of us to leave a sustainable planet for our future generations and other species in co-habition. If adequate measures are not taken to address this problem, the future generations will face natural resource scarcity and a polluted environment. As transportation is one of the major contributors to total carbon emissions, hence, adoption of electric vehicles is considered to be the utmost solution. Electric vehicles are environment friendly due to zero carbon emissions and hence, countries across the world are going for electrification of the automotive industry to decarbonize the transport system. For this, various measures, such as subsidies and tax incentives, are given. The car makers in different countries have also started manufacturing electric vehicles.
India launched its National Electric Mobility Mission Plan in 2013 to address the issues of vehicular pollution, national energy security, and growth of domestic manufacturing capabilities. Reiterating its commitment to the Paris Agreement, the Government of India has plans to make a major shift to electric vehicles by 2030. The Government of India has announced a very ambitious plan of making India a primarily electric car driven nation by 2030. The government in this regard launched a scheme for the Faster Adoption and Manufacturing of (hybrid &) Electric Vehicles in India (FAME India) under the National Electric Mobility Mission (NEMM) in 2015. The scheme was successful in increasing the share of hybrid and electric passenger vehicles sales from almost zero per cent in 2012 to 1.3% by 2016. The government also plans to introduce 6–7 million electric vehicles (EVs) /hybrid vehicles on Indian roads by the year 2020.

India's journey in electric vehicles began way back in 1996 with the launch of an electric three wheeler Vikram SAFA developed by Scooters India Ltd; however, it was not successful in the market. Later, Mahindra and Mahindra launched its first electric three-wheeler in 1999 and also launched a new company, based in Coimbatore in 2001, to make and sell electric vehicles named Bijlee. Bijlee could not succeed due to lack of demand. Bharat Heavy Electricals Limited (BHEL) also introduced an electric bus using 96 V lead acid battery pack, however the project didn't pick up due to the product quality inconsistency

1 Mismatch between the natural resources usage and availability of natural resources

and cost. In 2001, a Bengaluru-based company 'REVA' entered the Indian e-vehicle sector in the four wheel segment and could sell more than 1,500 vehicles. In 2010, Mahindra acquired this company and continued producing and selling electric vehicle, REVA. The efforts for electric vehicles in the past may not have been remarkable successes but now, with the consistent efforts by the government towards greater usage of e-vehicles, the Indian auto industry is geared to make National Electric Mobility Mission a reality by 2030.

Adoption of electric vehicles is, on the one hand, going to provide us an environment-friendly option, and on the other hand, it will reduce our dependence on oil imports. The government aims to achieve national fuel security by promoting hybrid and electric vehicles in the country and is expecting to save roughly ₹3.9 lakh crore (approximately $60 billion) in 2030. According to NITI Aayog Report (2017), India can save 64% of anticipated passenger road-based mobility related energy demand and 37% of carbon emissions in 2030 by pursuing a shared, electric, and connected mobility future. Amongst the world's 20 most polluted cities in the world, 13 are in India (WHO, 2016). Vehicular pollution is one of the major contributors to air pollution. India is in the group of countries that has the highest particulate matter (PM) levels. Its cities have the highest levels of PM_{10} and $PM_{2.5}$ (particles with diameter of 10 microns and 2.5 microns). These figures are six times more than the World Health Organization's (WHO) 'safe' limit of 25 micrograms and represent the exigency for electric vehicles. Electric vehicles are 100% eco-friendly. As per WHO Global Ambient Air Quality Database update (2018), two Indian cities (Delhi and Mumbai) appeared amongst the most polluted mega cities (population more than 14 million habitants) in the world (Figure 1). As it can be seen, the PM_{10} levels of Delhi are close to 300 micrograms which is way above the WHO limits. According to the 2018 World Health Organization (WHO) report, as many as 14 of the world's top 20 most-polluted cities are located in India.

Further if we look at the air quality of Indian cities, we find that out of 126 cities, 21 cities in India have PM_{10} levels more than 150 (WHO, 2018). The PM_{10} levels of most polluted cities in India are presented in Figure 2. As we can see, the air quality of Gwalior and Allahabad is worse than Delhi.

The PM_{10} levels for all cities in India are given in Table1. It is highly disappointing to note that out of 126 cities under observation, 125 cities reported PM_{10} level more than the WHO's minimum limit of 25. Such an alarming scenario of quality of air in the country calls for urgent attention. As quality of air declines, the risk of acute and chronic respiratory diseases, such as asthma, lung cancer, and heart disease increases for the people who reside in these cities.

As is visible in Table 1, 125 cities in India are above the WHO limit. The PM_{10} level in top 48 cities is 100 or more. Vehicular pollution is one of the major contributors to India's carbon emissions. The transportation accounts for about 14% of total carbon emissions. Further, road transport accounts for 88% of the total carbon emissions (Figure 3). Hence, electric vehicles as a green transportation option is the only way forward as a solution for this major source of air pollution in the country.

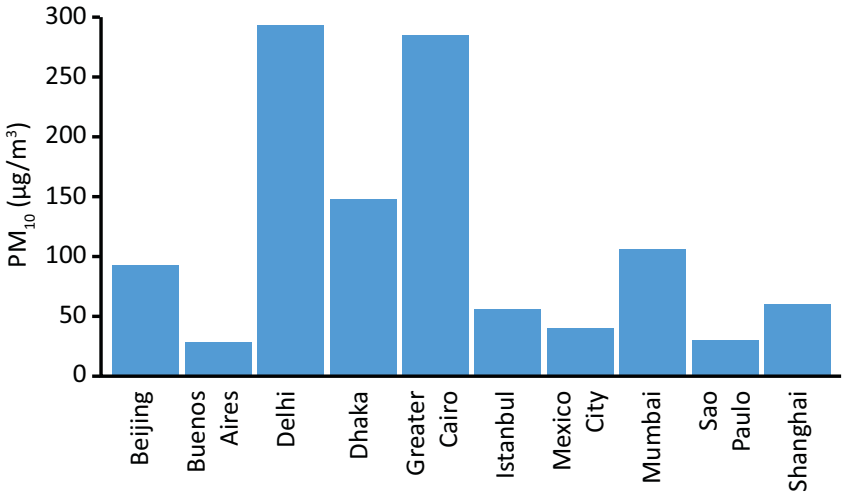

Figure 1: PM_{10} levels for mega cities (more than 14 million inhabitants)

Source: WHO Global Ambient Air Quality Database update, 2018

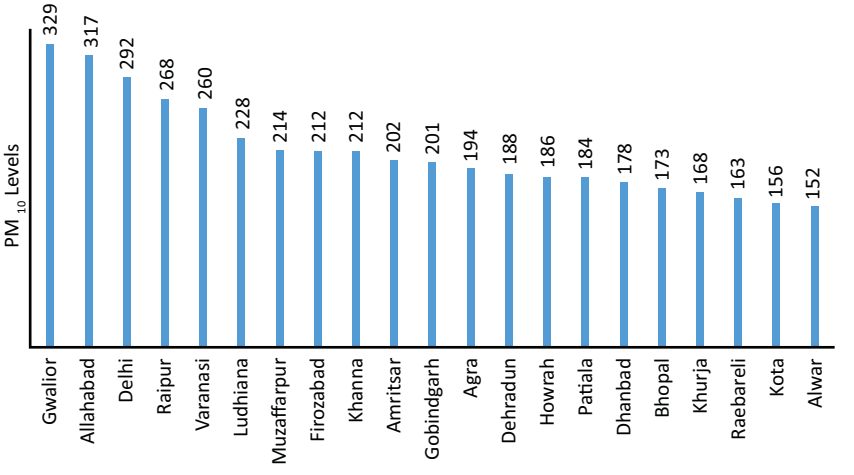

Figure 2: PM_{10} levels for most polluted cities in India

Source: Author construction based on WHO Global Ambient Air Quality Database update, 2018

Table1: PM_{10} level of Indian Cities

City	PM_{10} Level	City	PM_{10} Level	City	PM_{10} Level	City	PM_{10} Level	City	PM_{10} Level
Gwalior	329	Noida	136	Rajkot	98	Jabalpur	79	Shimla	58
Allahabad	317	Meerut	129	Rourkela	98	Nagaon	79	Dibrugarh	56
Delhi	292	Raniganj	126	Udaipur	98	Nalgonda	79	Kollam	56
Raipur	268	Gurgaon	124	Surat	97	Nashik	77	Kottayam	56
Varanasi	260	Jammu	119	Bangalore	96	Vizag	76	Kozhikkode	56
Ludhiana	228	Faridabad	117	Dewas	92	Devanagere	75	Sunder Nagar	56
Muzaffarpur	214	Jalgaon	115	Dimapur	90	Guntur	75	Tinsukia	56
Firozabad	212	Chandigarh	110	Silchar	90	Trichy	75	Golaghat	55
Khanna	212	Jhansi	110	Pune	89	Kurnool	74	Aizwal	54
Amritsar	202	Kolhapur	110	Naya Nangal	88	Thane	73	Margherita	54
Gobindgarh	201	Chandrapur	109	Nagpur	86	Kochi	70	Rayagada	54
Agra	194	Rishikesh	109	Hyderabad	84	Coimbatore	68	Thiruvananthapuram	54
Dehradun	188	Sibsagar	109	Balasore	82	Cuttack	68	Nanded	53
Howrah	186	Durgapur	108	Kohima	82	Tirupati	68	Sambalpur	53
Patiala	184	Angul	106	Nalbari	82	Navi Mumbai	67	Tezpur	52
Dhanbad	178	Mumbai	104	Ramagundam	82	Panaji	67	Tura	49
Bhopal	173	Bhilai	103	Bhubaneshwar	81	Shillong	65	Warangal	49
Khurja	168	Nagda	103	Guwahati	81	Vishakhapatnam	65	Madurai	48
Raebareli	163	Vadodara	102	Korba	81	Singrauli	64	Thiruvananthapuram	48
Kota	156	Jamnagar	101	Aurangabad	80	Kothagudem	63	Alappuzha	46
Alwar	152	Amravati	100	Berhampur	80	Nellore	62	Bongaigaon	46
Indore	143	Anklesvar	100	Chennai	80	Tirumala	62	Aizwal	44
Jalandhar	140	Vapi	100	Parwanoo	80	Salem	60	Puducherry	42
Akola	139	Baddi	99	Sangli	80	Panchkula	59	Chitoor	40
Kanpur	139	Guwahati	99	Ujjain	80	Kakinada	58	Hasan	36

Source: Author construction based on WHO Global Ambient Air Quality Database update, 2018

So far, five states—Karnataka, Andhra Pradesh, Maharashtra, Telangana, and Uttar Pradesh—have rolled out their policy for e-vehicles. Reiterating their commitment to the transition from combustion vehicles to the electric vehicles, they are extending special incentives and concessions to attract investments in electric vehicle manufacturing, battery manufacturing, charging infrastructure, etc. Apart from the environmental gains, states are also looking at the job creation potential. With policy framework in place, it is expected that along with the

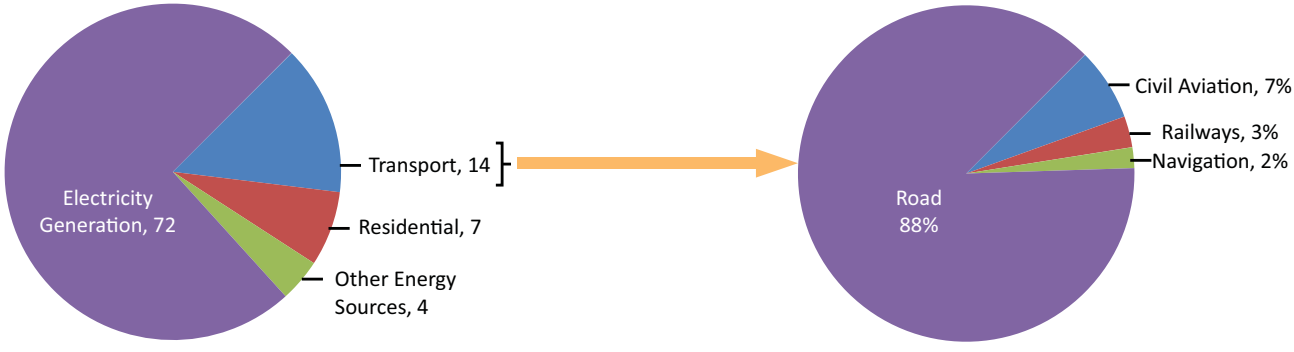

Figure 3: India's energy-related CO_2 emissions (2010) and share of different sectors, and share of different transport modes in total CO_2 emissions from the transport sector

Source: Ministry of Environment, Forest and Climate Change, 2015

decarbonization of the transport sector in India, the e-vehicle ecosystem has tremendous potential for generating livelihood opportunities.

Objective and Methodology

As environmental sustainability is one of the biggest concerns of the present times, it is important to understand the perceptions of the people towards green practices and their adoption. In this work, we attempt to study and understand the perceptions of the future consumer towards adoption of e-vehicles in the passenger vehicle segment. For this, a survey was conducted amongst the potential users of e-vehicles. The respondents were selected using the vehicle ownership criterion. A person owning a car was considered to be the potential user for e-vehicles. Two hundred and twenty car owners from different parts of the city were surveyed for this study. The data was further analysed and plotted with the help of bar and pie charts.

Data Analysis: Consumer Perceptions towards Adoption of e-vehicles

The data collected through the survey was analysed to understand the perceptions of the potential users of e-vehicles; the results of the same are presented in Figures 4 to 14. Before knowing the perceptions of the respondents about the e-vehicle, it was crucial to understand their level of awareness about the harmful impact of human activities on nature. Hence, the first question in our survey focused on learning the answer to this question. The responses are plotted in Figure 4. As we can see, 95% of the respondents concur with the statement that human activity has caused tremendous damage to the environment.

This indicates that car owners in Delhi are sensitive to the environmental damage carried out by normal day to day activities. In the second question, we try to find out their awareness level about the e-vehicles; the results are plotted in Figure 5.

As is visible in Figure 5, 85% of the car owners are aware of the e-vehicles. Those (15% of the sample respondents) who were not aware were explained about the concept of an e-vehicle. Further, when questioned about the preference of e-vehicles over diesel or petrol vehicles, 92% of the respondents preferred use of e-vehicle over the conventional vehicle (Figure 6).

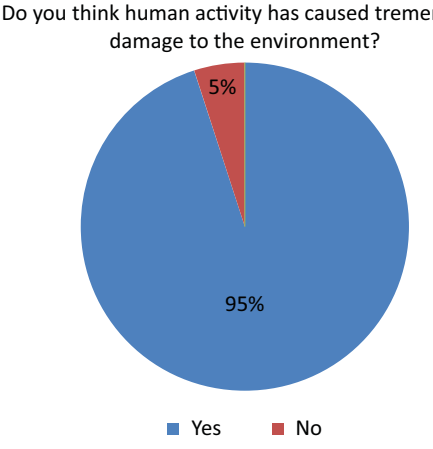

Figure 4: Awareness about human activity causing damage to the environment

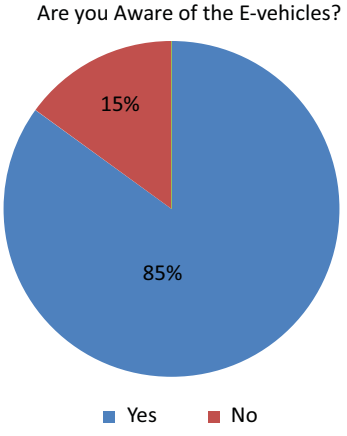

Figure 5: Awareness of respondents about e-vehicles

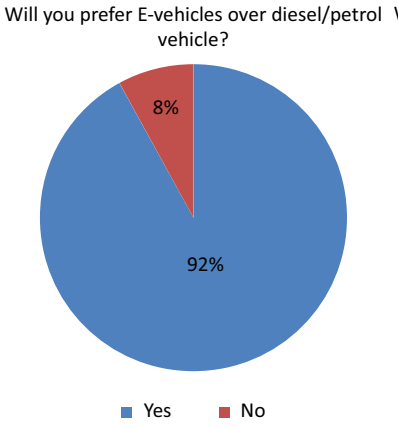

Figure 6: Preference of e-vehicles over diesel/petrol vehicles

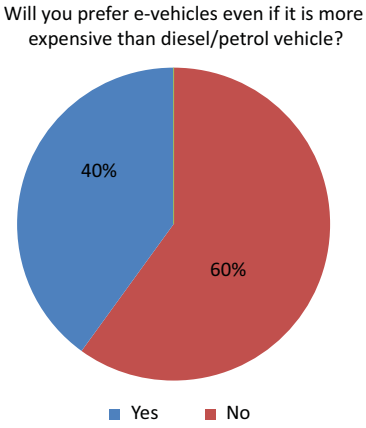

Figure 7: Preference of e-vehicles even if they are expensive than diesel/petrol vehicles

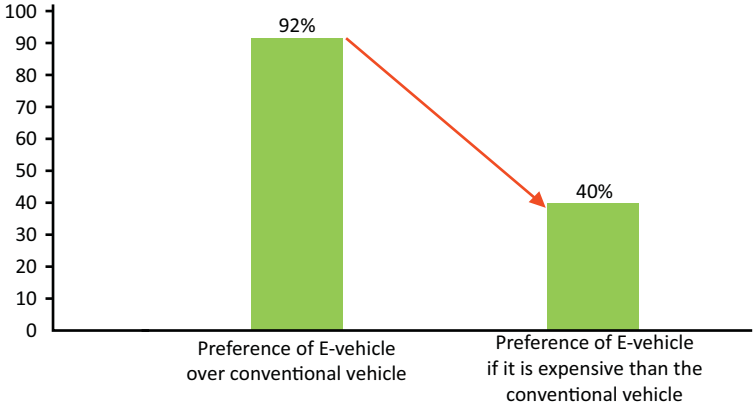

Figure 8: Preference of e-vehicles in different scenarios

However, when asked whether if people prefer e-vehicle, considering it is expensive than the conventional vehicle, the proportion of the preference came down from 92% to 40% (Figures 7 and 8). This finding is highly important for understanding the future of e-vehicles in India. The policymakers must consider the affordability aspect of the e-vehicle to make its adoption a success. Further, when questioned about charging infrastructure, 100% of the respondents said that they would consider charging infrastructure before buying an e-vehicle (Figure 9). All the respondents expressed their consideration for safety (Figure 10).

Further, majority of the respondents stated maintenance cost and speed as other key factors (Figures 11 and 12). Regarding the charging infrastructure, respondents were asked to express their preference for charging stations and swappable batteries. Around 95% of the respondents exhibited their preference for swappable batteries (Figure 13). All the results are summarized in Figure 14. It was therefore, found that there is a strong preference for electric vehicles amongst most of the people. However, they are concerned about the price of this vehicle. When asked on shifting to EV even if it is more expensive than traditional vehicle, 60% people responded with a clear "No". Safety, maintenance cost, and charging infrastructure also came out to be major concerns of the respondents. Also, most of the potential EV users preferred swappable batteries than the charging stations.

Conclusion and Recommendations

There is an urgent requirement for replacement of conventional vehicles with electric vehicles. The Government of India is dedicated towards adoption of electric vehicles for a cleaner and greener environment. In this context, this article presents results of the survey conducted on potential

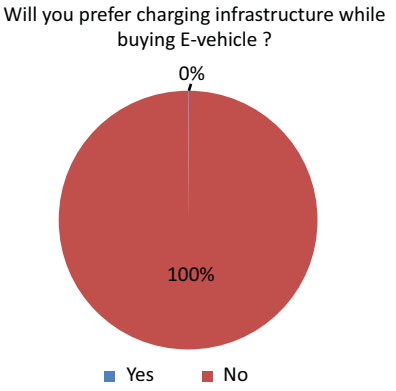

Figure 9: Consideration of charging infrastructure while buying e-vehicles

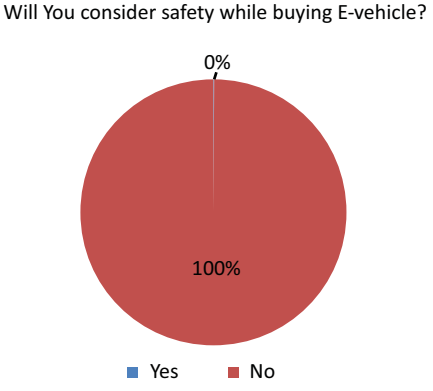

Figure 10: Consideration of safety while buying e-vehicles

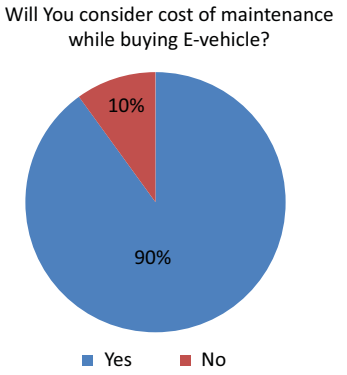

Figure 11: Consideration of cost of maintenance while buying e-vehicles

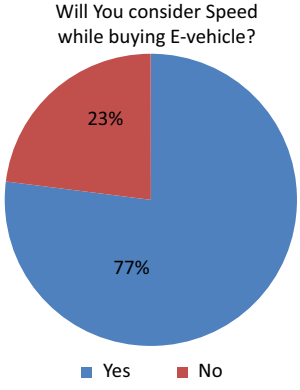

Figure 12: Consideration of speed while buying e-vehicles

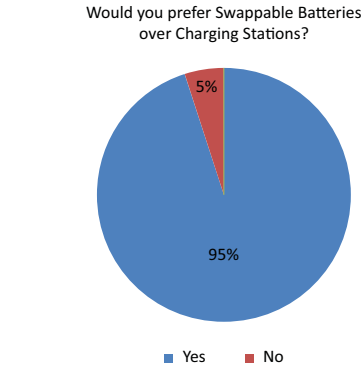

Figure 13: Charging stations vs. swappable batteries

e-vehicle users and shows that majority of the people are ready to shift to greater usage of electric vehicles. Albeit they are concerned about the price, maintenance cost, safety, and charging infrastructure of e-vehicles. In the study, potential users preferred the swappable batteries over the charging stations.

This study recommends that for quicker adoption of e-vehicles, affordability can be ensured via incentives, such as subsidy and tax exemptions (for seller as well as buyer). This coupled with availability of swappable batteries on the one hand will avoid long waiting queues for charging stations, and on the other hand, the e-vehicle ecosystem will lead to new livelihood opportunities. The swappable battery industry can create tremendous employment opportunities. Availability of such batteries will also be helpful to people while travelling long distances. Hence, we can say that robust supporting infrastructure with financial incentives can help India achieve the dream of cleaner vehicles faster.

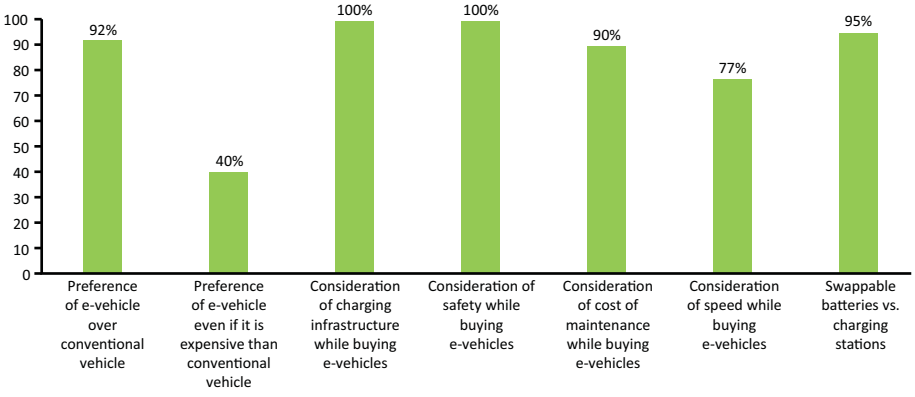

Figure 14: Responses for critical factors

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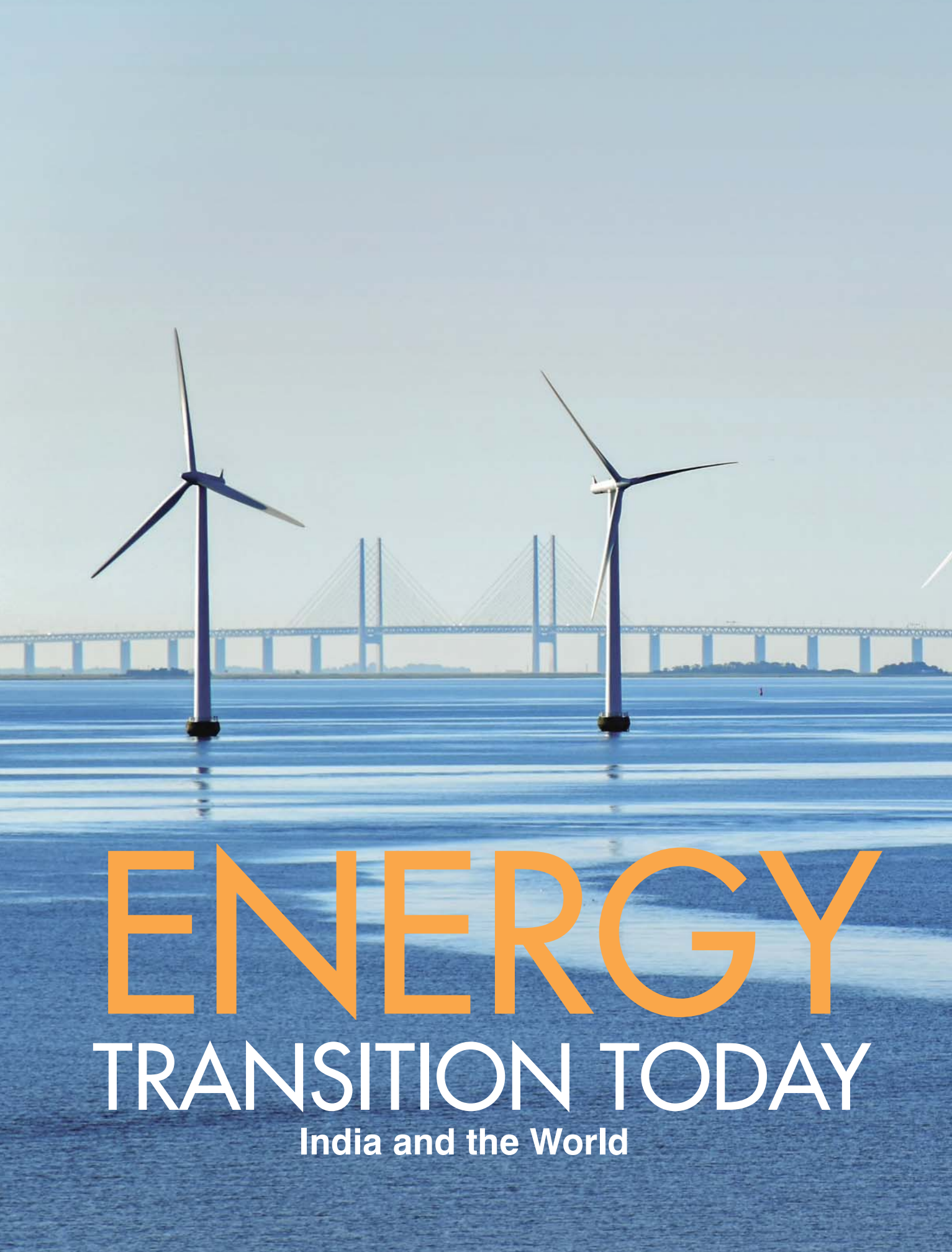
Abhishek Sharma is intern and M Vijay Kumar is Joint Advisor at the National Institution for Transforming India (NITI) Aayog, New Delhi.



ENERGY TRANSITION TODAY

India and the World

Climate change is real and happening right before our eyes. Recently, we witnessed how Kerala received 2,378 mm rainfall in just over 88 days flooding the state beyond recognition; eastern North Carolina in the USA saw 30 inches rain on a single day while the states of New South Wales and Queensland in Australia have been suffering from continuous drought conditions since 2012. Virtually every continent in the world faced severe droughts, wildfires, hurricanes, and unprecedented floods in recent years. The global weather norm has been changing to either too much flooding or drier and hotter summer or droughts. Through this article, **Jyothi Mahalingam** explains the warning of the climate research scientists that the biggest is yet to come and the main challenge before us is how we are going to tackle the current situation. The researchers are equally worried about meeting the energy needs of our growing population sustainably without further damaging the environment.

Worldwide Power Scenario

The traditional energy landscape is changing drastically, making far-reaching implications for worldwide oil companies, oil-exporting countries, and coal industries. The conventional fossil fuel segment after years of oversupply is currently managing with regulated supply. The industry now witnesses a healthy trend with a nearly 25 % rise in oil prices compared to the prices in 2017. The oil production is mainly dominated by OPEC, the USA, Russia Iran, Iraq, and others. The producers, however are facing a real problem in addressing the oversupply as well as undersupply in the market.

The increase in tight oil and shale gas production in the USA created a glut in the global oil market. Liquefied natural gas (LNG) continues to witness growth due to increased availability and its broad-based utility. Global coal consumption is declining due to fall in demand from China, the leading coal consumer. The use of gas in place of coal significantly contributed to the reduction in carbon emissions. Overcoming the intrinsic volatility is the biggest problem faced by the fossil fuel sector now. The oil and coal segments are taking efforts to safeguard their portfolio by making it more secure to address the tricky energy transition to renewable energy sources.

Globally, there are still more than a billion people who lack access to dependable energy systems and this figure will get added up by another two billion in 2050. The energy demands of these people need to be met at low-cost while cutting down the growing carbon footprint. In recent years, worldwide energy systems supported by technological inventions have undergone significant changes. Such events are the results of shifts in government policies, supply dynamics, and above all changes in usage patterns. The policymakers are still trying to figure out the ways to accelerate the installation of renewable energy systems for such countries that will allow smoother energy transition. But, this enormous task needs resolved participation of the society, the government, and the businesses.

Renewable Energy Sector

Globally, the renewable power sector is growing dynamically and rapidly, supported by falling capital costs. In recent years, the flooding of the market with cost-effective and more efficient photovoltaics and wind turbines enabled the renewable energy production costs to match with those of conventional energy. The encouraging news is, in 2017, the renewable energy sector outsmarted the fossil-fuel power segment in receiving huge investments. Most of such investments took place in emerging-economy countries—China, Europe, and the USA alone contributed to 75% of the worldwide renewable energy investments made in 2017. China leads the table with 30.7% more investments than it made in 2016. Surprisingly, even the small countries such as Guinea-Bissau, the Solomon

Islands, Rwanda, Marshall Islands, and a number of developing countries have made significant investments in renewable energy when evaluated by the total gross domestic product (GDP) of the respective countries.

The solar PV energy installations topped the table with a 33% increase adding 98 GW in 2016. It is estimated that solar PV alone contributed to 402 GW of the total generated power in 2017. The year 2017 saw 92 GW additions in wind power generation and the offshore wind achieved a growth of 30%. The total cumulative capacity of renewable energy grew to 539 GW, that is, a whopping 11% increase. In 2017, renewable energy technologies alone added 70% to the new power generation compared to its share of a 63% increase in 2016. The reports from International Energy Agency (2017) and BP (2018) forecast how renewable energy will play a dominant role in the future energy mix.

It is a fact that supportive government policies helped in the proliferation of renewable energy during its nascent stages. But it is the introduction of innovative cost-effective technologies in the manufacture, storing of generated power, and transferring it with the least cost facilitated in the growth of renewable energy technologies. To be more specific, five years ago the wind power and solar power costs were $11c and $17 per kilowatt hours (which includes capital costs) with subsidy, now according to the International Renewable Energy Agency (IRENA) report in 2018, the costs of wind and solar have come down to $5 c/kWh and $6 c/kWh, respectively. The Sakaka solar plant at Saudi Arabia received a bid in 2017 to generate solar power at $1.8 c/kWh. The report further states the cost of wind power will go down to $4 c/kWh before 2020. The digitization of processes, in particular, helped in optimizing the operation of renewable energy systems. McKinsey's Global Institute finds the digital technologies alone will save around $750 to $1,210 million in the investment costs by 2035. But, the fast-maturing renewable energy technologies continue to confront new roadblocks due to the dearth of cost-effective and reliable system integration technologies for the last mile connectivity.

Regrettably, the encouraging developments in renewable energy power sector contribute to only 20% of the global energy transition process. The transition is very negligent or yet to begin in other sectors, such as transport, heating, and cooling, which account for other 80% of the worldwide energy demand. Only a handful of countries are in the process of implementing regulatory measures to assist the renewable energy growth in the hitherto neglected segments. Now, the mature renewable energy technologies look forward to holistic and refined policies to move forward progressively.

Energy Transition

The historic 2015 Paris climate accord sought to keep the rise in global temperature levels within the 2 °C compared to pre-industrial revolution period. But, such efforts need to scale up the renewable energy generation by at least six times quicker than the present level. This technically feasible solution requires supporting policy efforts and a large-scale transformation in the worldwide energy systems. The shift from the fossil fuel to renewable energy usage is seen as the apogee of 'energy transition' and has begun in many parts of the world. This time the approach is not for a mere electricity transition, it is for a real energy transition.

The World Economic Forum report, *Fostering Effective Energy Transition*, supported with inputs from McKinsey & Company, provides an Energy Transition Index (ETI) evaluating the energy systems available in 114 countries. The countries with top GDP are responsible for 98% of the worldwide carbon discharges and hold nearly 90% of the global populations where nearly 60% live without proper access to electric power. The ETI index is prepared using a system performance (evaluating the existing energy system for secure reliable access, environmental protection and economic growth of the country) and transition readiness (preparedness of the system, capital availability, regulations and government commitment, supportive business infrastructure, and human capital) as basic criteria. The top ten countries ready for energy transition include Sweden, Norway, Switzerland, Finland, Denmark, the Netherlands, the United Kingdom, Austria, France, and Iceland. Amongst the emerging economies, Brazil stood at 38th place, Russia at 70th, China at 76th, and India at 78th position.

Energy Transition Focus Areas

Energy transition is identified as being economically viable and technically feasible. In order to speed up the process, proper policy decisions are needed. Some of the focus areas identified to speed up the process include the following:

a. Over 80% of the global countries though equipped with better energy systems, still lack features to meet the present energy-related challenges. The carbon mitigation budget allocation from most of them will get exhausted within the next 20 years. Unless policies for budget provision change radically, the dominance of fossil fuel will continue to dominate the global energy mix.
b. There must be concerted efforts to transform the way the energy systems are viewed to increase the share of renewables in the power sector. Such an effort needs a vital shift in the way we conceive and operate our energy systems. An all-inclusive policy planning and approach is needed globally across all energy-consuming sectors. In order to achieve cost-effective integration of wind and solar power generation, the power sector demands the restructuring of the present policy regulations. Such an action will assist the timely

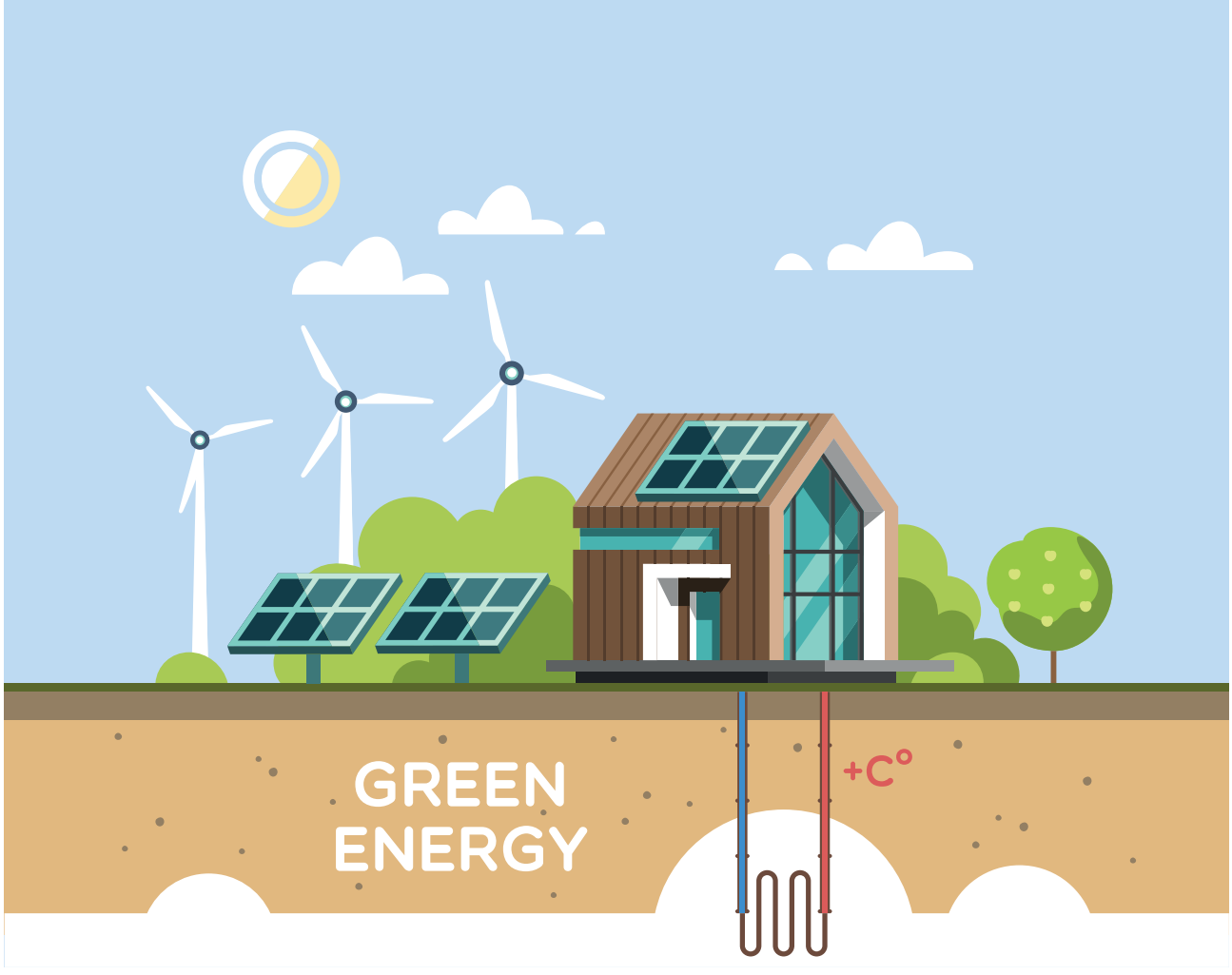
deployment of infrastructure to achieve renewable energy goals envisaged for 2050.

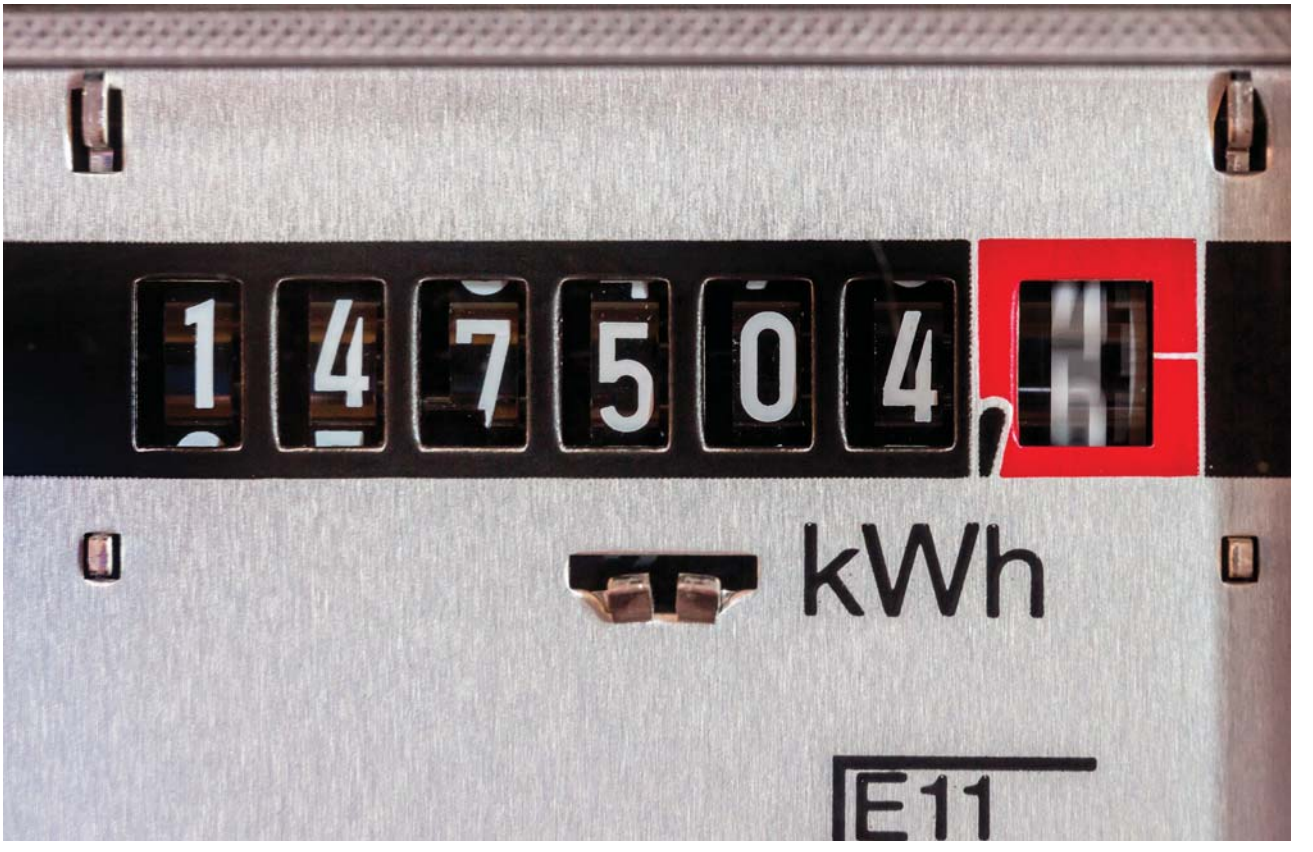
c. To better the use of electricity in industry, building, and transport sectors industrial policies, building regulations, and urban planning need to be integrated cohesively. The policies for transport and building heat sector are required to assist speedy electrification to encourage cost-efficient decarbonization. In the building and transport sectors where it is difficult to achieve full electrification, the policy framework should assist to try other renewable energy options such as geothermal, solar thermal, and bioenergy.
d. The total share of renewable energy needs to expand from the present 20% of the total primary energy supply (TPES) to at least two-thirds of the total energy usage by 2050. This requires fixing a long-term value as the sole criteria to derive the most out of the energy transition. Only specific plans for individual sectors, ordinate with suitable incentives with a long-term view will help to achieve it.
e. The transition path followed needs to be tailor-made for each country with a comparative analysis amongst the peers to understand the opportunities for improvement. An energy transition roadmap suggested by the International Renewable Energy Agency (IRENA) predicts renewables will constitute nearly 60% of the total final energy consumption (TFEC) of most of the countries by the year 2050. It anticipates that China will achieve 67% from its 7% in 2015, the European Union (EU) 70% from its 17% and expects the USA and India will achieve two-thirds or more increase from its current levels.

Energy Transition—India

India is ranked at 78th position amongst the 114 countries globally in the World Economic Forum's Energy Transition Index 2018. The country generates nearly 4% of worldwide power generation and adds 4.43% to the global renewable energy capacity. The country consumes approximately 36,000 PJ energies every year and 74% of its energy comes from fossil fuels.

Over the years, India has enhanced its renewable power generation capabilities and posted 9.29% CAGR for FY08–18. During 2017–18, the country added a record 11,788 MW





of renewable energy (both off-grid and grid-interactive) in the period April–July 2018. The signing of COP21 Paris agreement has made this sector more vibrant with better government support and increased investments. The country is planning to achieve 15,820 TWH power by 2040. As of July 2018, India generates a total of 345.49 GW power, out of which 116.82 GW (33.81%) comes from the renewable energy sector. Assisted with favourable policies primarily focussed on renewable energy, the country is planning to exploit its 363 GW potential, where northern India will play a vital role.

A government release from the Department of Industrial Policy and Promotion (DIPP) indicates the renewable energy sector received $6.84 billion FDI from the years 2000 to 2018. Since 2014, the sector received more than $42 billion as the investment. It is pertinent to note here that 'Shakti Sthala', the world's largest solar park opened in Karnataka with an investment of ₹16,500 crore ($2.55 billion) in March 2018. Compared to $630 million investment in 2016, the country received $920 million from 1st January to September 2018 witnessing an increase of 47%. Under the National Biogas and Manure Management Program (NBMMP), India installed biogas plants to power around 4.96 million households. The country is planning to achieve 175 GW renewable power generating capabilities by the year 2022 of which 100 GW will be generated using solar, 60 GW using wind, and the rest using other renewable sources.

It is to be seen how the country is going to make its energy transition smooth while it is trying to balance the growing energy demand of its middle-class population and rising industries. This it has to manage while controlling the environmental impacts of energy production and usage and improving its energy security.

Worldwide Energy Transition

China

According to the Energy Transition Outlook 2018, offered by DNV GL, a Norway-based agency, China is planning to get 27% of its energy from renewable sources by the year 2020. Currently, it generates nearly 82% of its energy by burning coal and oil where coal is the biggest source. The country is planning to increase its nuclear and natural gas use to bring down the use of coal to 11% by 2050. The country has plans to increase its oil consumption by 41% more than the present till the year 2030. Similarly, China wanted to achieve 19% natural gas usage by 2050 from its present 7%. The report estimates the solar photovoltaics (PV) installations with a total 7 TW (terawatt) installed capability will meet 52% of China's power supply by 2050. The steadily growing onshore wind will contribute 26% of total power in 2050, while the offshore wind generation will

contribute another 6%. The country, a leader in the electric car industry, also has plans to introduce electrification in its transport sector.

European Union

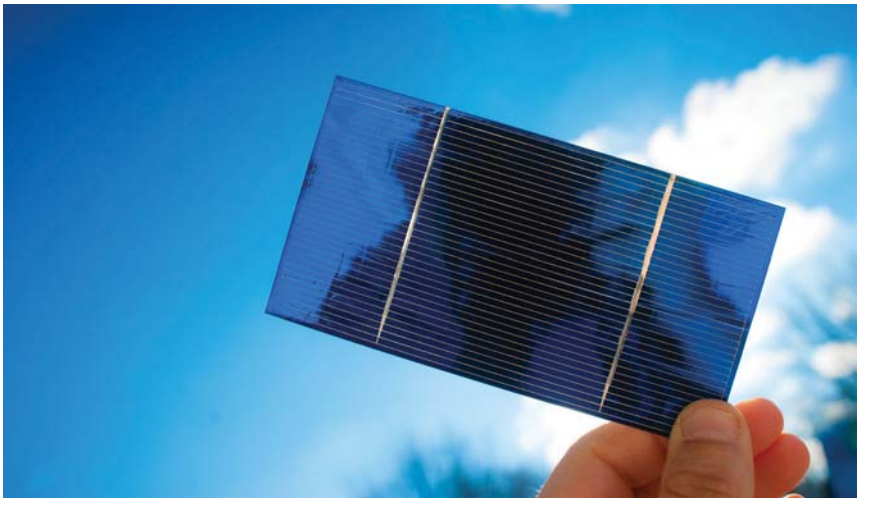
The European Union (EU) countries expressed their desire to unitedly lead the battle against climate change. The EU has agreed to spend €180 billion, that is, nearly 20% of its total budget in climate mitigation actions from 2014–2020. The European Council in October 2009 set its target to cut down greenhouse gases emissions up to 95% by 2050 compared to the levels in 2009. The EU plans to set up a monitoring agency to introduce a solid framework (market structures, regulations, infrastructure, etc.) to achieve dynamic development in the energy transition.

The USA

The USA continues to be a leader in renewable energy transition. A report from the Federal Energy Regulatory Commission's (FERC) indicates, renewable energy added nearly 50% of the total 24. Nearly 6 GW new power generation in 2017 and the rest were met by gas. The country meets nearly 20% of its energy needs from renewable energy sources at the end of 2017. The data estimates how utility-scale wind and solar alone will add 116 GW by December 2020, thus, doubling the presently installed capability of 115.5 GW. The International Renewable Energy Agency (IRENA) roadmaps assess though the country has the potential to achieve 27% renewable energy with an investment of $86 billion per year, with the present investments it is projected to reach only 10% renewable energy generation.

Saudi Arabia

The biggest exporter of oil declared its intentions to invest $7 billion in renewable energy projects at the beginning of 2018. Initially, the country aimed to add 4 GW of renewable energy (solar 3250 MW and wind 800 MW) by exploiting its natural sunlight and wind potential. The country announced its strategy to invest $50 billion to achieve 9000 MW renewable energy capability before 2023.



Innovative Factors Contributing to Energy Transition

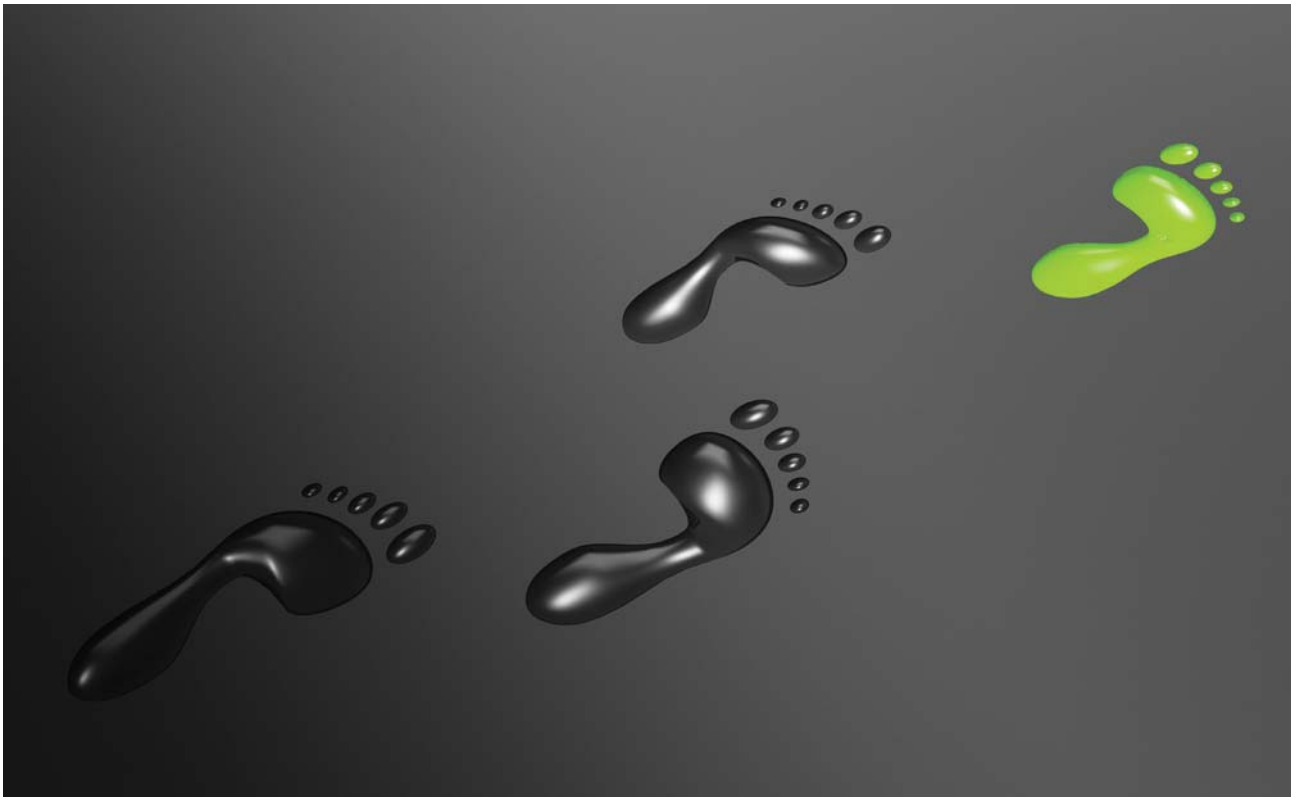
Technological advances - The renewable energy sector has seen technology advancements in the form of first, bigger wind turbines to sweep increased area and harness increased energy; second, floating wind turbines that can be moved to potential offshore wind locations; third, efficient solar cells to increase energy generation potential; and fourth, solar thermal and solar heating with the potential to serve the industrial sector.

Digitalization - Digitized grid networks linked to ultra-highspeed-communication networks monitor the operations of renewable energy installation. Such networks with cybersecurity assist to cut down the operation and maintenance costs while helping to plan the outages to better the power generation and network output efficiency.

Virtual power plants and blockchain - The joint platform includes power generating utilities, network managers, and third-party users. The rooftop solar energy producers are linked to an intelligent cloud platform called virtual power plants. A cloud-connected-interlink system combines such plants to assist the utility companies to discharge the stored power when more power is generated. Similarly, such an arrangement enables variable renewable energy (VRE) to get linked to the grid with stability. Blockchain provides the feature to record all the digital transactions in a distributed ledger incognito and confirm the same. The blockchain finds more users because of its utility.

Increasing energy access - The mini and microgrid sectors are growing at a rapid pace in developing countries. Introduction of efficient storage batteries, LEDs, control instruments, and meters assisted such growth. Also, solutions such as remote supervising of systems, data analytics, customer care, and defrayals enable remote users to access the energy with ease. Lastly, the introduction of direct current using appliances, such as refrigerators, fans, and television that are designed to operate at low-level current enables increased energy access.

Sector coupling with electric vehicles - The joining of utilities and grid operators help in the introduction of technologies that will assist electric vehicles to charge and store grid-supplied power for future use.



Battery and thermal storage - The introduction of lithium-ion rechargeable batteries with high-level storage and tiny memory effect (loss of saved current when idle) features are revolutionizing the renewable energy sector. Similarly, the thermal energy storing features either allows its conversion into electric power or direct usage of it for heating and cooling purposes.

Conclusion

Energy is a central cohesive source of all our economic prosperity. The demand for energy goes up along with the quality of life we all pursue. The increase in energy demand is often reflected in sectors, such as transport, construction, workplaces, schools, and homes. The global energy landscape is undergoing rapid changes. A report from the World Energy Council predicts that global energy demand will reach its peak in 2030 to 470 EJ/year from the 400 EJ/year in 2016. The biggest question before us is how to manage the growing energy demand now while checking the rising carbon footprint.

A safe and viable alternative before us is to end the dominance of oil and coal and encourage energy transition to safer and cleaner renewable energy sector. A new awakening is taking place and the global energy industry is under the threshold of energy transition to cost-effective and carbon-free renewable energy technologies. It is time for the countries to choose the journey path to energy transition on their own, keeping in mind both the mid-term and long-term energy objectives. EF

Mr Jyothi Mahalingam is a freelance environmental journalist who has been writing on renewable energy, climate change, and water conservation. Based in Chennai, he has contributed for several TERI publications. He also writes on technology, tourism, and social issues. He can be reached at ajm0750@gmail.com

CLEAN ENERGY TRANSITION

A RESILIENT MOVE WITH STRATEGIC GROWTH

Increasing industrialization is leading to a steep demand for electricity, especially in the developing and under developed countries. Worldwide, it is becoming economically viable to generate clean power and phase out fossil fuels which emit harmful greenhouse gases due to renewable solar energy technology. In this article, **Dr O P Nangia** describes the state of energy transition today, enumerates the challenges on the path, and the trends of the future.

Background

In the context of climate change and the state of renewables today, the International Energy Agency has been promoting sustainable development and combating climate change as an integral part of energy planning and policy making. The general approach being adopted for clean energy transition together with strategic growth, especially in sun-rich nations (lying between the tropics of Cancer and Capricorn) is mainly towards large investments in electricity networks with their capability through innovative and cost-effective solar resources. The resilient move is in support of the International Solar Alliance's agenda for clean energy access in bringing about transformative action by providing access to electricity for around 1 billion deprived population across the globe. The agenda, basically an offshoot of the collaborative resolution signed by 197 nations during the United Nations Conference for Climate Change (UNFCCC) COP 21 in Paris during December 2015, would benefit millions while protecting the universal ecosystem. In his address to the first assembly of the International Solar Alliance (ISA) on October 2, 2018, at New Delhi, the Prime Minister of India, Shri Narendra Modi applauded the United Nations for their support and identified the ISA as a beacon of hope for the world.

Renewable solar technology can provide energy security for any developing country by generating power with zero greenhouse gas (GHG) emissions. Several countries are gearing up with their renewable energy