October–December 2017

ENERGY FUTURE

The Complete Energy Magazine

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FEATURE

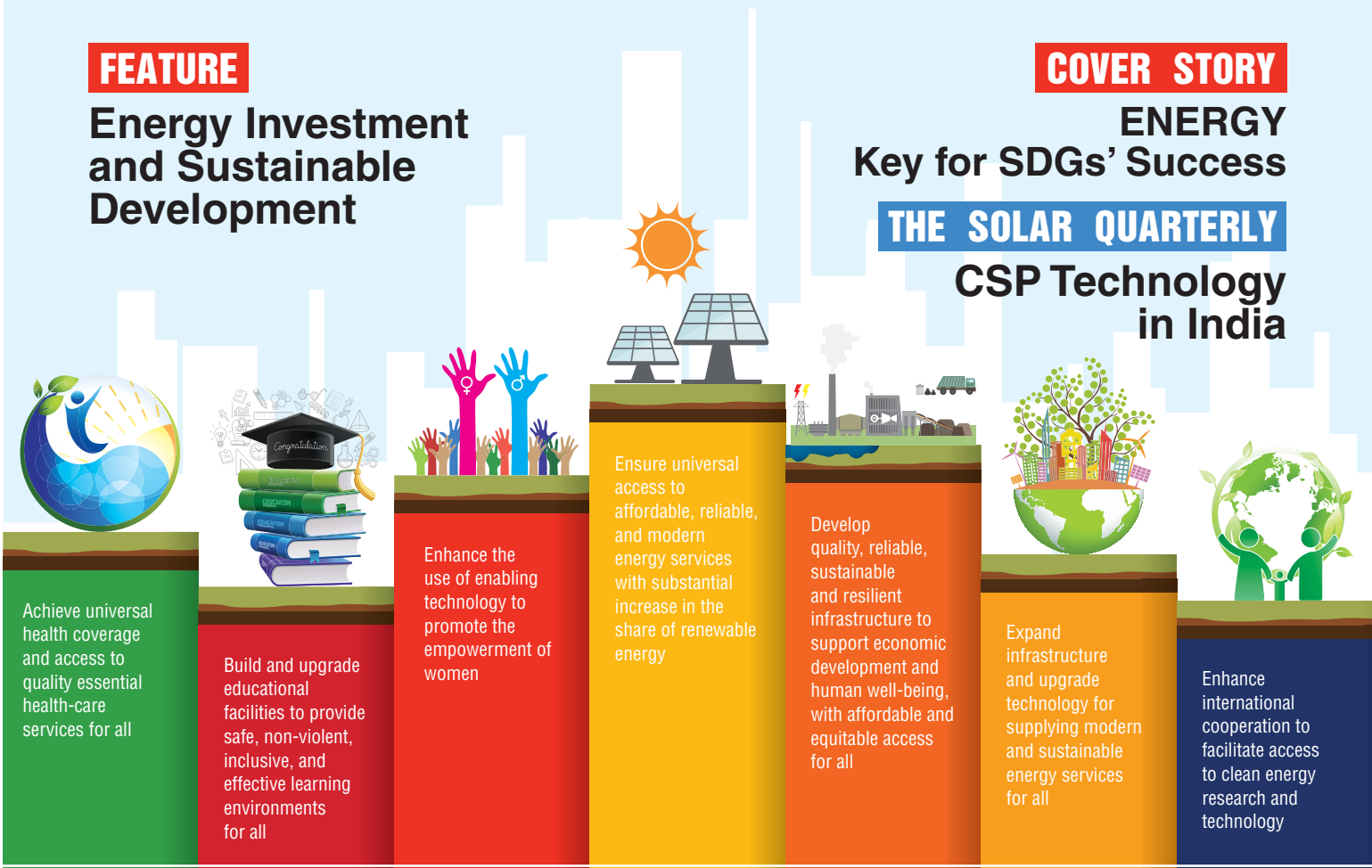
Energy Investment and Sustainable Development

COVER STORY

ENERGY Key for SDGs' Success

THE SOLAR QUARTERLY

CSP Technology in India



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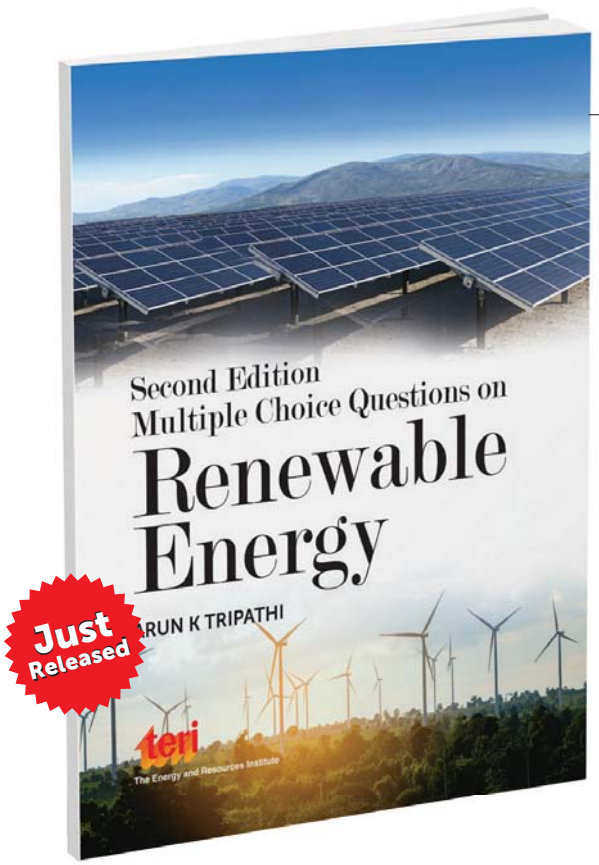
"Know all about renewable energy in multiple choice question format"



Major topics covered

- Renewable energy development in India
- Renewable energy potential in meeting the growing energy demand
- Sustainable energy sources of the future
- Current status of the energy generation through renewables
- Solar power—the future energy supplier of India
- Three levels of renewable energy exercises for self-evaluation

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The second edition of *Multiple Choice Questions on Renewable Energy* explores renewable energy sector in a multiple choice question format. It contains more than 1500 questions that focus on solar, wind, biomass, biogas, biofuels, hydro, energy from wastes, hydrogen, geothermal, ocean, tidal, and waves. Similar to the previous edition, this edition too has three levels of questions. The book provides a comprehensive overview of renewable energy development in India. This book is useful for academicians, students pursuing engineering or agriculture-related courses, aspirants of various competitive exams, professionals, and stakeholders in the renewable energy sector. It can also be used for quiz programmes organized in schools, universities, engineering institutions, and on television.

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From the editor's desk...

The 17 Sustainable Development Goals (SDG), comprising 169 targets, were adopted as a part of the `2030 Agenda for Sustainable Development' by the UN General Assembly on September 25, 2015. These SDGs aims to address issues pertaining to poverty, hunger, food security, health, education, gender equality, water and sanitation, universal energy access, and employment among others.

If one were to look SDGs carefully, energy would emerge as a common thread among most of them. Essentially, energy is a key ingredient of socio-economic development and economic growth. The production and consumption of energy is often linked to other major challenges in the society, including poverty alleviation, environmental degradation, and security concerns. The experience shows that there is a definite correlation between access to energy on the one hand and education attainment and literacy on the other, among the rural and urban poor. Consequently, the goals of poverty eradication, improved living standards, and increased economic output imply increasing energy requirements, which are further exacerbated by rising population and urbanization. Moreover, all of this has to be accomplished without impacting the environment negatively.

Thus, to contain the climate change and local environmental degradation, the key lies in reducing the energy intensity of the economy on the one hand and, to the extent possible, meet the growing energy needs through renewable energy resources, such as solar, wind, biomass, or hydro energy. Renewable sources of energy assume importance in the present context because unlike fossil fuels they are proved to be much cleaner and with negligible carbon footprint. Realizing that renewables are the mainstay of any effective climate change mitigation strategy, there is now a global thrust on renewables. The fact also remains that conventional ways of providing energy services have had limitations, even if one was to discount their implications. The `2030 Agenda for Sustainable Development' clearly implies accelerated deployment of clean energy to help meet SDGs in the given timeframe, thereby heralding a future with sustainable energy being the key enabler.

Amit Kumar

Amit Kumar
Senior Director, Social Transformation, TERI

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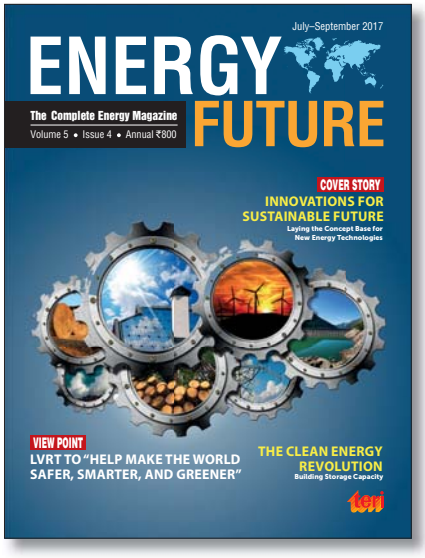

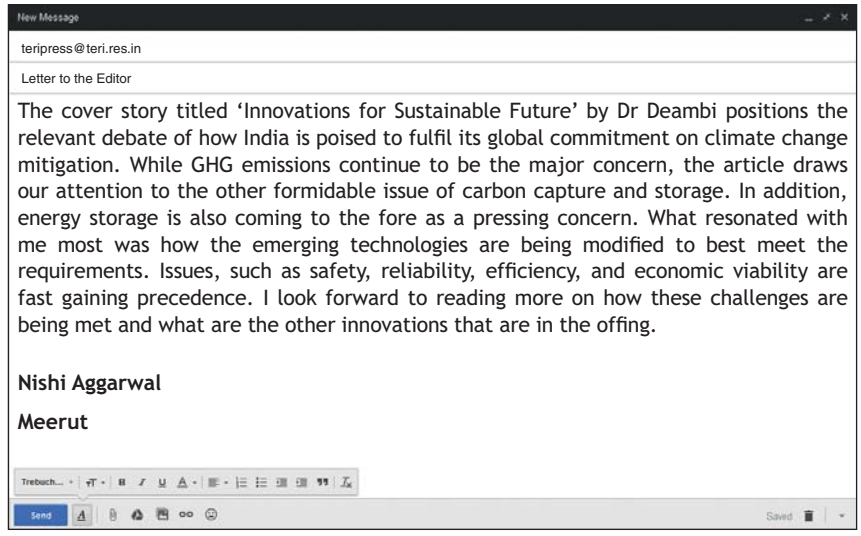

"'The Clean Energy Revolution' a feature article published in the July–September issue of Energy Future talks about how wind and solar energy, in addition to proper harnessing, need proper storage as well. Given that one-fourth of the Indian population lacks access to clean energy, mini grids are the most obvious solution and this technology needs to be perfected. In my opinion, while the move towards clean energy should be hastened, measures should be taken to ensure a smooth transition wherein the government and other stakeholders are prepared to face the inevitable challenges. From what I can tell, the ban on heavy-diesel vehicles is one of the most prominent steps in that direction. Awaiting more information from the magazine...."

Ajit Chatterjee
Delhi

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

"Sapna Gopal's contribution to the July–September issue titled 'A Necessary Switch' is as inspiring as it is informative. In a proactive initiative to reduce energy consumption, reduce health hazards, and offset the rising CO_2 emissions in the Lucknow, Shaista Ambar has not only made a significant contribution towards India's global commitments to rein in climate change, she has also situated women at the centre of sustainable solutions. It was a refreshing change to read about how gender issues are closely knit with environmental solutions and how the mosque has been mobilized to provide shelter to women who are new to the city. Truly inspiring!

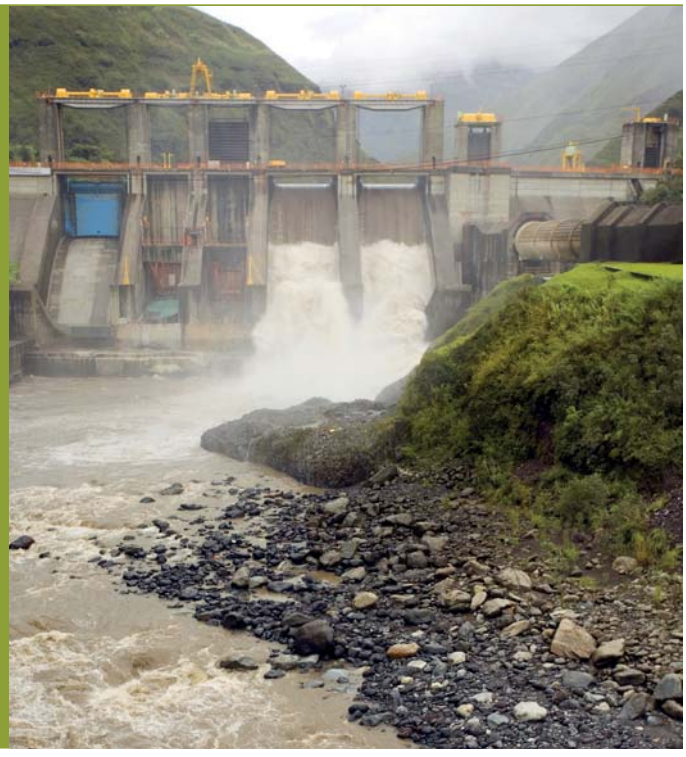
Shafaq Khan
Allahabad

"The solar-powered auto rickshaw that can travel up to 125–130 km is one of the recent, accessible, and long-term solutions to the energy crisis. The article 'Solar-Powered Auto Rickshaw' published in the July–September issue of *Energy Future* takes a close look at this environment-friendly transportation option. Addressing the need to revise public transportation options in semi-urban areas, this product seems to be a viable option for many. I was happy to read that in addition to cars, authorities are also focusing on public transportation systems in order to curb GHG emissions. Hope to see many such products catering to the developing and under-developed pockets of the country.

Gaurav Malhotra
Mumbai

CONTENTS

HP NOD TO 167 HYDROELECTRIC PROJECTS IN 4 YEARS



Himachal Pradesh, with a power generation potential of about 27,000 MW, has accorded approval to 167 hydroelectric projects in four years. During this period, 31 projects aggregating to 2,067 MW capacity were commissioned, including 800 MW Kol Dam, 412 MW Rampur, 130 MW Kashang, and 520 MW Parbati projects, said an official spokesman.

The Himachal Pradesh State Electricity Board Ltd has started execution of at least 22 projects totalling 300 MW capacity. To start with, an 18 MW project will be executed at Raisan in Kullu district on a pilot basis. The World Bank will provide funding for it, he said.

Of the 27,000 MW power potential in Himachal, 10,400 MW has been tapped so far, he said. EF

Source: The Pioneer

ESSAR OIL TO DOUBLE COAL BED METHANE OUTPUT FROM RANIGANJ BLOCK BY 2018

Essar Oil and Gas Exploration and Production Ltd plans to double coal bed methane (CBM) production from its flagship Raniganj block in West Bengal by 2018.

"Essar Oil and Gas Exploration and Production Limited is currently producing close to 1 mmscmd (million standard cubic metres per day), from about 350 wells in its Raniganj block. We expect to reach a production of about 2 mmscmd by 2018 and expect to maintain this level for the next few years," a company spokesperson said in an emailed response.

CBM is a natural gas stored or absorbed in coal seams and contains 90%–95% methane. According to the Directorate General of Hydrocarbons, India has the fifth-largest proven coal reserves in the world and therefore holds significant prospects for exploration and exploitation of CBM.

The Raniganj (East) block has sizeable CBM reserves with 25–30 years of field life. For the offtake of the increased gas production, Essar said it already has the required customer tie-ups. EF

Source: LiveMint

DELHI'S SOLAR ENERGY MODEL BEST FOR POWER-HUNGRY CITIES, SAYS STUDY

An international report on how energy-poor cities can be powered while containing polluting has cited Delhi's net-metering policy for solar rooftop systems as a probable solution for providing cheap electricity. The World Resources Institute's report, titled "Powering Cities in the Global South", was released on September 6, 2017. The report also pointed out that Brazil was contemplating legislation changes to its renewable energy norms to enable a Delhi-like policy.

While highlighting the three solutions—decentralized solar photovoltaic (PV) system, clean cooking fuel, and energy-efficient buildings and appliances—the system in the Indian capital was pointed out as exemplary. Net-metering was introduced in Delhi in 2014. Under this, home owners can either own a solar power system or lease their roof space to project developers. Roof owners can also pay a monthly lease rent to have a solar PV system put up by project developers. "The electricity generated from such a system is used to meet the household's or rooftop owner's energy needs, with the excess being fed into the grid," the report stated.

The report stated that underutilized rooftops in cities could be put to use under policies such as Gujarat's "Rent a Roof" in which residents give their rooftops to private solar energy companies that pay them around ₹3 for every unit of energy produced. There is mention also of Bengaluru's net-metering programme in which owners of rooftop solar PV systems are paid a promotional rate every month for net excess generation flowing to the grid.

Scaling up decentralized PV systems would also curb emission, the report said. This low-pollution measure could be crucial in mega cities of South Asia, where the polluting $PM_{2.5}$ concentrations are double that in cities in developed countries, the report said. EF

Source: The Times of India

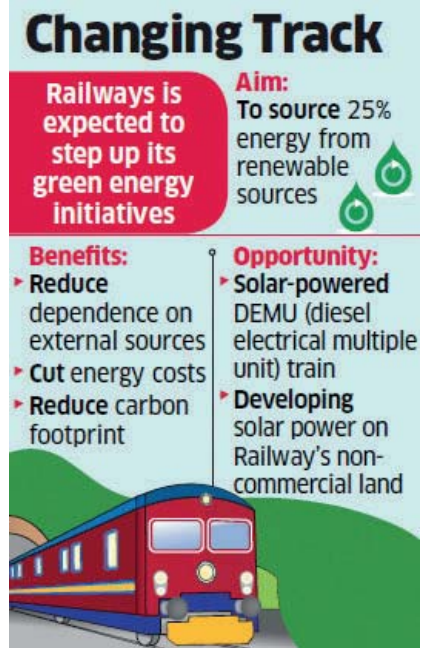
RAILWAYS MAY GET RENEWABLE ENERGY PUSH UNDER PIYUSH GOYAL

Indian Railways is expected to step up its renewable energy initiatives under new minister Piyush Goyal who was earlier heading the Ministry of New and Renewable Energy. Railways has an ambitious target to source 25% of its energy requirement from renewable energy sources by 2025 by setting up 5,000 MW of capacity, and solar and wind energy companies are hopeful that Goyal would push for scaling up the target and expanding the scope of the plan.

Indian Railways has one of the world's largest rail networks and it's the single largest consumer of electricity in the country, accounting for a little less than 2% of India's total power generation. Electricity accounts for 20% of Railways' operational costs and former minister Suresh Prabhu had said that ₹41,000 crore would be saved in ten years by increasing use of renewable energy.

Experts believe that besides savings for Railways, thrust on renewable energy will boost order books of companies in this sector. EF

Source: The Economic Times



TANGEDCO SETS RECORD IN SALE OF WIND POWER TO OTHER STATES

The Tamil Nadu Electricity Generation and Distribution Corporation (TANGEDCO) has created a record in selling wind power to other states for 2017. The power utility has so far sold 11.938 million units to various states and has also earned a few crore of rupees from the sale.

Apart from selling wind power to other states, Tamil Nadu has also evacuated the maximum amount of renewable energy from wind this year. On an average, nearly 3,500 MW to 4,000 MW of wind power was used by the DISCOM to distribute power.

"The average cost at which wind power was sold to other states was ₹5.16 per unit. Since wind power was sold through the electricity exchange, TANGEDCO does not know which states purchased it in the exchange," a senior official told TOI. The exchange does not share information about states selling and purchasing power in the electricity exchange. Wind power is generally available from evening to early morning. "TANGEDCO sold wind power on 14 days in August during peak hours in the evening. On an average, wind power was sold for two to four hours per day and it works out to around 500 MW per day," he said. EF

Source: The Times of India

300 HOMES IN 4 TELANGANA HAMLETS GET UNINTERRUPTED SOLAR POWER

About 300 homes in four hamlets of Nalgonda district in Telangana are getting 24-hour power supply to meet their domestic needs, thanks to solar power.

The Indian Institute of Technology (IIT) Madras, Verizon Data Services India, Southern Power Distribution Company of Telangana Ltd and Rural Electrification Corporation have joined hands to install a 125 W solar panel in the hamlets of Ramunigandla, Kesya, Jogi and Mantriya Thanda of Devarakonda mandal in the backward Nalgonda district.

The IIT has developed the technology that does not require an inverter and can power a fan, a tubelight, two bulbs, a mobile charger, a power socket, and a remote controller to operate the fan and tubelight. The performance of the installed systems are being monitored remotely, with data being collected via mobile phones and synchronized to a central server.

The residents of these hamlets, located about 100 km from Hyderabad, are poor and dependant on paddy and cotton farming for livelihood. They have been facing frequent power outages, especially during monsoons and peak demand times. EF

Source: The Hindu Business Line

ARMY LOOKS TO TAP RENEWABLES TO SUPPLY POWER TO JAWANS DEPLOYED AT HIGH ALTITUDES

The Army is looking for durable power supply in high altitudes to enhance the living conditions of its personnel.

The plan is to have renewable energy in place of fossil fuels that are unreliable and face transportation and maintenance hassles. The project has been placed under the Technology Development Fund scheme and the Army is discussing the project with the industry and subject experts.

The scheme envisages funding the industry that can develop technologies or prototypes for potential use with the help of scientists. The first option is fuel cell, which would convert chemical energy from a fuel into electricity through a reaction of hydrogen-containing fuel with oxygen or another oxidizing agent. Solar and wind energy, in abundance at high altitudes, are also under consideration.

Jawans deployed at altitudes as high as 22,000 feet in the northern and eastern sectors have to deal with sub-zero conditions almost throughout the year. Uninterrupted electricity supply, hence, becomes essential for cooking, heating, boiling water, and recharging batteries of communication and surveillance devices. Due to the absence of regular electricity, generators are used at present. Apart from the huge amounts of fuel consumption, transporting diesel and kerosene is a logistic challenge and costly proposition. Fuel is often carried by soldiers and mules. EF

Source: The Economic Times

SECOND AUCTION OF WIND POWER PROJECTS: TARIFF TUMBLES TO ₹3.42 A UNIT

Six months after the first auction of projects, the second one has seen wind power tariff falling to a record low of ₹3.42 per unit. The three companies that have qualified in the bidding, held by Tamil Nadu for 500 MW of wind power projects, would now set up 900 MW of wind power projects.

Regen Power Tech has won 250 MW of projects at the lowest quoted tariff of ₹3.42 per MW. It is followed by Leap Green Energy, promoted by F1 racer Narayan Karthikeyan, at a bid of ₹3.43 per unit for 250 MW. Neyveli Lignite Limited won 400 MW of projects at ₹3.45 per unit. These are fixed tariffs for a period of 25 years.

These three bidders would qualify to set up projects, as Tamil Nadu has put a ceiling tariff of ₹3.46 per unit. Anyone bidding below this qualified to set up power projects. In the first auction of wind power projects, held by central agency Solar Energy Corporation of India Ltd, the tariff was ₹3.46 a unit.

The bids received are much lower than the current average feed-in-tariff (FiT) of ₹5 per unit in the wind sector. EF

Source: Business Standard

STRAUSS ENERGY'S SOLAR ROOF TILES LIGHT UP A SCHOOL, STUDENTS' LIVES IN KENYA

So-called 'building integrated (solar) photovoltaic (BIPV)' energy technology is considered a keystone of distributed solar and renewable energy proponents' grand vision of economies and societies powered primarily by local, zero-emissions renewable energy resources.

An ambitious off-grid solar energy start-up based in Nairobi, Kenya, has developed and is installing its own, low-cost, locally made BIPV solar PV roof tiles and energy storage systems in the East African country. Reliably producing affordable, environment-friendly solar power and energy, the BIPV roofing system is enhancing energy service, energy security, and resilience at the Gaitheri Secondary School in central Kenya's Murang'a County, Thomson Reuters Foundation reported recently. The management is making plans to expand the organization and its reach much further.

Some 300 Strauss Energy solar PV roof tiles have been installed and integrated in a BIPV system at Gaitheri Secondary School, which provides education to some 275 students from surrounding rural communities. Encased in clay and durable plastic, Strauss Energy is producing its solar PV roof tiles in Kenya. In addition to on-site production of emissions-free renewable energy, they can be used to harvest rainwater.

Each set of 12 Strauss Energy solar PV roof tiles forms a circuit that is interconnected to form arrays that are in turn connected to inverters, charge and system controllers into which a battery energy storage system is also linked. That enables the school to draw power from the BIPV system at night and on rainy days, as well as harvest rainwater for future use. EF

Source: Solar Magazine

GREEN INVESTMENT GROUP ARRANGES WASTE-TO-ENERGY PROJECT FINANCING—FIRST UNDER NEW OWNERSHIP

Green Investment Group (GIG), formerly the Green Investment Bank, has arranged a £38 million ($51.6 million) debt facility for a waste-to-energy project, the first investment made by GIG since Macquarie Group purchased it in August 2017 from the UK government.

The investment is part of a £207 million (US$281 million) senior debt facility from a syndicate of lenders that will fund Wheelabrator Technologies' stake in Ferrybridge Multifuel 2 (FM2)—a new, large-scale merchant waste-to-energy facility near Knottingley in West Yorkshire, UK.

Once operational, the 70-MW facility will generate electricity for UK homes and businesses. FM2 is being built by Multifuel Energy Ltd, a joint venture of Wheelabrator and SSE plc.

GIG said FM2 will be located adjacent to the Ferrybridge Multifuel 1 facility, which began commercial operations in July 2015, and next to the recently decommissioned Ferrybridge C coal-fired power station. According to GIG, FM1 and FM2 combined will form the largest waste-to-energy site in the UK. EF

Source: Renewable Energy World

CHINA'S FIRST COMMERCIAL SOLAR THERMAL POWER STATION BEGINS TEST RUN

China's first commercial solar thermal power station has begun a test run and is scheduled to send power to the grid by the end of 2017, said the operator. The Delingha Solar Thermal Power Station operated by the China General Nuclear Power Group (CGN) in north-western province of Qinghai made its first test run on August 31, 2017, with all equipment running normally, the company said.

The project approved by the National Energy Administration in 2016 has an installed capacity of 50 MW of electricity, equivalent to the power produced by 60,000 tonnes of coal a year. Sources with CGN said the plant can reflect sunlight to a central receiver to heat water, which produces steam to power a turbine for generating electricity. It is the first time that the technology has been put into commercial use in China.

Built on the sparsely populated plateau, the demonstration plant is expected to boost China's efforts to meet the 2030 target of producing 20% of its overall energy from renewable sources. EF

Source: China Daily

DUBAI AWARDS CONTRACT FOR PHASE 4 OF MASSIVE SOLAR PARK

Dubai's government recently said its state energy utility has awarded a $3.9 billion contract for construction of a 700-MW solar power plant at the Mohammed bin Rashid Al Maktoum Solar Park. The government said the project includes an 850-foot-tall tower that will receive focussed sunlight, the world's tallest such structure in a solar park.

The contract was awarded to a consortium of Shanghai Electric and Saudi Arabia's ACWA Power. A spokesperson for ACWA Power in an email to POWER said the new plant is the fourth phase of the Mohammed bin Rashid Al Maktoum Solar Park, which ACWA says is the largest single-site concentrated solar power (CSP) facility in the world, with plans to produce 5 GW of solar power by 2030. The ACWA Power spokesperson said the phase 4 project will provide "renewable base load electricity at 7.3 cents per kilowatt hour," which ACWA says is "a global record for the lowest levelized cost [for such power] in an IPP [independent power producer] tender without benefit of any subsidy, including any carbon credit."

ACWA says the plant is part of the Dubai Clean Energy Strategy 2050, which was launched in late November 2015 and includes projects designed to produce at least 7% of the country's power from renewable sources by 2020, at least 25% by 2030, and 75% by 2050. EF

Source: www.powermag.com

COMBUSTIBLE ICE HERALDS CLEAN ENERGY

China's success in mining gas hydrate in the South China Sea is a breakthrough that could revolutionize the global energy industry and prove more significant than the United States' shale gas, experts said.

The gas hydrate, commonly known as combustible ice, is perhaps another 15 years away from commercial use, but its successful mining in China is a breakthrough nevertheless, said Lu Hailong, a professor at the Institute of Ocean Research, which is part of Peking University.

According to Li Jinfa, Deputy Director of the China Geological Survey, the South China Sea has an estimated 80 billion metric tonnes of oil equivalent of gas hydrate reserves. In all, there are 100 billion metric tonnes in the Qinghai-Tibet Plateau and in the South China and East China seas.

Combustible ice is formed under low temperature and high pressure in permafrost under the sea. One cubic metre of the hydrate can release about 160 cubic metres of gas, which would emit only half the amount of carbon dioxide produced by oil or coal. No country has been able to produce it commercially due to tough conditions and pollution concerns. China is eager to replace conventional energy, including coal, quickly with clean energy sources, to optimize the energy structure and relieve problems caused by energy shortages. According to Han Xiaoping, chief information officer of China Energy Net Consulting, combustible ice has great potential and could well be China's next big opportunity in energy. EF

Source: China Daily

ENEL, ENAP INAUGURATE 48 MW GEOTHERMAL POWER PLANT IN CHILE

Italian energy company Enel and Empresa Nacional del Petróleo (ENP) have inaugurated the 48 MW Cerro Pabellón Geothermal Power Plant in Chile. The Cerro Pabellón Geothermal Plant is owned by Geotérmica del Norte (GDN), which is a joint venture between Enel Green Power Chile (83.65%) and ENAP (16.35%).

Cerro Pabellón is located 4,500 m above sea level in Chile's Atacama Desert, in the Ollagüe district, Antofagasta region. It includes two units with an installed capacity of 24 MW each.

The geothermal plant is capable of producing around 340 GWh of power per year, which is equivalent to the energy needs of more than 165,000 households in the country. It also helps in avoiding about 166,000 tonnes of CO_2 emissions into the atmosphere.

Enel claims that the geothermal plant is a high-enthalpy binary cycle plant and is equipped with advanced geothermal technologies. Enel also says that the geothermal fluid extracted from the production wells is pumped back into the system once the power generation is completed. This practice, as per the company, ensures long-term availability and sustainability of the geothermal resource. EF

Source: Clean Technology Business Review

OFFSHORE WIND COSTS FALL BELOW NEW NUCLEAR PLANTS IN UK

The cost of generating electricity from offshore wind farms fell sharply in the UK to below the price the next nuclear reactors will charge, making the form of clean energy one of the cheapest ways to supply the grid.

In a government auction that handed out power-purchase contracts worth 176 million pounds ($232 million) a year, all the bids to build offshore wind farms and other renewable technologies were below the 92.50 pounds per megawatt-hour price awarded to the controversial Hinkley Point atomic plant.

Winners included the Danish utility Dong Energy A/S, with an offer of 57.50 pounds per megawatt-hour for power from its Hornsea 2 offshore wind farm, and EDP Renovaveis SA and Engie SA, which will receive the same for their Moray Fifth East project. Environmental and renewable energy groups said the 50% plunge in the cost of power from turbines sited in the sea indicates that clean-energy technologies are quickly rivalling traditional forms of generation without heavy subsidies.

This was the UK's second contracts-for-difference auction, where would-be developers compete for projects by bidding the price it would be willing to accept for electricity. The contest was for 'less-established technologies', such as offshore wind, tidal, and anaerobic digestion. EF

Source: Bloomberg Markets

SOLAR PLUS STORAGE TRIAL SET FOR REMOTE AUSTRALIAN COMMUNITY

The remote Australian Northern Territory community of Daly River is set to be powered by solar and energy storage under the $55 million (US$43.5 million) Solar Energy Transformation Program (SETuP), according to the Australian Renewable Energy Agency (ARENA).

The Daly River solar project will incorporate a battery system that enables diesel engines to be turned off during the day.

Jointly funded by ARENA and the Northern Territory government, and managed by Northern Territory utility Power and Water, the project's 2-MWh lithium-ion battery will be charged by 3,200 solar panels with 1-MW peak output, ARENA said.

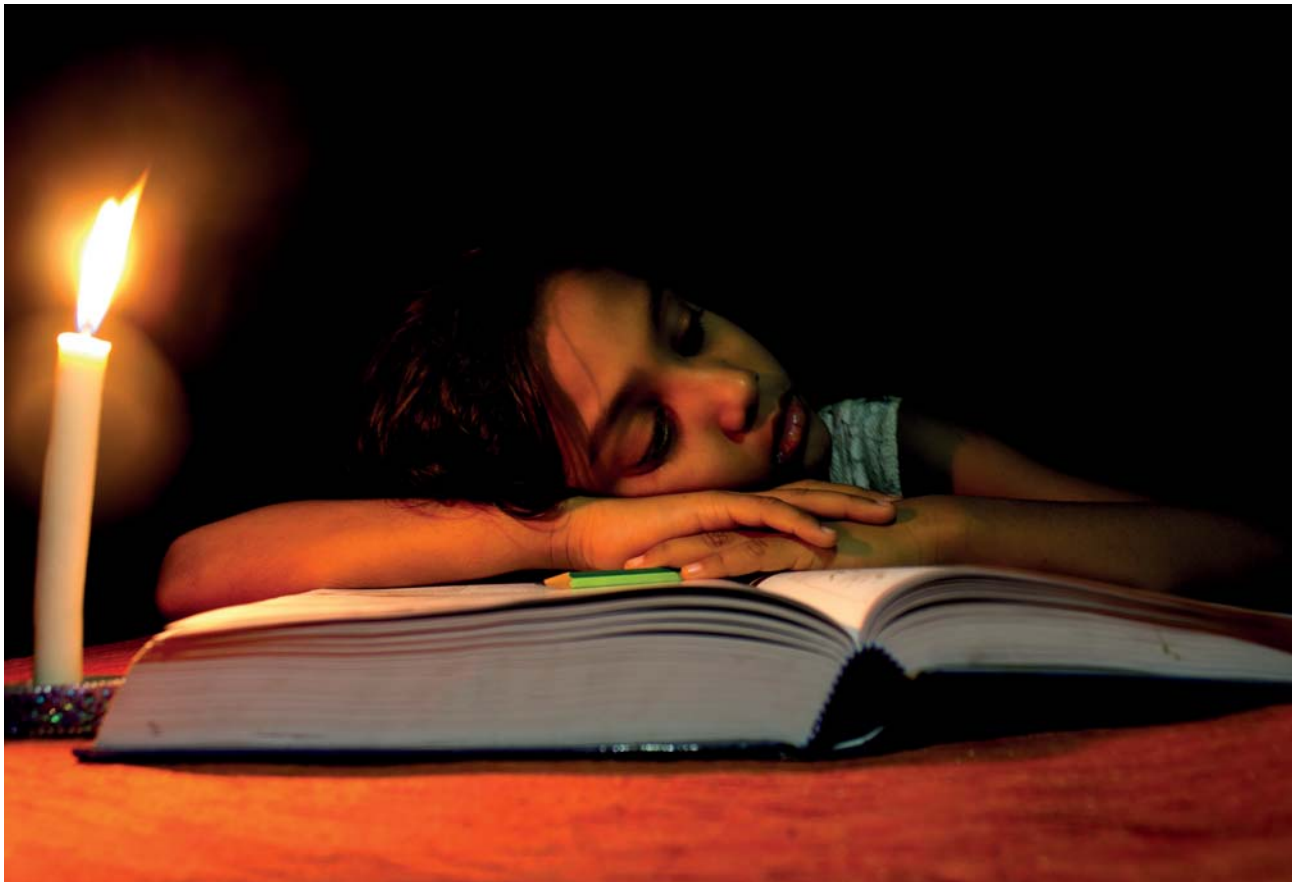
In a statement, ARENA CEO Ivor Frischknecht said the Daly River site trial was important in showing how renewable energy can reduce reliance on diesel.

"As battery costs reduce over the next few years, solar and battery technology will become more and more economically compelling as an alternative to traditional ways of powering remote communities," Frischknecht said. "We're excited to see the outcomes of the Daly River installation, which will help guide deployment of more renewable energy in other remote communities as the technology becomes more cost effective." EF

Source: Renewable Energy World

ENERGY
Key for SDGs' Success

This September of 2017, it would be three years since the world embarked on the journey to accomplish Sustainable Development Goals (SDGs). World over countries are working towards achieving these ambitious SDGs, and within these 17 goals, considerable efforts have been undertaken by nations. However, mammoth efforts are still awaited to be ensured in many aspects of SDGs. On July 19, 2017, India presented its first voluntary national report on the implementation of SDGs at the United Nations. Currently, India ranks at 116 out of 157 nations on the global index that assesses performance of countries towards achieving the ambitious SDGs. In this article, **Monika Paliwal** talks about energy as the connecting thread among all SDGs and as essential for meeting the goals.



In this era of Anthropocene, we have the Sustainable Development Goals (SDGs) which are formulated as a plan of action for addressing people, planet, and prosperity. These 17 goals are wide spectrum that go beyond the millennium development goals (MDGs) and seek to strengthen universal peace and freedom.

On September 25, 2015, countries adopted a set of goals to end poverty, protect the planet, and ensure prosperity for all as part of a new sustainable development agenda.[1] This new universal agenda comprises 17 SDGs and 169 targets. Prior to these were the aspirational MDGs. These were adopted at the UN Millennium Declaration of September 2000. Participating nations committed to a new global partnership in order to reduce extreme poverty and defined a series of time-bound targets. Following are the eight goals of MDGs that were worked towards a deadline of 2015. The goals were to eradicate extreme poverty and hunger; to achieve universal primary education; to promote gender equality and empower women; to reduce child mortality; to improve maternal health; to combat HIV/AIDS, malaria, and other diseases; to ensure environmental sustainability; and eighth goal is to develop a global partnership for development. However, by 2015 these goals were not uniformly achieved all over the world and there was huge disparity still left within countries and also across countries.

To continue this endeavour of sustainable development agenda, in 2015 the SDGs came into action to complete what MDGs could not accomplish. Thus, SDGs are built upon the achievements of the MDGs and are aimed at addressing their unfinished venture. SDGs endeavours towards linking the three dimensions of sustainable development in the realms of economic, social, and environmental sphere.

SDGs: At a Glance

SDGs and targets are planned to stimulate and enliven action over the next 15 years. Following are the 17 SDGs vested with transformational and ambitious aspirations that work towards a world free of poverty, hunger, diseases, and where diverse life can thrive.

First goal is to, 'end poverty in all its forms everywhere'. This goal targets to eradicate extreme poverty and works towards it by equal rights to economic resources and also helps build the resilience of the poor and vulnerable people in wake of climate change.

Second goal is to, 'end hunger, achieve food security and improved nutrition, and promote sustainable agriculture'. This aims towards doubling the agricultural productivity and end all forms of malnutrition. In order to attain this, areas highlighted are the genetic diversity of

[1] http://www.ipu.org/splz-e/unga16/2030-e.pdf

seeds and plant banks and livestock gene banks in order to enhance agricultural productive capacity, especially in the least developed countries.

Third goal is to, 'ensure healthy lives and promote well-being for all at all ages'. This requires widespread working among diverse sections, such as reducing the global maternal mortality; ending preventable deaths; ending the epidemics of AIDS, tuberculosis, malaria, and neglected tropical diseases; and combat hepatitis, water-borne diseases, and other communicable diseases. Access to quality essential health-care services and access to safe, effective, quality, and affordable essential medicines and vaccines for all.

Fourth goal is to, 'ensure inclusive and equitable quality education and promote lifelong learning opportunities for all'. Ensuring development of relevant skills, including technical and vocational skills, for employment, decent jobs, and entrepreneurship. Training and information and communications technology; technical, engineering, and scientific programmes, in developed countries and other developing countries.

Fifth goal is, 'achieving gender equality and empower all women and girls'. Work towards eliminating all forms of violence against all women and end all forms of discrimination against all women and girls. Enhance the use of enabling technology, in particular information and communications technology, to promote empowerment of women.

Sixth goal is to, 'ensure availability and sustainable management of water and sanitation for all'. And achieve universal and equitable access to safe and affordable drinking water for all.

Seventh goal is to, 'ensure access to affordable, reliable, sustainable, and modern energy for all'. By 2030, ensure universal access to affordable, reliable, and modern energy services and increase substantially the share of renewable energy in the global energy mix. Along with this, double the global rate of improvement in energy efficiency and enhance international cooperation to facilitate access to clean energy research and technology, including renewable energy, energy efficiency, and advanced and cleaner fossil-fuel technology, and promote investment in energy infrastructure and clean energy technology. It also works towards expanding infrastructure and upgrade technology for supplying modern and sustainable energy services for all in developing countries, in particular least developed countries, small island developing states, and landlocked developing countries, in accordance with their respective programmes of support.

Eighth goal is to, 'promote sustained, inclusive, and sustainable economic growth, full and productive employment, and decent work for all'. Achieve higher levels of economic productivity

through diversification, technological upgrading, and innovation. Improve progressively, through 2030, global resource efficiency in consumption and production and endeavour to decouple economic growth from environmental degradation.

Ninth goal is to, 'build resilient infrastructure, promote inclusive and sustainable industrialization, and foster innovation'. Promote inclusive and sustainable industrialization and enhance scientific research, upgrade the technological capabilities of industrial sectors in all countries, in particular developing countries.

Tenth goal is to, 'reduce inequality within and among countries'. By 2030, empower and promote the social, economic, and political inclusion of all, irrespective of age, sex, disability, race, ethnicity, origin, religion, or economic or other status.

Eleventh goal is to, 'make cities and human settlements inclusive, safe, resilient, and sustainable'. By 2030, ensure access for all to adequate, safe, and affordable housing and basic services and upgrade slums. By 2030, provide access to safe, affordable, accessible, and sustainable transport systems for all, improving road safety, notably by expanding public transport. By 2030, enhance inclusive and sustainable urbanization. By 2030, reduce the adverse per capita environmental impact of cities, including by paying special attention to air quality and municipal and other waste management.

Twelfth goal is to, 'ensure sustainable consumption and production patterns'. By 2030, achieve sustainable management and efficient use of natural resources. By 2030, substantially reduce waste generation through prevention, reduction, recycling, and reuse. Support developing countries to strengthen their scientific and technological capacity to move towards more sustainable patterns of consumption and production. Rationalize inefficient fossil-fuel subsidies that encourage wasteful consumption by removing market distortions, in accordance with national circumstances, including by restructuring taxation and phasing out those harmful subsidies, where they exist, to reflect their environmental impacts, taking fully into account the specific needs and conditions of developing countries and minimizing the possible adverse impacts on their development in a manner that protects the poor and the affected communities.

Thirteenth goal is to, 'take urgent action to combat climate change and its impacts'. Strengthen resilience and adaptive capacity to climate-related hazards and natural disasters in all countries.

Fourteenth goal is to, 'conserve and sustainably use the oceans, seas, and marine resources for sustainable development'. Increase scientific knowledge, develop research capacity, and transfer marine technology.

Fifteenth goal is to, 'protect, restore, and promote sustainable use of

terrestrial ecosystems, sustainably manage forests, combat desertification, and halt and reverse land degradation and halt biodiversity loss'.

Sixteenth goal is to, 'promote peaceful and inclusive societies for sustainable development, provide access to justice for all, and build effective, accountable, and inclusive institutions at all levels'.

Seventeenth goal is to, 'strengthen the means of implementation and revitalize the global partnership for sustainable development'. Assist developing countries in attaining long-term debt sustainability through coordinated policies aimed at fostering debt financing, debt relief, and debt restructuring, as appropriate, and address the external debt of highly indebted poor countries to reduce debt distress.

Energy: Key for Successful Implementation of SDGs

Energy in this era is crucial requirement in working and application of various goals and targets. Energy sources are critical for attaining many of these earlier-mentioned ambitious SDGs. Analysing these 17 goals, we see that there runs a connecting tread of essential requirements that are prerequisite for the successful application and functioning of these seventeen goals and that is availability of energy resources.

Goals such as ending poverty, food security, and healthy life are essential for moving on the path of sustainable development. However, we must address that one of the primary foundation for achieving these three goals is food resource. Currently, we are wasting approximately 1.3 billion tonnes of food due to lack of storage of food resource, collection or harvest of food resource, and distributional facility. This accounts for one-third of the food produced in the world for human consumption every year; on the other hand, this wastage could be tremendously reduced if we improve conditions for storing food supply and efficient handling of perishable commodities. A third of the world's energy is consumed by the food sector, but a third of food that is produced is lost or wasted. Countries where food commodities go waste due to lack of storage, processing, and transport facilities need to focus upon reducing food resource wastage. As per the data provided by the Food and Agriculture Organization of the United Nations, global food wastage occurring due to lack of storage (and processing) facility is 24%. Modern energy is needed as fuel for smooth transportation of food resource from field to customer. Figure 1 reflects percentage share of various sector in global food loss. Indeed, availability of energy source for efficient operation of storage and processing units could reduce this loss.

Countries moving on the path to development experience food wastage due to technical constraints in harvesting techniques and at storage facilities. This translates into loss of income for small farmers and reflects into higher prices for poor consumers. In India, meat accounts for just 4% of food wastage but contributes 20% in the economic cost of the wastage. Wastage of vegetables and fruits is 70% of the total produce, but it accounts for 40% of the economic losses. In India, the value of food wastage (harvest and post-harvest losses of major agricultural produce) is estimated at around 92,000 crore per annum at 2014 wholesale prices. Storage facilities are in dire need to enhance both structure and capacity; as per a recent survey by IIM Kolkata, only 10% food items get cold storage facility in India. One can reduce this wastage by investing in infrastructure, transportation, as well as in an expansion of food processing and packaging industry that could help to reduce the amount of food loss and waste. All these facilities shall require a consistent flow of energy.

Energy is essential for all three dimensions of sustainable development, that is, economic growth, social development, and human well-being, and clean energy is the need of the hour for maintaining healthy conditions for various life forms to thrive. It has been estimated that in the coming decades three billion people in developing and

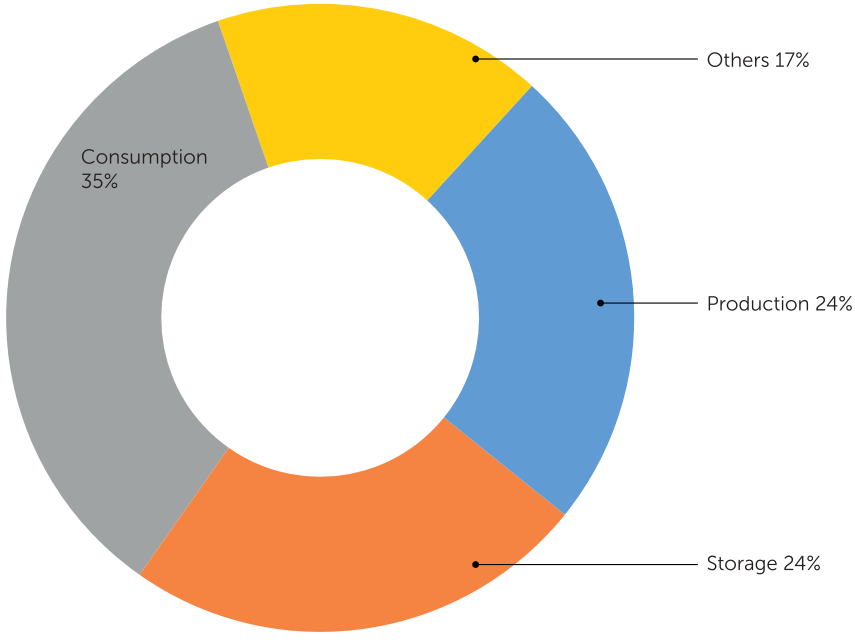


Figure 1 Percentage of global food loss

emerging economies will move out of poverty and enter middle-income group.[2] This shall also increase the energy consumption as they will require energy services at much higher levels than today.

All the basic requirements for a dignified life rally around availability of energy resources as in food, clothing, livelihood, security, communication, etc. This concern finds its reflection in SDG 7, to ensure universal access to modern energy. As shown in Figure 2, more than one billion people lack access to electricity, that is, 16% of the global population, over two billion people lack access to clean cooking facilities, and another billion people have only intermittent supply of power; these numbers also show us how lack of energy is a major barrier to development. More than 95% of those living without electricity are in countries in sub-Saharan Africa and developing Asia, and they are predominantly in rural areas.

Energy is a key enabler for several of the SDGs. Modern energy is a promising means to eradicating extreme poverty and hunger. Energy helps in powering pumps for drinking water as well as farm machinery and irrigation to improve agricultural yields. Energy availability may enhance work done to reach SDG 4, that is, energy contributes to universal education through lighting and reducing burden of fuel collection. Modern energy in the form of street lights can help empower women by improving safety and facilitates women to attend school or community activities after dark and in this way help reach SDG 5.

Approximately, 2 million people die every year from household air pollution. Among this, 44% die due to childhood acute lower respiratory infections (ALRI); another 54% deaths are due to chronic obstructive pulmonary disease and an additional 2% from lung cancer. Alarming reality is that, women are most vulnerable. Nearly half of deaths among children under 5 from ALRI are due to indoor air pollution; these emissions are from household solid fuels. However, as specified in SDGs, modern energy for cooking will remarkably reduce risks of respiratory illness. This move shall help in reaching SDG 3, SDG 5, SDG 7, SDG 9, SDG 11, and SDG13 as modern energy will help improve health, gender equality, provide clean energy, provide safety to the community, along with contributing towards climate change mitigation. Thereby, SDG 7: universal access to affordable, reliable, and sustainable

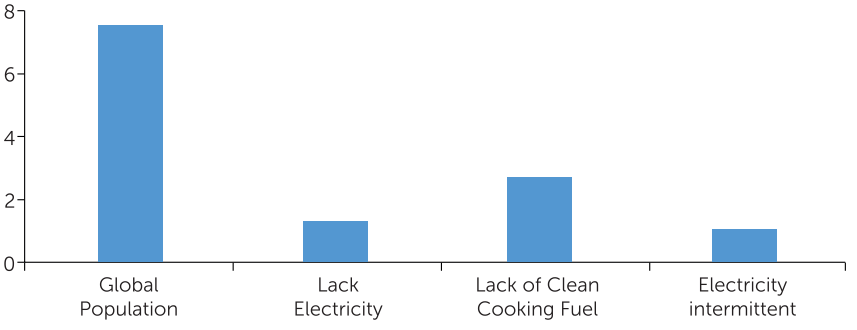


Figure 2 Energy and population

2 https://data.worldbank.org/data-catalog/world-development-indicators

energy has the potential to make people reach towards other SDGs. Thereby, successful implementation of goals require serious emphasis on the seventh goal: 'ensure access to affordable, reliable, sustainable, and modern energy for all'

India on the Path of SDGs

All of the earlier-mentioned seventeen goals are indeed ambitious. Presently, lot of countries are not able to work towards all seventeen goals in a holistic manner. Each country has its own set of issues and prevailing condition, for instance, India is steadily moving on the path of development. On July 19, 2017, India presented its first voluntary national report on implementation of SDGs at the United Nations. However, India selectively reported on just six goals. Those goals are as follows; Goal 1 to end poverty; Goal 2 to end hunger; Goal 3 to ensure healthy lives; Goal 5 to achieve gender equality; Goal 9 to build resilient infrastructure; Goal 14 to conserve and sustainably use oceans; and Goal 17 to revitalize global partnership for sustainable development. It is important to understand that India alone is home to more than 30% of the global estimate of over one billion people who live in extreme poverty, that is around 360 million people.[2] Within India, on state level estimates, Uttar Pradesh has the highest share of population living in extreme poverty, accounting to 8%. Thus, to reach all goals of sustainable development, India needs to address the state-level conditions.

In working towards SDG 7, the Ministry of New and Renewable Energy, Government of India, has achieved a total of 7,518 MW of grid-connected power generation capacity from renewable energy since January 2016 up to October 2016. India has attained fourth position in global wind power installed capacity during the year 2015/16. Approximately 7,060 MW of grid-connected power is generated from renewable energy sources, such as solar (3,019 MW) and wind (3,423 MW), small hydro power (218 MW), and bio-power (400 MW). In India, renewable energy is now being used in transport facilities too, and in 2017, the country launched its first solar-powered local train. This is a step to increase the use of renewable, clean, and alternative energy in the transport sector. This train has been powered entirely by the solar panels installed on its roof. Along with this, it has bio-toilets and a water recycling system. However, this train is expected to be used for commercial service in Delhi.

Changing Energy Profile with Changing Economic Levels

Energy is also considered as a prerequisite for economic development and is a functional basis for many economic activities. In the coming decades, over one billion people who live in extreme destitution shall rise from poverty. They shall also be requiring energy to move on the path of development. They have to be provided with the benefits of modern society and the opportunities that come with it. To meet the needs of these people, countries shall require a higher level of energy use and power supply capacity than the present demands of energy consumptions.

On this issue, Secretary-General's Advisory Group on Energy and Climate Change has provided detailing with regard to understanding terms as energy

access both in terms of 'basic human needs' and 'productive uses'. Productive uses have been defined as 'application of energy derived mainly from renewable resources to create goods and/or services either directly or indirectly for the production of income or value'. This highlights that productive use should not be limited to only engines and pumps. A broader interpretation of value and income include activity in agriculture, industries, retail and services, and public sector uses, such as health clinics, water supply and sanitation, educational institutes, etc. Thereby, all economic uses that go well beyond the low energy consumption profiles of households. The energy requirements for economic uses are not static perhaps and shall enhance when economies reach new levels of income. Scenario analysis by the Stockholm Environment Institute (SEI) and partners has provided with differences between pursuing a development agenda based on basic energy access and a 'shared development agenda' that entails productive uses for a development trajectory towards a middle income country status by 2050.[3] Thereby, unravelling how a country's developmental path and aspirations shall deter the energy requirements. Adding to this is the work of Steinberger and Roberts,[4] who probed the relationship between human needs and energy with the help of several indicators of human development, such as life expectancy, literacy, income, and the Human Development Index. They stated that increasing energy use past a moderate level does not necessarily contribute to higher living standards.

Energy demands and population are connected; however, between 1990 and 2013, worldwide energy use increased about 54%, whereas global population increased by 36%. Access to energy is fundamental to development, but as economies evolve, rising incomes and growing populations demand more energy. Meeting SDG 7 will require increasing access to electricity and must be accompanied by moving towards the clean fuels and renewable energies along with better energy efficiency for a better future.

Clean Energy and SDG 7

A momentous scaling up of renewable sources of energy is understood as the need of the hour and is widely agreed as indispensable for the energy sector and the environmental conditions. This is helping in mitigating climate change and air pollution. Also, currently fossil fuel industry is thriving on exports from oil-rich countries and renewable energy will aid in enhancing energy security through reduced import dependencies and diversified supplies. Globally, renewables are contributing around 17% of world's total primary energy use and this is mainly driven by supply of traditional biomass and hydropower. Global trends are reflecting that by 2030 renewables' share shall increase and reach approximately 30%.

3 Nilsson M, Lucas P, and Yoshida T. 2013. Towards an integrated framework for SDGs: Ultimate and enabling goals for the case of energy. *Sustainability* 5(10): 4124–51.

4 Steinberger JK, and Timmons Roberts J. 2010. From constraint to sufficiency: The decoupling of energy and carbon from human needs, 1975–2005. *Ecological Economics* 70(2): 425–33.

Renewable energy from solar panels and photovoltaic panels have become more affordable over the years and their life has also increased. This presents solar as a very promising form of renewable energy. On the other hand, wind energy and bioenergy are providing promising results in off-grid regions too. Renewables are also contributing in the non-electric energy production in transport, heating, and industry. Moving on the path of SDGs 7, bioenergy in the power sector can provide energy with minimum or negligible emissions.

Renewable-driven energy generation has tremendous potential in facilitating governments to reach SDGs. However, there are debates around biofuels on food security and availability of land and water resource. Additional aspects related to biodiversity and intensive agricultural practices are areas of disagreements and controversies. Bioenergy production is also associated with methane and other greenhouse gas emissions, such as nitrogen fertilizers and fuel. Another major source of renewable energy is hydropower. This is a hot bed of disputes both inter-state and intra-state; controversies revolve around biodiversity loss, resettlements, and loss of land and natural rivers and its water flow. Nonetheless, transformation is awaited in the current fossil fuel driven energy sector. Promising future of renewables is seen in estimates on global potential from bioenergy production in 2050 is approximately 50–150 EJ.

To reach SDGs and attain ambitious goals regarding people, prosperity, and environment, it is essential to use modern energy. While the contrary without giving apt attention towards clean energy will impact health, welfare, and delay development for billions of habitants. EF

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Energy Investment and Sustainable Development

The International Energy Agency's recent annual report, *World Energy Investment 2017*, analyses investment trends for affordable and clean energy, which is one of the Sustainable Development Goals set by the UN. **Michael Waldron** talks about the progress under SDG 7 from global as well as Indian perspective.

Access to reliable and sustainable energy is crucial to the success of the sustainable development goals (SDGs). Energy powers the schools that train the next generation of leaders, runs the hospitals that take care of our loved ones, and fuels the businesses that generate economic growth. When societies choose clean energy sources to provide these services, this helps to clean the air in our cities and fight against the impacts of global climate change.

Given their long lifetimes, the energy infrastructure built today will leave its mark for decades to come. To achieve SDG 7, which calls for universal access to affordable and clean energy by 2030 with a major role for renewables and energy efficiency in the overall system, investors and governments will need to deliver investments at the right time and in the right place, while considering long time horizons. Sound energy policy, a supportive enabling environment, and new financial and business models will be important to support this transition both globally and in India.

Present Status and Future Pathways

Recent years have shown mixed progress towards this energy objective, which is consistent with the UN Sustainable Energy for All framework put forth in 2012. A multi-agency tracking effort, led by the International Energy Agency (IEA) and the World Bank, recently highlighted the growing role of renewable energy in total final energy consumption, at over 18% in 2014; this is mainly due to good progress in development of new sources of electricity from solar, wind, and

hydropower.[1] The world is also making good progress in using energy more efficiently, particularly in industry, as demonstrated by the over 2% annual average improvement in energy intensity since 2012.

However, despite concerted efforts to expand power supplies, over 1 billion people remain without access to electricity. Only modest improvements have been made in the global electrification rate (85%) since 2012, and less than 40% of sub-Saharan Africa, the most challenged region, has access to electricity. Globally, access to clean and modern fuels and technologies for cooking is at 57%, which is even less than that for electricity. Moreover, much work remains to increase the role of renewables in the transport and heating sectors, where progress has lagged far behind that seen in the power sector.

Going forward, IEA scenario analysis suggests that current efforts set out by policy makers, including those targets in nationally determined contributions (NDCs) under the Paris Agreement, will not be enough to overcome this picture and achieve universal access to affordable and clean energy. Nevertheless, there are pathways to reaching this goal, with the right policy actions. To put the world on track to avoid dangerous climate change, the IEA's *World Energy Outlook 2016 (WEO)* has already assessed that a large reallocation of capital that contributes on average nearly $1 trillion of annual investment in clean energy supply would be needed over the next 25 years.

Forthcoming IEA analysis of the energy and development challenge will delve further into these pathways. Later this year, the WEO will present a new scenario assessing what will be required to achieve the main energy-related components of the UN 2030 Agenda for Sustainable Development,

1 http://www.iea.org/newsroom/news/2017/april/uneven-progress-on-achieving-access-to-sustainable-energy-for-all.html

including measures to provide universal access to modern energy by 2030 and enhance local air quality, all the while still putting the world on a path to tackle global climate change. A new WEO Special Report, *Energy Access Outlook*, will take a deeper look at trends and strategies in energy access and the wider implications of providing modern energy for all for the environment, economic growth, and other development objectives.

Global Investment Trends

Given this backdrop, is the world making the right energy investments now that will deliver on these goals in the future? At $1.7 trillion, investment in the energy sector represents some 2.2% of global gross domestic product, but has fallen by 17% since 2014. Does this trend signal that investors and governments are not spending enough to enhance the adequacy of energy supplies? Alternatively, does it indicate a more complex shift in the types of energy investments that may help us reach sustainability goals in the years ahead? The IEA's recent *World Energy Investment* report provides some indications as to whether investment trends for the world, and for India in particular, are moving towards a more sustainable energy path and what investment challenges remain.

Shift in investment towards cleaner sources

For the first time ever, the electricity sector edged ahead of the oil and gas sector in 2016 to become the largest recipient of energy investment. One of the encouraging implications of this trend is the continued rise of clean sources as share of investment in energy supply. During the past two years, low-carbon technologies, including renewables and electricity networks, have grown their share by 12 percentage points and now represent 43% of energy supply investment. This is a big change from the past, when fossil fuels consistently accounted for over two-thirds of energy supply investment. In part, this shift stems from plummeting investment in the oil and gas sector, with a combination of reduced drilling, but also improved cost control, driving down capital expenditures in the face of relatively low oil prices. Nevertheless, the trend also indicates fundamental shifts in the way the world is investing in new electricity supply.

Investment in clean power generation has displayed strong momentum in recent years. Renewables, at around $300 billion, have consistently accounted for nearly 70% of power generation investment. Thanks to sustained technology progress and cost reductions, we are getting much more renewable energy for the same cost. The expected generation from investment in wind and solar photovoltaic (PV) that came online, although broadly similar

in dollar terms to that five years ago, is nearly three-quarters higher than in 2011. In the case of solar PV, investment rose by over 20% in 2016, led by a surge in utility-scale plants in China, the United States, and India. Yet, capacity additions increased to a record 73 GW, or over 50% higher than in 2015, thanks to a big decline in unit capital costs.

Greater affordability of renewable technologies, combined with supportive policies, such as auctions for long-term power purchase agreements that help bring down financing costs, is expanding opportunities in newer markets, such as India, Mexico, and some African countries with supportive enabling conditions. Improved risk environments for private investors help to attract new sources of finance, as evidenced by a steady expansion of project finance for renewables in developing countries. At the same time, some public financial institutions structuring lending packages around NDCs and providing advisory and financing packages, including measures such as purchase guarantees, that aim to further de-risk renewable investments in newer markets.

A number of new business and financing models for renewables have also sprung up, some of which embody more decentralized supply and new sources of capital. In the United States and Europe primarily, but also in China, India, Mexico, and so on, non-energy corporations are contracting with renewable projects to more directly shape the sustainability of their power supply. Indonesia is changing its regulatory environment to allow private utilities to sell power directly to industrial parks and remotely located consumers. In some sub-Saharan African countries, entrepreneurs have pioneered innovative pay-as-you-go financing schemes, enabled by digital payment technologies. This enables households not connected to the grid to have access to electricity services from a combination of solar panels, batteries, and efficient appliances.

While coal power will continue to be a fixture of affordable power supply for years to come, investment in coal-fired power plants fell sharply in 2016, reflecting concerns about local air pollution, competition from renewables, and emergence of overcapacity in some markets, notably China, though investment remained elevated in India. The investment decisions taken in 2016, for plants to be built in the years ahead, totalling a mere 40 GW globally, signal a more dramatic slowdown ahead for coal power investment once the current wave of construction comes to an end.

This slowdown in coal power, and the smaller role played by inefficient sub-critical plants, is good news for achieving climate goals and is an important reason why the carbon intensity of new power coming online in 2016 fell to a record low. Nevertheless, it also raises questions of whether investment decisions for generation are enough to ensure supply adequacy, particularly in fast-growing developing countries. This increases the importance of ensuring system adequacy and flexibility through other dispatchable power, the efficient use of existing thermal generation, robust grids, and storage and demand-side response to enable the long-term integration of solar PV and wind.

Need for enhanced networks and improved regulatory frameworks

Steady rise in spending on electricity networks in recent years is an important enabler to deliver greater amounts of clean power. In 2016, spending on electricity networks reached an all-time high of $277 billion, nearly as much as investment in renewable power. About 45% of spending went to expanding the grid to accommodate new generation assets and expand access to new consumers. China accounted for 30% of total networks spending and another 15% went to India and Southeast Asia, where the grid is expanding briskly to accommodate growing demand. In a number of markets, electricity grid is modernizing and moving from a pure electricity delivery business to an integrated platform for data and services, enabled by rapid progress in digital information and communications

technologies, which accounted for over 10% of networks spending.

Continued modernization of institutional and regulatory frameworks underpinning the electricity distribution sector is also critical to unlocking these services for a wider set of consumers, enhancing reliability for those already connected to the grid and bringing supply to areas where it is lacking. A number of developing countries are set up as a single-buyer model for electricity, with state-owned distribution companies serving as the main investors and purchasers of power. However, in some markets, low regulated power prices have contributed to a mismatch between revenues and costs and monitoring infrastructure and practices are often inadequate to stem high operational losses.

As a result, distribution companies facing such challenges are often reluctant to procure power to be sold at a loss as well as undertake fixed investments to expand and upgrade the grid. The sub-Saharan Africa region accounts for less than 2% of electricity sector investment despite having 15% of the global population and 55% of the world's population without access to electricity. This under-investment stems in large part due to risky business model for private investors for selling power and often constrained financial positions of state-owned utilities.

Policies that enhance cost-reflectiveness of supply, assure the reliable purchase of power, and encourage private investment are important to creating more resilient and affordable electricity systems. Such reforms are being pursued in India, Indonesia, Mexico, and other emerging markets but to varying degrees and depend strongly on the local institutional and regulatory context. They should also be part of an integrated approach where decentralized energy solutions play a prominent role, particularly for consumers located in rural areas where expansion of the grid and centralized supply is difficult in any case.

Slowing progress in some low-carbon supply sources

Not all investment trends point towards continued robust growth for clean energy supply. Despite the importance of the heating and transport sectors, which together account for over 70% of final energy consumption and around half of energy-related CO_2 emissions, investment in renewables for use in heating and transport fell by 25% in 2016. In general, policies and progress for decarbonizing fuel supply in these areas are far behind that needed to meet climate goals. A recent IEA report on future of trucks highlighted that, if no action is taken, oil demand from road freight will represent two-fifths of all the projected increase in global oil use to 2050, adding the same level of CO_2 emissions growth as from coal use in the power and the entire industry sectors combined.

In the power sector, meaningful decarbonization requires growth in clean power to exceed that of electricity demand. While solar PV and wind have played an expanding role, there is a two-speed trend emerging, with nuclear and hydropower, the traditional sources of clean power, on the cusp of a slowdown. A sharp decline in their final investment decisions means that nuclear and hydropower projects sanctioned in 2016, to be built in the years ahead, are expected to generate 55% less electricity than those from five years ago. This slowdown is due to economic and social acceptance challenges to building new nuclear plants outside of China, and fewer opportunities and local environmental obstacles for new hydropower projects, despite robust potential in Africa, Asia, and Latin America.

Even with a steady contribution from other renewable sources, such as bioenergy and geothermal for power, a slowdown in nuclear and hydropower means that it will be difficult for new low-carbon generation to keep pace with demand growth. Global electricity demand growth has indeed slowed over the past five years, but has averaged near 450 terrawatt hours (TWh), or 50% higher than the total amount of new low-carbon generation sanctioned in 2016. To meet this supply–demand gap, a further acceleration of solar PV and wind, stronger policies to support development of other low carbon sources or more fossil fuel generation would be needed. However, addressing the demand side of the equation, through ways to deliver energy services using less electricity, is also essential.

Energy efficiency led investment in 2016

To this end, continued expansion of investment in energy efficiency is a very encouraging trend. The most sustainable and reliable energy is that which we do not need to use, and investments in better performing appliances, buildings, vehicles, and industrial equipment are often the most cost-effective way of achieving this end. In 2016, investment in energy efficiency grew by 9%, the fastest growing energy sector, to over $230 billion.

On a regional level, Europe remains the market with the largest spending in energy efficiency. In 2016, Europe invested more in buildings insulation and heating systems than it did in oil and gas supply. In this way, improving demand performance is helping solve a supply challenge—declining domestic production of gas—and reducing energy needs for heating will reduce Europe's reliance on gas imports and supply risks therein.

However, China was the fastest growing market for efficiency investment, in large part due to increase in sales of efficient cars, including a surge in electric vehicles, following the tightening of vehicle efficiency standards. Other emerging markets are yet to show investment growth on the level of the market leaders, though promising innovations and results have emerged in some markets. In India, a financing model for on-bill repayment, supported by domestic and international public funds, has enabled a significant roll out of more efficient LED lighting solutions. Now, an initiative has been launched to extend this approach to procurement and sales of efficient air conditioners.

While energy performance standards of equipment and appliances in emerging economies are gradually tightening, there is considerable room for improvement. For example, new air conditioners sold in 2016 will add up

to 90 TWh of power demand globally, or the equivalent of nearly one-fifth of 2017 global electricity demand growth, and 10 TWh in India alone, exacerbating peak loads. Going forward, meeting rapidly growing demand for cooling will be a significant challenge for electricity systems in a number of developing countries.

The expansion of energy efficiency hinges on policies that help incentivize investment even during periods of relatively low energy prices, as currently experienced in oil and gas. Government standards that lock in continued performance upgrades for buildings, vehicles, and industrial and consumer equipment have been most effective in driving efficiency investments. Today, more than 30% of world's energy consumption is linked to equipment that is covered by some sort of efficiency standard.

Going forward, progress will hinge not just on policies, but expanding the sources of finance for what are inherently smaller-scale investments often made on constrained balance sheets of consumers. New mechanisms for raising equity and debt are enabling investors to tap into larger financing pools from institutional investors, especially for refinancing assets and funding investments in smaller-scale projects, such as energy efficiency and distributed generation. For example, the issuance of green bonds to fund energy investments grew from $1 billion in 2011 to over $50 billion in 2016, with energy efficiency projects now benefitting from 35% of these proceeds.

Need for R&D funding

Finally, progress in all areas of energy investment, particularly in achieving clean energy transition, hinges on long-term oriented technology development. Despite the importance of fostering energy innovation as a way of achieving both energy and sustainable development goals, the IEA's first-ever measurement of spending on energy R&D has revealed that the energy sector is not doing enough to ensure continuous development of clean energy innovations of the future. We have tracked around $37 billion in annual clean energy R&D spending, but this level has remained stable since 2012 and pales in comparison to other sectors, such as in the information technology industry. Indeed, there is considerable scope for the public and private sectors alike to increase their focus and investment in energy innovation.

India's Energy Investment Trends

For India, the stakes could not be higher to bolster economic growth and enhance the living conditions for this nation of 1.3 billion people, which uses just 6% of the world's energy supply and suffers from poor air quality and unreliable power. This makes the energy sector transition a powerful driver for the government's reform plans to increase the robustness and sustainability of power supplies while expanding affordable energy access. These goals are behind the '24x7 Power for All' initiative to provide access to 245 million people without power by 2019. In 2016, India accounted for 8% of power investment, but is seen driving over 15% of global demand growth in the next decade.

So far, India is making good progress. In 2016, it was the fastest growing major market for energy investment. Power sector investment rose by 5% to nearly $55 billion, with both networks, which accounted for nearly 40%, and renewables (one-fifth) at record levels. Renewable auctions, often paired with financial de-risking measures, are helping reduce risks for investors and enhance cost effectiveness. Recent tenders have awarded over 1.5 GW of solar PV at prices $40-55/MWh, the cheapest in India and among the best worldwide. Solar PV prices in auctions have decreased by half over the last three years in India and in some cases, contracted prices have fallen below pricing for some coal power plants.

While renewables offer a way for India to meet strongly growing demand and improve energy security by diversifying supply while reducing environmental impacts, India faces persistent challenges integrating and financing new capacity. Low regulated power prices and high network losses continue to undermine the financial position of state distribution companies, often leading to unreliable purchase and delayed payments to all generators, and reluctance to undertake fixed investments to expand and upgrade the grid. These factors have also undermined utilization rates for coal power, whose investment case has grown uncertain. Investment in flexible gas generation is constrained by the relatively high LNG prices and a lack of infrastructure, while hydropower continues to face barriers.

To augment the reliability and flexibility of its power system and enhance access to affordable and sustainable electricity, India will require increased investment in all forms of flexibility. The government's Ujwal Discom Assurance Yojna (UDAY) scheme is trying to revive state distribution companies through debt restructuring and improving efficiency. However, further progress is needed to reform electricity tariffs to reflect the underlying cost of the system, to finance the build-out of the grid and stronger price signals for more efficient thermal generation. There is now an opportunity to upgrade the thermal power plant stock and retire some of the least efficient plants without compromising reliability. Integration would be enhanced by adding electricity storage and demand response from consumers themselves, supported by smart metering technology. Distributed solutions, such as rooftop solar PV and microgrids, can help quickly scale supplies in under-served areas. The degree to which market-based or regulated price signals drive these investments remains a crucial question. EF

Michael Waldron, Energy Investment Analyst, International Energy Agency

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SDG 7: AFFORDABLE AND CLEAN ENERGY

Status and role in transforming India

India committed on world stage to work on the Sustainable Development Goals (SDGs) during CoP 21 in Paris in December 2015. Continuing on the same vein, India voluntarily reported on six SDGs during CoP 22 in Marrakech in November 2016, including SDG 7: Ensure access to affordable, reliable, sustainable and modern energy for all. **Rudresh K Sugam**, **Sanchit Waray**, and **Saurabh Tripathi** analyse the progress towards achievement of SDG 7 in India in this article.

Energy has always been at the centre of growth, and the world has seen significant transformation in types of energy utilized across generations. Access to essential resources, such as water, food, and housing, is dependent on availability of energy. Transition from reliance on human- and animal-based power sources to modern forms of energy sources has been the main reason for rapid change in growth pattern. The negative consequences of dependence on coal-, oil-, and gas-based thermal power plants; large hydro-power plants for electricity generation; and fossil fuels for transportation is being felt across the globe; and thus a comprehensive plan is required for bringing a change in energy production and utilization pattern. Sustainable Development Goal (SDG) 7 is a step towards this cause (Figure 1). It targets to cut down over-reliance on fossil fuels, bring the renewable energy (solar, wind, geo-thermal, tidal, small-hydro, etc.) in to mainstream, work on developing technologies that could make this shift feasible, and also the output, that is, clean energy affordable to all. SDG 7 realizes that there is significant disparity in terms of energy availability and access across the globe; thus, it emphasizes specifically on bettering the situation in developing and least developed countries. As per the IEA report of 2017, 1.2 billion (16% of world population) people have no access to electricity and 2.7 billion (36% of world population) still cook their food using dangerous, polluting stoves. Figure 2 clearly shows the disparity in access to electricity across the globe. Africa specifically is lagging behind others and therefore needs special support.

The following sections highlight the status of SDG 7 indicators in India to get a sense of where we are and how far we are from achieving the set targets.

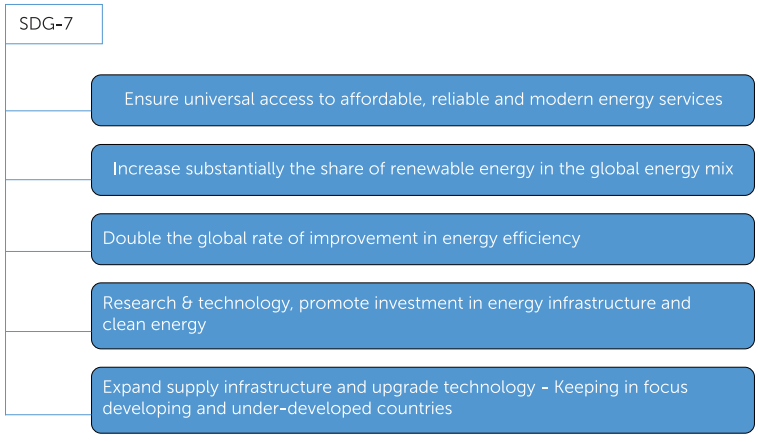

Figure 1 The targets of Sustainable Development Goal 7
Source: UN (2015)

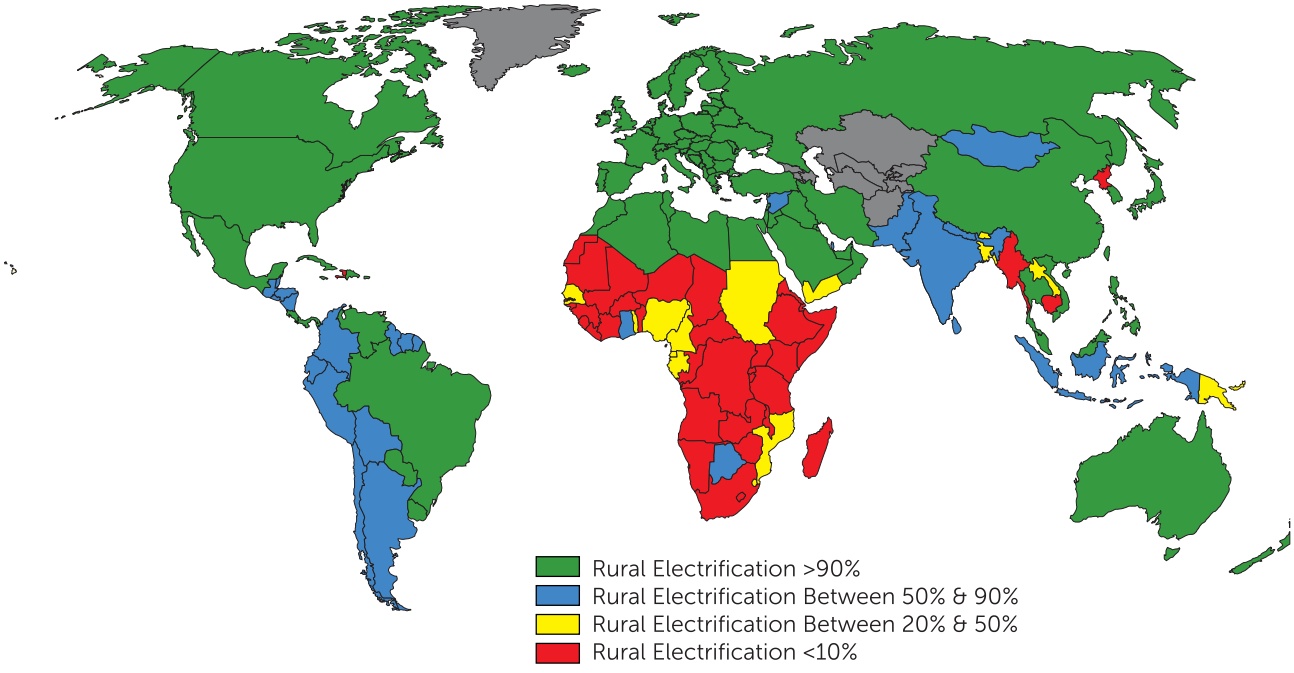

Figure 2 Energy access across the world
Source: Santiago Miret (2015)

Assessing India's Performance towards Achieving Goals of SDG 7

Proportion of population with access to electricity

As electrification is measured by the government at the household level, as per the Government of India data, 76.93% of rural households have been electrified as of August 27, 2017, which are roughly 137.44 million households of total 178.66 million rural households. While rural households in India are getting electrified at a faster pace, the quality of electricity service remains poor. Power cuts are frequent and therefore there is still huge dependence on diesel generators. Even the tier II cities suffer from frequent power cuts, which are negatively impacting the overall productivity of these cities.

Proportion of population with primary reliance on clean fuels and technology

Penetration of liquefied petroleum gas (LPG) in rural households in India is still limited. Major fuels used by more than two-thirds of rural households in India are firewood and chips. The Pradhan Mantri Ujjwala Yojana launched by the government in May 2016 definitely helped in enhancing the LPG penetration in rural households. As reported, the LPG consumption in the country has reached 19 million tonnes registering an annual growth rate of 10%.[1] However, the government has to assure that the practice continues and it would depend on behavioural change as well as uninterrupted and ease of access to supply of LPG cylinders.

Renewable energy share in the total final energy consumption

The share of renewable energy in total energy consumption is really low in India (Figures 3 and 4). However, the rate of growth in installed capacity for other renewable sources (solar, wind, biomass, etc.) was 19.25%, which is highest amongst all the sources.

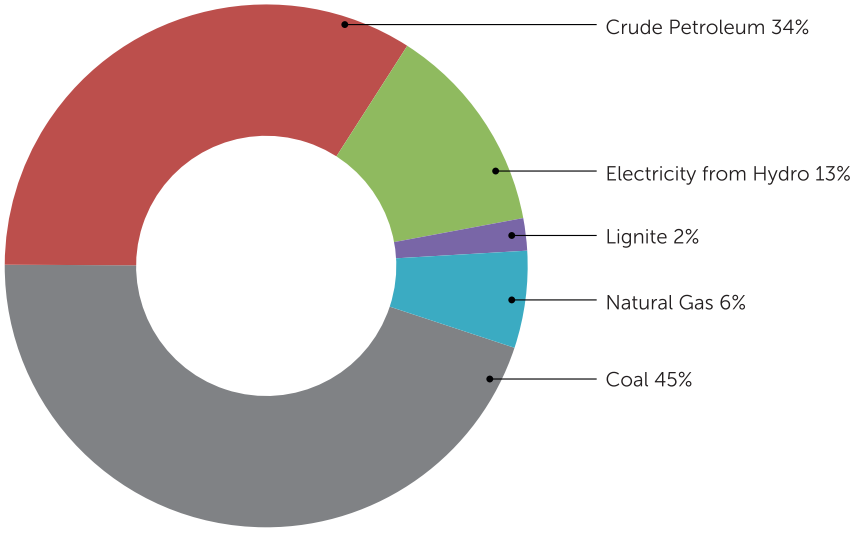

Figure 3 Source-wise consumption of energy during 2015/16
Source: CEA (2017)

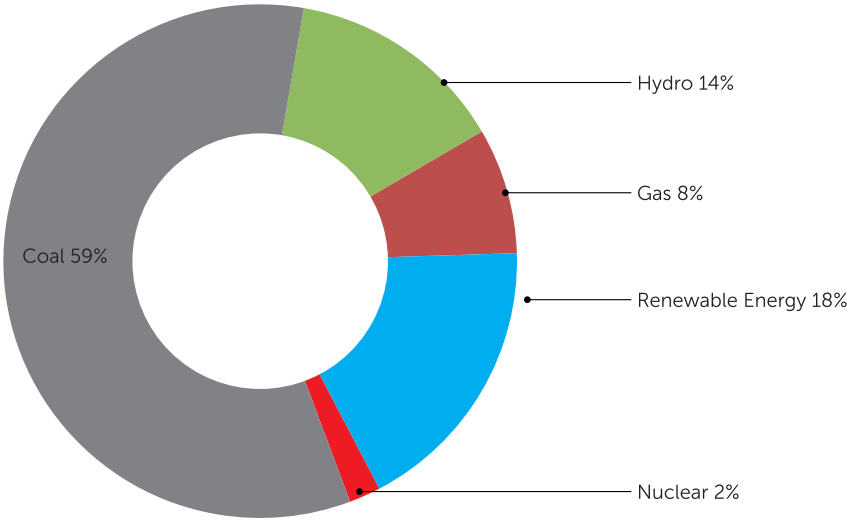

Figure 4 Source-wise installed electricity generation capacity (Total 330 GW)
Source: MoP, GoI, June 30, 2017

Energy intensity measured in terms of primary energy and GDP

India is urbanizing at a fast pace and therefore the per capita energy consumption has also increased in the last decade (Figure 5)

Energy intensity, which is defined as the amount of energy consumed for generating one unit of gross domestic product (GDP), has decreased from 0.46 MJ/rupee to 0.27 MJ/rupee between 2006/07 and 2015/16 (Figure 6). However, this trend could be a result of different base years for GDP estimation. The GDP estimates from 2005/06 to 2010/11 are at base 2004/05 price, whereas from 2011/12 to 2015/16 GDP estimates are at 2011/12 price.

1 http://timesofindia.indiatimes.com/business/india-business/india-becomes-second-largest-domestic-lpg-consumer/articleshow/57008531.cms

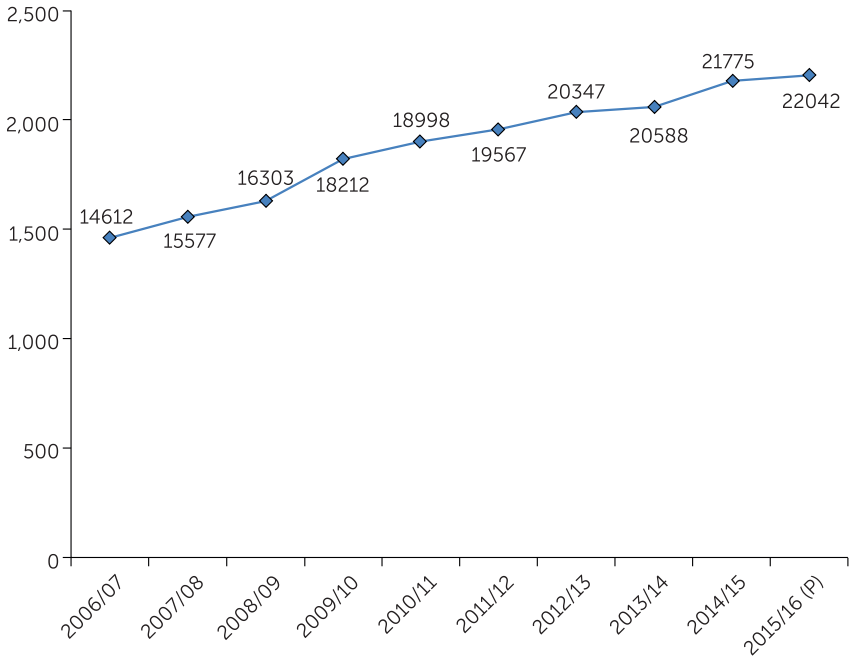

Figure 5 Per capita energy consumption (in mega Joules)
Source: CEA (2017)

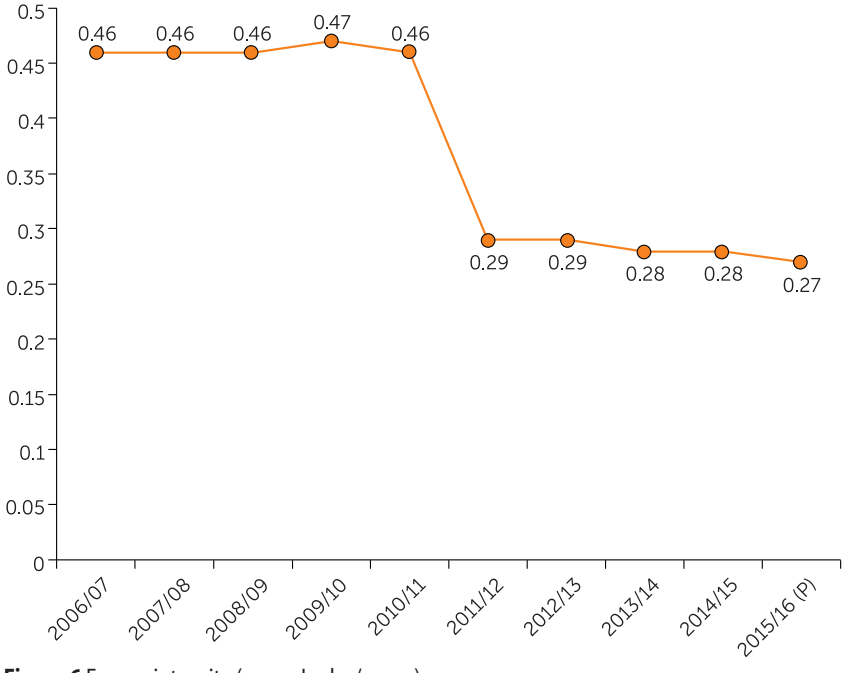

Figure 6 Energy intensity (mega Joules/rupee)
Source: CEA (2017)

Investment in the Renewable Energy

Renewable energy sector, especially solar, has gathered a lot of attention in India and globally. As per IEA calculations, renewable energy and networks made up 80% of all electricity investment ($718 billion), whereas new clean power projects attracted $297 billion in 2016.[2] As per the *New Energy Outlook 2017*, it is anticipated that improvement in storage could lead to renewable energy reaching 74% penetration in Germany by 2040, 38% in the US, 55% in China, and 49% in India.[3]

The waste-to-energy related initiatives have not taken off as compared to initiatives in the solar or wind energy sector; thus, it requires a push from both policy and investment fronts. As per the Ministry of New and Renewable Energy (MNRE), India generates 62 million tonnes of municipal solid waste annually, out of which 82% is being collected and the remaining 18% is littered. Further, processing of the collected waste stands at 28% only. The total potential of solid waste and sewage combined is around 1,700 MW and the country is operating a cumulative capacity of only 66.4 MW. If we are able to tap renewable energy from various sources, several challenges could be addressed simultaneously. For example, solid waste and sewage, which have become menace for every city given the scale of pollution and nuisance they cause, could be converted into resources by transforming them to sources of energy. The role of renewable energy in transforming Indian economy and livelihood is immense, as discussed in the following section.

How Affordable and Clean Energy Can Transform Rural India

Agriculture and allied sectors

Agriculture contributes to 14% of India's GDP, and it continues to be the main source of livelihood for more than 50% of the population. Traditionally, agriculture has been labour intensive, but the combined share of human and animal labour has dropped to 10% in 2013, as compared to 60% in the 1970s. Numerous studies have shown the importance of mechanization for

2 https://www.bloomberg.com/news/articles/2017-07-11/electricity-overtook-fossil-fuels-in-push-for-investment-in-2016

3 https://about.bnef.com/new-energy-outlook/

improving yields. According to FAO estimates, the average farm power availability (cumulative machinery power ratings) in India would increase to 4.5 kW/ha in 2050 from approximately 2 kW/ha (which is on the lower side as compared to advanced countries) in 2015. IEA estimates suggest that there could be a doubling of energy consumption in agriculture in India by the year 2040.[4] The challenge, therefore, is to develop agricultural systems that can feed future generations and drastically lower fossil fuel consumption concomitantly.

Most of the farming operations, ranging from land tilling to harvesting, are performed using diesel-driven machines; the penetration of diesel pumps is also high. Currently, there are nearly 9 million diesel pumps that are operational in the agriculture sector, which is either due to complete lack of access to electricity or unreliable electricity services. There is a case for adoption of clean energy for powering agriculture, and one such example is replacing diesel pumps with solar pumps for irrigation purposes. Even if we replace nearly half of the diesel pumps (5 million diesel pumps) with solar pumps, it would result in savings of nearly 18 GW of installed capacity, 23 TWh of electricity, 10 billion litres of diesel, and 26 million tonnes of carbon dioxide emissions. Specially, in states such as West Bengal, Bihar, etc., where irrigation water availability is limited because of access to power, a shift towards renewable energy could be a potential solution for improving livelihood of farming communities. Other farming operations, including land preparation, seed sowing, transplanting, fertilizer application, insecticide spraying, harvesting, threshing, among others, have seen increased levels of mechanization—half of the operational land holdings in India have either a tractor or power tiller performing multiple operations. The innovation in the renewable energy sector for supporting agriculture sector needs to focus on reducing the cost of operation or improving agricultural yields, thereby contributing to the farmer's net income.

Although agriculture is a major contributor to livelihood, it is the non-farm sector that assumes a higher share of household income in rural India. The share of non-farm sector in household incomes has increased from 30% in the 1990s to more than 40% in 2010. Activities, such as post-harvest processing of farm produce, custom tailoring, manufacture of textile garments and accessories, repair of vehicles, among others, are high value, but have seen low levels of mechanization. Introduction of machines would result in a productivity boost and lowering of operational costs, provided these rural businesses can effectively leverage existing market linkages in their region. For instance, post-harvest processing includes rice milling, flour milling, dal milling, oil extraction from oilseeds, among others. Today, these activities are being carried out in local agri-processing centres situated in villages, where electricity access remains a major bottleneck. Clean energy solutions, such as local mini-grids (that presently supply electricity to rural off-grid households), can use these processing centres as anchor loads.

4 https://www.iea.org/publications/freepublications/publication/IndiaEnergyOutlook_WEO2015.pdf

Another source of renewable energy in rural areas is conversion of biomass to energy. In most of the states, crop residues are burnt due to non-availability of labour, high cost of residue removal from the field, and increasing use of combines in harvesting the crops. Burning of post-harvest crops is causing extreme negative health impacts in states, such as Punjab and Haryana. It leads to air, water, and land pollution. However, there is immense scope to convert crop residues to energy by setting up decentralized biomass-based energy generation plants.

Entrepreneurs, financiers, policymakers, and other ecosystem supporters need to find synergies to overcome all of these challenges and work toward transforming livelihood in rural India.

Multi-utility battery-driven mobile platform for farming

Certain farming activities, such as transplanting, seed sowing, fertilizer application, pesticide application, etc., can be performed by a single battery-operated vehicle. The battery can be charged at local DRE mini-grids. Significant research and development (R&D) investment is needed to bring the proof-of-concept to fruition, by conducting lab as well as field trials in different locations. Government-sponsored agricultural universities can play a pioneering role in development of this innovation. However, substantial amount of cooperation would be needed from the farmers—this mobile platform could be championed by a few progressive farmers in each state.

Processing hubs powered by solar (or hybrid) minigrids

There are around 100–150 agri-processing centres in India, whereas according to YES Bank, there are around 1,200 custom hiring centres. These 'processing hubs' at the village or block level could be powered via DRE minigrids.

By leveraging existing processing centres, a lot of upfront investment can be avoided initially. This business model innovation can be driven by the government initially, but the role of local entrepreneurs is key for achieving scale. Organizations such as Indian Council on Agricultural Research (ICAR) conduct training programmes on several agricultural extension themes, and this particular model can be propagated via this route.

Domestic sector

A critical but often overlooked aspect of access to clean and affordable energy is access to clean cooking energy. According to the *2016 World Energy Outlook*, 819 million people (63% of the population) in India rely—partially or fully—on traditional biomass cookstoves. Of the 3.5 million premature deaths attributable to household air pollution annually, 1 million occur in India.

In 2011, while 53% households in India had LPG connections, only 28% used LPG as their primary cooking fuel. The monthly recurring cost and distance to the nearest LPG distributor might be reasons for households with LPG relapsing to traditional cookstoves. Further, behavioural inertia of having used traditional alternative for decades also makes such households unable to make an immediate and sustained transition towards LPG.

Focus must be placed on weaning the poorest households off free-of-cost biomass through targeted awareness campaigns that address the ill-health and low-efficiency aspects of traditional cookstoves and financial interventions that provide EMI-based connections and staggered and/or pooled community-level weekly payment mechanisms. Such demand-side management must be planned concurrently with supply-side policy adjustments—primarily scaling up the rural distributorship network of LPG and other clean cooking energy fuels and technologies, while also improving the operations and maintenance capabilities of clean cooking energy manufacturers and distributors. Further, there is a need to promote improved cooking stoves (ICS) and biogas in rural areas where there is low viability for LPG distributors so that households can transition to an intermediate form of clean cooking energy until they transition fully to LPG, PNG, or electricity-based solutions. Following recommendations could be the way forward to transform the cooking sector in rural areas:

Investments

- In R&D to drive down the prices of improved biomass cookstoves and biogas plants to reduce the gap between the general willingness to pay and market prices of such products.
- The government needs to allocate an appropriate proportion of clean cooking energy scheme-funds for awareness. The current outlay for awareness as part of such schemes is too low.
- In building a robust network of clean cooking fuel distributorships to improve the sustained use of the fuel.

Capacity building/institutional

- Improved training module and better salaries for turnkey workers to better install and maintain biogas plants in remote areas.
- Augment technical and personnel capacity of state nodal agencies (SNAs) to increase the targets they send to MNRE at the start of each year for biogas and ICS implementation.
- Enforce standardized monitoring and evaluation protocol (for SNAs) to ensure continued use of clean cooking options.
- Improved financial ecosystem is required for both enterprise-financing and end-user finance to improve scalability and affordability of technology.

Behavioural change

- Awareness drives are required to popularize the health- and convenience-related benefits of clean fuels.
- Community-level demonstrations should be done through self-help

groups or other local organizations to practically illustrate the use of new technologies.

Role of Energy in Transforming Livelihood in Urban India

Industry

Industries in India consume maximum energy (47%) out of all the sectors. Also, Indian industries have one of the highest energy intensity as compared to same industries in the world. According to IEA in 2011, if Best Available Technologies (BATs) are deployed in the five most energy-intensive industrial sectors (iron and steel, pulp and paper, chemicals and petrochemicals, cement, and aluminium), India could reduce the final energy use by 10%–25%. It would lead to a total estimated savings of 17 MTOE per year, which is equivalent to 11% of the industrial energy consumption in 2007 and 4% of India's total energy consumption.

Recommendations

» Stringent benchmarks for energy intensity.
» Push for use of renewable energy in the industry premises.
» Using life-cycle assessment approach for supporting locally available products.
» Incentives on using energy-efficient technologies or BATs.

Buildings and transportation

Access to electricity in the urban areas is definitely not that big challenge as compared to the rural regions, except for the urban poor. However, the energy use per capita in buildings and transportation sector is significantly high. This demand is for demand-side management, that is, enhancing the energy use efficiency in these sectors.

In the transport sector, switching to cleaner fuels and technologies (electricity, bio-diesel, bio-ethanol, etc.), enhanced used of public transport, use of efficient and less polluting vehicles, and transport-oriented development could lead to significant reduction in energy use and emissions.

Similarly, energy requirement for buildings could be cut down by *switching to alternative energy sources, such as renewables (deploying solar roof tops), use of materials that could reduce the heating/cooling requirements, use of energy-efficient appliances, etc.* As reported by TERI, a conference facility including accommodation with a built-up area of 3,000 sq. m reduced its energy requirements from 280 kWs to 96 kWs by employing the principles of energy-efficient building design. As per estimates, the upfront investment is higher for constructing energy-efficient buildings (cost increases from ₹19,000/m^2 to ₹29,500/m^2) but it will consume much lesser energy, and therefore in the longer run, the cost incurred could be easily recovered. Innovative approaches such as use of subterranean air tunnels could significantly reduce cooling energy requirements. Energy-efficient pumps could also cut down energy use as water pumping has high energy demands both at individual household and utility levels.

Urban poor

Often the forgotten one, as most of the policies either address the rural or the urban population. Sadly, the urban slums are generally not counted under any of these. More emphasis is required to connect urban slums to formal electricity grid and a separate research work is required to understand the availability and usage pattern of cooking fuels in these localities.

Recommendations

» Fine-tuning the land laws (learning from best practices) to provide basic energy needs to slums.
» Reducing the upfront connection costs.
» Empowering local non-governmental organizations/civil society organizations to support local community in getting loans/identity cards.
» Awareness programmes to spread the benefits of clean cooking fuels.
» Research to explore opportunities of setting-up decentralized plants. EF

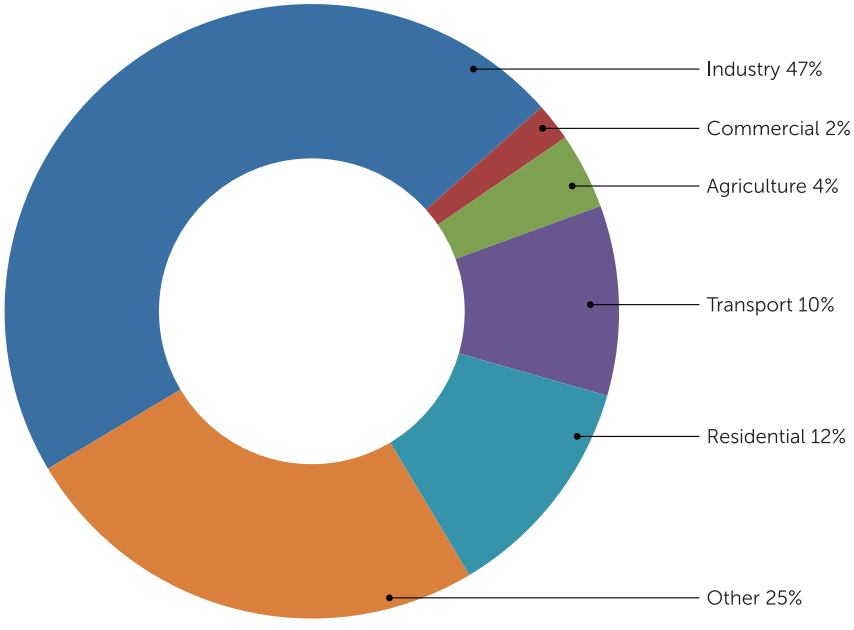

Figure 7 Energy Consumption by different sectors (2015)
Source: NITI Aayog

Rudresh K Sugam, Senior Programme Lead, Council on Energy, Environment and Water, Sanchit Waray, Programme Associate, Council on Energy, Environment and Water, & Saurabh Tripathi, Research Analyst, Council on Energy, Environment and Water

Energy and Environmental Challenges

A Move towards Probable Solutions

There are important energy problems facing the developing countries of the world. In this article, **D P Kothari** presents the current electric generation scenario with facts and figures with respect to India. It is hoped that with systematic, advance planning, and through measures, such as co-generation, energy management, and energy conservation, the electric energy supply scenario of the future will be free of the perennial problems of power shortages, voltage fluctuations, etc.

Conventionally, electric energy is obtained by conversion from fossil fuels (coal, oil, natural gas) and nuclear and hydro sources. Heat energy released by burning fossil fuels or by fission of nuclear material is converted to electricity by first converting heat energy to the mechanical form through a thermal cycle and then converting mechanical energy through generators to the electrical form. The thermal cycle, however, is a low-efficiency process.

The earth has a finite amount of non-renewable resources of fossil fuels and nuclear materials, while certain countries are over-endowed in terms of fossil fuel, others deficient. Hydro energy, through renewable, has its own limitations with regards to power generation. The world's increasing power requirements can only be partially met by hydro sources.