January–March 2016

ENERGY FUTURE

The Complete Energy Magazine

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International Efforts to Keep Global Warming Below 2°C

at COP21 World Climate Change Meet

DSSC: A New Era of Future Solar Cells

A Boon for Solar Energy Technique

The Momentous Paris Agreement and the INDCs

Bridging the Gap between Climate Action Plans of Developed and Developing Nations

VIEWPOINT

Vishal Pandya
Co-founder and Director
REConnect Energy Solutions Pvt. Ltd

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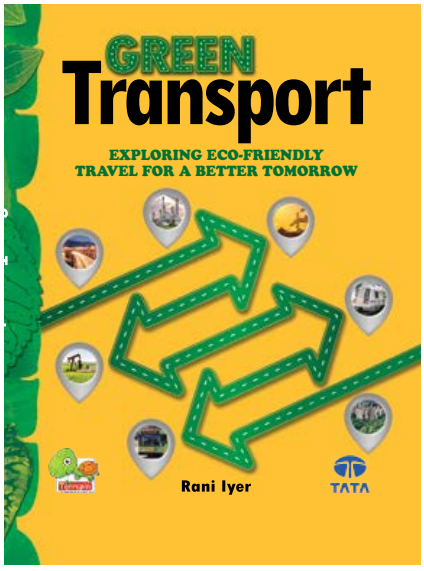

GREEN Transport

EXPLORING ECO-FRIENDLY TRAVEL FOR A BETTER TOMORROW

Rani Iyer

• 2016 • 180 x 240 mm • 120 pages
• Hardback • General Reference
• ISBN: 9788179934449 • Price: ₹295.00

Ages: 12+ years

Nothing can go faster than the speed of light. But it seems the superfast, snazzy, chic, and hi-tech vehicles will soon outshine this adage. Fast, faster, fastest technological advancements in transportation have made mobility of people and goods easy, connecting the entire world and expanding world trade. It has steered globalization giving a boost to the wealth of nations.

On the flipside, aircraft, ships, trucks, and trains powered by the combustion of fossil fuels, moving across the sky, oceans, and land have accelerated climate change, besides giving way to the problem of global energy crisis due to the huge demand and short supply of fossil fuels.

So the world now aims at combining energy-efficient technologies with clean fuels to enjoy the benefits of vehicles while being sensitive to the environment. Hybrids, electric cars, and biofuels are some of the examples in this regard. However, there is still a long way to go.

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From the editor's desk...

As per the recently released synthesis report on the aggregate effect of the 160 'Intended Nationally Determined Contributions (INDCs)' by 187 countries, a major shift to renewable energy and improvements in energy efficiency are the foundations of their climate change action plans. India's INDCs also reiterate its focus on renewable energy and energy conservation by aiming to have: (a) 40 per cent cumulative electric power installed capacity from non-fossil fuel based energy resources by 2030; and (b) Reduce the emissions intensity of its GDP by 33–35 per cent by 2030 from 2005 level.

World Energy Outlook Special Briefing for COP21, after analysing 125 INDC submissions (covering more than 150 countries), shows that, 'Around half of all INDC submissions include explicit energy-focused targets, either alongside a greenhouse gas (GHG) target or as a stand-alone goal. The most common energy-related measures are those that target increased renewables deployment (40 per cent of submissions), or improved efficiency in energy use (one-third of submissions).' It further estimates that with 70 per cent of additional electricity generation up to 2030 being projected to come from low-carbon sources, low-carbon resources would be contributing to the tune of about 45 per cent of total electricity generation by 2030, up from the present level of 33 per cent. This naturally needs heavy investments in the energy sector, estimated to be about $13.5 trillion from 2015 to 2030.

The successful transition to this intended outcome would also be dependent on technological innovations and ease of transfer of such innovative—and disruptive—solutions to the developing countries who have limited resources to address two equally important challenges, namely, country's socio-economic development and climate change. On the technology innovation front, an encouraging development has been the launch of 'Breakthrough Energy Coalition' which is a global group of high net worth corporate individuals committed to bring about innovations around clean energy, building on publicly funded basic research work. COP21 at Paris was also noteworthy for the 'International Solar Alliance' of 121 countries mooted first by India and launched jointly by India and France. This alliance is all about collaboration targeted towards making solar energy affordable so that its accelerated deployment becomes feasible in the developing nations. With such ambitious intentions and collaborative spirit to innovate, our energy future certainly looks sunny and much less carbon-intensive.

Amit Kumar

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Dean (Distance and Short-term Education),
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Letter to the Editor

The Cover Story published in the October 2015 issue of *Energy Future*, 'India's Transportation Fuel Requirements' is most appropriately written, keeping in mind the dwindling natural resources and the developing economy of India. If our national policies are suitable and we could start utilizing the alternative fuels like methanol, dimethyl ether, biodiesel, bioethanol, biogas, bio-oil, etc., then it would really help to decrease the burden on the fossil fuels in India and also globally. The Feature article on using genetic engineering of non-food crops for biodiesel production is also very informative.

Sonam Aggarwal
Jaipur, Rajasthan

"I really liked reading the case study article published in the latest issue of Energy Future. Recycling and reuse of human excreta for biogas generation is a pioneering work done by the Sulabh International Organization. This is a very good source of renewable and alternative energy. The article on green transport initiative by the Mumbai Police also makes for an interesting read. The cover page and all the designing aspects are also very impressive. Thank you for publishing such a useful magazine on energy issues.

Manisha Saikia
Guwahati, Assam

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

Email: teripress@teri.res.in

Editor
Energy Future

I read the last few issues of *Energy Future*. I must compliment you and your entire team for the outstanding quality of its articles, well researched, and yet reader friendly. The pictures and overall get up of the magazine is like a world class journal. Articles were very useful in my opinion. I got the latest statistics from the last issues about the power capacity and new technologies plus interesting insights like the solar rooftop on metros.

Deepak Bhatnagar
IIFT, New Delhi

The October–December 2015 issue of *Energy Future* has come out really nicely. I thank the entire editorial team for their efforts. I particularly enjoyed reading the article on small hydropower for sustainable development. There is a lot of potential for tapping this source of renewable energy in hilly states of India, such as Himachal Pradesh, Uttarakhand, and Arunachal Pradesh. Nice to know that apart from being environment-friendly, small hydropower has short gestation period having no fuel cost.

Amrit Sharma
Shimla, Himachal Pradesh

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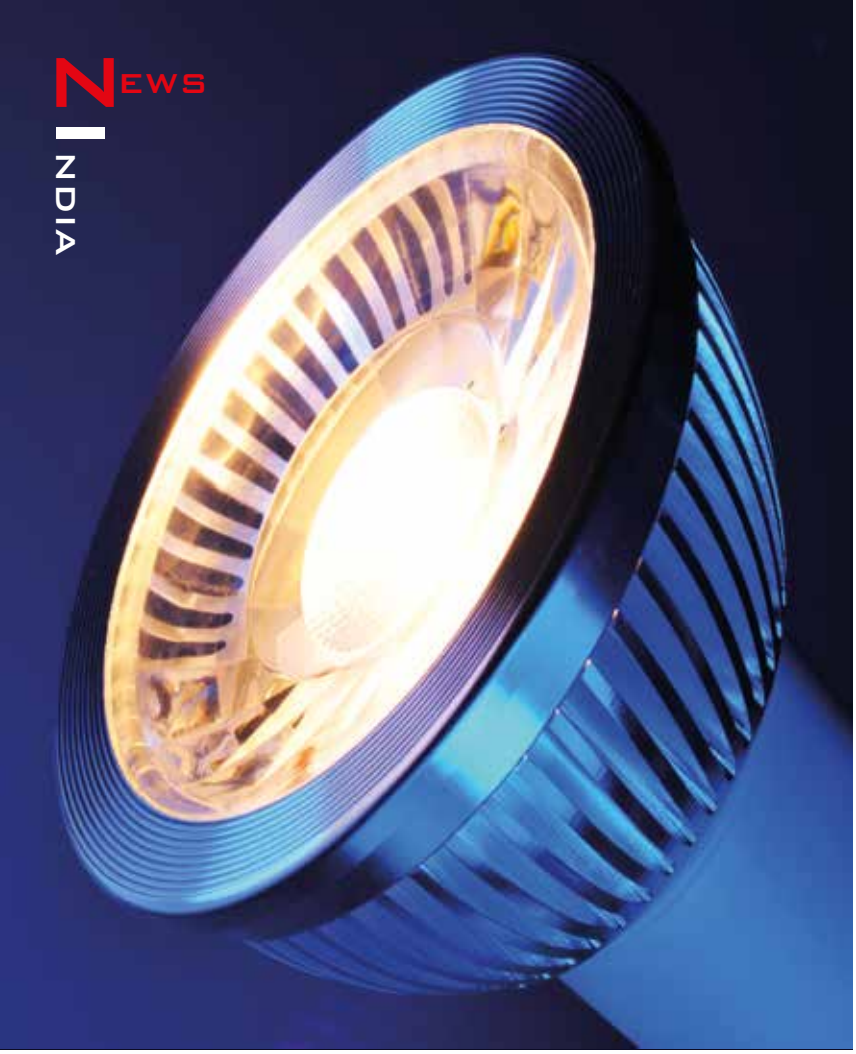


LED PLAN CUTS PEAK LOAD BY 145 MW, SAVES ₹61 LAKH DAILY

The Narendra Modi government's programme to get consumers to replace less efficient compact fluorescent lamps (CFLs) or incandescent lights with light-emitting diode (LED) bulbs at a discount has reduced Delhi's peak load by 145 MW, creating savings of over ₹61 lakh daily in power bill.

The Prime Minister had announced the campaign, called Domestic Efficient Lighting Programme (DELP), on January 5, 2015. Since its launch, 43 lakh bulbs have been distributed among nearly 11 lakh households in the capital, resulting in an estimated daily energy saving of 1.5 million units. The scheme is also yielding environmental dividends. Energy Efficiency Services Limited (EESL), the nodal agency implementing the scheme in the participating states, reckons a reduction in daily greenhouse emissions equivalent to 1,259 tonnes of CO_2 in Delhi. Under the DELP scheme, consumers in Delhi can avail of up to 10 LED bulbs per domestic household on upfront payment. These technically superior LEDs are available at a discounted price of ₹93 each, against a market price of around ₹350. Each LED bulb helps a consumer save anywhere between ₹160 and ₹400 per year and has a life expectancy of 25,000 hours. EF

Source: www.economictimes.indiatimes.com

SOLAR SECTOR SEEN ADDING 3.6 GW IN 2016

The country is expected to sustain the momentum in solar capacity addition and 2016 is forecast to see a significant increase in new capacity when compared to 2015 on the back of favourable policy support and continuing action at the ground level.

Annual solar installations are forecast at 3.64 GW for 2016 when compared with the expected addition of 2.15 GW in 2015, according to Mercom Capital, a global clean energy communications and consulting firm. For the calendar year 2015, solar segment added about 1,652 MW of new capacity (till November 2015), taking the cumulative solar installations in the country to 4,816 MW. The National Thermal Power Corporation Limited (NTPC) and Solar Energy Corporation of India (SECI) are expected to put about 5,500 MW worth of projects up for auction over the next several months. Meanwhile, 21 states have so far agreed to set up a total of 27 solar parks with a combined capacity of 18,418 MW, as part of the Union government scheme, according to the Mercom report. EF

Source: www.thehindu.com

WELSPUN RENEWABLES COMMISSIONS 126 MW PRATAPGARH WIND PROJECT

Welspun Renewables, one of India's leading clean energy companies, announced commissioning of its 126 MW wind project located in Pratapgarh district of Rajasthan. The project is the largest wind project in the company's portfolio. The project will generate 290 million units of clean energy and help mitigate 211,922 tonnes of carbon emissions annually. Eight hundred forty crore rupees were secured to build this mega wind capacity. Mr Vineet Mittal, Vice Chairman, Welspun Renewables said, "Our project site in Pratapgarh is one of the most suitable sites in the country for wind energy. Like most of our solar and wind projects, this will also be among the highest generating power plants in India. We are committed to powering a clean and a green India and this project takes us one step closer to our vision".

The company has successfully commissioned approximately 700 MW (DC) capacity of clean energy projects across the country till date. In line with the government's renewable energy initiatives, Welspun Renewables is well on target to commission 1 GW of solar and wind power projects by the end of this financial year, 2015–16. EF

Source: www.welspunrenewables.com

DELHI METRO BAGS ISO RATING FOR EFFICIENT ENERGY MANAGEMENT

The Delhi Metro has become the first metro service in the country to be certified with the prestigious "International Organisation for Standardisation (ISO) rating for efficient energy management." Fifteen stations of the Delhi Metro and one of its depots have been selected for this rating, enabling Delhi Metro Rail Corporation (DMRC) to save 13,730 MVAH (Mega Volt Ampere Hour) and 5,628 MVAH in year 2013 and 2014 which translates into monitory savings of ₹961 lakh and ₹394 lakh, respectively," a DMRC statement said. The stations and depots which have been certified are—Yamuna Bank, Anand Vihar, Sarita Vihar, Ashok Park Main, GTB Nagar, Vishwavidyalaya, Kashmere Gate, Rajiv Chowk, Mandi House, Janpath, Jawaharlal Nehru Stadium, Shahdara, Azadpur, HUDA City Centre, and the Khyber Pass depot.

The ISO 50001:2011 Energy Management System (EnMS) is a very recent ISO standard on Energy Management. It specifies requirements for establishing, implementing, maintaining and improving an Energy Management system, whose purpose is to enable an organization to follow a systematic approach on achieving continual improvement of energy performance, including energy efficiency, energy use, and consumption. EF

Source: www.business-standard.com

ReNEW POWER RAISES $265 MILLION VIA EQUITY

ReNew Power, a leading solar and wind energy firm, has raised $265 million (₹1,700 crore) of equity from the Abu Dhabi Investment Authority, Goldman Sachs, and Global Environment Fund, taking its total fund raising to $655 million, which is among the highest in the country after e-commerce firms. In the latest round of funding, the Abu Dhabi Investment Authority has committed $200 million for a significant minority stake in Sumant-Sinha-led ReNew Power, while existing investor Goldman Sachs has chipped in $50 million to raise its investment in the company to $370 million. Another existing investor, Global Environment Fund, will be investing $15 million to increase its exposure to $35 million. Sumant Sinha, Chairman and Chief Executive of ReNew Power, said that it was an exciting period for renewable energy. "We are at an inflection point where transformational use of natural resources will define our energy future. This fundraise comes at an exciting time for us as we enter a new phase of growth," he said.

ReNew Power owns about 1,600 MW of wind and solar power projects, of which 700 MW plants are commissioned. The company has plants in Gujarat, Haryana, Madhya Pradesh, Rajasthan, Maharashtra, Karnataka, Telangana, and Andhra Pradesh. EF

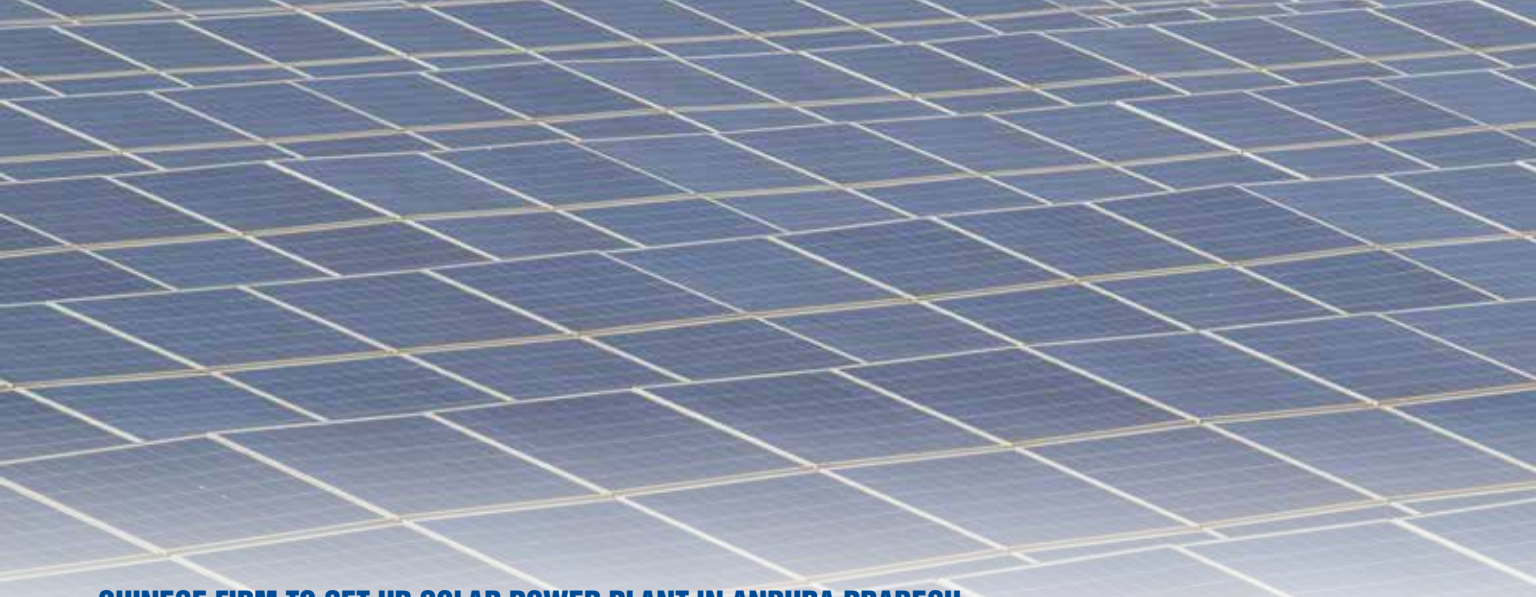
Source: www.economictimes.indiatimes.com

VIKRAM SOLAR EQUIPS TWO MORE INDIAN AIRPORTS WITH SOLAR PV ARRAYS

Vikram Solar, India's leading Tier 1 module manufacturer has successfully commissioned two more rooftop solar plants at international airports in India. Following the completion of the first rooftop installation at Cochin International Airport in Kerala, now completely powered by solar energy since March 2015, further projects were carried out at Calicut International Airport, also located in Kerala, and at Netaji Subhash Chandra Bose International Airport in Kolkata, West Bengal. The capacity at Netaji Subhash Chandra Bose International Airport is 2 MWp, while the capacity of the plant at Calicut International Airport in Kerala is 750 kWp. Vikram Solar was responsible for the design, engineering, procurement, supply, construction, installation, and commissioning for all the three airport projects. For the new projects, Vikram Solar has also been entrusted with overseeing the operations and maintenance (O&M) services for the plants under two-year contracts.

The new project at Netaji Subhash Chandra Bose International Airport in Kolkata consists of three separate installations: 180 kWp on the Operations Building, 572 kWp on the Cargo & APEDA building, and 1,248 kWp on the domestic building. It is expected to reduce CO_2 emissions by around 2,037 Mt each year. According to calculations, the solar rooftop plant at Calicut International Airport in Kerala is predicted to reduce CO_2 emissions by up to 823 Mt each year. EF

Source: www.solarnews.es



CHINESE FIRM TO SET UP SOLAR POWER PLANT IN ANDHRA PRADESH

Trina Solar, a leading Chinese solar power equipment manufacturer, has signed a Memorandum of Understanding (MoU) with the Andhra Pradesh Government for setting up a solar power plant with an investment of ₹2,800 crore. The proposed plant will come up at Atchutapuram in the coastal district of Visakhapatnam. The MoU was signed by SS Rawat, Andhra Pradesh's Secretary for Industries, and Chen Shou Chung, Vice-President of Trina Solar, in the presence of Chief Minister N Chandrababu Naidu in Vijayawada.

Welcoming the development, the Chief Minister said the proposed solar plant would give a huge fillip to the energy-efficient practices promoted by the state government and would create 3,500 jobs.

Trina Solar is one the world's leading companies that specializes in the manufacture of crystalline silicon photovoltaic modules and system integration. It also develops and produces ingots, wafers, solar cells, and solar modules. EF

Source: www.tribuneindia.com

JAPAN'S SOFTBANK WINS FIRST SOLAR PROJECT IN INDIA

Marking its debut in the Indian solar sector after its investment announcement of $20 billion, Japan's SoftBank won its first solar power project in India. The Japanese firm won the 350 MW project, under the Jawaharlal Nehru National Solar Mission (JNNSM), through its joint venture company SBG Cleantech. SBG Cleantech bid the lowest tariff of ₹4.63 per unit to win the entire tendered capacity of 350 MW. This is the lowest bid in 2015 for solar power."Our goal is to create a market-leading renewable energy company, to fuel India's growth with clean, reliable, and affordable sources of energy. This project will immensely contribute to the Prime Minister's vision of meeting the country's energy demands through clean sources and India's commitment to providing a safe environment, following the recent Paris convention," said Nikesh Arora, President and Chief Operating Officer of SoftBank. EF

Source: www.business-standard.com

MIT SPINOFF'S MICROBES TURN BEER WASTE INTO CLEAN WATER, ENERGY

Cambrian Innovation is extracting clean water and energy from waste streams at two California breweries with a secret set of microbes. "The Boston-based startup has raised $30 million to install its EcoVolt systems, and plans to market them using a model that is similar to the leases that are driving the residential solar market", Chief Executive Officer Matthew Silver said.

The technology uses bio-engineered microbes that consume much of the contaminants in wastewater and belch out methane. While the water is not clean enough for drinking, customers use it for cleaning or agricultural purposes, and the methane can be burned to produce heat or electricity. The process reduces the need for traditional wastewater treatment services.

The company is targeting brewers and other water-intensive industries in drought-stricken areas, such as California and Texas, and will use the funding to build as many as a dozen more. Cambrian plans to sell water-treatment plants through water-energy purchase agreements, where brewers and other customers sign 10- or 15-year contracts and agree to make payments based on the amount of water that's handled. Cambrian emerged from the Massachusetts Institute of Technology in 2006. Its EcoVolt systems can produce as much as 80,000 gallons (303,000 litre) of treated water a day, reduce fresh water consumption by 40 per cent, eliminate 1,600 metric tonnes of CO_2 emissions annually, and use the methane to produce as much as 130 kW of power.' EF

Source: www.renewableenergyworld.com

AUSTRALIAN BIOENERGY FUND LAUNCHED WITH $100 MILLION INITIAL COMMITMENT

The Sydney, Australia-based Clean Energy Finance Corporation (CEFC) recently committed $100 million for a new Australian Bioenergy Fund to advance the country's bioenergy sector.

The fund will support a broad range of projects seeking to produce energy from agricultural, council, forestry, and mining waste streams. According to the CEFC, the fund will invest in a range of technologies, such as energy from waste, anaerobic digestion, landfill gas capture, wood pelletization, etc. "We see this new fund as playing an important role in accelerating and widening the market uptake of bioenergy and energy from waste technologies that have a proven track record overseas but are not yet widely deployed in Australia's energy mix," CEFC CEO Oliver Yates said in a statement. In a report on Australia's bioenergy market released in November, the CEFC said that, given the low penetration of bioenergy and energy from waste technology in Australia to date, it sees considerable opportunities to increase investment in the sector. EF

Source: www.renewableenergyworld.com

TORONTO HYDRO UNVEILS COMPRESSED AIR ENERGY STORAGE SYSTEM

Toronto Hydro unveiled its first underwater compressed air energy storage system located in 180 feet of water about two miles off the coast of Toronto Island in Ontario. The system, which was supplied by Toronto, Ontario-based Hydrostor, is connected to Toronto Hydro's electricity grid under a two-year pilot study. Toronto Hydro said the system is expected to improve power quality and resiliency for island residents. Toronto Hydro said it is actively exploring energy storage as a way to extend the life of some of its equipment.

The project uses compressed air and the pressure of water to run its system with zero emissions. According to Toronto Hydro, the technology works by running electricity through a compressor and converting it into compressed air. The compressed air is sent underwater where it is stored in large balloon-like structures that are made out of the same type of material used in marine lift bags to raise shipwrecks. When electricity is needed again, the weight of the water pushes the air to the surface through a large pipe and an expander converts the air back into electricity.

The company said that, at peak output, the storage unit is capable of powering approximately 330 homes (660 kW). Depending on how much power is drawn, the system can currently run for a little over an hour, and future expansion of the underwater air cavity is expected to increase that duration. EF

Source: www.renewableenergyworld.com

SUNEDISON SIGNS LARGE-SCALE ENERGY STORAGE CONTRACT WITH ONTARIO IESO

SunEdison has signed a 10-year agreement with Ontario's Independent Electricity System Operator (IESO) to supply 5 MW/20 MWh of energy storage to the province.

"By integrating energy storage into their grid, the Ontario IESO gains access to a powerful new tool that has the potential to transform how it operates the power system," Tim Derrick, SunEdison General Manager of Advanced Solutions, said in a statement. SunEdison said that the IESO intends to use data from the energy storage project to analyse how storage can be used to smooth the power flow from wind and solar, defer expensive system upgrades, and ultimately shape the future of its grid. The project, which will use Imergy's vanadium redox flow battery technology, is SunEdison's first commercial large-scale, grid-connected energy storage project, and is one of the first commercial applications of flow batteries in Canada. EF

Source: www.renewableenergyworld.com

SOLAR FRONTIER ACHIEVES WORLD RECORD THIN-FILM SOLAR CELL EFFICIENCY

Solar Frontier has set a new world record for thin-film solar cell efficiency. In a joint research with the New Energy and Industrial Technology Development Organization (NEDO) of Japan, Solar Frontier has achieved 22.3 per cent conversion efficiency on a 0.5 cm^2 cell using its CIS technology. This increase of 0.6 percentage points over the industry's previous thin-film record of 21.7 per cent. The Fraunhofer Institute, Europe's largest organization for applied research, has independently verified this result. "This is a proud achievement for Solar Frontier and a significant advancement for our CIS technology. This is the first time that CIS has crossed the 22 per cent efficiency boundary—a level not yet surpassed by any other thin-film or multi-crystalline silicon technology," said Satoru Kuriyagawa, Chief Technology Officer of Solar Frontier. "This latest achievement brings us a step closer toward realizing Solar Frontier's long-term goal of exceeding 30 per cent efficiency using CIS."

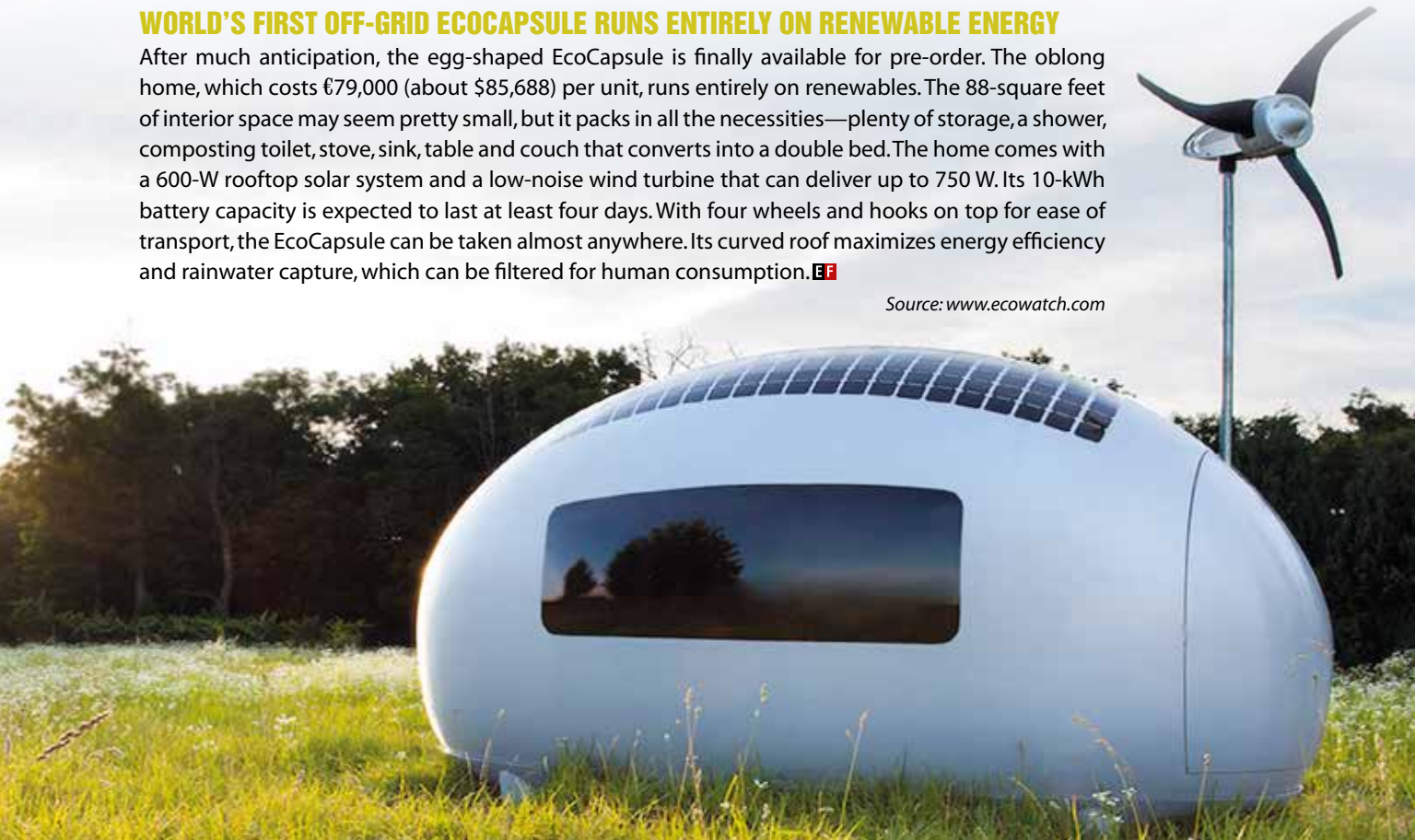
Solar Frontier has created the cell using the same sputtering-selenization process that it uses in mass production. This enables it to apply its latest advancements in all of its production plants in the future. The new production plant will harness Solar Frontier's most advanced lines to produce modules of 14.7 per cent efficiency once it begins commercial production. EF

Source: www.renewableenergyfocus.com

WORLD'S FIRST OFF-GRID ECOCAPSULE RUNS ENTIRELY ON RENEWABLE ENERGY

After much anticipation, the egg-shaped EcoCapsule is finally available for pre-order. The oblong home, which costs €79,000 (about $85,688) per unit, runs entirely on renewables. The 88-square feet of interior space may seem pretty small, but it packs in all the necessities—plenty of storage, a shower, composting toilet, stove, sink, table and couch that converts into a double bed. The home comes with a 600-W rooftop solar system and a low-noise wind turbine that can deliver up to 750 W. Its 10-kWh battery capacity is expected to last at least four days. With four wheels and hooks on top for ease of transport, the EcoCapsule can be taken almost anywhere. Its curved roof maximizes energy efficiency and rainwater capture, which can be filtered for human consumption. EF

Source: www.ecowatch.com



AFRICA RENEWABLE ENERGY INITIATIVE TO BUILD 10,000 MW OF RENEWABLES IN AFRICA BY 2020

The Africa Renewable Energy Initiative (AREI) aims at enabling the installation of large-scale renewable energy capacity on the African continent by 2020. The African-led plan has just received a big boost with over $10 billion worth of financial backing from various members of the international community at COP21 in Paris. Most of the $10 billion came from the European Union, Sweden, and the G7 countries. In particular, Germany will contribute $3.25 billion, France $2.2 billion, Sweden $500 million, and Canada $110 million. This will help provide clean power to millions across the continent. This clean electricity is sorely needed: Approximately 600 million people have no access to electricity in Africa, with the figure expected to rise to 700 million by 2030 without further action, according to a 2015 UNEP report. As a result, many rely on wood or other biomass to cook and heat their homes, leading to hundreds of thousands of deaths each year from indoor air pollution. EF

Source:www.treehugger.com

38 COUNTRIES LAUNCH GLOBAL GEOTHERMAL ALLIANCE AT COP21

A coalition of 38 countries and over 20 development and industry partners have joined forces to increase the share of geothermal energy in the global energy mix. Launched at a high-level event at the UN Climate Change Conference in Paris (COP21), the Global Geothermal Alliance, an initiative facilitated by the International Renewable Energy Agency (IRENA) aspires to achieve a 500 per cent increase in global installed capacity for geothermal power generation and a 200 per cent increase in geothermal heating by 2030."Geothermal energy has proven its potential to be part of both the global climate and energy action agenda," said IRENA Director-General Adnan Z Amin. "While geothermal can provide baseload power at some of the lowest costs for any power source, it remains underdeveloped. The Global Geothermal Alliance will provide a platform for partners to share best practices, further reduce costs and get the most benefit out of this sustainable energy resource", he further said.

Nearly 90 countries have potential for geothermal energy resource development; however, just 13 GW of installed capacity exists worldwide. A proven technology, the main obstacle for geothermal power investment and development has historically been the high upfront costs of surface geophysical studies and drilling to explore for geothermal resources. But, once a geothermal project is in operation, it can generate electricity at a low cost. The Alliance will aim to overcome these barriers by mitigating risks, promoting technological cooperation, coordinating regional and national initiatives, and facilitating geothermal energy investments into energy markets. EF

Source: www.irena.org

The Momentous Paris Agreement and the INDCs

Bridging the Gap between Climate Action Plans of Developed and Developing Nations

The year 2016 will be pivotal in charting out the roadmap towards limiting global warming in COP22 at Morocco during November–December, following the conclusion of the 21st session of the Conference of the Parties (COP21) in Paris and the Intended Nationally Determined Contributions (INDCs) are going to be very crucial in furtherance of the climate action. In this article, **Dr Srikanta K Panigrahi** *presents an analysis of the significance of the mechanism of the INDCs and the contribution of the INDCs, which is key to the Paris agreement. He particularly dwells on India's INDCs, which he feels are not only ambitious and unique but nonetheless highly progressive at the same time. He also presents a comparative analysis of India's INDCs with China and the USA. Keep reading to know more about these historic developments for safeguarding the planet earth from the perils of climate change…*

The 2015 United Nations Climate Change Conference, COP21 was held in Paris, France, from November 30 to December 12, 2015. It was the 21st yearly session of the Conference of the Parties (COP) to the United Nations Framework Convention on Climate Change (UNFCCC). COP21 was meant to be a very important and a landmark event in the history of world climate change action because the world is pursuing a new emission reduction instrument called Intended Nationally Determined Contributions (INDCs). Countries across the world have geared up to act against climate change and that is evident in their INDCs for climate change adaptation and mitigation. INDCs is a term used under the UNFCCC for reductions in greenhouse gas (GHG) emissions that all countries, which signed the UNFCCC, were asked to submit in the lead up to the COP21 summit in Paris.

SIGNIFICANCE OF THE INDCs MECHANISM

The Intended Nationally Determined Contributions (INDCs) came in search of a new mechanism with an objective to see the planet, carbon neutral. Countries are increasingly communicating, and in fact most of the member countries, more than 160 nations, have already communicated, their INDCs under the UNFCCC and pledging their support for the cause of saving the planet earth. The INDCs would serve as critical inputs in this national policy setting process, where the countries would determine their contributions in the context of their national priorities, circumstances, and capabilities with a global framework that drives collective action towards a low carbon and climate resilient future. For the INDCs to be successful, they would have to be based on concrete research results and facts. INDCs shall make it possible to track progress and achieve a collective ambition level sufficient to limit global warming to below 2°C relative to pre-industrial levels. They should be considered as an initial attempt to put the planned actions into force and form a new climate economy in order to tackle climate change.

FATE OF THE KYOTO PROTOCOL

Kyoto Protocol had come into existence in 1997 at COP3 in Kyoto, Japan where, all the member countries had signed the Protocol including the USA. Later, since US Congress did not approve it, USA did not ratify the Kyoto Protocol. Although, the Protocol came into operation since February 16, 2005, subsequently the important Member Countries, such as Canada and Japan walked out of the Protocol and the emission reduction targets which all the 41 developed industrialized nations had accepted on the basis of 5.2 per cent reduction on the base year of 1990; failed to achieve during its

first commitment period, i.e., January 1, 2008 to December 31, 2012. Now, although the second commitment period is operational since January 1, 2013 to December 31, 2020 after Doha Amendment since many parties have walked out; there is little hope that the Protocol will be successful in achieving its committed targets.

BACKDROP TO THE MECHANISM OF INDCs

In fact, INDCs did not arrive all of a sudden. By December 2009, most of the world had already realized that the Kyoto Protocol might not be successful, hence, at COP15 in Copenhagen, Denmark, the whole world got engaged in discussions that the world needs a new emission reduction mechanism where, all the member countries irrespective of their 'developed', 'developing', or 'least developed' tag should come forward to share some burdens of GHG emission cut to save the planet from the grave dangers of global warming. India had declared 20–25 per cent reduction in its carbon intensity with respect to the base year of 2005 by 2020, which was declared by the former Prime Minister Dr Manmohan Singh at Copenhagen. It was also decided that the modalities for a new mechanism would be worked out by 2015 which would be operational during 2020–30. Discussions on new mechanism were carried out, in all subsequent COPs at COP16 at Cancun, COP17 at Durban, COP18 at Doha, COP19 at Warsaw, and COP20 at Peru, Lima. The concept of INDCs was initiated at Warsaw, where its scope was largely confined to emission reduction, GHG cut, or mitigation. Finally, during COP20 at Peru, the member countries of UNFCCC realized that at that point of time, 'adaptation' is even more important than 'mitigation' for which the 'adaptation measures' found a place in INDCs conceptualization.

The pledges made by the member countries of the COP so far would still result in global warming of at least 2.7°C, even if they are all met—this is much better than the 5°C rise, we might expect without action but still short of the 2°C goal. Negotiators have virtually given up on the idea that the pledges should be legally binding. Shirkers would face no real sanction, other than international opprobrium. And that means a system to check and report what each country does, seems to be critical.

CONTRIBUTION OF INDCs TO THE PARIS AGREEMENT

INDCs are another experiment in emission reduction space, similar to emission trading experimentation. Nothing is cent-percent guaranteed or confirms to water-proof mechanisms. All these mechanisms have emerged out of the necessity of the time to meet the challenges of protecting the planet against the perils of climate change. The pledges made by the member countries of the COP so far would still result in global warming of at least 2.7°C, even if they are all met—this is much better than the 5°C rise, we might expect without action but still short of the 2°C goal. Negotiators have virtually given up on the idea that the pledges should be legally binding. Shirkers would face no real sanction, other than international opprobrium. And that means a system to check and report what each country does, seems to be critical. But the rules for monitoring, also remains unfinished. The plans to regularly review and 'ratchet' up the pledges to contain global warming to 2°C or lower, i.e., capping global temperature rise to 1.5°C by the end of the century, i.e., by the year 2100 are not finalized either. In the upcoming COP summits, UNFCCC strategists must calculate if we can achieve 2°C temperature reduction to stabilize the planet's climate and what are the shortfalls in the sum total of each of the individual commitments of INDCs. The strategists should also discuss if some capable/abiding developed and developing countries would be asked to take some more commitments. It is hoped that this new Paris Agreement is ready before December 2020 so that it can be implemented starting from January 1, 2021.

INDIA'S POSITION AND RESPONSIBILITY AS A RAPIDLY DEVELOPING ECONOMY

A few questions that can come into the mind of any attentive Indian citizen are, "*Our per capita emission is least in the world, why should we agree to some commitments for which we are not responsible? The developed countries have enjoyed over thousands of years through the series of industrial revolutions one after another, especially when we do not have any access to the basic human necessities, such as clean drinking water for our survival, electricity for studying, houses to live in; why should we spend money in cutting industrialized countries' emissions to make the earth carbon neutral? In fact, this is our time for growth and survival*…." This is how many Indians may think. To a certain extent these apprehensions may be true. 'Equity' is an important issue in our climate change negotiations during COPs. All the citizens of the planet should have equal rights over the planet's resources including that of their air or water space. The entitlements and the quota of the developing and least developed countries should not be ignored.

But we, at the same time must not forget that we are the third largest emitter of the GHGs to the

planet's atmosphere (Table 1). Our GHG emissions are constantly and geometrically increasing, whereas, in developed and industrialized countries carbon emissions are geometrically reducing. Most of them argue that our industries are not doing their bit, taking the advantage of demographic figures of India. But, this perception is in fact slowly changing, and the Indian industries are now stepping forward in standing up to their counterparts abroad, to be more energy efficient, water efficient, and adopt sustainable industrial technologies and development practices to ensure a long-term green growth. We all have to equally think for the survival of our planet earth, hence the survival of ourselves. Who is responsible if we don't have safe drinking water, even after 68 years of independence? Being a civilized citizen of the planet we need to feel equally responsible, like everybody else in the world. We need not block our growth but at the same time, we need to balance it along with environment on equal footings.

Table 1: Top seven polluters in the world

Country	Total CO_2 emissions in 2013 (million)
China	9,977
USA	5,233
India	2,406
Russia	1,812
Japan	1,246
Germany	759
South Korea	615

(Source: Agencies, Global Carbon Project, 2013)

India is the third largest producer of GHGs, which is 6 per cent of the total GHG emissions of the planet (World Resources Institute 2014). Its share of global GHG emissions has almost doubled in the last quarter of a century and now, with an accelerated economic growth, it is increasing at a faster rate. With the projections being made by various national and international agencies, its emissions could be at least two–three times its present level by 2030, and it may well end up being the world's second-largest emitter after China soon, if we fail to take stronger proactive action to reduce our GHG emissions (Figure 1).

INDIA'S INDCs—A PROGRESSIVE ROADMAP FOR THE FUTURE

"India's climate action plan submitted to the United Nations is 'comprehensive, ambitious and progressive' which would help reduce emission intensity by 33–35 per cent by 2030", Environment Minister Shri Prakash Javadekar said after India declared/disclosed its INDCs on October 2 (Gandhi Jayanti), 2015. He further said, "The developed world has polluted the earth and we are suffering. Still we want to become a part of the solution and give results. We want to walk on a cleaner energy path."The Indian government declared its futuristic adaptation and mitigation actions starting from 2020 till 2030 after doing a complete homework. The nodal Ministry, i.e., the Ministry of Environment, Forest and Climate Change (MoEF&CC) had administered different questionnaires to various

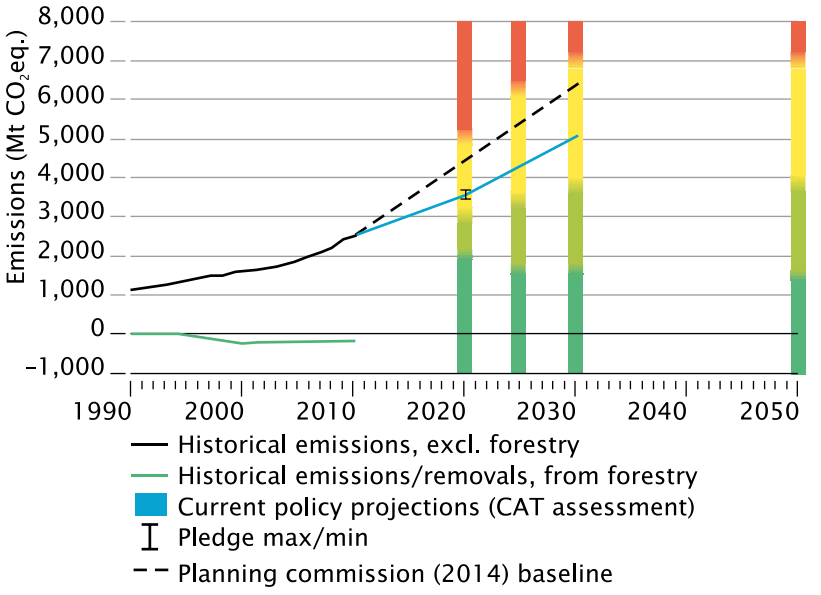


Figure 1: India's GHG emission trend over the years. (*Source: www.climateactiontracker.org*)

industries and other stakeholders who are responsible for the GHG emissions in India through their affiliated respective ministries and asked what are the adaptation and mitigation measures they are likely to undertake or commit from 2020 to 2030 and therefore, after getting their responses, government undertook a collective consolidative perspective regarding its adaptation and mitigation preparedness during 2020–30. India submitted its INDCs in the form of a 38-page document containing the details of the pledge.

India's plan to cut carbon pollution builds on its pledge at the COP15 in Copenhagen to reduce the intensity of its GHG emissions by 20–25 per cent by 2020 from 2005 levels. The cost of this climate action between now and 2030 is estimated to total more than $2.5 trillion.

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India's goals may seem highly ambitious, but they are in fact achievable with the right strategy, policy measures, and actions.

India's INDCs Commitment by 2030

- To put forward and further propagate a healthy and sustainable way of living based on traditions and values of conservation and moderation.
- To adopt a climate friendly and a cleaner path than the one followed hitherto by others at corresponding level of economic development.
- To reduce the emissions intensity of its GDP by 33–35 per cent by 2030 from 2005 levels.
- To achieve about 40 per cent cumulative electric power installed capacity from non-fossil fuel based energy resources by 2030 with the help of transfer of technology and low cost international finance including from Green Climate Fund (GCF).
- To create an additional carbon sink of 2.5–3 billion tonnes of CO_2 equivalent through additional forest and tree cover by 2030.
- To better adapt to climate change by enhancing investments in development programmes in sectors vulnerable to climate change, particularly agriculture, water resources, Himalayan region, coastal regions, health and disaster management.
- To mobilize domestic and new and additional funds from developed countries to implement the above mitigation and adaptation actions in view of the resource required and the resource gap.
- To build capacities, create domestic framework, and international architecture for quick diffusion of cutting edge climate technology in India and for joint collaborative R&D for such future technologies.

Source: India's INDCs, October 2015, MoEF&CC

INTENDED MEASURES BY INDIA TO TACKLE CLIMATE CHANGE—ARE WE DOING ENOUGH?

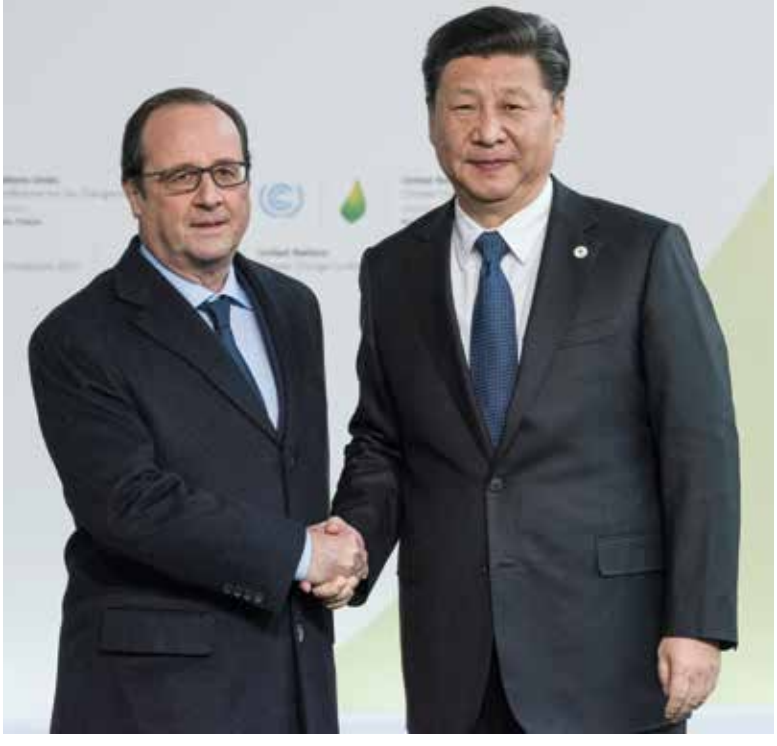
There was a huge pressure on India from international community to declare its future climate change actions including INDCs. The Prime Minister of India was also very keen that India takes a front seat in delivering very strong and dynamic actions against climate change in comparison to rest of the world since India is one of the worst sufferers of climate change. India has currently targeted renewable energy capacity of 175,000 MW by 2022; which could be more than doubled by the end of 2030. An earlier target of installing 20,000 MW by 2022 of solar energy has been raised five-fold to 100,000 MW and similarly, wind power capacity of 60,000 MW has also been put in place which would be crucial in the abatement of 326 million tonnes of CO_2 equivalent.

In addition, India is determined for many dynamic initiatives, which would include introduction to new, more efficient, and cleaner technologies in thermal power generation, promotion of renewable energy and increasing share of alternative fuels in the overall fuel mix, reducing emissions and waste from transportation sector, promotion of energy efficiency in economy, industry, transportation, building and appliances, development of climate resilient infrastructure, and full implementation of *Green India Mission* and other afforestation schemes. The initiatives also comprise widening the scope of Perform, Achieve and Trade (PAT) scheme, a market-based energy efficiency trading mechanism that at present covers 478 plants in eight energy-intensive industrial sectors, accounting for one-third of the total energy consumption in the countries. The scheme has been deepened to include additional sectors, such as railways, electricity distribution, and refineries in the next cycle and cover more than half the commercial energy consumed in India. Moreover, India is undertaking many dynamic, proactive adaptation and mitigation measures through the formulation of appropriate policy guidelines and having right strategies and an implementation framework in place through eight of its climate change missions as prescribed by the Prime Minister's National Action Plan on Climate Change (NAPCC).

INDCs OF CHINA AND THE USA BY 2020–30 IN COMPARISON TO INDIA'S INDCs

Being the largest emitter of GHGs, China's climate action commitment was under the international radar, and it has clearly shown efforts on enhancing GHG emission reduction actions by lowering the same per unit of GDP by 60–65 per cent from the 2005 levels. It has planned to double its wind power capacity to 200 GW and install 100 GW of solar power capacity. It has also planned to increase the share of green buildings, heading towards low-carbon communities and technologies. The country has definitely put forward an ambitious contribution declaration to bring down GHG emissions.

China is followed by the USA, which is the second largest GHG emitter. The US has undertaken substantial policy action to reduce its emissions,



China's INDCs Commitment by 2030

- Achieve CO_2 peaking around 2030 and making best efforts to peak early.
- Lower CO_2 emissions per unit of GDP by 60–65 per cent from the 2005 levels.
- To increase the share of non-fossil fuels in primary energy consumption to around 20 per cent.
- To increase the forest stock volume by around 4.5 billion cubic metres on the 2005 level.

Source: unfccc.int, 2015

USA's INDCs Commitment by 2030

- The USA intends to achieve an economy-wide target of reducing its greenhouse gas emissions by 26–28 per cent below its 2005 levels in 2025 and to make best efforts to reduce its emissions by 28 per cent. The USA will introduce domestic carbon trading system.
- The US target covers all greenhouse gases included in the 2014 Inventory of United States Greenhouse Gas Emissions and Sinks.
- The US will only have about 30 per cent of its electricity capacity on non-fossils.
- It has introduced changes in domestic laws for decarbonization of economy.

Source: unfccc.int, 2015

taking the necessary steps to place it on a path to achieve the 2020 target of reducing emissions in the range of 17 per cent below the 2005 levels in 2020. Additional action to achieve the 2025 target represents a substantial acceleration of the current pace of GHG emission reductions. According to the US, achieving the 2025 target would require a further emission reduction of 9–11 per cent beyond its 2020 target compared to the 2005 baseline and a substantial acceleration of the 2005–20 annual pace of reduction, to 2.3–2.8 per cent per year, or an approximate doubling. Table 2 presents a comparative data analysis of the INDCs of India, China, and the USA.

Including India, China, and the USA, more than 160 countries, representing more than 87 per cent of global GHG emissions, have submitted their intended national climate action plans to the United Nations. The European Union has pledged 40 per cent reduction in carbon emission of 1990 levels by 2030, while 10 per cent cuts could be additional target seeking a fair climate regime in the Paris agreement. Brazil, Russia, India, China, and South Africa together form the BRICS, wherein Brazil has pledged to increase its renewable share, mostly hydro, by 45 per cent uptill 2030; Russian federation pledged 6–11 per cent reduction level below 1990 by making maximum use of forests to absorb CO_2, while South Africa said that its emissions would peak between 2020 and 2050, and decline later. Eastern countries like Japan and South Korea have also pledged a reduction of 26 per cent and 37 per cent, respectively, in carbon emissions by 2030. To help achieve such ambitious targets it is important that the advanced economies keep their promise of providing $100 billion per year to help developing nations mitigate the effects of climate change.

Under the INDCs, India does not commit to absolute cuts in emission levels unlike bigger emitters, such as the USA, European Union or China, but plans to slow down the pace of emission growth without hurting economic development. China's per capita CO_2 emissions in 2030 are projected be about 12 tonnes, similar to the USA, but again four times higher than India (Centre for Science and Environment, New Delhi, India 2015), which might not prove to be in line with keeping the global temperature rise within manageable limits. India's INDC is unique and one of the most

Table 2: INDCs of India versus China and the USA

Category	China	USA	India
Electricity Production (2014)*	5,649,500 GWh	4,297,300 GWh	1,208,400 GWh
GDP**	$11, 212 US (billion)	$18.125 US (billion)	$2, 308 US (billion)
Share of Global GHG Emission	25.36%	14.4%	6.96%
Per Capita CO_2 Emissions (2011)***	6.7 metric tonnes per capita	17 metric tonnes per capita	1.7 metric tonnes per capita
Share of Renewable Energy Mix in 2014	9.6%	10%	8.2%
Pledge to Reduce Carbon Intensity of the Output	60–65%	26–28%	33–35%
Share of Non-fossil Fuel Electricity Generation	20%	30%	40%
Absolute Cuts in Emission Level	Has committed	Has committed	Has not committed

*(Source: The Ministry of New and Renewable Energy (MNRE), Government of India, 2014; *BP Statistical Review of World Energy, 2015, **knoema.com, World GDP Ranking, 2015; ***The World Bank, 2015)*

ambitious INDCs not only among developing countries but also in comparison to INDCs of most of the developed countries.

INTERNATIONAL SOLAR ALLIANCE (ISA)

India's Prime Minister Shri Narendra Modi and French President Mr François Hollande launched the International Solar Alliance (ISA) at the COP21 Climate Conference in Paris on November 30, 2015 as a special platform for mutual cooperation among 121 solar resource rich countries lying fully or partially between the Tropic of Cancer and the Tropic of Capricorn. The alliance includes 121 countries that support the 'Declaration on the occasion to launch the international solar alliance of countries dedicated to the promotion of solar energy'. This international solar collaboration sets an encouraging tone as the representatives of over 121 countries gathered at the earliest stage of COP21 conference to reach a new agreement to ramp up renewable energy—particularly solar energy. It also has the potential to propel international solar markets forward while fighting climate change, improving global health, and boosting economies. This international alliance will facilitate widespread implementation of solar projects and infrastructure of these 121 tropical countries.

This new alliance is seen as a symbol of India's unique leadership in centrestaging solar as a clean energy on the global arena. New Delhi will be the headquarter of this alliance and the Government of India has already committed to finance its secretariat for the first five years. International organizations, such as The World Bank, the United Nations Development Programme (UNDP), the United Nations Environment Programme (UNEP), the International Renewable Energy Agency (IRENA), and many others will partner this initiative. This international alliance brings together developed and developing countries to expand energy access, accelerate solar power deployment, and stimulate economic development. Backed by $1 trillion investment, the alliance should drive down the costs of solar power, making it affordable for a growing number of communities. India has emerged as the natural leader for this alliance with its ambitious targets to install 175 GW of renewable energy out of which 100 GW would come from solar basket in particular, by 2022 and non-fossil fuel electricity generating systems accounting for 40 per cent of the cumulative installed capacity by 2030.

TEN SIGNIFICANT TAKEAWAYS FROM THE PARIS AGREEMENT

- The Paris Agreement sets a goal of keeping warming well below 2°C and also for the first time agrees to pursue efforts to limit the increase in temperature to 1.5°C.
- Under the Agreement, all countries will communicate their emission reduction targets every five years, starting in 2020. Targets must be submitted 9–12 months before they are finalized, creating time for other countries and Civil Societies to seek clarity about the target submitted.
- Each target should reflect progress from the prior one, reflecting the highest possible ambition that each country can achieve this durable long-term framework and will drive the greater emission reduction ambition as technologies and circumstances improve.

- To help inform further domestic and global efforts, the Agreement puts in place a mechanism to assess collective progress on global mitigation action using the best available science. This process will begin in 2018 and occur every five years to help inform countries' future targets and strategies.
- These mitigation components of the Agreement combined with a broad push on innovation and technology, will help significantly scale up energy investments over the coming years—investments that will accelerate costs reduction for renewable energy and other low carbon solutions. This set of actions will create a mutually reinforcing cycle in which enhanced mitigation increases investment and this allows additional mitigation by driving down costs.
- To help make sure that all countries are living up to their commitments, this will send a market signal to the private sector and investors that countries are serious about meeting the targets they have set.
- A critical component of the Agreement, the transparency framework agreed to by Parties ensures that all countries are on a level playing field with a flexibility for those developing countries with less capacity.
- For the first time, the Agreement requires all countries to report on national inventories of emissions by source. This breakthrough will give an unprecedented clarity to the public's understanding of emission and pollution in countries throughout the world.
- Also, countries are required to report on information necessary to track progress made in implementing and achieving the targets and strategic countries have put forward.
- To help and ensure that countries are meeting transparency requirements, countries are subject to a comprehensive technical expert review process that analyses whether reporting is in line with the standards adopted. Countries will also engage in a multilateral review with their peers to share their experience and lessons learned. EF

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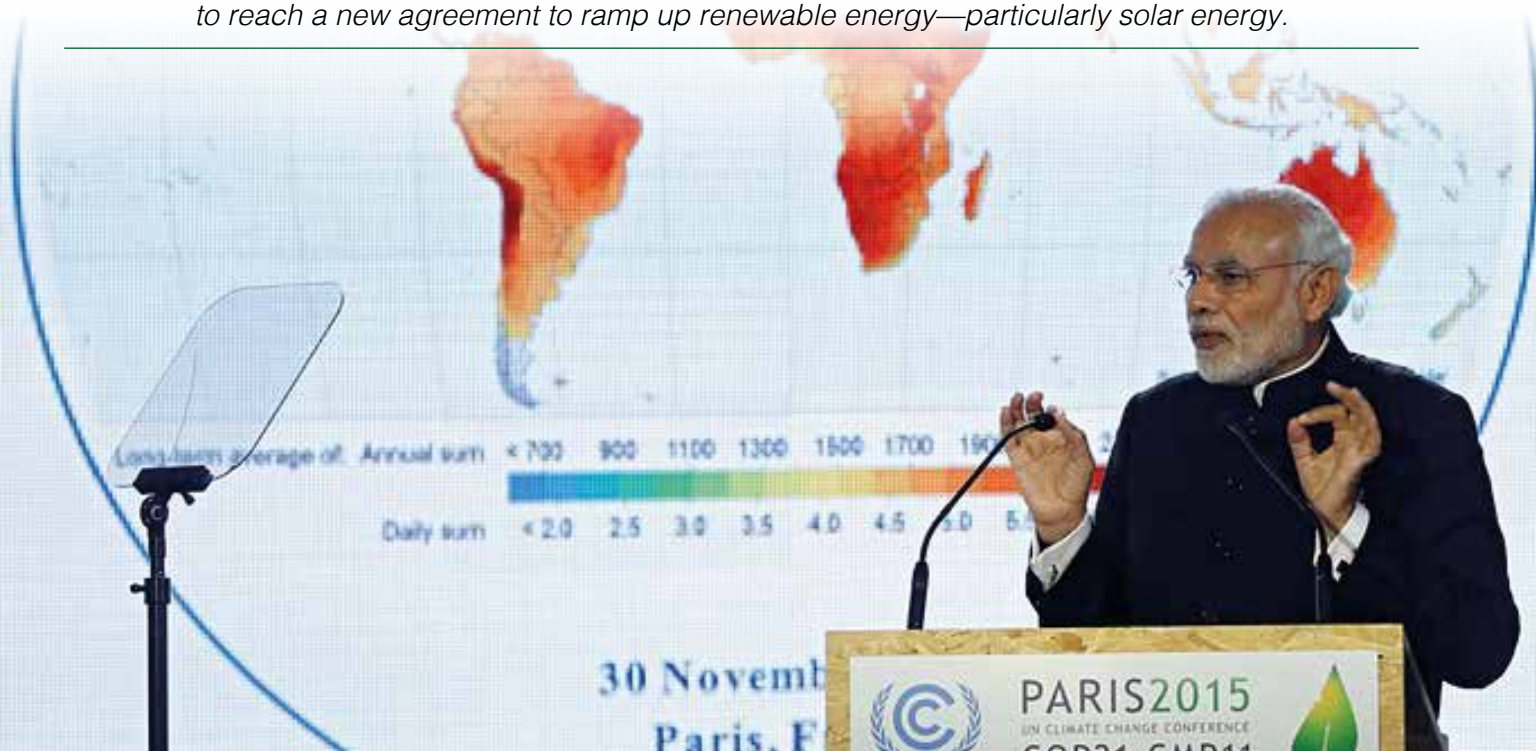
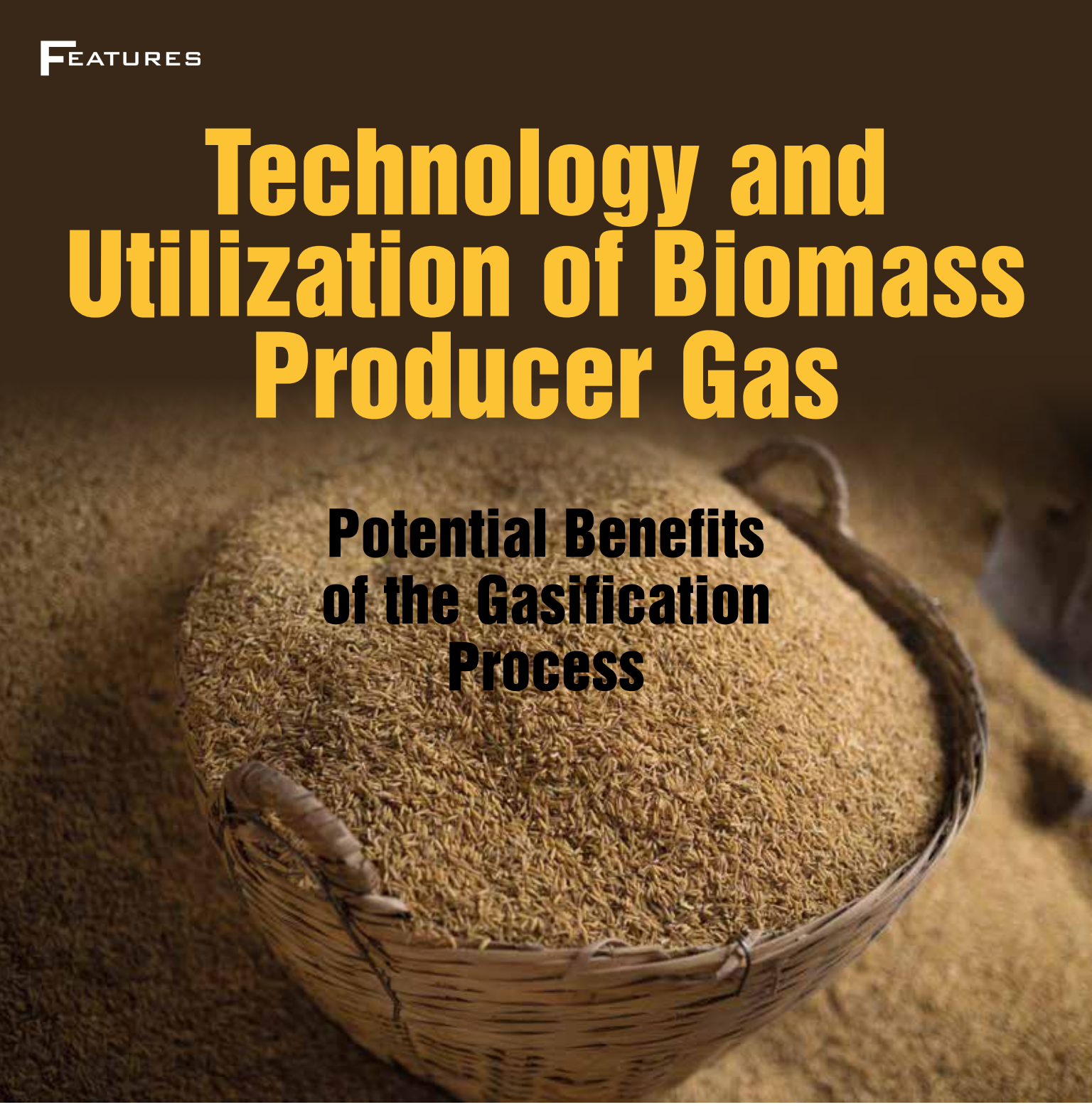


Technology and Utilization of Biomass Producer Gas

Potential Benefits of the Gasification Process



In the context of increasing requirements of non-renewable and exhaustible sources of energy, such as coal and petroleum, ***Dr R R Gajera*** *and* ***Dr D C Joshi*** *discuss the advantages of biomass gasification technologies that offer an alternative process for the conversion of low-value materials, such as sawdust, wood chips, corn cobs, nut shells, rice hulls, etc., to a more valuable product—producer gas, which has high heating value and thus can be used for energy generation applications. They also analyse the production technology, conditioning, production yield, and utilization of producer gas. Keep reading…*

The power produced from non-renewable sources, such as coal and petroleum are not going to last for a long period of time due to their exhaustive nature. Further, the high price of petroleum products compels to search and develop renewable energy sources, such as solar, wind, and biomass, which are available in abundance in India. Nuclear energy production being a highly costly process discourages its use in daily activities. The installation of dams for hydel energy is not always possible. Tidal energy is a much localized energy source. Significantly, biomass is a clean and safe energy source. The energy from biomass may be obtained either through biochemical reactions (biomethanation) or thermochemical reaction. Both the processes are practically feasible. The process for utilizing biomass to produce producer gas through a thermochemical process is called gasification. The term gasification, in its widest sense, covers the conversion of any carbonaceous fuel to a gaseous product with usable heating value. This definition excludes combustion, because the product flue gas has no residual heating value. It does include the technologies of pyrolysis, partial oxidation, and hydrogenation. The dominant process is partial oxidation, which produces the fuel producer gas (otherwise known as synthesis gas or syngas) consisting of carbon monoxide and hydrogen in varying ratios, whereby the oxidant may be pure oxygen, air, and/or steam.

BIOMASS

Biomass is the term used to describe all biologically produced matter and it is the name given to all earth's living matter. Biomass energy is derived from the plant sources, such as wood from natural forests, waste from agricultural and forestry processes, and industrial, human or animal wastes. Paper trash, rice husk, saw dust, sugarcane trash, wood, coconut shells, dry grass, and food processing waste are various sources of biomass. It is a natural process that all biomass ultimately decomposes to its molecules with the release of heat. And the combustion of biomass imitates the natural process. So, the energy obtained from biomass is a form of renewable energy and it does not add CO_2 to the environment in contrast to the fossil fuels. Of all the renewable energy sources, biomass is unique in that it effectively stores solar energy inherently. Furthermore, it is the only renewable energy source of carbon and is able to convert into convenient solid, liquid, and gaseous fuels. Various fuels usually considered unusable or low-value wastes, such as sawdust, wood chips, corn cobs, nut shells, rice hulls, etc., are used in the biomass gasifier to produce a high calorific value gas. Gasification technologies offer an alternative process for the conversion of low-value materials to a more valuable product—producer gas. Producer gas is a combustible mixture of gases, usually consisting of carbon monoxide, hydrogen, CO_2, methane, and traces of other gases. The producer gas has high heating value and thus can be used for energy generation applications. The producer gas can be used for co-firing applications in existing boilers or to directly fire a boiler. The value-added process of gasification is the conversion of carbonaceous food byproducts by the application of heat to generate a producer gas that is combustible. Gasification has many potential benefits when compared to conventional options, such as incineration or disposal by combustion. Gasification for different biomass sources, such as wood, coal, straw from grains, husks from rice, coconuts or coffee, and bagasse from sugarcane has been tested in the past. Commercial gasifier systems, such as updraft gasifiers, downdraft gasifiers, cross current gasifiers, and fluidized bed gasifiers have been used for various biomasses and have been proven for their performance.

BIOMASS GASIFICATION

Gasification can be defined as a process technology designed and operated for the purpose of producing syngas or synthesis gas, or fuel gas through the thermochemical conversion of biomass. Gasification usually involves the partial oxidation of the feedstock in a reducing atmosphere in the presence of air and/or steam. Gasification when compared to Waste-to-Energy (WtE) facilities has an advantage of lower emission levels and higher energy content in the producer gas. In the case of gasification, the chemical reactions take place in an oxygen-lean reducing atmosphere, in contrast to combustion where reactions take place in an oxygen-rich, excess-air environment. The excess air oxidizes the sulphur and nitrogen in the feedstock to SOx and NOx, which are not prevalent in the case of gasification and is a major disadvantage to incineration. Several different biomass fuels have been used in the past for energy generation purposes. Biomass energy sources include wood, wood wastes (e.g., sawdust and bark), short rotation energy woods and crops (e.g., willow and switch grass), agricultural crops and their residues (e.g., sugarcane bagasse, husks from rice, and stalks from maize), some municipal solid wastes, animal manure, wastes from food processing, waste sludge from pulp and paper industry (black liquor), and aquatic plants and algae. The most important properties relating to the thermal conversion of biomass are: moisture content, ash content, volatile matter content, heating value, and bulk density.

DESIGN OF GASIFIERS

The design depends heavily on the specific biomass material; its morphology, moisture content, and mix of contaminants (Figure 1).

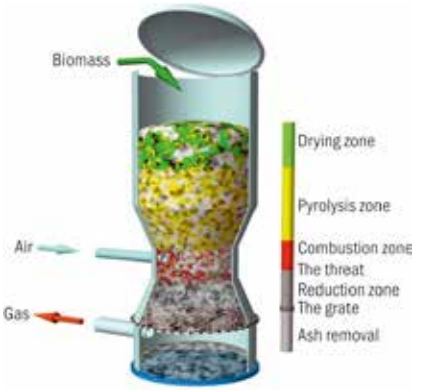


Figure 1: Basic process/design of gasifiers
Source: http://www.redeemre.com/downdraft-gasifier.html

Depending on the hydrodynamic properties of the reactors, gasifiers can be fixed or moving beds, bubbling or circulating fluidized beds, spouted beds or rotary kilns, or some combination of these types. The reactor is a cylindrical mild steel (I.S. 2062) shell insulated from outside with cera wool of 50 mm thickness and covered with aluminium sheet of 26 gauges. Ash removal grate is made up of SS310 and ash falls into the water seal pit tank made up of mild steel. The most common types of gasifiers used in the industries are updraft, downdraft, and cross draft design.

Updraft gasifiers

Updraft gasifiers (Figure 2) are one of the oldest and simplest gasification technologies. In updraft gasifiers, gas is drawn out of the gasifier from the top of the fuel bed while the gasification reactions take place near the bottom. The fuel is fed from the top, successively passing through a drying zone, pyrolysis zone, reduction zone, and hearth zone, and the ash is removed from the bottom of the gasifier, from where the sub-stoichiometric air is supplied. The major advantages of this type of gasifier are its simplicity, high charcoal burnout, ability to handle a variety of feedstocks, and internal heat exchange that leads to low gas-exit temperatures and high conversion efficiencies.

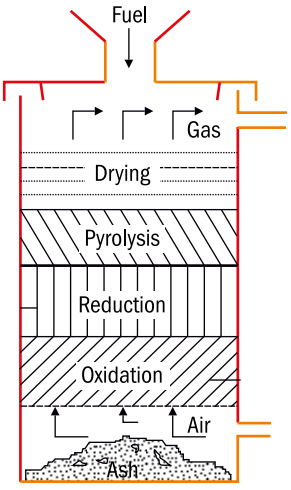


Figure 2: Design of updraft gasifier
Source: http://cturare.tripod.com/ene.htm and Biomass_Gasification_Technology_Utilization_2002 pdf

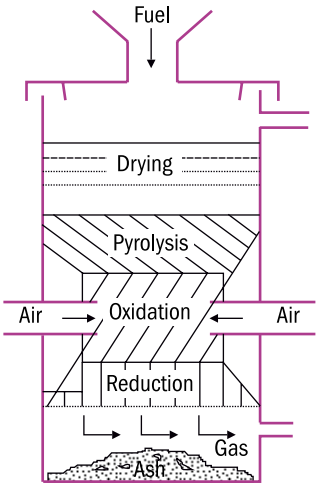


Figure 3: Design of downdraft gasifier
Source: http://cturare.tripod.com/ene.htm and Biomass_Gasification_Technology_Utilization_2002 pdf

Downdraft gasifiers

In a downdraft gasifier (Figure 3), biomass is fed at the top and the air intake is at the top or the sides. The gas leaves at the bottom of the reactor and moves in the same direction. Although, this design claims to enable tar-free gas production, it suffers from weak fuel flexibility and flow problems. One of the major disadvantages of updraft gasifiers is the high percentage of tar in the producer gas. This problem is minimized in a downdraft gasifier.

Cross draft gasifiers

Cross draft gasifiers (Figure 4)—although they have certain advantages over updraft and downdraft gasifiers—are not of ideal type. The disadvantages, such as high exit gas temperature, poor CO_2 reduction, and high gas velocity are the consequence of the design. Unlike downdraft and updraft gasifiers, the ash bin, fire and reduction zone in cross draft gasifiers are separated. These design characteristics limit the type of fuel for operation to low ash fuels, such as wood, charcoal, and coke. The load following ability of cross draft gasifier is quite good due to concentrated partial zones which operate at temperatures up to 2,000°C. Start-up time (5–10 minutes)

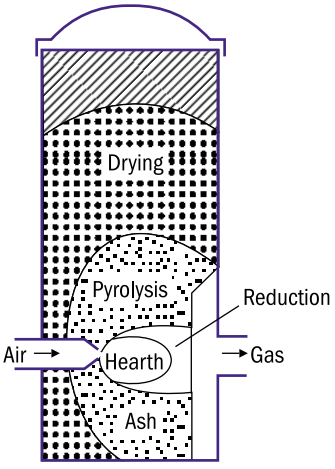


Figure 4: Design of cross draft gasifier
Source: http://cturare.tripod.com/ene.htm and Biomass_Gasification_Technology_Utilization_2002 pdf

is much faster than that of downdraft and updraft units. The relatively higher temperature in cross draft gas producer has an obvious effect on gas composition, such as high carbon monoxide, and low hydrogen and methane content when dry fuel such as charcoal is used. Cross draft gasifier operates well on dry air blast and dry fuel.

PRODUCER GAS

Producer gas is a combustible mixture of gases, usually consisting of carbon monoxide, hydrogen, CO_2, methane, and traces of other gases

(see box matter below). Gasification technologies offer an alternative process for the conversion of low-value materials to a more valuable product, i.e., producer gas. The producer gas has high heating value and thus can be used for energy generation applications. This producer gas can be used for co-firing applications in existing boilers or to directly fire a boiler. The process has many potential benefits when compared to conventional options, such as incineration or disposal by combustion. Commercial gasifier systems have been used for various biomasses and have been proven for their performance.

Producer gas mixture
Useful gases
Carbon monoxide (CO)
Hydrogen (H_2)
Methane (CH_4)
Acetelene (C_2H_2)
Ethelene (C_2H_4)
Ethane (C_2H_6)
Destructive elements & gases
Carbon dioxide (CO_2)
Tar vapour
Water vapour
Mineral vapour
Dust (Carbon, ash)

Constituents

Producer gas is the mixture of combustible and non-combustible gases. The heating value of producer gas varies from 4.5 to 6 MJ/m^3 depending upon the quantity of its constituents. Carbon monoxide is produced from the reduction of CO_2 and its quantity varies from 15 to 30 per cent by volume basis as shown in Figure 5.

Production technology

Conversion of biomass into producer gas is done by thermochemical process accomplished in air-sealed, closed chamber, under slight suction or pressure relative to ambient pressure in the following steps:

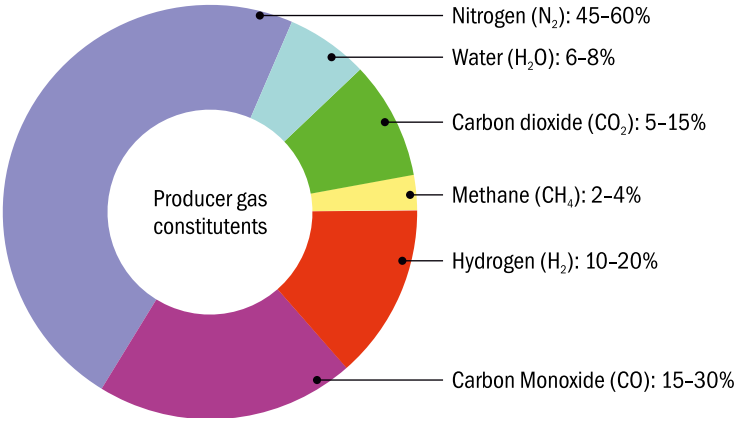


Figure 5: Producer gas constituents
Source: http://cturare.tripod.com/ene.htm and Biomass_Gasification_Technology_Utilization_2002 pdf

I. Drying: Biomass consists of moisture ranging from 5 to 35 per cent. At the temperature above 100°C, the water is removed and converted into steam. In the drying, fuels do not experience any kind of decomposition.

II. Pyrolysis: Pyrolysis is the thermal decomposition of biomass fuels in the absence of oxygen. Pyrolysis involves release of three kinds of products: solid, liquid, and gases. The ratio of products is influenced by the chemical composition of biomass fuels and the operating conditions. The heating value of gas produced during the pyrolysis process is low (3.5–8.9 MJ/m^3).

III. Oxidation: Introduced air in the oxidation zone contains, besides oxygen and water vapours, inert gases, such as nitrogen and argon. These inert gases are considered to be nonreactive with fuel constituents. The oxidation takes place at the temperature of 700–2,000°C. Heterogeneous reaction takes place between oxygen in the air and solid carbonized fuel, producing carbon monoxide.

$$C + O_2 = CO_2 + 406 \text{ [MJ/kmol]}$$

In the reaction, 12.01 kg of carbon is completely combusted with 22.39 m^3 of oxygen supplied by air blast to yield 22.26 m^3 of CO_2 and 393.8 MJ of heat. Hydrogen in fuel reacts with oxygen in the air blast, producing steam.

$$H_2 + ½\ O_2 = H_2O + 242 \text{ [MJ/kmol]}$$

IV. Reduction: In reduction zone, a number of high temperature chemical reactions take place in the absence of oxygen. The principal reactions that take place in reduction are mentioned below.

1. Boudouard reaction

$$CO_2 + C = 2CO - 172.6 \text{ [MJ/kmol]}$$

2. Water-gas reaction

$$C + H_2O = CO + H_2 - 131.4 \text{ [MJ/kmol]}$$

3. Water shift reaction

$$CO_2 + H_2 = CO + H_2O + 41.2 \text{ [MJ/kmol]}$$

4. Methane production reaction

$$C + 2H_2 = CH_4 + 75 \text{ [MJ/kmol]}$$

(Plus and minus sign indicate the release and supply of heat energy during the process respectively.)

The main reactions show that heat is required during the reduction process. Hence, the temperature of gas goes down 800–900°C during this stage. If complete gasification takes place, all the carbon is burned or reduced to carbon monoxide, a combustible gas and some other mineral matter is vapourized. The remains are ash and some char (unburned carbon).

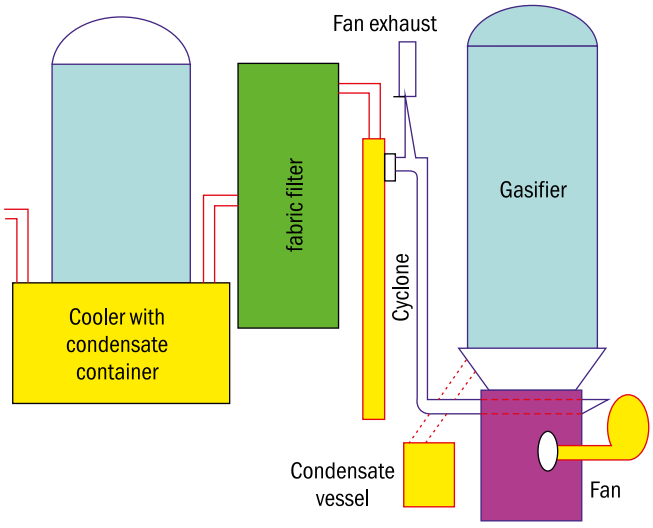


Figure 6: Cleaning and cooling of producer gas
Source: http://cturare.tripod.com/ene.htm and Biomass_Gasification_Technology_Utilization_2002 pdf

Conditioning

1. *Cleaning of gas:* Cleaning of the producer gas is trickier and is very critical. Normally, three types of filters are used in this process. They are classified as dry, moist, and wet. Cyclone filters are in the dry category. They are designed according to the rate of gas production and its dust content. The cyclone filters are useful for particle size of 5 µm and greater. Since 60–65 per cent of the producer gas contains particles above 60 µm in size, the cyclone filter is an excellent cleaning device. After passing through cyclone filter, the gas still contains fine dust particles and tar (Figure 6). It is further cleaned by passing through either a wet scrubber or dry cloth filter. In the wet scrubber, the gas is washed by water in counter-current mode. The scrubber also acts like a cooler, from where the gas goes to cloth or cork filter for final cleaning. Since cloth filter is a fine filter, any condensation of water on it stops the gas flow because of increase in pressure drop across it. Thus, in quite a number of gasification systems, the hot gases are passed through the cloth filter and then only do they go to the cooler. Since the gases are still above dew point, no condensation takes place in filter.
2. *Cooling of gas:* The temperature of gas coming out of generator is normally between 300–500°C. This gas has to be cooled in order to raise its energy density. Various types of cooling equipment have been used to achieve this end (Figure 6). Most coolers are gas to air heat exchangers where the cooling is done by free convection of air on the outside surface of heat exchanger. Since the gas also contains moisture and tar, some heat exchangers provide partial scrubbing of gas. Thus ideally, the gas going to an internal combustion engine should be cooled to nearly ambient temperature.

PRODUCTION YIELD

On an average, 1 kg of biomass produces about 2.5 m^3 of producer gas at standard temperature and pressure (STP). In this process, it consumes about 1.5 m^3 of air for combustion. For complete combustion of wood, about 4.5 m^3 of air is required. Thus, biomass gasification consumes about 33 per cent of theoretical stoichiometric ratio for wood burning. The average energy conversion efficiency of wood gasifiers is about 60–70 per cent and is defined as:

$$\eta Gas(\%) = \frac{\text{Calorific value of gas/kg of fuel}}{\text{Avg. calorific value of 1 kg of fuel}} \times 100$$

UTILIZATION OF PRODUCER GAS

Natural gas, diesel, or furnace oil can be replaced by producer gas for making steam in order to generate electricity and heat for industries (Figure 7). It is estimated that for each 100 kcal of potential energy in biomass fuels, gasification can extract about 80 kcal in hot raw gas. The process is more efficient than many other devices that burn biomass directly in a hearth or firebox. Very little modifications are required in most conventional oil-fired installations to run on producer gas for various applications, which are now described.

Thermal applications

As in boilers, dryers, oven, stove, thermic fluid heaters, hot air generators, heat exchangers, etc., as shown in Figures 8 and 9.

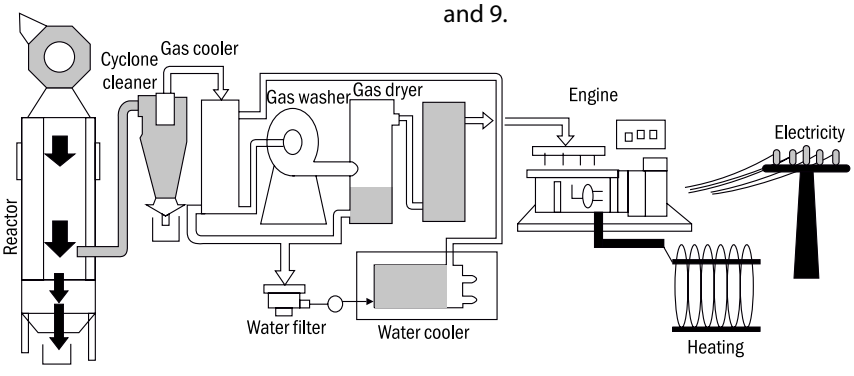


Figure 7: Producer gas system (production and utilization)
Source:http://cturare.tripod.com/ene.htmandBiomass_Gasification_Technology_Utilization_2002pdf

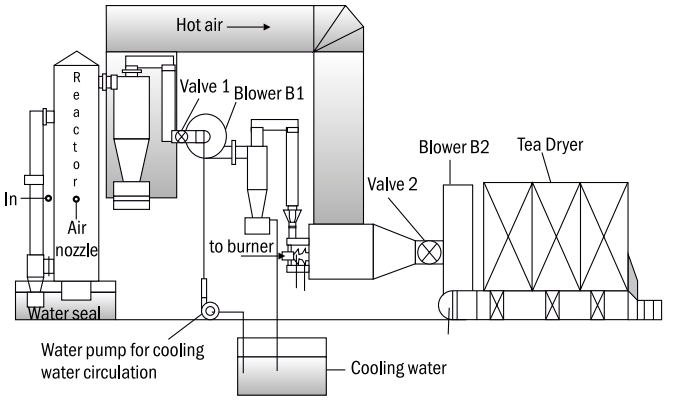


Figure 8: Producer gas tea dryer

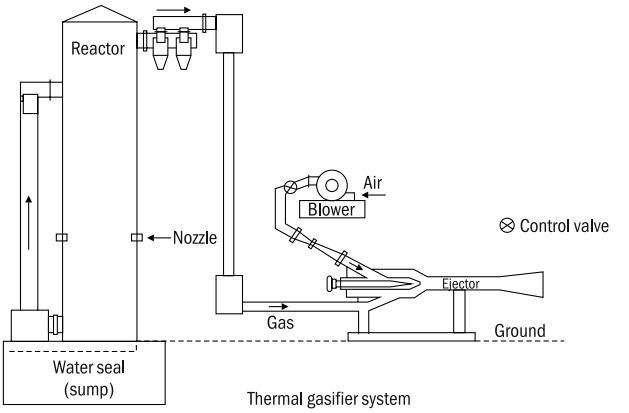


Figure 9: Producer gas thermal application

Source: Department of Aerospace Engineering, Indian Institute of Science, Bangalore

Power generation

For irrigation pumping, village electrification, captive power (industries), grid-fed power, etc., as shown in Figures 10 and 11.

ENVIRONMENTAL POLLUTION

As biomass is heated for combustion or gasification, many hydrocarbons are produced as the material pyrolyzes and breaks down. These hydrocarbons become tars and particulates. In open burning, the tars and particulates are carried into the environment through the stack. Since many of them are considered pollutants, they must be scrubbed out of any emissions from the combustion process. This is typically done by maintaining high stack temperatures to further break down and destroy the tars and then scrubbing out what is left. These approaches reduce efficiency and add cost to the process. Since gasification is a closed process, these pollutants are broken down within the process and then whatever is left is filtered out of the gas. No efficiency is lost and the gas filtering is done in a closed system. There is no stack or any significant emissions from the gasification process.

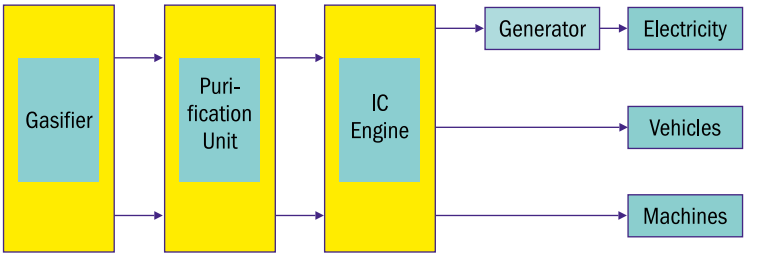


Figure 10: Producer gas electrical application

Source:http://cturare.tripod.com/ene.htmandBiomass_Gasification_Technology_Utilization_2002pdf

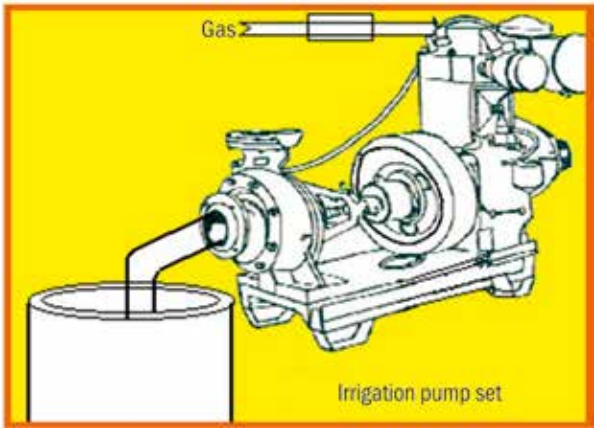


Figure 11: Producer gas mechanical application

Source:http://cturare.tripod.com/ene.htmandBiomass_Gasification_Technology_Utilization_2002pdf

COST-ECONOMICS AND SUBSIDIES

Cost of power generation generally depends on size of the plant and the cost of input, i.e., biomass, oil, labour, etc., and maximum utilization of plant load factor. The Ministry of New and Renewable Energy (MNRE), Government of India, New Delhi, is providing attractive capital subsidy for setting up producer gas units either for power generation or thermal applications. Subsidy amount is on a pro-rata basis or in multiples thereof. Government institutes such as the Indian Renewable Energy Development Agency (IREDA) and the National Bank for Agriculture and Rural Development (NABARD) are offering soft loan @ 5 per cent interest p.a. for seven years.

LIMITATIONS IN THE PRODUCTION OF PRODUCER GAS

Getting the producer gas is not difficult, but obtaining it in the proper state is a challenging task. The physical and chemical properties of producer gas, such as energy content, gas composition, and impurities vary from time to time. All types of reactors have fairly strict requirements for fuel size, moisture, and ash content. Inadequate fuel preparation is an important cause of technical problems with reactors. Reactors require at least half an hour or more to start the process. Raw material is bulky and frequent refuelling is often required for continuous running of the system. Handling residues such as ash and tar condensates is a time consuming work.

CONCLUSIONS

A large amount of biomass is available in the country. Using surplus biomass, more than 16,000 MW of grid quality power can be generated utilizing modern technologies to reduce the crisis of power shortage in the country. In addition, about 5,000 MW of power can be produced, if all the 550 sugar mills in the country switch over to modern techniques of co-generation. Various research organizations are doing commendable work in development and utilization of producer gas technology. The MNRE, is providing technical know-how and finance for the establishment of biomass-based producer gas units for electricity generation and thermal applications in various parts of the country. Technology provides a good opportunity to make wealth out of wastelands, promote employment opportunities, improve land use patterns, and produce a good raw material needed by industry. Waste disposal in the food processing industries is a major concern that includes both environmental and capital issues. Most of the waste is disposed into landfills and only a very small percentage of this waste is recovered. If the waste can be utilized for the production of producer gas, then there is nothing better than it. EF

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International Efforts to Keep Global Warming Below 2°C

at COP21 World Climate Change Meet

*The global warming induced climate change risks have now become the biggest risk ever faced by the human race. In this article, **Jyothi Mahalingam** analyses the threats posed by the gradual global warming and further dwells on the INDCs of some of the major economies of the world submitted prior to the COP21 event in Paris. He also reports some of the salient features of the proceedings and the agreement reached at the premier climate conference. Keep reading…*

"We stand on a cliff edge. This is the time, Excellencies that we must stand together and shape our future, let's do it for Tuvalu, for if we save Tuvalu, we will surely save the world", said the Prime Minister of Tuvalu, Enele Sopoaga, on the opening day of Conference of the Parties (COP21) at Paris. He said it before the Heads of States from nearly 195 nations, who took part in the world climate change meet organized by the United Nations Framework Convention on Climate Change (UNFCCC). The island states, such as Tuvalu, Marshall Islands, Kiribati, Tonga, the Federated States of Micronesia, and the Cook Islands (in the Pacific Ocean); Antigua and Nevis (in the Caribbean Sea); and the Maldives (in the Indian Ocean), will all disappear, into the ocean, if the rising sea levels due to climate change goes unchecked. The global warming induced climate change risks have now become the biggest threat ever faced by the human race. Now for nearly 38 successive years, worldwide temperatures topped the annual averages with extreme climate impacts. A new research, published in July 2015, by the National Oceanic and Atmospheric Administration's (NOAA) National Centers for Environmental

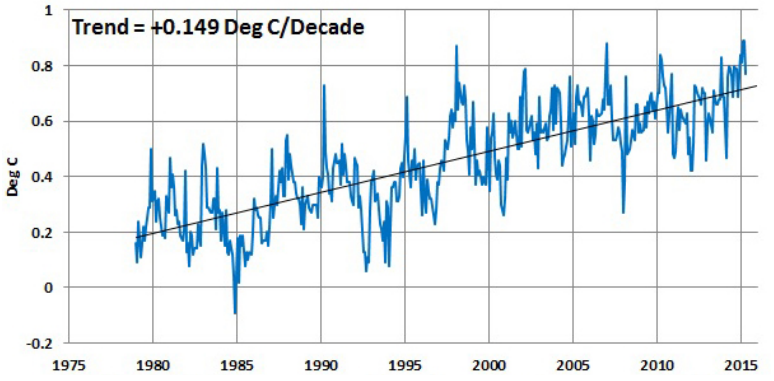


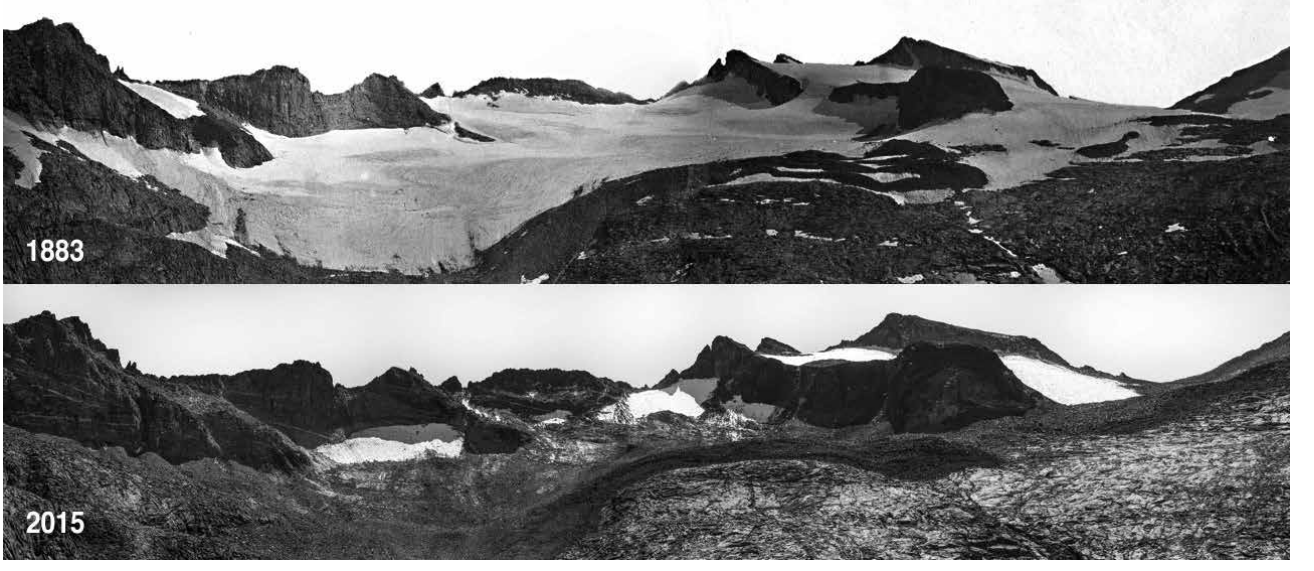
Figure 1: NOAA data on global land and ocean warming (from January 1979 to April 2015)
Source: www.noaa.gov

Information (NCEI), USA, supports the fear expressed by the island nations. The report finds a rapid increase in global warming levels in the last 15 years than it was in the last part of the twentieth century. The high end temperatures experienced in 2014 and even in 2015 showed the continuation of long-term warming trend experienced globally in recent years. The hotness variations observed in recent years were attributed to El Niño or La Niña occurrences that warm or cool the tropical Pacific region. Figure 1 presents global land and ocean surface temperature data from January 1979 to April 2015.

NASA, in one of its recent topical report observes that the global average atmospheric CO_2 intensity has reached 398.5 parts per million (ppm) in 2014 from 356 ppm in 1992. The UN climate control, citing the report, warned on the need to control the worldwide atmospheric CO_2 concentration levels well within the 450 ppm limits, in the coming years, to control the global warming levels within 2°C. Picture 1 shows the shrinking Lyell Glacier, which has lost nearly 80 per cent of its surface area between 1883 and 2015 due to warm and very dry weather attributed to global warming. Picture 2 shows that the Aral Sea has shrunk dramatically over the last 30 years. As the sea has shrunk, there have been noticeable changes in the local climate, contaminated dust storms, and the loss of drinking water.

BIGGEST CONTRIBUTORS TO GLOBAL WARMING

The Concordia University, Montreal, Canada, in its published study on post-2005 global warming, indicates that the biggest industrial economies such as the USA, the UK, Russia, Germany, China, Brazil, and India as the main contributors to global warming. The study formally revealed the level of CO_2 released from the use of fossil fuels, deforestation along with discharge of methane, nitrous oxide, and sulphate aerosol emissions. The study finds that the USA contributed most to the global warming levels in the last 200 years, by adding 20 per cent to it, resulting in 0.15°C rise in global temperatures. The research points out that China and Russia added 8 per cent, the UK and Germany lent 5 per cent, and Brazil and India contributed 7 per cent to increase in global warming levels. Unlike other countries, India and Brazil suffered from land-use CO_2 emissions, owing to deforestation and not due



Picture 1: The shrinking Lyell glacier
Source: http://climate.nasa.gov

Picture 2: The dramatic shrinking of Aral sea
Source: http://climate.nasa.gov

to burning of fossil fuels. The research also established that the countries which released larger quantities of CO_2, used aerosol discharges to offset CO_2 emissions.

PRELUDE TO THE COP21 SUMMIT IN PARIS

The erratic climate incidences and global warming demanded for a valid political response to climate change from various countries. It led to convening of the first Earth Summit in Rio de Janeiro in 1992 and the forming of the UNFCCC in 1994. The UNFCCC, in order to draw a consensus among the global countries, on controlling the catastrophic climate change, convened the first ever Conference of the Parties (COP) at Berlin in 1995. Since then, the annual COP turned out to be a regular feature and it plays a key role in the climate change slowing down activities.

The third COP held at Kyoto, Japan, in December 1997, introduced a legally binding agreement known as Kyoto Protocol. The agreement, made it mandatory for the industrialized countries to cut down their greenhouse gas (GHG) emission levels by 5.2 per cent in comparison to the year 1990. Unfortunately, the protocol came into force only from February 16, 2005. The COP18 held at Doha in 2012, agreed to extend the Kyoto Protocol beyond its 2012 expiration date to December 31, 2020. The COP15, held at Copenhagen in 2009, did not produce meaningful results despite the attempts by the leaders from 115 countries, to negotiate a political agreement between the US President Barack Obama and Chinese Premier Wen Jiabao. Though a Green Climate Fund (GCF) was launched in COP17 held at Durban, South Africa, in 2011, it failed to hold legal features to assist developing countries. The twentieth session of the UNFCCC COP, held at Lima, Peru, in 2014 continued the third of the four round discussions to give a shape to COP21 that was to be held at Paris in 2015. The conference, which commenced with promising discussions on $10 billion climate fund and post-2020 emission targets for China and the USA, quickly deviated from it to discuss other issues.

SIGNIFICANCE OF INDCs AT COP21, PARIS

Unlike the earlier UNFCCC annual conferences, the COP21 held in Paris was keenly followed and received maximum attention, from all over the world. In the wake of earlier agreements, assurances, and voluntary pledges agreed by the polluting countries, coming to an end by the year 2020, the COP21 certainly kindled the hopes on reaching a new global agreement, to come into effect from 2021, to prevent further damages to the climate. Attaching more importance to the event, even a release from the UN stated, "COP21, also known as the 2015 Paris Climate Conference, will, for the first time in over 20 years of UN negotiations, aim to achieve a legally binding and universal agreement on climate, with the aim of keeping global warming below 2°C level."

As agreed to the decisions of COP20, Lima, out of the 195 plus global nations that showed interest to participate in COP21, 185 global countries, including the European Union (EU) singularly representing 28 countries, submitted their Intended Nationally Determined Contributions (INDCs) before the beginning of COP21. The 158 INDCs include entries from all the developed nations and 75 per cent of developing countries. The INDCs, covered nearly 94 per cent of the worldwide emission levels excluding Land Use, Land-Use Change and Forestry (LULUCF) related emissions and include additional 3 per cent emissions from international aviation and maritime transport.

The INDCs submitted by countries, such as China, the USA, the EU, Brazil, South Africa, Australia, Russia, and India were considered as important in shaping up the course of the meet. Before going into the details and outcome of the COP21, a quick look

at the submitted key INDCs of some of these nations will enable us to understand the important elements briefly. Figure 2 presents the GHG emissions of various countries as per their submitted INDCs to the UNFCCC.

India

India, as a developing country suffers from shortage of energy supply. The country, third largest emitter of GHGs after China and the USA, is highly prone to the impacts of climate change. The country showed bold initiatives, in its well-balanced INDC action plan, to tackle the climate problem, while simultaneously covering vital issues, such as its plaguing poverty, food security, health care for all, and education. The main features are as follows:

- To reduce the emissions intensity of its Gross Domestic Product (GDP) by 33–35 per cent by 2030 from 2005 levels.
- To increase its renewable power generation (non-fossil fuels) capabilities to 40 per cent of the installed electric power generation, by the year 2030 with the help of transfer of technology and low-cost international finance including from GCF.
- To create an additional carbon sink of 2.5–3 billion tonnes of CO_2 equivalent by the year 2030 through additional forest and tree cover.

India is ambitious to invest more in the development programmes in climate vulnerable sectors, such as agriculture, water resources management, Himalayan region, and its long coastal regions, and health and disaster management. For the purpose of mobilizing capital, to bridge its resources gap and to carry out its plans, the country intends to call up for new and additional funds from domestic investors and developed countries. In order to install and improve its capabilities in climate technology designs, the country is planning to enter into R&D joint ventures, with both domestic as well as international companies in the future.

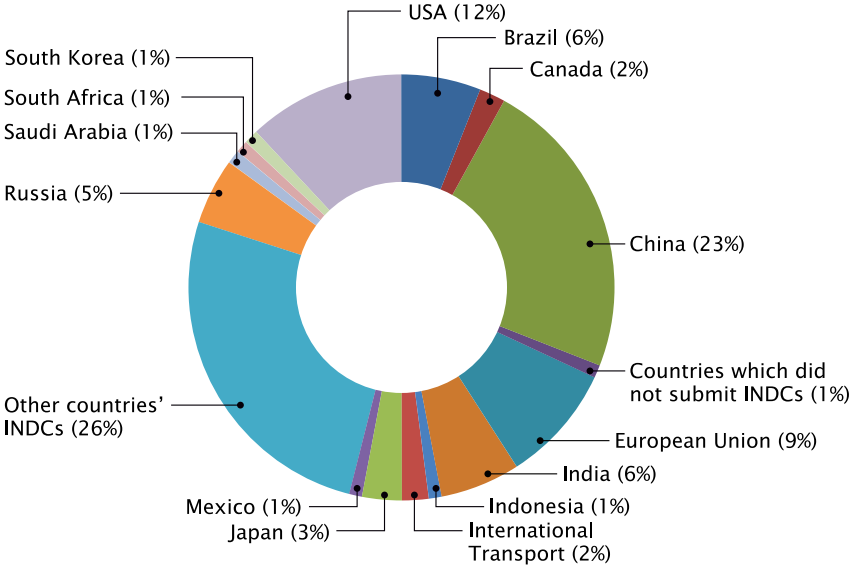


Figure 2: GHG emissions by countries as per the submitted INDCs to the UNFCCC prior to COP21 in Paris

China

China became the world's largest emitter of GHGs in 2005 after surpassing the EU in 2003 and the USA in 2005. The country, which accounts for nearly 25 per cent of the present global emissions, achieved its double digit economic growth by maximizing the use of pollution causing coal. Some of the salient features of its INDCs include:

- Peak CO_2 emission levels in 2030 or earlier by disassociating its economic growth from carbon emissions, to cut down its carbon intensity by 40–45 per cent by 2020.
- Cutting down its CO_2 emissions per unit of GDP by around 60–65 per cent below its levels by 2030.
- Use of non-fossil primary energy from 15 per cent to 20 per cent by 2030.

The USA

The USA, the second most polluting country and the second major economy in the world, filed its INDCs, quoting its strong commitment to cut down its GHG emission levels. The unconditional climate action plan submitted with a strong political will is in sequence to its joint announcement with China made in November 2014. The details in its INDCs include:

- Bring down the total emissions by 26–28 per cent below its emission levels in 2005 by the year 2025.

- Long-term goals to cut down its emission levels by 83 per cent below its 2005 levels in 2050.
- Sprucing up the regulatory framework to fulfill 2020 and 2025 targets.

The EU

The European Union submitted its INDCs, discussed and agreed by the leaders of its 28 Member States outlining the following climate goals for 2030:

- To cut down the domestic EU GHG emissions by "at least 40 per cent" by 2030, keeping 1990 as baseline. This includes 100 per cent of all types of its emissions.
- Its long-term goals to achieve 80–95 per cent reductions by the year 2050.

CONVERGENCE OF WORLD LEADERS AT THE COP21 SUMMIT

Laurent Fabius, French Foreign Minister, formally got elected as the President of COP21. In his opening speech, he optimistically stated, "The eyes of the world are upon us and there are great hopes, it is therefore for us to meet our responsibilities head on." French President, Mr François Hollande, while naming the day of the meet as historic, also called on developed nations to take the brunt of the responsibility and assist developing countries to cut down their emission levels. UN Secretary General, Ban Ki-moon said, "We have never faced such a test; political momentum like this may not come again. You have the power to secure the well-being of this and succeeding generations. The time for brinkmanship is over." Barack Obama, while accepting the accountability for historic emissions stated, "One of the enemies we will be fighting at the conference is cynicism. Our progress should give us hope during these two weeks. Our task here in Paris is to turn these achievements into an enduring framework." The President of China Mr Xi Jinping wanted the conference to showcase the international community a 'win-win' situation. Mr Vladimir Putin, the President of Russia, while calling climate change as gravest, intimated the proposal of Russia to hold a UN scientific conference on new technologies.

The Indian Prime Minister Modi said, "Over the next few days we will decide the fate of this planet. We do so when the consequences of the industrial age powered by fossil fuel are evident, especially on the lives of the poor. The prosperous still have a strong carbon footprint and the world's billions at the bottom of the development ladder are seeking space to grow. So, the choices are not easy. But we have advances in technology; we now need a genuine global partnership."

The opening day also saw the launch of 'Mission Innovation' (Clean Tech) initiative—a programme to accelerate clean energy revolution. This is a commitment by states to double their research and development budgets by 2020 and by private investors to increase their own investments. India's Prime Minister, Shri Narendra Modi along with the French President, Mr François Hollande launched an International Solar Alliance of 121 countries. The project will mobilize public finance from richer nations to assist the developing nations to install solar projects.

PROCEEDINGS OF THE CONFERENCE

The COP21 proceedings saw some interesting and never before happenings. The small island states that face extinction due to global warming received the support of the USA, the EU, and other developed countries and tried to push 1.5°C. While, China and India were prepared to agree for 2°C, to buy longer period to use coal and develop their economy, Saudi Arabia, heading other Gulf States, tried to block any reference to 1.5°C, to continue to market their oil reserves for longer period of time. The developed nations, for the first time, owned historical responsibility and sought the cooperation of the developing countries in arriving at a final decision.

The climate summit concluded on December 12, 2015—a day later than it was actually scheduled to end. After intense discussions, the 50-page draft agreement introduced earlier, finally surfaced as final document with 31 pages at the end of the summit. The President of COP21, Mr Laurent Fabius, recalled the legal proceedings that took place to arrive at the final document and banged the gavel to indicate the adoption of COP21 Paris document. The agreement will come into force when the countries sign it on April 22, 2016, at New York. It should get ratified by 55 countries that represent a minimum of 55 per cent of worldwide emission levels.

SALIENT POINTS OF COP21 AND THE AGREEMENT

France, as the host nation of COP21, played a stellar role in handling the conference proceedings, addressing the concerns of all the countries in developing the final document and passing of the deal without much hitch. The deft leaders from countries, such as the USA, China, and India, cooperated with France to achieve the deal. The strong commitments from the countries made a positive impact in the meet. The climate vulnerable small island countries formed a group under the leadership of Marshall Islands, received the support of more than 100 countries including the EU, the USA, and Brazil, to push hard for the more ambitious 1.5°C deal and nearly succeeded to achieve it.

For the first time in 100 years, fossil fuels will lose importance as key ingredients to economic growth in the coming years. The agreement united both the developed and developing

countries and even the countries that rely on income from fossil fuel for their economic growth. The deal will make it morally binding on all the countries that ratify it, to peak GHG emission levels sooner to cut it down. The signed nations are expected to cooperate in keeping the global warming levels from rising over 2°C by the year 2100 and will try to control the rise below 1.5°C.

The signed accord will extend monetary support to manage poor soil conditions due to climate change, construction of walls to stop sea erosion and increasing the use of clean energy technologies such as wind power and solar energy. The developed countries agreed to provide $100 billion every year from the beginning of 2020, to support the clean energy efforts of developing countries. While the signed agreement provides a substantial level of scope to the countries in deciding the level of emission cuts, but, made it mandatory to maintain transparency in the efforts. For every five years, the signed countries need to quantify the progress in meeting the commitments and present newer plans to make further progress in cutting down the global warming levels.

CONCLUSION

The two weeks of political rhetoric and active participation by the climate affected island countries that could garner the support of bigger nations has finally brought us the COP21 deal. As UN Secretary General Ban Ki-moon said at the conclusion, "We have entered a new era of global cooperation on one of the most complex issues ever to confront humanity. For the first time, every country in the world has pledged to curb emissions, strengthen resilience and join in common cause to take common climate action. This is a resounding success for multilateralism." Much of the success of the deal depends on how every country adheres to every single promise made in its INDC and takes efforts to cut down the carbon levels between 2016 and 2030. Now, it is to be seen how the successive generations are going to take this deal in the best interests of humanity. EF

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