energy systems are already functional at the refineries and marketing locations, which also includes the retail outlets. Total solar PV capacity corresponding to this specific use is 250 KWp. Nearly 20 000 units of solar energy stands utilized during 2014/15. That is not all, as 50 MW equivalent wind power projects are under different stages of project implementation. Amongst the proposed initiatives is providing solar power to the retail outlets. Presently, a 258 KWp solar PV power plant is taking shape for captive power consumption at Encore terminal of the company. There is a well-formulated plan of action to use solar power at marketing locations across the length and breadth of country.

Oil and Natural Gas Corporation

Oil and Natural Gas Corporation (ONGC) is a public sector company functioning under the aegis of Ministry of Petroleum and Natural Gas. It is capable of producing about 70% of India's crude oil, which is equivalent to about 25% of the cumulative demand, besides 60% of natural gas. One of the elemental considerations of its mandate is with respect to clean development mechanism or simply the CDM. The company has managed to set up 12 CDM projects, of which one relates to 102 MW wind power plant in the state of Rajasthan. More recently, it has installed small capacity wind turbines at its residential apartments at Bandra in Mumbai. The underlying objective is to demonstrate the effectiveness of both large and small wind regimes for grid-connected power generation.

Oil India Limited

Oil India Limited (OIL) happens to be a fully integrated upstream petroleum company that shot into prominence with its discovery of crude oil in the far east of India, that is, Digboi, Assam, in 1989. OIL showcased its commitment to the renewable energy area with the setting up of two wind power projects at Jaisalmer in Rajasthan. These had respective capacity figures of 13.6 MW and 54 MW. Two more wind-specific projects of a combined capacity (38 MW + 16 MW) were put up at Chandigarh and Patan in Gujarat, respectively. Also, a 5 MW solar energy power plant was also commissioned on January 20, 2014, at Ramgarh, Jaisalmer, in Rajasthan.

Gas Authority of India Ltd

Gas Authority of India Ltd (GAIL) has a massive network of around 11 000 km of gas pipelines besides 2040 km of LPG pipelines. Additionally, the company has about seven gas processing plants of 1.4 million metric tonnes per annum (MMTPA) LPG/LHC capacity and a gas-based petrochemicals plant of 410 000 TPA polymer capacity. GAIL has a strong mandate to reduce the greenhouse gas emissions besides exploring new and renewable sources of energy. The company installed wind energy projects of 118 MW capacity during 2011/12 besides bagging the order to set up a 5 MW solar PV power plant under the ambit of Jawaharlal Nehru National Solar Mission (JNNSM). It has set up a portfolio of renewable businesses (solar and wind) with an investment exceeding ₹700 crore. Importantly, solar power has replaced natural gas as a fuel source to run closed circuit vapour turbines. To meet its water heating end-use application at the residential township in Vijaipur,

it has installed a solar water heating system. This has resulted in massive saving of about 120 000 kWh of annual electricity consumption. GAIL is currently embarking on an ambitious plan to reinforce its renewable energy hallmark. It is planning to establish a 500 MW capacity wind power capacity in the near future. With the present era being that of green buildings, the company has showcased GAIL Jubilee Tower as a LEED green building norm compliant. This includes meeting its captive power generation requirements such as gas engine generators, waste heat recovery to run the air conditioning plant, sewage treatment plant, rainwater harvesting system, zero water discharge feature, and importantly, a 30 kWp solar PV power plant. It is worth mentioning that the green building has been designed to use energy optimally with integration of solar power.

Bharat Petroleum Corporation Limited

The company has been actively pursuing its multi-pronged objective to produce environment-friendly, long-lasting products for the society and, importantly, towards ensuring a cleaner environment. It has accorded high priority to minimizing the energy consumption at the distribution outlets and centres. Bharat Petroleum Corporation Ltd has been successful in providing green lighting and solar systems at about 205 retail outlets during 2014/15. Importantly, it has set up a 5 MW wind farm project at Kappatguda in Karnataka, which stands duly registered with the United Nations Framework Convention for Climate Change (UNFCCC). It is worth mentioning that it has thus received carbon credits for the same. The company is also working on several other renewable energy projects. It includes a 4 MW solar PV power plant installation at Bina dispatch unit besides a 1 MW solar facility at Central Research and Development Centre, NOIDA. Likewise, a 6.3 MW capacity wind farm facility is under active stages of implementation in Karnataka.

Chennai Petroleum Limited

It came into being as a joint venture between the Government of India, AMOCO, and National Iranian Oil Company (NIOC) way back in 1965. This company owns two refineries with a total refining capacity of about 11.5 MMTPA. As is well known, power from solar energy and wind energy technologies is being produced for abatement of greenhouse gas emissions, principally CO_2. The existing CO_2 emission is 2.26 MMT/year, and it has been provisioned to bring down the same by 0.15 MMT by the year 2020 via: (a) improvements in the energy efficiency, (b) utilization of renewable energy technologies, and (c) development of green belt.

As a case-specific initiative, the company has already installed a 100 KWp solar PV power plant at the rooftop of administrative building at Numaligarh during 2014/15.

Mangalore Refinery and Petrochemicals Limited

Mangalore Refinery and Petrochemicals

Table 1 Mitigation efforts of various petroleum companies

Company	Actionable Mitigation Measure (s)
Oil India Limited	■ Wind energy projects of 67.6 MW in Rajasthan ■ Solar power of 5 MW capacity besides 9 MW in Rajasthan ■ 100 kWp solar captive power plant in Rajasthan ■ 20 kWp solar power plant at repeater station no. 5, Jagiroad in pipeline sphere of OIL
Oil and Natural Gas Commission	51 MW wind power project at Bhuj, Gujarat, with an emission reduction of 238 341 MT CO_2e for two years. Certified verification of the monitoring mechanism by UNFCCC-accredited verifying agencies
Indian Oil Corporation	■ 5 MW solar PV plant installed in Rajasthan with cumulative generation of more than 27 GWh and resultant carbon emission reduction of about 22 TMT CO_2e ■ 1.3 MW of off-grid solar power installed at refineries, office buildings, etc. with total annual generation capacity of 1.6 GWh and resultant carbon emission reduction potential of 1.3 TMT CO_2e ■ 3298 retail outlets/Kisan Sewa Kendras solarized with a cumulative capacity of 12 MW. Annual generation capacity of 14 GWh accompanied by resultant carbon emission reduction of about 12 TMT CO_2e
Bharat Petroleum Corporation Limited	■ Wind farm of 4 × 1.250 MW, i.e., 5 MW capacity installed at Kapatgudda in Karnataka with an annual power generation of 9 119 000 units and resultant annual CO_2 mitigated quantity of 7386.390 MT ■ Wind farm of 2 × 250 KW installed at Muppandal in Tamil Nadu with annual power generation of 415 362 units and resultant CO2 mitigated quantity of 336.444 MTPA ■ Two solar PV projects, i.e., MMBPL solar project of 157.2 KW and at various other locations (total capacity of 154.67 KW) installed. Annual power generation of 261 643.68 and 477 458.11 units and annual CO_2 mitigated quantity of 211.931 MT/386.741 MT, respectively ■ Total annual power generation (i.e., units) via both wind power and solar power equivalent to 10 273 464.59. Total annual CO_2 mitigated due to both these sources equivalent to 8321.506 MT

Ltd (MRPL) is a subsidiary of Oil and Natural Gas Commission. It is widely regarded as a state-of-the-art grassroots refinery with a versatile design and high flexibility to process the crudes of various types. The company possesses the design capacity to process 15 MMTPA. As a part of its renewable energy commitment, it has provided solar lights in many places both within the refinery and associated township. Much in accordance with an on-going favour for solar PV rooftop systems, MRPL laid bare solar modules on around 10 000 m^2 area during the FY 2015/16. The purpose is to save energy via utilization of the freely available solar energy. The company is planning a massive deployment of solar modules on a rooftop area of 50 000 m^2 on the sub-stations and central control rooms in phases I and II within the refinery premises.

Bharat Oman Refineries Limited

Bharat Oman Refineries Ltd is a joint venture company of Bharat Petroleum Company and Oman Oil Company, Sultanate of Oman. The company has put in place an energy policy in 2014/15 as per which it has already identified several initiatives much in accordance with the 'National Action Plan for Climate Change (NAPCC). Some of these initiatives are clearly mentioned here.

- One solar and wind power systems each at refinery and township. Solar power thus produced is used for providing power to the wireless cameras and networking systems for the surveillance system.
- Installation of solar power based electric fence cicumfencing the refinery area and township property, of around 22 km.
- Installation of 2 × 1000 LPD capacity of solar water heating systems at the residential township.

Balmer Lawrie Initiative

The company has installed solar power plants ranging in capacity between 1 and 60 kWp at its industrial packaging units located in Asaoti and Navi Mumbai way back in 2004. It is proposed to install a solar PV power plant of about 250 kWp capacity at its manufacturing units by 2019.

The cumulative impact on mitigation

As is quite evident, each company within the petroleum sector has taken up a series of initiatives towards incorporation of renewable energy technologies. These companies have viewed these technologies from the consideration of greenhouse gas abatement promise as well. Table 1 summarizes the mitigation efforts of these companies at a quick glance.

The Growing Alliance

Renewable energy technologies, specially wind and solar, are marching from strength to strength on several counts. In fact, solar power is regarded as the fastest growing energy source worldwide. The favourable policy regulations provided by the concerned Ministry of New and Renewable Energy in India has made solar power the most talked about, both in the echelons of power as well as common streets. Expectedly, the Indian petroleum sector may enhance its utilization of renewable energy manifold in the backdrop of its well-demonstrated experience with such technologies. There is no other choice except to have a judicious energy mix so as to reap the maximum possible dividends regardless of the traditionally held beliefs about a certain technology area. EF

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TORREFACTION OPTION FOR CLEANER COOKING SOLUTION

Billions of people around the world, especially in developing countries, continue to use polluting and hazardous biomass fuel for cooking and other domestic purposes. One of the solutions to this problem is torrefaction of the biomass to coal-like material, which has better fuel characteristics than the original biomass. **Paltu Acharjee** and **Avishek Goel** reports the process and benefits of this process.

Globally, energy supply from biomass accounts for 10% of the total energy demand, of which roughly two-third of the energy is required for residential applications. Nearly 3 billion people (600 million households), which accounts for approximately half of the world population, still depends on solid fuels for cooking and heating their homes each day. Even many of the households using modern fuel cookstoves as their primary cooking solution (nearly 1.8 billion people) still use traditional solid fuel cookstoves as their secondary cooking solution. Hence, across the world, wood is still the primary fuel for cooking with use of over 1 billion MT annually with developing countries being the major consumer using 720 million MT of demand.

In developing regions such as Africa and South East Asia, the dependency on solid fuel for cooking is still as high as 77% and 61%, respectively (Figure 1). Even developed regions such as Americas and Europe still use 14% and 7% solid fuel for cooking, respectively.

In developing country such as India, over 180 million tonnes of biomass is used for cooking in nearly 166 million households every year. Top 10 states of India with maximum use of biomass for cooking have been listed in Figure 2.

As per census of India (2011), nearly 75% of rural households use solid biomass as fuel for cooking and heating purposes, and nearly 50% of the total cooking fuel consumed in the country comes from firewood combustion (Figure 3).

This energy, which is said to be a pre-requisite for good health, has a harsh reality that has largely been ignored by the world.

How Healthy is Our Cooking System?

The use of traditional biomass cookstoves and open cooking fire techniques, a common practice in almost all the developing countries, generates greenhouse gas emissions that pose serious threats to health, especially to the health of women and children. For most of the women in rural areas, their working hours are stretched from dawn to long after dark. Cooking and fuel collection are the most strenuous task for a rural women,

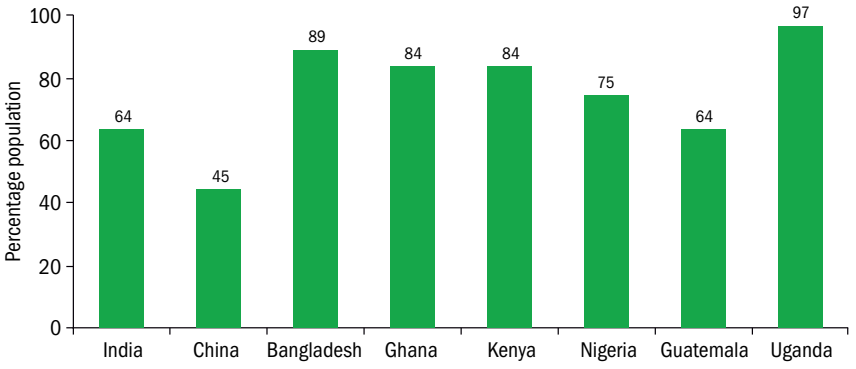

Figure 1 Dependency of some countries on solid biomass fuel for cooking

Source: Country Profiles: Global Alliance for Clean Cookstoves. Retrieved from http://cleancookstoves.org/country-profiles/focus-countries/index.html

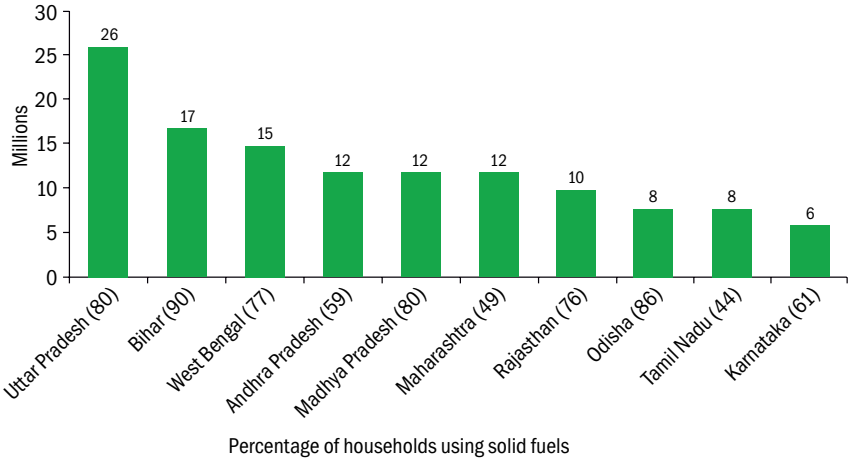

Figure 2 Number of household using solid fuel

Source: India Cookstoves and fuel market assessment (2013). Global Alliance for Clean Cookstoves

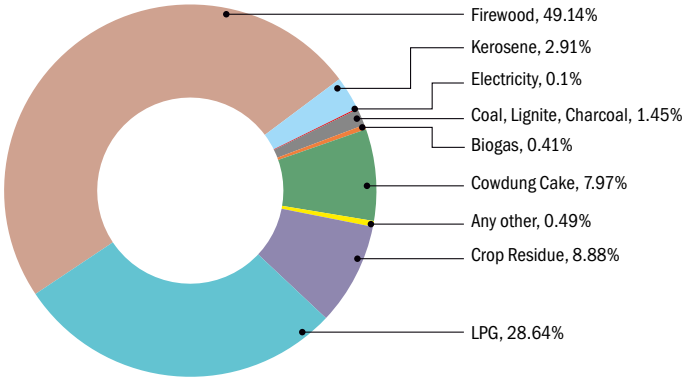

Figure 3 Percentage share of cooking fuel in India

especially because they spend nearly 1.5 hours every day on collecting fuel and around 3.5 hours each day to prepare meals. It is estimated that 78 million households in India do not have proper indoor kitchen facility, and cooking is usually done in one corner of the room. While 138 million households have indoor kitchen facilities, most of them are poorly lit and ventilated. Long duration of exposure to carrying heavy loads and indoor air pollution due to cooking can lead to spinal and head injuries, maternal mortality and pregnancy complications, and other serious health issues.

Across the developing world, solid fuel cooking increases the annual carbon footprint by 1.3–1.7 billion MT of CO_2-equivalent, which includes 1500 Gg of black carbon; CO_2-equivalent emissions from N_2O and CH_4, carbon monoxide, and non-methane hydrocarbons generated due to incomplete combustion. Indoor air pollution contributes 12% of the global ambient air pollution. It has been reported that pollutant released indoors causes more harm to humans as it is thousand times more likely to reach a person's lungs than any pollutant released outdoors.

As per a World Health Organization report in 2012, household air pollution (HAP) accounts for a total of 4.3 million premature deaths annually, making it the fourth biggest health risk in developing countries (Table 1).

Table 1 Deaths due to HAP

Country	No. of deaths
India	1 250 325
China	1 467 954
Bangladesh	85 035
Ghana	17 465
Kenya	21 691
Nigeria	128 481
Guatemala	5138
Uganda	20 954

Higher risk of health is for women and children as they are majorly involved in cooking activities. Nearly 41% women with age of 25 years and above are affected due to HAP while children below 5 years accounts for 13% of the total deaths due HAP, the same report suggests. Figure 4 represents deaths caused by various diseases due to HAP.

Thus, lack of inconvenience related with the use of traditional fuels along with indoor air pollution itself is one of the key drivers for transiting to modern forms in clean cooking energy.

Biomass Pre-treatment: An Option for Clean Cooking Solution

Although many initiatives have been taken up and millions of cookstoves

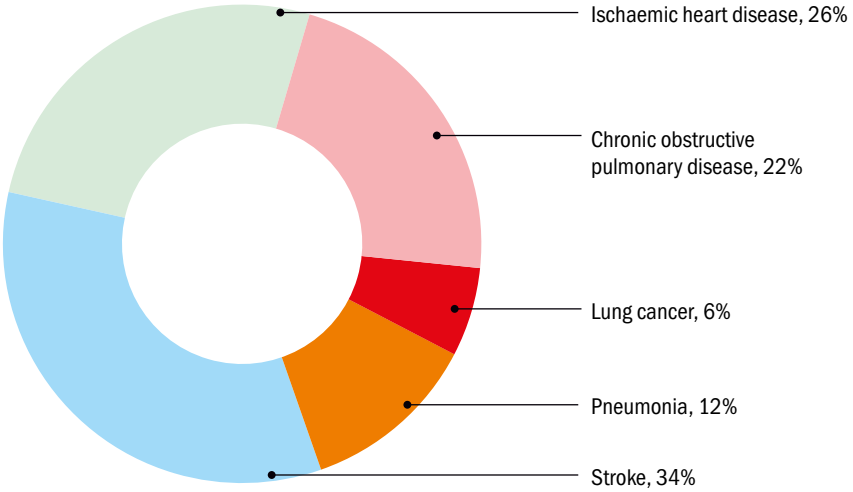

Figure 4 Percentage deaths caused by various diseases due to HAP

been distributed to provide clean cooking conditions, clean still remains a nebulous term. Until now, concentration has been mainly on the technology advancement of cookstoves and its distribution. However, it is clear that real benefits will involve use of pre-treated fuel with appropriate physiochemical characteristics.

Biomass pre-treatment will therefore play an important role for access to clean cooking solution in the developing world, particularly where solid-fuel–based cooking will remain dominant in the future. Although there are practices of using conventional processed biomass in the form of pellets and briquettes, users have expressed their concerns against its use due to the smell it creates and the emission it generates.

Emissions generated by burning them produces great amount of smoke during initial combustion, which is due to its high volatile content. Therefore, it becomes important to process or pre-treat the fuel to increase cleanliness and efficiency of cooking, thus making fuel an essential part of the equation for ensuring access to clean cooking.

Torrefaction: An Effective Method for Biomass Pre-Treatment

Torrefaction is a thermochemical process that lowers the O/C and H/C ratio of biomass, which is carried out for the upgradation of raw biomass to improve its product properties such as energy density, hydrophobicity, grindability, etc. with the removal of smoke-producing compounds while retaining around 80%–90% of its energy content. Compared to original wood, torrefaction decreases volatile and moisture content while increasing the heating value, thus making it a clean burning fuel. Biomass mainly consists of hemicellulose, cellulose, lignin, as well as other minor components. The degradation of each of these occurs within distinct temperature range. The volatile content of the biomass is generated from decomposition of hemicellulose and cellulose while decomposing major part of hemicellulose. The main reactions of torrefaction include dehydration,

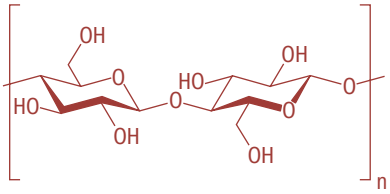

Figure 5 Cellulose structure

decarboxylation, and deacetylation, majorly of the xylan-containing hemicellulose polymers. Thermal treatment that the biomass undergoes during torrefaction affects majorly the hemicellulose fraction of the biomass by breaking the bonds that provides strength to the fibrous structure of trees. Since hemicellulose gives the biomass its tenacious nature, torrefaction results in vast grindability improvement of the fuel. Due to chemical complexity of lignin, it is more difficult to decompose.

Cellulose (Figure 5) is a linear homopolymer composed of D-glucopyranose units linked by -1,4-glycosidic bonds. The complex structure of cellulose consists of unbranched chains of linked glucose units. It decomposes in the temperature range of 305–375°C.

Phenylpropane units when non-linearly and randomly linked forms a complex structure called Lignin, which mainly consists of three monomers: coumaryl alcohol, coniferyl alcohol, and sinapyl alcohol (Figure 6). Lignin gradually decomposes over the temperature range of 250–500°C.

Hemicellulose (Figure 7) are branched polymers (also a polysaccharide)

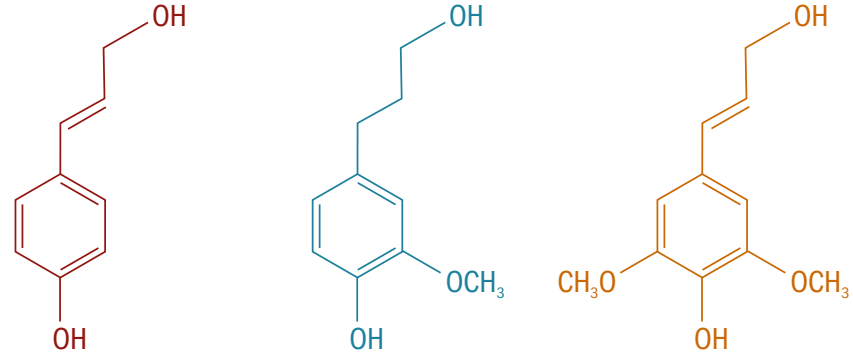

Figure 6 Monomers of Lignin

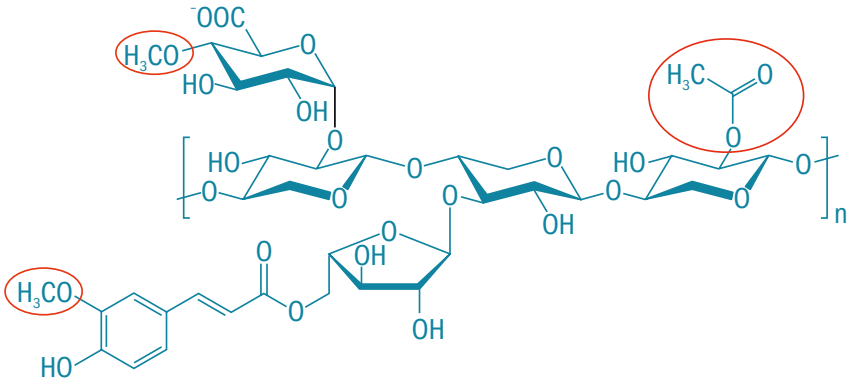

Figure 7 Hemicellulose structure

consisting of shorter chains (500–3000 sugars units as compared to 7000–15 000 glucose molecules per polymer in cellulose). Hemicellulose is the glucan in the matrix of the cell, and the main components are xylan, xyloglucan, glucomannan, manna, galactomannan, callose. Hemicellulose being the most reactive compound during torrefaction decomposes in the temperature range of 225–325°C.

Dry torrefaction process starts with the loss of biomass moisture in the temperature range of 50–150°C due to the evaporation of free and bound moisture. Hemicellulose start drying and lignin enters into the glass transition phase where it begins to soften. In the temperature range of 150–200°C, depolymerization and recondensation of hemicellulose begins whereas cellulose starts to dry and lignin still remains in the glass transition phase. Hydrogen and carbon bonds begin to break. Near 200°C, hemicellulose and lignin starts decomposing to an extent of around 10% and 15%, respectively, while mass of cellulose almost remains same.

Temperature between 200°C and 300°C is called the torrefaction range, in which hemicellulose begins to devolatilize and carbonize. Xylan, which is the most reactive polymer, begins to decompose resulting in the formation of acetic acid and methanol due to breaking of acetoxy and methoxy groups (shown in Figure 7), which are attached to the polysugars of hemicellulose present in side chains of xylose units. Lignin begins to devolatilize and carbonize, which results in the formation of CO_2 due to the decarboxylation of acid groups.

The thermal decomposition of hemicellulose during wet torrefaction, carried out in a hydrothermal media with elevated temperatures and at a pressure higher than the saturated vapour pressure at wet torrefaction temperature has been shown in Figure 8.

When the temperature reaches 250°C, hemicellulose and lignin decompose to around 50% and 80%, respectively, while

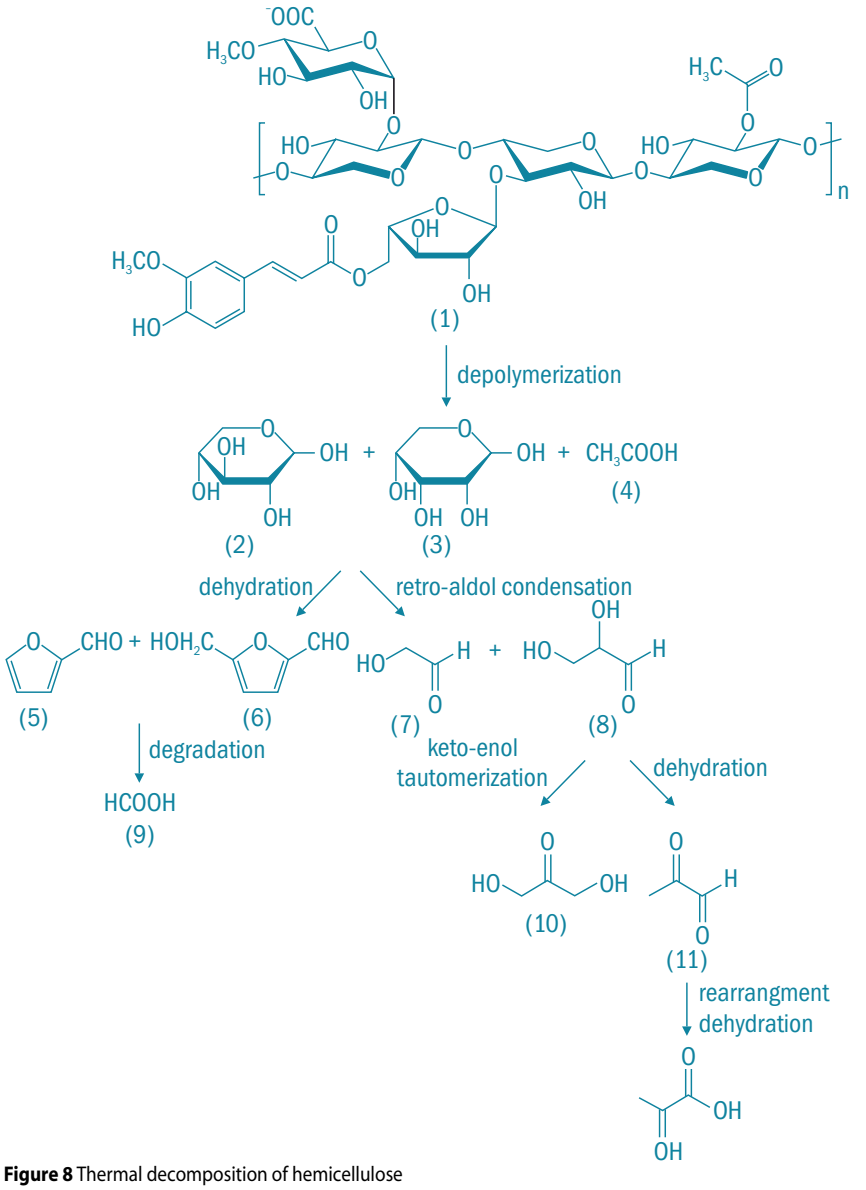

Figure 8 Thermal decomposition of hemicellulose

Source: Quang-VuBach n, ØyvindSkreiberg (2015). Upgrading biomass fuels via wet torrefaction: A review and comparison with dry torrefaction.

cellulose decomposes to around 90%. Cellulose being least reactive starts to devolatilize and carbonize near 280°C. This is also called a phase of destructive drying as it observes the disruption of inter and intra-molecular C-C, C-O, and hydrogen bonds. Formation of hydrophilic extractives, such as carboxylic acids, aldehydes, alcohols, ethers, and some gases, such as CO, CO_2, and CH_4, are also registered during this phase. Formation of CO can be attributed to the reaction of steam and carbon dioxide with porous char.

Thus, torrefaction results in the formation of three major products:

- Solid, which mainly consists of sugar structures, modified sugar structures, newly formed polymeric structures, char, and ash. Solid yield can vary between 68.9% and 86.9% (moisture and ash free basis) depending on the torrefaction temperature.
- Condensable liquid, that is, water; organics, such as sugar, polysugar acids, alcohols, furans, and ketones; lipids, such as terpenes, phenols, fatty acids, waxes, and tanins. Condensable liquids can vary between 11.5% and 26.3% (moisture- and ash-free basis), depending on the torrefaction temperature.
- Non-condensable volatiles comprising hydrogen, carbon dioxide, carbon monoxide, methane, toluene, benzene, etc. Yield of non-condensable volatiles or gases can vary between 1.6% and 4.8% (moisture and ash free basis), depending on the torrefaction temperature.

TERI-designed Gasifier-integrated Biomass Torrefier (GBT)

The TERI-designed torrefier is a fully automatic gasifier integrated system with precise temperature control that makes it suitable for production of both torrefied biomass and biochar (Figure 9).

What Torrefaction can Offer

Torrefaction yields a more uniform solid product with high energy content and lower moisture content as compared to initial biomass, and it can substitute charcoal in a number of applications, such as residential heating, manufacture of improved fuel pellets, and domestic fuel for cooking. Its properties are similar to coal with more stable combustion characteristics than untreated biomass.

Improvement in the biomass quality due to torrefaction

Biomass becomes hydrophobic: Torrefied biomass has a hydrophobic nature because torrefaction process destroys the hydroxyl (-OH) groups and forms of C=O group, which forces the biomass to lose the capacity to form hydrogen bonds. These chemical rearrangement reactions result in formation of nonpolar unsaturated structures, thus preserving the biomass for a longer time from any biological degradation. A polar characteristic of condensed tar is another reason for prevention of water vapour condensation through the pores. A comparison chart depicting hydrophobicity has been shown in Figure 10.

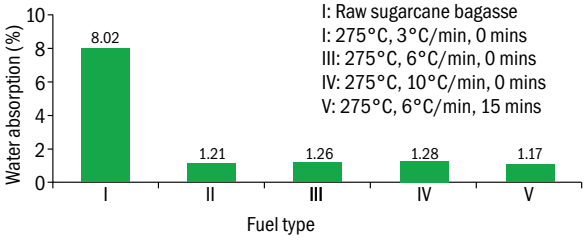

Figure 10 Hydrophobicity for raw and torrefied sugarcane bagasse

Source: Dijan Supramono, Yosephine Merry Devina, Dewi Tristantini (2015). Effect of heating rate of torrefaction of sugarcane bagasse on its physical characteristics.

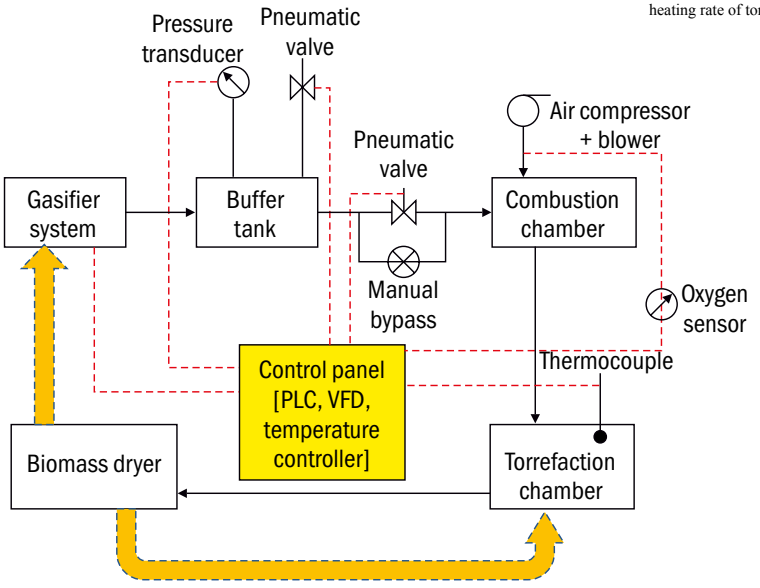

Figure 9 Schematic of Integrated Gasifier Torrefier System

High heating value and high energy yield

Torrefaction of biomass retains 90%% of the energy value whereas charcoal retains only around 45%–55% of the original wood species. The increase in heating value per unit mass can be attributed to the loss of less energy dense volatiles such as acetic acid, methanol, water, and carbon dioxide. As the torrefaction temperature and residence time increases, the carbon content increases while decreasing the hydrogen and oxygen content, thus increasing the calorific value of the biomass.

Experimentally, it has been proved that when wheat straw and rice straw

are torrefied at 260°C for a period of 1 hour, their heating value increased by more than 15%. For bamboo, the heating value increases approximately 20%, that is, from 18 MJ/kg to 21 MJ/kg when torrefied at 250°C for 30 minutes. As the severity of torrefaction increases, the mass yield decreases while increasing the heating value of the biomass.

Increased grindability

Torrefaction helps in increasing grindability as it makes the biomass more brittle, thus producing greater amounts of fine particles than raw biomass. Torrefied biomass becomes more brittle due to the breakdown of lignin, hemicellulose, and cellulose, thus destroying the tenacious structure of lignocellulosic biomass.

Reduced emissions

Torrefied wood combustion generates very less smoke and pollutants, such as CO, NOx, and particulate matter as compared to raw biomass thus making it a cleaner fuel than the raw biomass itself. A comparison of smoke emissions for raw and torrefied wood has been shown in Figure 11.

In conclusion, Figure 12 shows an example of emissions generation from hardwood, torrefied wood, and coal during various phases of combustion. EF

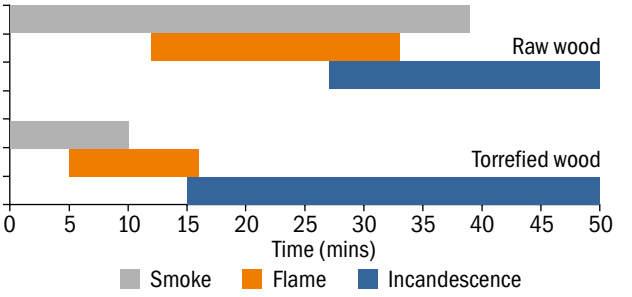

Figure 11 Combustion characteristics of raw and torrefied wood6

Source Ranu pentananunt, A. N. M. Mizanur rahman, and S. C. Bhattacharva (1990). Upgrading of Biomass by means of torrefaction.

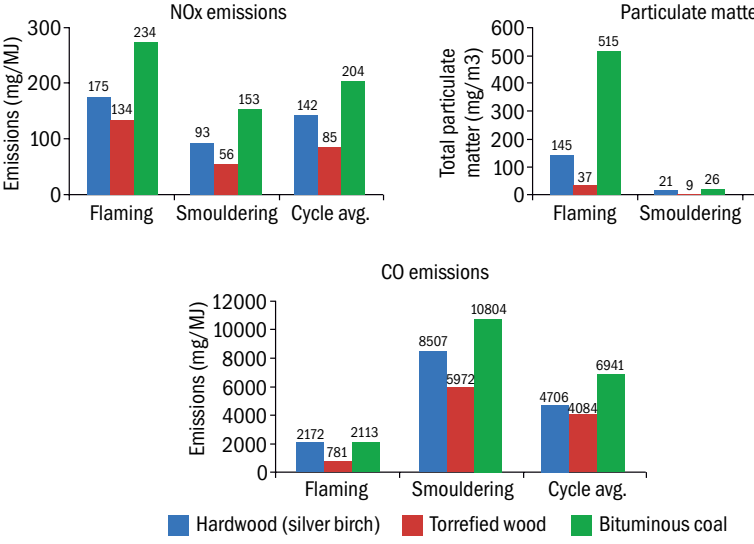

Figure 12 Emissions from hardwood, torrefied wood, and coal

Source E.J.S. Mitchell, A.R. Lea-Langton, J.M. Jones, A. Williams, P. Layden, R. Johnson (2016). The impact of fuel properties on the emissions from the combustion of biomass and other solid fuels in a fixed bed domestic stove.

INDIA'S PLACE IN THE SUN

THE INTERNATIONAL SOLAR ALLIANCE

The COP21 held in Paris, in December 2015, adopted the first-ever universal, legally-binding global climate deal with 195 countries ratifying it. The agreement sets out a global action plan to put the world on track to combat climate change by limiting global warming. During the global summit, the International Solar Alliance was launched, jointly by India and France, with more than 120 countries to boost solar power in developing nations. It was then formally inaugurated in India by the French President, His Excellency Francois Hollande together with India's Prime Minister Shri Narendra Modi in January 2016 at Gurugram, Haryana. **Om Prakash Nangia**, through this article, presents an overview of the ISA and its India connection.

Since COP21, the International Solar Alliance (ISA) is engaging itself with international organizations/ agencies that are at the forefront of development of a vast reservoir of solar energy applications and help in mitigating global warming. The alliance, formed under India's initiative along with the COP21 host country, France, has been consolidating the roles of the partner agencies vis-a-vis their own mandate for facilitating technology transfer in the area of solar energy, focussing on capacity building and skill development, and raising project investment funding with global collaborations.

With a view to create an emission-free environment, ISA plans to exploit high solar potential, in different continents of the world, by organizing a series of technology- and finance-oriented conferences. With the vigorous worldwide momentum developed at COP21 towards climate change (year of enforcement being 2020), the alliance has great technological merits in establishing low-carbon fuel sources as an alternative to fossil fuels to generate green power and provide energy security. To meet the ambitious goals in the energy sector by increasing clean energy investments, an important declaration has been signed recently in New Delhi between ISA Cell and World Bank for global promotion of solar energy.

The Government of India aims to lead the world in the field of clean energy. The responsibility lies in meeting climate change challenge via harvesting of solar energy on a mass scale with cost effectiveness, a time-bound target, and the motivation of youth manpower in skill development. Towards the INDC (Intended Nationally Determined

Contribution) commitment at COP21, India has set a huge target of achieving 100 GW solar power by 2022 and thereby meeting the goal of providing 'Electricity for All' in the country. India, today, is one of the fastest progressing countries in solar energy installations and its solar market is the fourth largest in the world.

Technological Merits

Solar PV transforms the lives of millions through affordable modern solar energy applications. At COP21, it was declared that 100% renewable energy is the achievable target. Increasing industrialization is leading to a steep demand for electricity, especially in the developing and under developed countries, and it is becoming economically manageable due to solar becoming a major energy source.

With the objective of reducing carbon footprints through generation of green electricity from the infinite solar resource, the technological merit lies in innovative advancements and know-how transfers from the developed world. As per the Solar Energy Industry Association (SEIA)—USA, the country has reached, in May 2016 an amazing one million mark of solar installations. Similar leadership and commitment towards clean energy, by virtue of the combined strength of both technology and finance, has been demonstrated by Germany. The ISA is embarking to carry out activities in a similar model to achieve its clean energy objectives of developing and utilizing low carbon fuel sources. With World Bank support, a declaration has been signed with ISA in India and the major technical areas of joint working for development and deployment of solar energy include—(a) technical assistance and (b) knowledge transfer.

In a short span of time, the ISA activities have increased significantly. Two of its programmes, that is, 'Affordable finance at scale' and 'Scaling solar applications for agricultural use', have been launched. Solar, being a reliable and clean fuel source,

establishment of a 24x7 knowledge centre is underway with the help of UNDP and NIC, GoI. The government is also planning to give a boost to technology upgradation for the domestic PV industry, thus, fostering economic production of clean power while limiting the impact of global warming.

New Solar Developments

The new developments—energy storage, floating PV, and solar roadways—involving solar technologies are fast leading to commercialization. The technological merits of these novel applications could be a part of ISA's agenda for the benefit of mankind in mitigating global warming.

Energy storage

An important ongoing R&D work at the international level is the stability in performance of solar systems, which comes across certain challenges in terms of intermittent nature of renewable energies (solar, wind). The research on energy storage systems, coupled with renewable energy, is basically targeted to smooth out the variable outputs. Recently, the energy storage demonstration projects have been undertaken with initial funding of USD 18 bn by US Department of Energy. These projects are likely to pave way for development of integrated and economically viable and reliable solar technologies in tandem with commercial energy storage systems. The combination of renewable energy technologies, especially solar, with energy storage systems is likely to be economically productive to fuel further growth.

Floating PV

The floating PV systems are in the process of development since 2007. The world's first floating photovoltaic system was installed in 2007 by SPG Solar at Far Niente Winery in Napa, USA. In this project 1000 floating solar panels were linked to 1300 stationary panels on land to produce a total of 4 MW.

Some of the benefits of floating PV systems are:

- Water absorbs heat collected by the floating solar arrays, thereby cooling them.
- The cooler environment also reduces stress on the system, extending the system's lifespan.
- The water cooling effect on silicon solar cells (increasing solar panel

efficiency), ensures power production. NTPC Ltd (a GoI enterprise) is readying its 5 kWp floating solar PV project at Karakulam combined cycle power project site, in collaboration with the Central Institute of Plastics Engineering and Technology. Another state-owned enterprise, NHPC Ltd, is also venturing in the new floating PV project in a big way in India.

The challenges with reference to usage of floating PV are:

- Presence of water and humidity could mean faster than average corrosion of components—from pontoons to the panels. What measures need to be taken to prevent this?
- How much does pontoon technology add to the overall price of a solar project, taking all factors into account?

Solar roadways

Highways, also known as solar roadways (developed in US first in 2006), have emerged as another novel technological development of solar. The new technology replaces the traditional carriageway surface with solar panels. The project involves paving a section of the highway with these large, thick hexagon-shaped installations, built to stay all weather, and strong enough to handle a load capacity of 110 000 kg. Amongst the solar panels' innovative feature is their capability to heat a road to keep its surface free of ice and snow. The developers believe that the technology is sturdy, durable, efficient, and they foresee the application as a smart grid (an electricity supply network that can sensor usage and respond to needs as required). With further development work by ISA, it could make a head start in benefitting from a new application with unique merits of harnessing solar energy.

The Netherlands and France have also initiated development activities on solar roadways technology. The French government announced, in February 2016, a pilot project to power street lighting for a township, using solar panel paving technology laid out over 1 km of road.

Under ISA's initiative, India, with high solar insolation levels, could be next in line to follow France, to exploit and derive merits of solar technology towards generation of emission free clean energy for masses and taking on the climate change challenge.

Climate Change Challenges

With a focussed view to save Earth from global warming, the Climate Accord at the UN COP21 in Paris has been finalized on limiting global warming by maintaining the surface temperature below 2°C limit and reducing greenhouse gas (GHG) emission from 26% to 28 % by 2025 (from the 2005 levels). The severe impact of climate change essentially requires an action plan to combat and ward off its dangers.

Solar, being the focal point, is the key to restrict climate change; the initiatives taken by the ISA in this regard are highly crucial. Over reliance on fossil fuels has to be minimized at any cost globally, which otherwise could be dangerous for global warming, thus, causing high tides of sea levels, submersion, and mass destruction of cities. The other hazardous effects are severe health problems of citizens, scarcity of food and agriculture, and overall slowing down of development process.

The major areas of work on climate challenges and the initiatives being undertaken in India in the context of ISA's objectives are:

- Limiting global warming vis-a-vis harmful emissions.
- Switching over to cleaner fuel sources and boosting green power output.
- Developing energy infrastructure with dedicated renewable energy transmission corridors.
- Skill development for large manpower resources (young age group).
- Earmarking a fund corpus and encouraging investments in clean energy systems.

The Government of India has pledged to foster less carbon-intensive economic production in the country. It has planned to boost renewable energy capacity to 175 GW by 2022 and the target of clean energy generation through solar alone has steeply increased to 100 GW from the earlier 20 GW level. The overall aim is to source at least 40% from clean sources, such as solar and wind, by 2030.

The final UN agreement in Paris includes a commitment from developed countries to provide USD 100 billion a year, to developing countries, for mitigation and adaptation from 2020 onwards.

The joint declaration recently signed in India by the ISA and the World Bank is likely to ease the mobilization of finance for solar energy and the World Bank will have a major role in

mobilizing more than USD 1000 billion in investments that will be needed by 2030. The following major areas for the joint working have been identified in the declaration:

- Developing a roadmap to mobilize financing
- Developing financing instruments including credit enhancement, reduce hedging costs/currency risk, bond raising in locally denominated currencies, etc., which support development and deployment of solar energy
- Supporting ISA's solar energy plans through technical assistance and knowledge transfer
- Working on mobilization of concessional financing through existing/new trust funds

At present, there is a shortfall in power evacuation infrastructure as the current grid capacity is totally inadequate to handle the large inflow of renewable power. The current grid capacity is not designed for evacuating 175 GW of renewable energy target and, so, introduction of dedicated transmission highways will be essential for transmitting power from renewable sources of energy through enhanced grid capacity. A stable grid is necessary to facilitate delivery of power on utility scale. The Green Energy Transmission Corridors project, under implementation by the GoI enterprise, Power Grid Corporation of India Limited (PGCIL), to transmit clean energy, will be the backbone for renewable power evacuation. It shall be a dedicated transmission network for mass chunks of power from rich renewable power states to the ones requiring higher energy demand. Investment in efficient, inter-state transmission infrastructure to address the intermittency of renewable energy, is therefore, critical to optimal use of renewable energy.

The Asian Development Bank is providing a USD500 million government-backed loan and a further USD500 million in non-sovereign lending to PGCIL for the government's Green Energy Corridor initiative. The new transmission lines, connecting renewable energy-rich areas to the national grid, will enhance connectivity, making the overall power system rugged and efficient.

Suryamitra Skill Development Programme is a flagship programme of the Ministry of New & Renewable Energy (MNRE), GoI. It is implemented by National Institute of Solar Energy (NISE), Gurugram (Haryana), across the country, through training institutions identified by state nodal agencies and approved by NISE. It is a residential programme and there is no training fee charged from the participants. Certificates to the successful candidates are provided by National Council of Vocational Training (NCVT), GoI. The trained candidates shall have vast opportunities for employment in the growing solar energy project installation, commissioning, operation, and maintenance in India and abroad and entrepreneurship in the solar energy sector.

According to the International Energy Agency (IEA), a cumulative investment of USD 53 trillion is required by 2035 in the energy sector alone. The new funds are likely to enable institutional investors to benefit from the existing growth opportunities. For the first time, the investment strategy encompasses the entire value chain spectrum within renewable sources such as wind power, solar, hydropower, etc. The latest report from the Climate Bonds Initiative, an investor-focussed non-profit organization, found that of the USD 694 billion of climate bonds outstanding in 2016, energy accounted for 19% at USD130 billion, exemplifying a push in investment for renewable energy projects.

Another joint announcement between USA and India signals to work closely for climate change so as to take proactive measures and consolidate the commitment made under the COP21 agreement. The intent of the communication is to be a catalyst for a global solar revolution, enabling high renewable investment funding, through ISA's action plan and in line with Paris Accord for the control of emissions as per set targets. Similarly, the State Bank of India (SBI) and the World Bank signed agreements for a facility of USD 625 million for supporting Grid Connected Rooftop Solar Programme; this will help SBI in financing Grid Connected Rooftop Solar Photovoltaic (GRPV) projects at competitive rates and in turn, supporting the Government of India to achieve its target to generate 40 GW under rooftop solar programme. The eligible beneficiaries would be developers, aggregators, and end-users who wish to set up solar PV projects, mainly on commercial, industrial, and institutional rooftops. The scope of the programme also aims at improving the investment climate for solar PV, strengthen capacity of key institutions, support development of the overall solar rooftop PV market, and help find jobs in solar industry for the technically trained 'Suryamitra' workforce.

Conclusion and Recommendations

The integrated approach towards technology development for establishing manufacturing infrastructure and deploying renewable solar energy systems on a large scale in a cost-effective manner will greatly help in achieving the goal of meeting the challenges of climate change. The existing growth opportunities along with high employment potential in the solar sector with entire value-chain under its gamut, is likely to benefit the diversified investors and funding agencies in bringing transformation in clean power generation while reducing dependence on fossil fuel sources. The emission-free clean environment will be linked to the continued efforts of ISA along with cooperation from other international agencies at the global level. EF

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FLOATING SOLAR POWER PLANT

A novel solution to power and land scarcity!

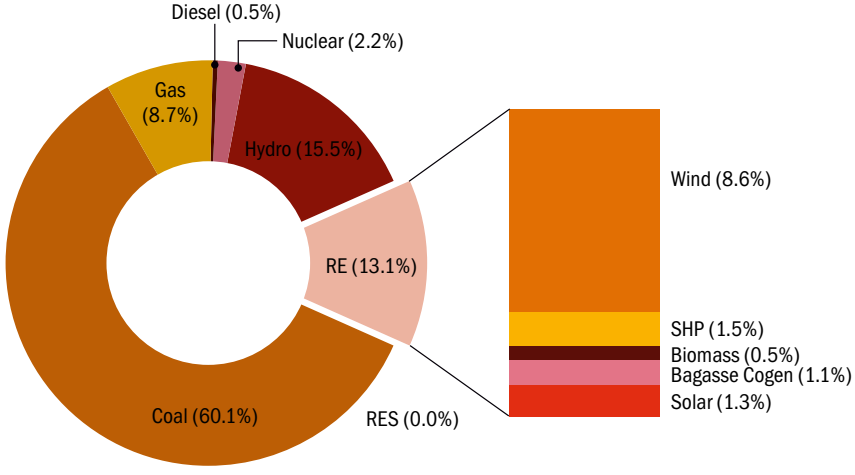
India has set for itself a target of 100 GW of solar power by 2020. However, many problems plague the expansion of solar power. One of the issues facing development of solar plants is scarcity of space. Land is a premium resource in our country already. And, solar plants require large tracts of clear land. A novel solution to resolve this issue is installing floating solar power plants. **Varun Vartak** informs of an upcoming project where water body is being used to build up a solar power plant with added benefits.

More than 300 million Indian inhabitants face inaccessibility to regular electricity on a daily basis. In 1982, Department of Non-Conventional Energy Source enabled India as the first country to set up a ministry dedicated to renewable energy, which was Ministry of New and Renewable Energy (MNRE). Currently, India ranks sixth in power generation at 3.3 GW. Around 175 GW of renewable energy will contribute to 18.9% of the entire power consumption in India by 2022.

The three major demand drivers for renewable energy in India are as follows:

- *Energy security:* The energy deficit is around 30% (as of 2012) as India is a large importer of oil.
- *Economic viability*: By 2019, solar is expected to be cheaper than imported coal.
- *Rural electrification*: Over 85% of rural India is a potential market.

India is one of the best places to produce and consume solar energy because of several factors:



Break-up of Energy Sources Capacity in India (as per MNRE, GoI, and CEA statistics)

- Natural factors such as having states in regions near the equatorial zone.
- Having plateau regions with available sunlight that can be used to harness power.
- Policy reforms allowing a total of 100% of foreign direct investment.

Grid Parity of Solar Power in India

- Price of solar power has reduced from ₹17.91/kWh in 2010 to ₹7/kWh in 2015.
- India seems to have the highest GDP contribution in RE at around 5%–6%.[1]
- In India, almost 60% of the solar capacity is expected to be installed by 2017 with a lot of focus on the southern part of India.

Renewable Initiative of Floating Solar

With India being the seventh largest country in terms of geographical area

[1] IEEFA, November 2015

and gifted with moderately fair sunshine for almost 300 days in a year, it has immense potential for solar power. The geography of India has large areas of fresh water reserves that are stagnant in nature.

The limiting factors affecting application of solar energy set ups in India are as follows:

- High initial cost
- Need for space to install the panels
- Limited electricity production

Small solar-systems (~₹45 000) can generate power for only three lights, a couple of fans, and a television.

Floating Solar Power and India

Floating solar plants are a rarity in the world and not many countries have invested in this technology for R&D or its implementation. Countries such as Japan, France, and Australia other than India are working towards successfully commissioning the floating solar plants.

India's first floating solar plant technology was developed by Renewable Energy College. The funding was provided by the MNRE. As a pilot project, a power plant was successfully established and tested by India-headquartered module manufacturer Vikram Solar in Rajarhat Newtown in Kolkata in December 2014. India's leading hydro power generator National Hydro Power Corporation (NHPC) in association with Renewable Energy College is planning to set up a 50 MW solar photovoltaic project in Kerala.

Working Principle

Unlike land-based solar plants, floating solar power plants are installed on water reservoirs such as dams, lakes, or rivers. A floating solar power station would be a revolutionary step as it aims to solve the perennial problem of land. The technology is fairly simple; it comprises solar panels that are set up on floating platforms that will be anchored firmly so that it does not sway and resists strong winds. A study by CleanTechnica has also shown that if the inner surfaces of solar panels are kept cooler, then their ability to generate power increases by 16%. As these solar panels would be floating on water, they are expected to stay cool and hence can generate more power than those set up on land. A single megawatt from a conventional generator, such as a coal plant, can theoretically power 400–900 homes. From a solar plant, a single megawatt can power approximately 160 homes. This number can rise or shrink depending on primary factors as follows:

- Amount of sunlight collected
- Amount of energy the homes use/need
- The weather

By building energy generation capacity over water, Government & energy company developers can save both cash and valuable real estate.

Chairman of the Renewable Energy College, SP Gon Choudhury, told *The Economic Times* in 2014, 'The ecology of the water body is not likely to be affected much and it will also reduce evaporation, thus helping preserve water levels during extreme summer.

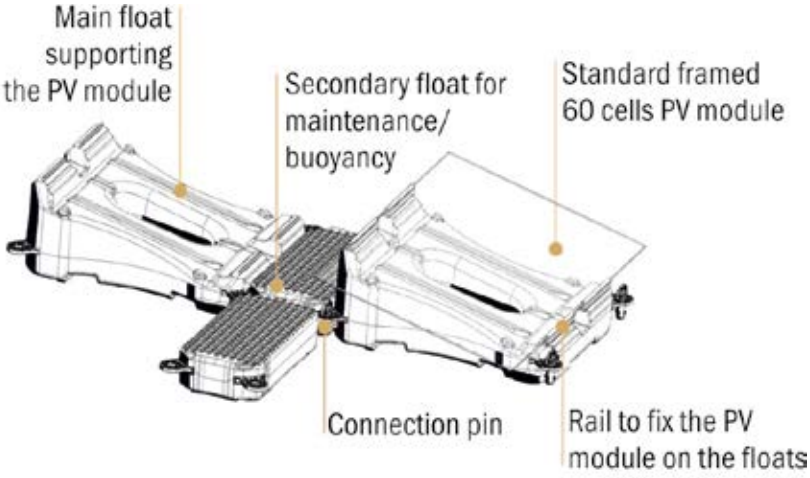
Solar panels installed on land face reduction of yield as the ground heats up. When such panels are installed on a floating platform, the heating problem is solved to a great extent. The College will assist in sourcing material till commissioning of the plant'.

Technology

The technology involved in developing the infrastructure comprises some of the latest used in developed countries. The key challenge in adapting the solar technology to the floating concept was highlighted by K Valsala Kumari, chief engineer of Kerala State Electricity Board (KSEB), 'As usual, water level in dams is rising in monsoon and decreasing in summer. A floating solar power farm is feasible only if the difference between the highest and lowest water level is limited within 10 meters'.

Technical engineers from India Climate Dialogue have predicted that the technology if applied at a magnitude of one-hectare floating solar farm can generate 1 MW power. The floating solar plant consists of the following:

- Main float supporting photovoltaic (PV) module
- Secondary float
- Tab connection
- Gasket to mount PV module
- Standard 60 cells PV module



Project Details

There are large stretches of water bodies in Kerala that NHPC wants to harness for solar power. It is believed that there is a possibility of a Memorandum of Understanding (MoU) between the KSEB and Solar Energy Corporation of India for a joint venture that will implement solar energy programs in the State.

There is news of a proposed solar park that requires around a thousand acres, of which 500 acres is expected to be released to the Kerala board. The proposed solar park is among a slew of projects ranging from rooftop solar photovoltaic facilities to floating solar farms lined up by a multiple agencies in the State that will generate more than 300 MW in two to three years. The State's rush to tap solar power is being led by the Kerala board, which expects to produce more than 250 MW of solar power.

The first project in the proposed solar park is of NHPC located in the West Kallada Panchayat, Kollam district of Kerala.

After the government announced of having provisions for around 200 GW of solar power generation capacity, the land cost of the most susceptible land spaces used for solar generation has gone up by around 20%–30%. Thus, to keep the solar power generation prices from increasing, the water bodies can be used as better alternatives. Benefits that may come across for this project initiative are as follows:

- State and central subsidy that the government provides as part of its solar mission.
- Savings on the land price and yield.
- Surface of the water body can be rented out by the owner, and the rent will be minimal because such water surfaces can be put to no other use.
- Installation of floating solar panels on the water bodies is not expected to affect the ecology of the water body.
- Reduces water evaporation and discourage growth of the algae. This helps in preservation of water levels during extreme summer conditions.

Disadvantages and challenges of the project initiative are as follows:

- Technological challenges associated with installing and commissioning of panels.
- Corrosion of panels due to high moisture content.
- Adverse environmental conditions and stability of the panels during adverse weather conditions.
- Safe transportation and storage of the power from the floating objects.
- Feasibility in use of shock-proof materials.

Status of the Project

The current status of the initiative is as follows:

- Kerala Board will procure the power generated from this project according to a tariff fixed by the Kerala State Electricity Regulatory Commission.
- NHPC has been approached for the project and is likely to procure the land on lease.
- The board and NHPC Limited have signed a MoU for setting up the project.
- The electricity board, in its tender notice inviting Expression of Interest, pointed out that most parts of Kerala receive solar radiation to produce 5–6 kWh of power with about 250 sunny days in a year.
- From financial perspective, 50% of the initial cost will be funded by the KSEB, which would be paid to the developer against bank guarantee, 40% after successful installation and commissioning, and the remaining 10% after the defect liability period.
- The project is projected for completion by 2017.

Inferences and Conclusions

As per the current scenario in India, Renewable Energy is emerging as a good investment decision for less risky

investors. For now, the expected Internal Rate of Return is about 20%. However, this gap will further reduce over time due to economies of scale that drive solar capital costs down while oil becomes even more expensive, because of:

- Inflation
- Increase in demand of energy
- Increased transportation costs

Forecasts show annual 5%–8% decline in the total installed cost of solar projects. But this forecast is predicated on continued double-digit growth in global installations that will drive economies of scale, which combined with technology advances, should continue to improve solar-conversion.

IEEFA forecasts scope to reduce balance of system solar costs by 5%–10% per annum over the next two decades.

Key drivers of this forecast are as follows:

- Lower financing costs,
- The module conversion efficiency,
- Grid parity.

Globally, solar electricity prices in the US have fallen by 20% in just 15 months. In India, the solar energy still poses a short-term challenge of commercial viability even with electricity costs down to ₹5 per kWh against the average cost of wholesale electricity in India of ₹3–4 per kWh.

Prices hit a record low of ₹5.17–5.35/kWh in July 2015. Under current federal policies, the cost of support for meeting India's renewable energy targets is ₹2.71/W.

To conclude, a concept of CSR (Corporate Social Responsibility) in renewable energy should be developed and all key opinion leaders should probe the feasibility of the concept. EF

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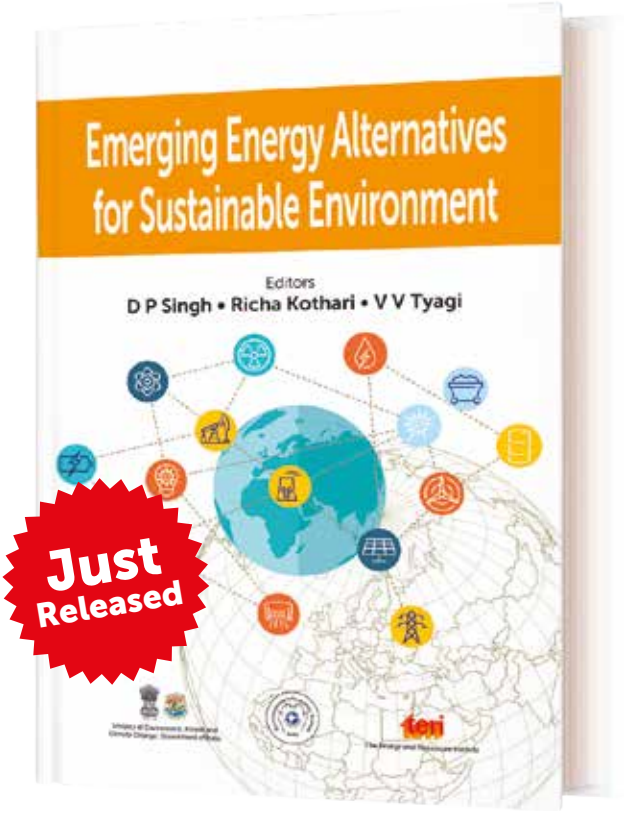
INDIA'S FIRST FLOATING SOLAR PLANT TECHNOLOGY WAS DEVELOPED BY RENEWABLE ENERGY COLLEGE. THE FUNDING WAS PROVIDED BY THE MNRE. AS A PILOT PROJECT, A POWER PLANT WAS SUCCESSFULLY ESTABLISHED AND TESTED BY INDIA-HEADQUARTERED MODULE MANUFACTURER VIKRAM SOLAR IN RAJARHAT NEWTOWN IN KOLKATA IN DECEMBER 2014.

"Sustainable technologies—the only hope for human survival"



Major topics covered

- Renewable energy sources and recent advances
- Emerging green technologies for sustainable development
- Solid waste management and its potential for energy generation
- Solar energy applications, storage system, and heat transfer
- Hydrogen energy: present and future

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This latest TERI publication aims to address the role of sustainable technologies in energy generation options for clean environment. Emerging Energy Alternatives for Sustainable Environment covers a wide spectrum of energy generation approaches. It provides essential and comprehensive knowledge on green energy technologies that will be useful for engineers, technocrats, and researchers working in this field.

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SEVENTH WORLD RENEWABLE ENERGY TECHNOLOGY CONGRESS AND EXPO 2016

The Seventh World Renewable Energy Technology Congress and Expo was held August 21–23, 2016, at Manekshaw Centre, New Delhi, served as an excellent energy platform for the global renewable energy industry to address various industry issues, including innovations, new technologies, investment opportunities, and project financing. The event was organized by Energy and Environment Foundation. The theme of the event was 'Renewable Energy: What Works'.

Dr Upendra Tripathy, Secretary, Ministry of New and Renewable Energy (MNRE), Government of India, delivered the inaugural address and highlighted the importance of promoting renewable energy and green technology for sustainable future.

Energy and Environment Foundation awarded the prestigious the 'Energy and Environment Foundation Global Excellence Awards 2016' in the Renewable Energy Sector to Dr Upendra Tripathy; Smt. Arundhati Bhattacharya, Chairperson, State Bank of India; Mr Ramesh Kymal, CMD, Gamesa India; Mr Walter Howard, CEO, Alter NRG Corporation; Dr Bibek Bandyopadhyay, Former Advisor, MNRE, Government of India.

The Seventh WRETC 2016 conference deliberated various issues related to Renewable Energy Innovative Financing; Renewable Regulatory Issues—Road Map, Smart Cities, Energy Storage, and Electric Vehicles; Role of Mini Grid for Enabling 24×7 Power for All; Waste-to-Energy; Make in India: Developing Solar–Wind Industries; Solar Rooftop—Emerging Opportunities; Bio-Energy, Biomass: Future Energy for Transportation; and Indo-Swiss Cooperation in Clean Energy: Promoting Innovation.

The conference and expo was attended by national and international delegates. The conference brought together leading international and domestic players, policymakers, government officials, and technocrats on a common platform. The concurrent conference sessions were comprised interesting workshops, interactive panel discussions. The conference had served as an important gateway for worldwide new energy companies to access the Indian market to foster partnerships and collaborations with local players.

The conference and expo was supported by MNRE, Government of India; IREDA; UNESCO, New Delhi; Bergen; State Bank of India; Smart Power India; ReNew Power; NTPC; Alter NRG; Coal India Limited; Oil India Limited; PowerGrid Corporation Ltd; Organic Recycling Systems; ACME; Hero Future Energies; and a large number of professional associations. Entrepreneurship and Management Process International (EMPI) were the knowledge partner of the conference. Participation of future leaders; students from IIT, RGIPT, GERMI, EMPI institute, UPES, Sardar Swaran Singh National Institute of Renewable Energy.

Some of the main features of the resolutions adopted in the conference are as follows:

- Renewable energy has come to the centre stage with the support given by various governments through setting up of RE targets and through their nationally determined commitments. It is time now to identify initiatives that work and scale these up to achieve these targets.

- Financial commitments and innovative financial measures will be essential for large scale adoption of RE options.
- Market-based mechanism for spread of RE needs to be further strengthened by addressing policy and regulatory issues so as to accelerate the 'ease of doing RE business'.
- Sharp reduction in the cost of the solar PV modules and, consequently, energy, provides an opportunity to boost storage options in tandem with solar PV through various innovative mechanisms.
- Given the large opportunities that would be created by the RE markets, development of requisite manpower and generation of employment thereof is essential to sustain the momentum that has been generated.
- In developing countries, these opportunities should also be exploited by strongly promoting initiatives such as 'Make in India'. Strong investment in applied R&D is therefore a must.
- Renewable purchase obligations need to be enforced effectively.
- Off-grid solutions will remain an important component of the RE story. These require massive encouragement; firstly, through policy and then through creation of a large assured market to bring down the costs. Experience has shown commercial viability of 24×7 mini-grid solutions reflected in a good track record of payment by users. Mini- and microgrid policies should be finalized early to boost green power.
- The sub-system costs in the renewables remain an area of concern. Innovative technological and engineering interventions should be promoted so that sub-system costs are also controlled and reduced.
- Renewable energy application, demand side management, and smart grids are the major pillars of Smart City concept. As governments are focusing on Smart Cities, renewable-energy–based systems for their infrastructure requirements should be incorporated at the architectural and design stage, both for passive as well as active formats.
- Given the necessary trend of urbanization and increasing volumes of urban waste, advanced plasma based biomass/waste to biofuel power technologies need to be encouraged to avoid the need for land fill.
- Renewable Energy Policy Frameworks should be put in place at the earliest with a focus separately on grid-connected and off-grid applications. The economic and social advantages should be specifically included in these policies.
- In the solar roof top sector, tariff at the consumption end needs to take into account the avoided cost of the high 'T&D' losses. In addition, it is important that the procedure of roof top installations is accelerated through initiation of simple procedures for such installations.
- Solar thermal technologies have a huge potential for process heat and have attractive payback period. Financing for this sector should be a major initiative.
- Banking sector should be incentivized or mandated to offer preferential rate of interest for sustainability-based projects.
- Electric vehicles and biofuels must be promoted to extend renewable energy applications in the transportation sector. EF

AIM TO EMPOWER OFF-GRID FAMILIES WITH CLEAN ENERGY

In remote, far-flung areas without access to power, lives have changed incredibly, owing to a unique distribution model that aims at providing high-quality solar lamps. Initiated by Frontier Markets, which introduced the concept of Solar Sahelis, it involves a network of trained women who are also the face of the company's marketing and after-sales service. **Ajaita Shah**, Founder and CEO of Frontier Markets, details the company's work so far and the importance of Ashden recognition.

The London-based Ashden charity works in the field of sustainability. Since 2001, the charity has been organizing Awards to recognize different aspects of sustainable living and development. In 2016, two organizations—**Frontier Markets** and **Greenlight Planet**—working in India won the prestigious award. Sapna Gopal speaks to the winners to winners to learn about their success story, targets, and what it means to win the Ashden

What was the main idea behind the launch of Frontier Markets?

Founded in 2011, Frontier Markets serves low-income households in India to provide access to quality and affordable clean energy solution to eradicate the use of deadly kerosene and the dependency on intermittent energy access. It works within local communities to provide employment and income-generating opportunities for women and men through skill development in sales, marketing, technology, and repair.

How has the concept of *Solar Sahelis* helped promote solar products and create awareness?

The *Solar Sahelis* model uses women as the vehicles of change, who connect to rural households within their communities to address the challenges to access solar energy and clean cooking solutions. They have been trained to conduct dark room demos, financial literacy trainings on the savings of solar versus kerosene, coordinate marketing

campaigns, and facilitate story-telling, thereby helping people to recognize solar as a positive change for their lives.

Whose idea was it to launch the *Unnat Chullah*? In what way has it helped women in the villages?

Unnat Chullah was launched by various partners in India—Global Alliance for Clean Cookstoves, Sri Ratan Tata Trust, and the MNRE—who recognized the hazardous realities of traditional stoves used in rural villages for cooking. The purpose of *Unnat Chullah* was to understand the types of traditional cook stoves being used, their challenges, possible alternatives, and then create guidelines on how LPG stoves or induction stoves can be introduced to reduce health, wealth, and safety challenges or how biomass cook stoves can help reduce smoke. In fact, biomass cook stoves have helped reduce the need for wood, made cooking easier, reduced the level of smoke, allowed women to sit with others during this daily task, and helped them control their flame to improved food quality. The programme's activities have also enabled women to discuss their needs with their families and engaged men in the family's health issues.

Frontier Markets has made an inroad into Rajasthan, in over 12 districts of the state. Are there plans to tap other states of India as well?

Yes, the aim is to be in three states of India in the next three years; we are targeting the states of Maharashtra and Madhya Pradesh other than Rajasthan.

Has the Rajasthan government's policy helped spread the cause of solar? What about the solar policy by the Union government? How conducive is it to promoting solar?

Rajasthan's government policy supported solar, introducing many schemes to push the movement. Frontier Markets has been working with several government departments to explore opportunities to translate the policies into action. Specifically, we work with the Rajasthan Rural Livelihoods Department as well as the Forestry Department to tackle electricity challenges in remote areas through solar distribution. The Union government has encouraged Rajasthan to continue including solar as a critical part of their agenda.

Challenges include aligning technology innovation with schemes, mapping out programmes that are being implemented through subsidies, and evaluating subsidy requirements. In order to scale our efforts in solar, we understand that we must work in conjunction with the government and align our missions.

What are your thoughts on Frontier Markets winning the Ashden award?

It is an extremely important award for Frontier Markets. We have always dreamt about winning an Ashden as it's a pinnacle award for our sector. We believe this will be a massive opportunity for us to share our story, create more partnerships, and truly scale our efforts effectively while building the business case for integrating women into the clean energy value chain.

Apart from Frontier Markets, the other company to have won the 2016 Ashden award is **Greenlight Planet** for Increasing Energy Access. **Patrick Walsh**, founder and chief technical officer, speaks on their aim of electrifying 20 million homes by 2020 and how they intend to achieve the target.

What was the aim behind incepting Greenlight Planet? How has it impacted lives?

Founded in 2007, Greenlight Planet is focused on delivering affordable energy to the world's two billion under-electrified consumers. The idea for Greenlight Planet took shape in a University of Illinois dorm room, when I realized that residents in rural villages had a need for healthy, affordable, and sustainable energy options. I also found that rural customers are not charity cases; rather, they are worthy of respect and have preferences and demands for robust, quality products. Hence, I committed myself to making and delivering quality solar lights.

We are on a mission to replace dirty fuel sources across the world with smart, bright solar energy solutions and empower off-grid and rural families with clean energy solutions; hence, catalysing their transformation towards a better life. Our product range addresses the needs of all income groups, and we are now selling in 54 countries with 100+ partners across the globe.

Greenlight Planet has given five million households across the world access to solar via the Sun King lamps. As a result, it has impacted the lives of 20 million people globally. It has also resulted in saving kerosene (360 million litres/year). Owing to these lamps, there has been a 75% increase in study time, 84% claim better air quality at home than before, 48% claim that they have less breathing problems, 94% users feel safer at night, and 13% teachers declared that it has improved the results of school-going children.

Economically, there has been a 25% increase in household income, and it has increased working hours by 2 to 4 hours per day, leading to an additional income of USD14 per month (average). They have broken even on their investment in Sun King within 4 to 10 months (depending on their local kerosene and phone charging. Also, our Sun King agents (executive officers/ business associates) have witnessed a 30% income increase from selling lights and reached 30 000 new off-grid homes per month.

The Sun King lamps reduce pollution by 1 MM tonnes/year. A typical kerosene lamp, used daily, burns about 80 litres of kerosene each year, thus emitting 0.2 tonnes/year of carbon dioxide. The 5 000 000 solar lanterns sold to date are therefore saving at least 360 million litres/year of kerosene, and reducing carbon emissions by at least 1 000 000 tonnes/year.

What is the level of accessibility which Greenlight has achieved? Is it easy to make an inroad into villages? What are the challenges the company faces, when it comes to convincing inhabitants to adopt alternate sources of power such as solar?

Greenlight Planet has reached over nine million households in rural India till date. Our journey to this scale has been interesting, motivating, and filled with unique challenges. These include:

- *Trust*: Rural consumers have been burned for decades by low-quality products sold by shoddy, fly-by-night companies. Hence their trust is solar technology is shaken and now they look for quality-associated brands and prioritize purchase decisions on 'seeing is believing' or word-of-mouth recommendations from existing users.
- *Reach*: Lack of infrastructure and logistics to reach rural areas is a challenge.
- *Kerosene subsidy*: Kerosene is highly subsidized in India, leading to some

of the toughest competition to the spread and use of solar lamps. The break even period of solar lamps in India is twice as compared to other geographies such as Kenya.

- *Lack of awareness*: Customers in rural off-grid locations are unaware of harmful health effects of using of kerosene lamps. They also uninformed of the option to shift to solar lamps that are reliable and affordable.
- *Purchase barrier*: Due to limited employment opportunities in rural India, earning is limited and a large number of people cannot buy a solar lamp at its upfront cost, while they spend more money over a period of time (on daily or a weekly basis) in buying kerosene.

MNRE recently announced a draft 'National Policy for renewable-energy–based micro and minigrids.' It wants Energy Service Companies to implement RE based micro and mini grid projects. Will this enable more people in India access to power?

Yes, definitely, MNRE's new draft guideline will enable more people in India to access power. Having said that, we also acknowledge that energy requirement in rural India is more than the project's target of 10 000 RE-based micro- and minigrid projects across the country in the next five years. Being a community-based project, it comes with its peculiar challenges of service consistency and maintenance.

Nearly 50% of India's rural population—80 million households—have little or no access to grid-based electricity. It is a huge requirement, and multiple solutions are needed to solve a problem of this magnitude.

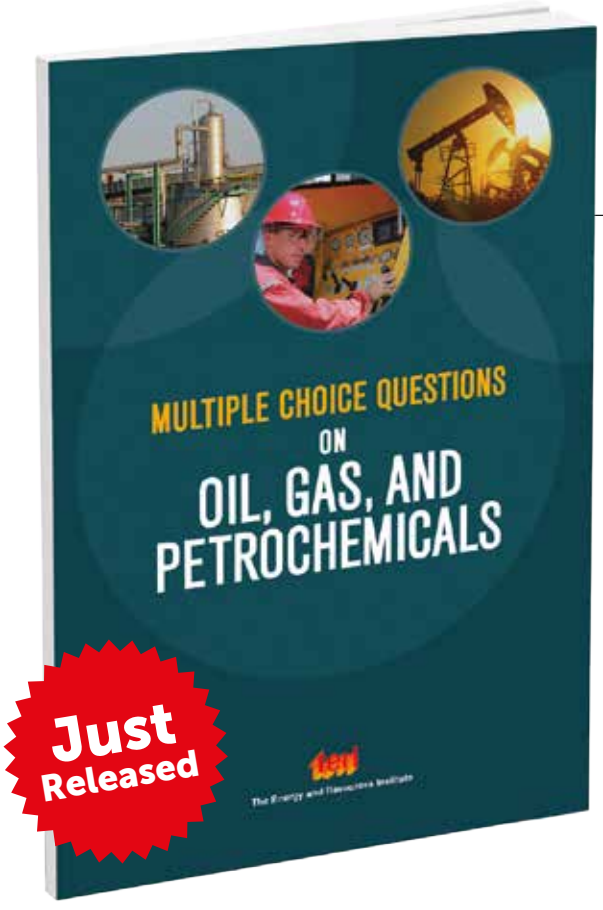
We are making off-grid energy solutions, which includes solar lanterns, solar home systems (SHS), and decentralized renewable energy increasingly attractive to consumers. While solar lanterns can meet basic lighting and mobile charging needs, SHS and DRE solutions are better positioned to serve the evolving demand for consumer goods and desire for more reliable services.

What are the company's future plans?

Our vision is to replace fuel sources with clean, affordable energy to two billion people who still do not have access to electricity. We see a future where everyone—rich or poor, urban or rural—has uninterrupted access to energy and lead healthier, more comfortable lives. We have set ourselves a target of 20 million homes (100 million people) by 2020. We will do this in following ways:

- *Direct sales*: Expansion of our direct sales agent networks across all states in India.
- *Retail distribution*: Develop our retail distribution network to reach 30 000 small-scale retail outlets in key markets to make our entry-level Sun King Pico products available to off-grid consumers close to their homes.
- *Micro-finance*: Replicate the success of our running microfinance partnerships to 10 new markets.
- *Consumer finance*: Develop the best PAYGO business model through our direct sales network in India and offer to high-scale partners.
- *Products*: Introduce new solar home lighting products significantly improving affordability for high-quality solar light and power devices. EF

"Exploration of oil, gas, and petrochemical sectors in MCQ format"



Highlights

- Covers different forms of oil and gas sector
- Includes more than 1500 questions that are classified into easy, medium, and tough levels
- Questions presented in MCQ format makes it easier for readers to evaluate their understanding of the sector or refresh it on a regular basis

ISBN: 9788179935422 • Price: ₹350.00

This TERI book on oil gas and petrochemical is in multiple choice question format. It covers areas, such as oil refining, natural gas, and petrochemical sector and presents the subject in a simple and concise manner. The book will prove useful for students pursuing their bachelor's or master's degree in petroleum exploration, professionals working in the petroleum industry and those who aspire to excel in various competitive exams.

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CURRENT R&D SOLAR

Dye-sensitised Solar Cells: Development, Structure, Operation Principles, Electron Kinetics, Characterisation, Synthesis Materials and Natural Photosensitisers

Renewable and Sustainable Energy Reviews, Volume 65, November 2016, Pages 183–213

Mahmoud A M Al-Alwania, Abu Bakar Mohamada, Norasikin A Ludin, Abd Amir H Kadhum, Kamaruzzaman Sopian

The energy economy is highly dependent on oil, coal and natural gas, which constitute 37%, 27%, and 20% of energy usage, respectively. However, the reserves of fossil fuels (e.g., crude oil) are limited and could run out in approximately 40 years based on a daily consumption of 82.5 million barrels and the current reserves to production (R/P) ratio. Solar energy is the source of nearly all energy on Earth. Of all renewable power sources, solar energy is the most easily exploitable, inexhaustible, quiet, and adaptable to different applications. Photovoltaic cells (PVCs) are devices that directly convert sunlight into electricity without pollution, sound, or moving parts, which makes them long-lasting and dependable. PVCs use an elegant method to take advantage of sunlight. Solar cells offer one of the most promising and environment friendly methods for producing electricity. This paper reviews the emergence, principles, electron kinetics, and components of PVCs with a focus on the molecular engineering of several metal complexes, organic dyes, and natural dyes that are used as photosensitizers in dye-sensitized solar cells (DSSCs).

Performance Ratio—Crucial Parameter for Grid Connected PV Plants

Renewable and Sustainable Energy Reviews, Volume 65, November 2016, Pages 1139–1158

Ahmad Mohd Khalid, Indradip Mitra, Werner Warmuth, Volker Schacht

Performance Ratio (PR) is a globally accepted indicator to judge the performance of grid connected PV Plants. There are good examples from countries like the US, Australia, and those in the European Union which have used PR as a key performance indicator to judge the performance of their PV systems. Such an analysis has helped these countries in continuously increasing the performance of their plants by rectifying system faults and thus plan for better investment decisions. The main focus of the paper is to highlight the importance of PR as a crucial performance indicator citing literature and research progress. In literature review, mainly, a few internationally acclaimed PV monitoring standards, guidelines, expert works and company methodologies, have been discussed and compared as to how they calculate the PR of a grid connected PV plant. Important issues over the definition of PR have also been discussed briefly. Later, arguments have been presented to support the claim of sticking to a bare minimum PR approach as defined by IEC 61724. This could significantly help countries in ramping up their grid PV capacities in the initial stages of development. At the end the economic and environmental benefits of using PR as a performance indicator by illustration of a case example from the SolMap project in India has also been highlighted.

Off-grid Electrification with Solar Home Systems: An Appraisal of the Quality of Components

Renewable Energy, Volume 97, November 2016,
Pages 585–598
Shahriar Ahmed Chowdhury, Monjur Mourshed

Solar home systems (SHS) are seen as an attractive option for off-grid electrification in rural areas in developing countries. The combined effect of declining photovoltaic module costs and success in micro-finance has resulted in increased SHS installations in emerging economies in Asia, such as Bangladesh. Majority of the SHS components are now manufactured locally with the exception of PV cells. Considering the role of component quality in SHS performance, technical quality of four key SHS components: solar panel, battery, charge controller, and lamp circuit (inverter) from market-leading manufacturers, were evaluated in this study in laboratory settings, against national and international standards. All of the tested components met some evaluation criteria in their respective categories but none met all. Key performance failures were found to be related to inverter efficiency, reverse polarity protection in charge controllers, and battery capacity, which are critical for optimum performance of the system. Findings in this study point towards an ineffective regulatory mechanism for quality assurance and the protection of consumer rights, which needs to be rectified for maintaining public confidence and sustaining the growth of SHS based off-grid electrification.

Role of Various Concave/Convex Walls Exposed to Solar Heating on Entropy Generation during Natural Convection within Porous Right Angled Triangular Enclosures

Solar Energy, Volume 137, November 1, 2016,
Pages 101–121
Pratibha Biswal, Tanmay Basak

The solar heating of the inclined wall has the direct application for the processing of various porous materials. Analysis of natural convection is carried out for the built structure where the right wall is exposed to the sun and the left wall is exposed to the cold ambience in the presence of the bottom adiabatic wall. The current work also involves with the study of the entropy generation for natural convection in porous right angled triangular enclosures with the concave/convex right wall. The finite element simulations are performed for a wide range of Darcy number ($10^{-5} \leqslant Da_m \leqslant 10$) at a representative high Rayleigh number ($Ra_m = 10^6$) for various fluids of industrial importance ($Pr_M = 7.2$: saline water, 0.7: air, and 0.01: molten metal). An extensive investigation on the effect of Dam for the entropy generation due to heat transfer ($S\theta$) and fluid friction ($S\psi$) is carried out for various cases of wall curvatures. In addition, the total entropy generation rate (S_{total}), average Bejan number (B_{eav}), and average Nusselt number ($\overline{Nu}_1$) are presented for various Da_m and Pr_m. Overall, the built structure with the concave right wall (case 1) may be recommended for the thermal processing of fluids of all PRM at all Dam via the solar heating on the curved wall.

The Use of Parking Lots to Solar-Charge Electric Vehicles

Renewable and Sustainable Energy Reviews, Volume 66,
December 2016, Pages 679–693
Pedro Nunes, Raquel Figueiredo, Miguel C Brito

The concept of solar parking lots aims at coupling the development of clean solar electricity and electric mobility. Solar panels provide shade and generate electricity to charge parked electric vehicles. In a vehicle-to-grid approach, the vehicles may also feed the grid and support it with ancillary services. In this paper, the potential of this solution has been explored, starting with a concise overview discussing the technical, environmental, and financial issues constraining the development of solar parking lots. A comprehensive review of the literature follows, and finally open issues and prospects for future work have been identified. It is intended that this paper may serve as a standalone summary of the most important work on this topic to date.

Research Progress in the Development of Natural Gas as Fuel for Road Vehicles: A Bibliographic Review (1991–2016)

Renewable and Sustainable Energy Reviews, Volume 66,
December 2016, Pages 702–741
Muhammad Imran Khana, Tabassam Yasmeen, Muhammad Ijaz Khan, Muhammad Farooq, Muhammad Wakeel

Among all alternative fuels, compressed natural gas (CNG) has been considered as one the best solutions for fossil

fuel substitution because of its availability throughout the world, inherent clean burning, being an economical fuel, and its adaptability to the gasoline and diesel engines. This bibliography reviews the potential of CNG as a transportation fuel. The added bibliography at the end of this article contains 1102 references to papers, conference proceedings, and theses/dissertations on the subject that were published between 1991 and 2016. These references have been retrieved from 137 scientific journals. The references have been classified in the following categories: Regional Experience with CNG Vehicles; Economic Aspect of CNG Vehicles; CNG Engine's Design, Control and Performance; Combustion and Fuel Injection Characteristics of CNG Engines; CNG/ Diesel Dual Fuel Operations; Hydrogen Enriched CNG Vehicles; Environmental Aspect of CNG Vehicles; and Safety Aspect of CNG Vehicles.

Do National-Level Policies to Promote Low-Carbon Technology Deployment Pay Off for the Investor Countries?

Energy Policy, Volume 98, November 2016, Pages 400–411
Gokul C Iyer, Leon E Clarke, James A Edmonds, Nathan E Hultman

National-level policies to promote deployment of low-carbon technologies have been suggested and used as a means to reduce greenhouse gas emissions in the context of international climate change mitigation. The long-term benefits of such policies in the context of international climate change mitigation depend on their effects on near-term emissions abatement and resultant long-term technological change that will reduce abatement costs of achieving global mitigation goals. There is also an argument that these policies might foster early-mover advantages in international low-carbon technology markets. Firstly, the factors that could influence such benefits and use a global integrated assessment model to present an illustrative example to understand the potential magnitude of these benefits have been reviewed. It has been found that reductions in long-term abatement costs might not provide sufficient incentives to justify policies to promote the deployment of low-carbon technologies, in particular, the emerging, higher-risk, and currently expensive alternatives. It is also found that early-mover advantages can potentially provide substantial benefits, but only if these advantages are both strong and persistent. The results suggest a role for international cooperation in low-carbon technology deployment to address the existence of free-riding opportunities in the context of global climate

A Gobal Stocktake of the Paris Pledges: Implications for Energy Systems and Economy

Global Environmental Change, Volume 41, November 2016, Pages 46–63
Toon Vandycka, Kimon Keramidas, Bert Saveyn, Alban Kitous, Zoi Vrontisi

The United Nations-led international climate change negotiations in Paris in December 2015 (COP21) trigger and enhance climate action across the globe. This paper presents a model-based assessment of the Paris Agreement. In particular, the mitigation policies implied by the Intended Nationally Determined Contributions (INDCs) put forward in the run-up to COP21 by individual member states and a policy that is likely to limit global warming to 2°C above pre-industrial levels have been assessed. The technology-rich bottom-up energy system model has been combined with an economy-wide top–down CGE model to analyse the impact on greenhouse gas emissions, energy demand, and supply, and the wider economic effects, including the implications for trade flows and employment levels. In addition, it has been explained how the gap between the Paris mitigation pledges and a pathway that is likely to restrict global warming to 2°C can be bridged. Results indicate that energy demand reduction and a decarbonization of the power sector are important contributors to overall emission reductions up to 2050. Further, the analysis shows that the Paris pledges lead to relatively small losses in GDP, indicating that global action to cut emissions is consistent with robust economic growth. The results for employment indicate a potential transition of jobs from energy-intensive to low-carbon, service-oriented sectors. EF

SOLPAD™

THE FUTURE OF SUSTAINABLE PERSONALIZED ENERGY

SunCulture Solar Inc. announced the launch of SolPad™ in September 2016, a new series of energy products designed to be the most advanced integrated-home or off-grid solar energy products in the world.

The SolPad's integrated solar panel combines multiple patented technologies into a single beautiful device, including breakthrough battery storage, an innovative inverter system, and intelligent software that engages and interacts with the user, giving them an unparalleled personal energy experience that gamifies energy distribution, delivery, and usage. SolPad is truly the world's first fully integrated solar energy solution created for the modern smart home and sustainability-minded global citizen.

SolPad Home™: An Unprecedented Sustainable Energy Solution

SolPad Home™ is the ultimate sustainable energy solution for powering an entire home with clean solar power. It offers homeowners an unprecedented level of control over their electricity generation, energy storage, and usage. While SolPad Home is designed to be a gorgeous rooftop solar solution, it is much more than just a solar panel.

Each SolPad Home panel is like a smart-energy computer on your roof, with each device being its own energy powerhouse that is completely self-sufficient. Homeowners can start with one SolPad and easily add more with minimal installation time.

SolPad Home panels store both solar and grid energy with forthcoming solid-state battery technology. This battery technology is inherently safer than standard lithium-ion-based batteries. They have a broader operating temperature range and longer life.

Each SolPad device is equipped with its own 'solar micro-storage', or built-in battery storage at the panel level, and the solid-state low-voltage battery design is optimized for safe rooftop operation.

SolPad's Home's flexgrid™ is designed to seamlessly integrate with built-in solid-state 'solar micro-storage', and this innovative combination allows SolPad to operate with electrically optimized power efficiency. SolPad's flexgrid inverter can automatically detect when to charge from the sun or charge from the local utility grid, adjusting for cloudy or rainy days, as well as changing local electricity rates.

Once off the grid, SolPad automatically forms a personal solar micro-grid that will keep delivering power to specific lights and appliances. The SolPad Home Connect™ system is the most innovative power delivery interface to get power from your roof into your home. Connect is a wire-free system that links two or more SolPad Home panels together on your roof, completely eliminating the need for any complicated cabling or wiring and simplifying the installation and greatly reducing cost and installation time.

SolPad Home combines solar and smart home components that have traditionally always been bought and installed separately. Due to this integration and elimination of parts, SolPad's fully integrated product design approach reduces the total cost of installed solar and energy storage by up to 50% when compared with other existing product offerings.

SolPad: Personal Power, Anywhere in the World

SolPad is the thinnest, lightest, and most powerful fully integrated IoT solar panel device in the world, representing a quantum leap in personal solar power. As a stand-alone device, SolPad seamlessly integrates into your home's power environment, yet can also be used outside the home for off-grid uses, such as recreational or humanitarian purposes.

SolPad's design uses a breakthrough unibody enclosure that houses solar power generation, energy storage, and communication together as one fully integrated product. SolPad has two universal outlets that output grid-quality, pure sine wave AC power. It includes three fast-charging USB ports that provide unlimited smartphone charging when in direct sunlight. And if you need more AC power, you can add more power: A standard IEC power outlet links two or more panels together. SolPad includes the same 'flexgrid' inverter technology found in SolPad Home, so increasing your available AC power is as simple as linking two or more panels together.

Integrating SolPad into your home is as easy as plugging SolPad into one of your home's outdoor outlets. Once connected, SolPad delivers solar energy into your home. SolPad works with SolControl hardware and software, allowing you to decide which specific items to run with stored solar power, such as a coffee maker, television, or lights. SolControl also includes built-in home automation technology for automated home energy management, giving you total control over your solar power, and an elegant and efficient way to add solar power to a home, town home, or apartment.

Behind SolPad's easy-to-use user interface is sophisticated technology that has many thoughtful features aimed at enhancing and personalizing the energy experience. SolPad is a solar panel that literally speaks to you. Fun, engaging, and helpful, SolPad tells you useful information, such as how much power you're collecting and how much power you're using, and will even remind you when to turn things off. A talking digital compass guides you through positioning SolPad so you can collect maximum solar energy throughout the day. With built-in tap recognition technology, tapping anywhere on SolPad is a quick way to get updates on your personal power consumption.

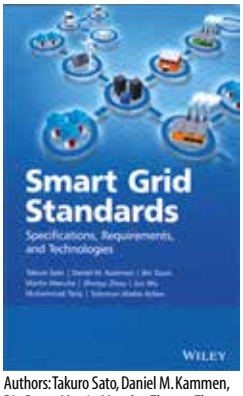
One of the most revolutionary features of SolPad is that it also acts as a powerful internet hot spot. Now, consumers can have power and the web in one place. This feature is especially valuable in developing countries where both power and the internet are not readily available.

For the developing world, SolPad can bring power to those in need where a grid infrastructure is non-existent. There are billions of people who don't have access to AC power or internet. SolPad will empower people around the world and leave a lasting, positive impact for future generations in the developing world.

SunCulture Solar is selecting its manufacturing partners for SolPad and SolPad Home, and will bring SolPad to market in the second half of 2017. The full product release timeline and pricing will be available once manufacturing plans are finalized. EF

Source: http://solpad.com/

Smart Grid Standards: Specifications, Requirements, and Technologies



Smart Grid Standards: Specifications, Requirements, and Technologies is a fully comprehensive introduction to smart grid standards and their applications for developers, consumers, and service providers. The book begins with an overview of the smart grid, and introduces the opportunities in both developed and developing countries. It then examines the standards for power grid domain of the smart grid, including standards for blackout prevention and energy management, smart transmission, advanced distribution management and automation, smart substation automation, and condition monitoring. The authors highlight the most advanced works and efforts now underway to realize an integrated and interoperable smart grid and the latest joint research project results between the world's two largest economies, US and China. The book is written in an accessible style, ideal as an introduction to the topic, yet contains sufficient detail and research to appeal to the more advanced and specialist reader, and it also enables readers to fully understand the latest achievements and ongoing technical works of smart grid standards and assist industry utilities, vendors, academia, regulators, and other smart grid stakeholders in future decision making. EF

Authors: Takuro Sato, Daniel M. Kammen, Bin Duan, Martin Macuha, Zhenyu Zhou, Jun Wu, Muhammad Tariq, Solomon Abebe Asfaw
Publisher: Wiley-Blackwell; Year: 2015

Research Handbook on Climate Governance

The 2009 United Nations climate conference in Copenhagen is often represented as a turning point in global climate politics, when the diplomatic efforts to negotiate a successor agreement to the Kyoto Protocol failed and was replaced by a fragmented and decentralized climate governance order. In the post-Copenhagen landscape, the top-down universal approach to climate governance has gradually given way for a more complex, hybrid, and dispersed political landscape involving multiple actors, arenas, and sites. The *Research Handbook on Climate Governance* takes stock of the developments before the UN climate conference in Paris in December 2015. Drawing upon contributions from more than 50 internationally renowned scholars, the book assesses the state and direction of climate governance at multilateral, EU, national, and local levels. The volume mobilizes multiple scholarly traditions ranging from grand theorizing to close empirical studies of micro-political practices, and span the ideation and the material, the historical and the contemporary, the normative, and the critical. The resulting collection of chapters represents state-of- the-art and most recent thinking in the rich and expanding scholarship on climate politics and governance. EF

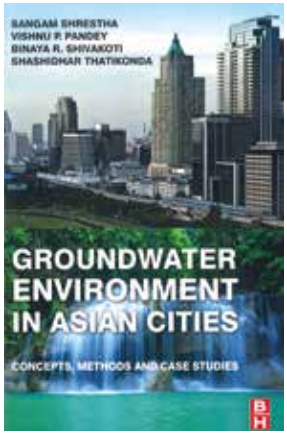
Editors: Karin Backstrand, Eva Lovbrand
Publisher: Edward Elgar Publishing Ltd

Smart Materials for Advanced Environmental Applications (RSC Smart Materials)

The development of smart materials for environmental applications is a highly innovative and promising new approach to meet the increasing demands of the society for water resources and pollution remediation. Smart materials with surfaces that can reversibly respond to stimuli from internal and external environments by changing their properties show great promise as solutions for global environmental issues. Many of these functional materials are inspired by biological systems that use sophisticated material interfaces to display high levels of adaptability to their environment. Leading researchers present the latest information on current and potential applications of omniphobic slippery coatings, responsive particle stabilized emulsions, and self-healing surfaces among other functional materials. The book contains a section dedicated to water treatment and harvesting, describing and explaining strategies, such as use of co-polymer membranes and surfaces with patterned wettability. It provides a valuable source of information on environment, materials, and polymer for nano-scientists interested in environmental applications of functional material surfaces. EF

Editor: Peng Wang
Publisher: Royal Society of Chemistry

Groundwater Environment in Asian Cities: Concepts, Methods and Case Studies



Editors: Sangam Shrestha, Vishnu Prasad Pandey, Shashidhar Thatikonda, Binaya Raj Shivakoti
Publisher: Butterworth-Heinemann

Groundwater contributes to the sustainable development of many Asian cities by providing water for domestic, industrial, and agricultural uses and regulating ecosystem flows. However, groundwater has not always been properly managed, which often has resulted in depletion and degradation of the resource. *Groundwater Environment in Asian Cities* presents the up-to-date scientific knowledge on groundwater environment in fourteen Asian cities using Driver-Pressure-State-Impact-Response (DPSIR) framework. In detail, the book presents the facts and figures of groundwater dependency, problems related to groundwater over-exploitation, implementation of various policy instruments, and management practices and their results in selected fourteen Asian cities, namely Bandung (Indonesia), Bangkok (Thailand), Beijing (China), Bishkek (Kyrgyzstan), Chitwan (Nepal), Delhi (India), Dili (East Timor), Ho Chi Minh (Vietnam), Hyderabad (India), Khulna (Bangladesh), Lahore (Pakistan), Seoul (South Korea), Tokyo (Japan), and Yangon (Myanmar). The book provides one-step platform to get sufficient details about groundwater aquifers, hydrogeology, groundwater status, impacts on groundwater environment, and the responses deployed in the case study cities and therefore, provides a snapshot of Asian groundwater environments. The theoretical background of the topics discussed along with the case studies help the readers understand the similarities and differences about the status of groundwater development and use in each city. In addition, the information in the book will serve as a baseline for other research, such as mitigation of groundwater-related problems, impact of climate change on groundwater, and importance of groundwater for implementing sustainable development goals in future. EF

Research Handbook on Intellectual Property and Climate Change (Research Handbooks in Intellectual Property Series)

Editors: Joshua D. Sarnoff
Publisher: Edward Elgar Publishing Ltd

Written by a global group of leading scholars, *Research Handbook on Intellectual Property and Climate Change* provides insightful analysis, useful historical perspective, and a point of reference on the controversial nexus of climate change law and policy, intellectual property law and policy, innovation policy, technology transfer, and trade. The contributors provide a unique review of the scientific background, international treaties, and political and institutional contexts of climate change and intellectual property law. They further identify critical conflicts and differences of approach between developed and developing countries. Finally, they put forward and analyse the relevant intellectual property law doctrines and policy options for funding, developing, disseminating, and regulating the required technologies and their associated activities and business practices. The book will serve as a resource and reference tool for scholars, policymakers, and practitioners looking to understand the issues at the interface of intellectual property and climate change. EF

RENEWABLE ENERGY TECHNOLOGY DEVELOPMENT

New tool can calculate renewable energy output anywhere in the world

Researchers have created an interactive web tool to estimate the amount of energy that could be generated by wind or solar farms at any location. The tool, called Renewables.ninja, aims to make the task of predicting renewable output easier for both academic and industry.

The creators, from Imperial College London and ETH Zürich, have already used it to estimate current Europe-wide solar and wind output, and companies, such as the German electrical supplier RWE are using it to test their own models of output.

To test the model, a team of researchers have used Renewables.ninja to estimate the productivity of all wind farms planned or under construction in Europe for the next 20 years. They found that wind farms in Europe presently have average 'capacity factor' of around 24%, which means they produce around a quarter of the energy that they could if the wind blew solidly all day on a daily basis. This number is a factor of how much wind is available to each turbine. The study found that because new farms are being built using taller turbines placed further out to sea, where wind speeds are higher, the average capacity factor for Europe should rise by nearly a third to around 31%.

This would allow three times as much energy to be produced by wind power in Europe compared to today, not only because there are more farms, but because those farms can take advantage of better wind conditions. Wind and solar energies have a strong dependence on weather conditions, and these can be difficult to integrate into national power systems that require consistency. If there is excess power generated by all energy sources, then some supplies have to be turned off. Currently, wind and solar power generators are the easiest to switch on and off, so they are often the first to go, meaning the power they generate can be wasted. Making use of a larger capacity for solar energy generation relies on changes to the national energy system, such as adding new types of electricity storage or small and flexible generators to balance the variable output from solar panels. Renewables.ninja uses 30 years of observed and modelled weather data from organizations, such as NASA to predict the wind speed likely to influence turbines and the sunlight likely to strike solar panels at any point on Earth during the year. These figures are combined with manufacturer's specifications for wind turbines and solar panels to give an estimate of the power output that could be generated by a farm placed at any location.

According to manufacturer, this tool will make it easier for other researchers to answer important questions, such as modelling wind and solar power data, which is now a very difficult and time-consuming task as they depend on complex weather systems for getting the same, building a model, and checking that it works.

https://www.sciencedaily.com/releases/2016/09/160906085539.htm

New fabric uses sun and wind to power devices

Fabrics that can generate electricity from physical movement have been in the works for a few years. Now a team of researchers have taken the next step forward by developing a fabric that can simultaneously harvest energy from both sunshine and motion. Combining two types of electricity generation into one textile paves the way for developing

garments that could provide their own source of energy to power devices such as smart phones or global positioning systems.

According to the researchers, this hybrid power textile presents a novel solution to charging devices in the field from something as simple as the wind blowing on a sunny day. To make the fabric, the researchers used a commercial textile machine to weave together solar cells constructed from lightweight polymer fibres with fibre-based triboelectric nanogenerators.

Triboelectric nanogenerators use a combination of the triboelectric effect and electrostatic induction to generate small amount of electrical power from mechanical motion such as rotation, sliding, or vibration. The new fabric, is 320 micrometres thick woven together with strands of wool, could be integrated into tents, curtains, or wearable garments. Fibre-based triboelectric nanogenerators capture the energy created when certain materials become electrically charged after they come into moving contact with a different material. For the sunlight-harvesting part of the fabric, researchers used photoanodes made in a wire-shaped fashion that could be woven together with other fibres.

According to the researchers, the backbone of the textile is made of commonly-used polymer materials that are inexpensive to make and environmentally friendly and the electrodes are also made through a low cost process, which makes it possible to use large-scale manufacturing.

https://www.sciencedaily.com/releases/2016/09/160913141508.htm

New tech promises to boost electric vehicle efficiency

Researchers have developed a new type of inverter device with greater efficiency in a smaller, lighter package, which should improve fuel-efficiency and range of hybrid and electric vehicles. Electric and hybrid vehicles rely on inverters to ensure that enough electricity is conveyed from the battery to the motor during vehicle operation. Conventional inverters rely on components made of the semiconductor material silicon. Now researchers have developed an inverter using off-the-shelf components made of the wide-band-gap semiconductor material silicon carbide (SiC). This silicon carbide prototype inverter can transfer 99% energy to the motor, which is about 2% higher than the best silicon-based inverters under normal conditions. Range is an important issue because so-called 'range anxiety' is a major factor limiting public acceptance of electric vehicles. People are afraid they will not be able to travel very far or that they'll get stuck on the side of the road.

The new SiC-based inverter is able to convey 12.1 kilowatts of power per litre (kW/L)–close to the US Department of Energy's goal of developing inverters that can achieve 13.4 kW/L by 2020. By way of comparison, a 2010 electric vehicle could achieve only 4.1 kW/L. The power density of new SiC materials allows engineers to make the inverters—and their components, such as capacitors and inductors—smaller and lighter.

The current SiC inverter prototype was designed to go up to 55 kW. The researchers are now in the process of scaling it up to 100 kW, which is can be used in a fully electric vehicle, using off-the-shelf components. They are also in the process of developing inverters that make use of the new, ultra-high density SiC power component that they developed on-site.

https://www.sciencedaily.com/releases/2016/09/160915175457.htm

New technology puts solar power to work all night long

Energy storage is crucial for taking full advantage of solar power, which otherwise suffers interruptions from cloudy skies and nightfall. In the past few years, concentrating solar power plants have begun producing additional electricity at night and during peak demand periods by using stored heat energy to propel a steam turbine.

Current thermal energy storage systems rely on materials that store less energy per kilogram, requiring more material at a greater cost to meet energy storage requirements. Now, researchers have designed an inexpensive thermal energy storage system that will be significantly smaller and perform more than 20 times better than current thermal systems. With collaboration with the US Department of Energy's Sunshot initiatives, the team is building a pilot-scale prototype of their high-efficiency latent heat thermal energy storage system for testing. This thermal energy storage system relies on a 'phase-change' material that melts as it stores thermal energy and releases energy as it re-freezes—similar to the charge–discharge cycle in a battery.

Inexpensive salts, such as rock salt (sodium chloride), can be used as phase-change materials, but their use in existing thermal storage systems is limited because of the poor thermal conductivity of the salts. However the system drastically improves the conductivity of these salts by integrating them with high-conductivity graphite foam. This combination reduces the overall amount of material needed to build the system and its cost while making the thermal energy transfer significantly more efficient and still providing up to 8 to 12 hours of energy storage—a typical night of storage for a concentrating solar power plant.

https://www.sciencedaily.com/releases/2016/09/160912122848.htm

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NATIONAL AND INTERNATIONAL EVENTS

NATIONAL

Intersolar India 2016

October 19–21, 2016

Mumbai, India
Website: www.intersolar.in

International Conference on Recent Advancement in Air-conditioning and Refrigeration

November 10–12, 2016

Bhubaneswar, India
Website: http://cvrce.edu.in

International Conference on Advanced Materials for Power Engineering

November 11–13, 2016

Kottayam, Kerala, India
Website: http://www.power.macromol.in

4th International Workshop/ Conference on Computational Condensed Matter Physics and Materials Science: Materials for Energy and Environment

November 18–20, 2016

Gwalior, Madhya Pradesh, India
Website: http://tiiciiitm.com/profanurag/iwccmp/

International & National Conference on Fluid Mechanics and Fluid Power (FMFP)

December 15–17, 2016

Allahabad
Website: http://10times.com/fmfp-allahabad

RACON 2016

December 16–17, 2016

Kolkata, India
Website: http://racon.co.in

International Conference on Emerging Trends and Advances in Electrical Engineering and Renewable Energy

December 17–18, 2016

Gangtok, India
Website: http://www.etaeere.in

Smart Electric Grid

December 22–23, 2016

Vijayawada, India
Website: http://10times.com/smart-electric-grid

12th International Battery and Alternate Energy Exhibition and Conference

January 6–8, 2017

New Delhi, India
Website: http://www.batteryfair.co.in/

Windergy India 2017

January 10–12, 2017

New Delhi, India
Website: http://windergy.in

INTERNATIONAL

UNFCCC COP22

November 7–18, 2016

Marrakech, Morocco
Website: http://unfccc.int

HydroTech Caucasus 2016

November 9–10, 2016

Tbilisi, Georgia
Website: http://www.energyinsight.info/conference_hydrotech_caucasus.html

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Solar Power PV Conference & Expo

November 9–10, 2016

Chicago, Illinois, USA
Website: http://www.enfsolar.com

Renewable Energy from Waste Conference and Exhibition

November 14–16, 2016

Long Beach, CA, USA
Website: http://www.rewconference.com

Smart City Expo World Congress

November 15–17, 2016

Barcelona, Spain
Website: http://www.smartcityexpo.com

Turkey International Renewable Energy Congress

November 28–December 1, 2016

Istanbul, Turkey
Website: http://www.energyinsight.info/turkey-international-renewable-energy-congress.html

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Solar Canada Annual National Conference and Exposition

December 5–6, 2016

Toronto, Canada
Website: http://solarcanadaconference.ca

Maintenance for Offshore Wind

December 7–8, 2016

London, UK
Website: http://www.energyinsight.info/maintenance-for-offshore-wind-2016.html

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Energy from Waste

December 8–9, 2016

London, UK
Website: https://www.smi-online.co.uk/energy/uk/conference/energy-from-waste

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Renewable Energy World Conference & Expo North America

December 13–15, 2016

Orlando, USA
Website: http://www.rewintl.com

RENEWABLE ENERGY AT A GLANCE

Ministry of New and Renewable Energy Programme/ Scheme wise Physical Progress in 2016/17 (& during the month of August, 2016)			
Sector	FY 2016/17		Cumulative Achievements
	Target	Achievement (April - August, 2016)	(as on 31.08.2016)
I. GRID-INTERACTIVE POWER (CAPACITIES IN MW)			
Wind Power	4000.00	897.10	27674.55
Solar Power	12000.00	1320.32	8083.17
Small Hydro Power	250.00	36.40	4310.35
BioPower (Biomass & Gasification and Bagasse Cogeneration)	400.00	51.00	4882.33
Waste to Power	10.00	7.50	115.08
Total	**16660.00**	**2312.32**	**45065.48**
II. OFF-GRID/ CAPTIVE POWER (CAPACITIES IN MWEQ)			
Waste to Energy	15.00	1.23	161.39
Biomass(non-bagasse) Cogeneration	60.00	0.00	651.91
Biomass Gasifiers -Rural	2.00	0.00	18.15
-Industrial	8.00	1.80	166.04
Aero-Genrators/Hybrid systems	1.00	0.20	2.79
SPV Systems	100.00	28.30	342.18
Water mills/micro hydel	1 MW + 500 Water Mills	0.10 MW + 100 Water Mills	18.81
Total	**187.00**	**31.63**	**1361.27**
III. OTHER RENEWABLE ENERGY SYSTEMS			
Family Biogas Plants (in Lakhs)	1.00	0.09	48.64

Source: www.mnre.gov.in

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General information

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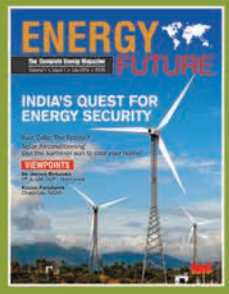
- All colour
- Matte paper
- Number of pages: 96



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