use, industries, power development, and other activities.

Agriculture sector is largely affected by the climate change crisis. It contributes about 17.6 per cent of the total greenhouse gas (GHG) emissions. In 2010, the total emission from agriculture sector was 334.41 million tonnes of CO_2 equivalent. Other changes in climatic conditions, such as frequent floods, droughts, and cyclones have affected the productivity of the agriculture sector in India. The irrigation water demand and energy consumption would increase with growing population of the country, changes in climatic conditions, and to meet the food requirement of more than 1.2 billion people. At present, in order to meet the water demand, farmers are dependent on rains or irrigation through inefficient pumpsets which in turn is responsible for high energy consumption and overutilization of groundwater. Therefore, depletion and contamination of the groundwater table and extensive use of conventional fuels are the key factors responsible for environmental degradation.

In India, agriculture sector is benefitted from heavy subsidy, which includes cheap supply of grid power and subsidized diesel for running irrigation pumpsets. This leads to creation of black market and subsidy burden on government. Unreliable power and high cost of backup power also aggravates the situation, thereby affecting the agriculture sector at large in terms of sustained energy supply. Renewable energy and clean technologies could be deployed for dealing with the crisis of energy security and environmental degradation in the country. For instance, the uptake of renewable energy and energy efficient solutions can lead to a substantial reduction in water consumption through meeting the growing energy demand for water pumping, while ensuring the long-term reliability of water supply.

The Agri-Food Value Chain

In context of agriculture sector, the food value chain largely covers four key components: (i) Production; (ii) Post-Harvest; (iii) Processing; and (iv) Retailing. Each component of the food value chain would require the use of water and energy for production of high quality value-added food products. An overview of the value chain is given in Figure 1.

Agri-food value chain would function efficiently if the three aspects of food, water, and energy are dealt in an interlinked and interrelated manner. The trade-offs within the triad could lead to a sustainable agri-food value chain.

The need assessment study for mapping the scope and potential of 'Food-Water-Energy Nexus' in agri-food value chain was carried out with support from The Renewable Energy and Energy Efficiency Partnership (REEEP) and The Energy and Resources Institute (TERI). The study intended to integrate the regulatory, technological, financial, and entrepreneurship aspects of sustainable crop management, processing distribution and retailing; thereby creating favorable environment for the Food-Water-Energy Nexus in the country. The study deliberated that farmers are at the suffering end of climate change impacts, but there exist other factors, such as meagre prices of produce, lack of market linkages, proper storage and processing facilities,

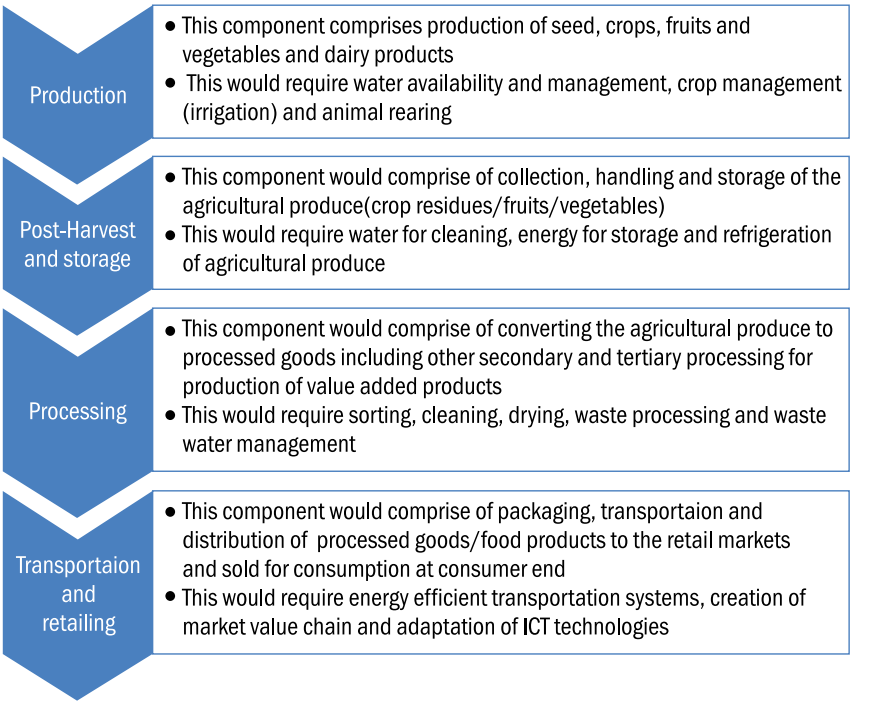

Figure 1: An overview of agri-food value chain

especially for perishable items, such as fruits and vegetables—these are also significant concerns for them which has complicated the situation more. Each component in the agri-food value chain at large is facing major concerns which are listed in Table 1. As part of the study, primary and secondary research was carried out to find clean energy and energy-efficient solutions to combat the above mentioned barriers. For instance, renewable energy sources, such as solar and biomass hold significant potential for multiple applications in this regard, provided appropriate and customized technology solutions are developed and deployed, such as solar dryers, solar irrigation, biogas plants, etc. The study identified some possible clean energy (both energy efficiency and renewable energy) interventions in agri-food value chain, which could be explored in the country's perspective (Table 2).

As India is running one of the largest renewable capacity expansion programmes in the world (India has set an ambitious target for installation of 175 GW renewable power by 2022), it is pertinent to adopt these clean energy technologies in India's agriculture sector within the purview of the programmes. For example, in Karnataka, the area under cultivation is 120 lakh ha of which 41 lakh ha is under irrigation. In order to meet the growing demand of food through increased productivity and to manage the high requirement of water availability for irrigation, it is therefore required to consider alternate and clean energy options for sustainability. Karnataka had recently launched the 'Surya Raitha' Scheme under which the state government plans to install grid-connected solar powered irrigation pumpsets under small PV power plant on net-metering basis. In the first phase, 2,400 solar powered irrigation pumpsets of 10 HP capacities are expected to be installed with the help of the central subsidy. It would also help the farmers draw up to ₹50,000 per annum by selling excess power to the grid.

Additionally, other decentralized solutions could be explored for efficient utilization of locally available resources to enhance the efficient farming and overall reduction in environmental degradation. The expected impacts from adoption of clean energy interventions in agri-food value chain are listed in Table 3.

In recent times, the government of India's initiatives has bolstered the development of the sector in terms of increased crop production, improved agricultural practices, energy-efficient irrigation mechanisms, improved farming machinery equipment, better electricity supply, and ease of access to finance. Also, with the allocated budgetary support of ₹35,984 crore for agriculture

Table 1: Major concerns in agri-food value chain in India

Production	Post-Harvest and Storage	Processing	Transportation and Retailing
■ Small land holdings ■ Diesel generators for pumping and black market for diesel purchase ■ Unreliable electricity supply for irrigation purposes ■ Climate change is impacting yields	■ Lack of storage facilities	■ Decaying food items due to improper storage facilities	■ Unhygienic conditions except for bigger retail markets ■ Limited market access especially for farmers ■ Poor handling during loading and unloading at market points

Table 2: Possible clean energy interventions in agri-food value chain in India

Production	Post-Harvesting and Storage	Processing	Transportation and Retailing
■ Solar-based water pumping ■ Biofuel-powered machinery ■ Bio-energy crops ■ Bio-manure from waste to energy plants ■ Solar desalination, heating/ cooling	■ Solar- and biomass-based cold storage systems ■ Solar food drying for storage ■ Solar cooling and refrigeration	■ Solar, wind, hydro milling, pressing, cooking, drying, etc. ■ Solar- and biomass-based drying of food ■ Energy efficiency for food processing at SMEs ■ Energy from anaerobic digestion of food waste ■ Solar-based heating and cooling ■ Solar thermal systems for milk pasteurization ■ Energy from biomass gasification of agro-residues	■ Biofuels-based road transport ■ Solar cooling and refrigeration, mobile refrigerated units

Source: http://www.reeep.org/sites/default/files/South_Asia_Need_Assessment_REEEP_SA.pdf

Table 3: Expected impacts from clean energy interventions in agri-food value chain in India

Components of Agri-Food Value Chain	Expected Impacts from Clean Energy Interventions
Production	■ Efficient use of natural resources (solar, biomass, water, etc.) ■ High yielding crops ■ Judicious utilization of groundwater ■ Biomanure would improve the productivity and quality of the soil as well as crop productivity at large ■ Reduced dependency and cost savings on highly polluting conventional fuels
Post-harvest	■ Locally available resources (solar and biomass) for reliable and timely supply of energy to cold storage systems ■ Reduced dependency and cost savings on highly polluting conventional fuels ■ Better utilization of agro-waste ■ Improved shelf-life of the agro-produce and improved returns to farmers
Processing	■ Energy-efficient processing systems ■ Cost savings to the SME sector ■ Opportunity for farmers to produce value-added products in the existing processing system ■ Better quality food products
Transportation and retailing	■ E-platforms will enable farmers to sell their products in India and abroad ■ Access to market for value-added products ■ Development of self-employment and entrepreneurial opportunities in the value chain ■ Better handling of food products for selling in the market

and farmers' welfare in the Union Budget-2016, has provided an immense opportunity for investment and promotion of agricultural activities in the country. The Government of India has initiated several plans and schemes, such as the National Food Security Mission, Mission for Integrated Development of Horticulture, National Mission for Sustainable Agriculture, *Paramparagat Krishi Vikas Yojana* to promote organic farming practices, *Pradhan Mantri Krishi Sinchayee Yojana* to promote efficient irrigation practices and National Mission on Agricultural Extension and Technology. In this context and with these schemes in place, the Government of India estimated that by replacing 20.27 million pumpsets with energy-efficient pumpsets would result in annual energy savings of 46 billion kWh and would lead to reduction of 45 million tonnes of CO_2 emissions annually.

With the promotion and speedy uptake of renewable energy technology in India, powering agri-food value chain through clean energy interventions at each step, could tackle the issues of energy and food security in a better way. This would further provide direct access to market for the farmers to sell their produce at a good cost. For deploying such clean energy technology for applications in agriculture sector, it is essential to provide a conducive environment by integrating food, water, and energy through supportive policy and market interventions. The identified key measures to promote clean energy deployment in the country are:

- Efficient resource management
- Formation of policy and regulatory framework in agri-food value chain
- Financial support to promote clean energy technologies
- Identifying stakeholders for improved participation in the sector
- Introducing Public–Private Partnership models
- Skill development and capacity building
- Information dissemination and awareness
- Capacity building for farmers, traders, etc., to improve understanding of value
- Access to finance for commercialization.

The Way Forward

The agriculture sector still remains one of the most promising saviour for our agricultural-based economy. Yet, it remains less explored. Each component of the agri-food value chain provides immense opportunities for research and innovation through inclusive and interactive approach. With the upcoming advancements in mechanization of farms, the possibility of new interventions in renewable energy and energy efficiency can boast of huge opportunities for the farmers for improving their returns on investment and creation of market. This would rally towards betterment of local community, development of skills, and generation of livelihood opportunities. EF

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STEAM OPTIMIZATION MEASURES IN ENERGY INTENSIVE INDUSTRIES

The Cost-effective and Green System

Steam is used in a wide range of industries. The common applications of steam include steam for processes heating in plants and factories and steam driven turbines in electric power plants. Through the medium of this article, **Pratosh Saxena** intends to spread awareness amongst the masses about the importance of using steam optimally in order to save money, natural resources, such as coal, water, oil, and encourage a culture of uninterrupted improvement in steam usage and its management in all energy intensive industries.

Steam is used for generation of electrical power as well as for the purpose of process heating applications in industries, such as sugar, paper, fertilizer, refineries, petrochemicals, chemicals, foods, synthetic fibre, and textiles. A very high percentage of all the fuel burned in the world is consumed to produce steam. Steam systems account for around 50 per cent of the total energy used in industrial applications for product output. Its optimum usage results in huge monitory savings and environmental benefits.

Steam is easy to transport and carrying large amount of heat means it is relatively inexpensive, pumping and piping is not required compared to any other heating media. The characteristics which make steam so popular are its:

- Highest specific heat and latent heat
- Highest heat transfer coefficient
- Easy to manage, i.e., control and distribution
- Cheap, clean, and inert.

One of the key reasons for suggesting the optimization measures is the scarcity of knowledge in its proper usage despite the fact that steam is critical for the plant's processes requirements. The losses in steam system (industrial, commercial, and institutional) in general are shown in Figure 1. Steam is an expensive utility, so one should not spare any opportunity through which steam utilization can be optimized and wastages can be drastically reduced. Now, we shall discuss the major ways through which steam can be utilized precisely and economically.

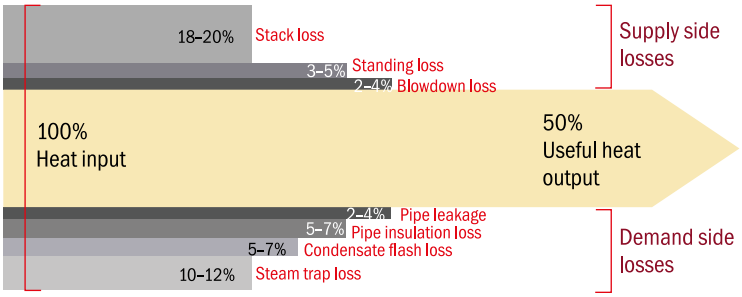

Figure 1: Steam system losses

Loss Reduction by Means of Steam Pressure Reduction in Process Plant

Steam pressure reduction is the technique of lowering of the boiler pressure and temperature in turn influences boiler performance, high-pressure steam distribution system, and also results in steam consumption reduction at the boiler outlet but this needs to be done after carefully studying the complete system for varying operating conditions. Steam pressure reduction has the huge potential to reduce the steam and fuel consumption as a result of the changes that occur in the high pressure side of the steam system.

The following losses are reduced on account of lowering of the steam pressure:

- *Reduction in combustion loss:* Dry flue gas loss varies directly in proportion to the boiler's net stack temperature (difference between the flue gas temperature and combustion ambient air temperature). Lowering the boiler pressure results in lower stack temperature, which results in a slight improvement in the combustion efficiency.
- *Reduced boiler blowdown losses:* Minimizing boiler blowdown rate can substantially reduce energy losses, as the temperature of the blown-down liquid is the same as that of the steam generated in the boiler (Figure 2). Minimizing blowdown will also reduce makeup water and chemical treatment costs. If the energy from the blowdown is not being recovered and the water is being drained and flash steam is vented and wasted, then the savings resulting from steam pressure reduction are substantial.
- *Reduced radiation and convection losses from boiler:* The external surface of an operating steam boiler is hotter than its surroundings and therefore loses heat by both radiation and convection. The radiation and convection loss is proportional to the external surface area of a unit, whereas the unit's capacity is proportional to its volume (Figure 3).

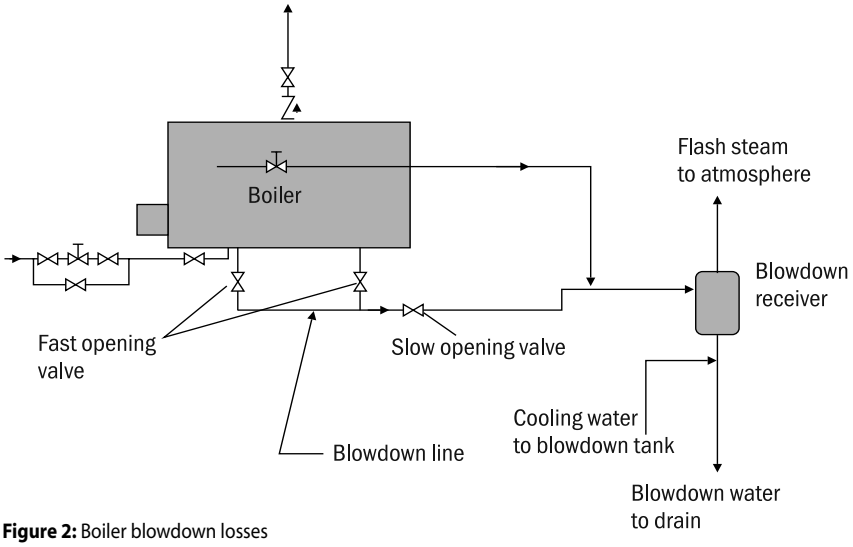

Figure 2: Boiler blowdown losses

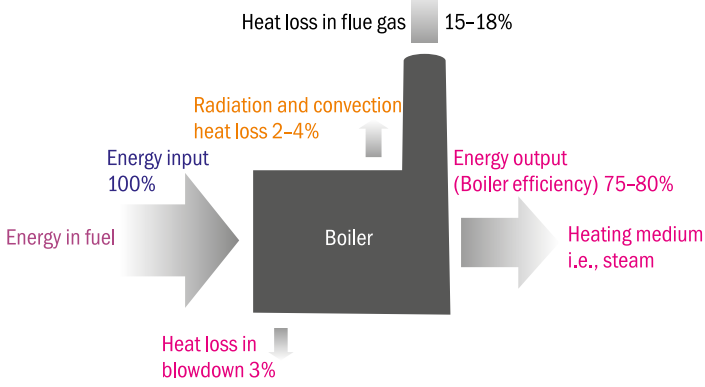

Figure 3: Losses in a process steam boiler

- *Reduced high-pressure steam distribution header losses:* High-pressure distribution header loss from the system decreases with the decrease in system pressure that includes repairing leaks. The degree of leakage depends on how well the system is maintained, in general, approximately 35–40 per cent of steam saving opportunities exist related to improved maintenance.
- *Reduction in radiation heat loss from steam and condensate piping:* With the reduction in steam pressure, less heat is lost by radiation and convection to ambient air from condensate and steam piping.
- *Reduction in loss from steam traps of high pressure system* (Picture 1):

Picture 1: Reduction in loss from steam traps of high pressure system

Reduction in steam pressure results in reduced losses from steam traps of High Pressure (HP) system. Further, steam leaking from the HP steam trap can be avoided by performing the routine maintenance services to minimize the steam wastages.

Picture 2: Steam leakage from valve

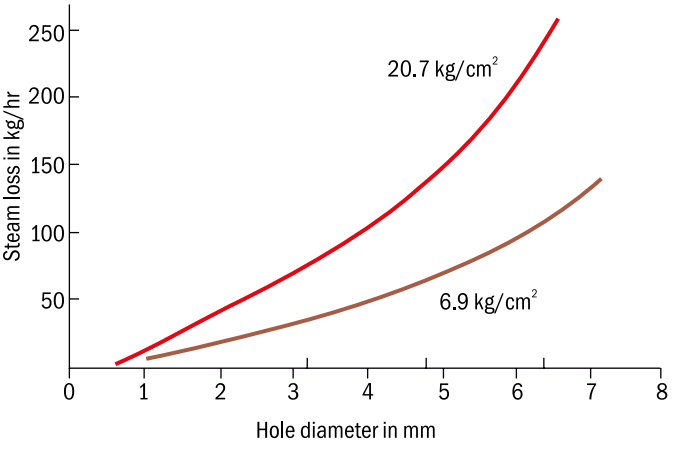

Figure 4: Steam leakage losses

- *Reduction in steam leaks from high pressure valves, piping, and other components (Picture 2):* Substantial reduction in steam leaks from the piping and other components on account of reduction in operating pressure. As shown in Figure 4, it is clear that steam loss from a 1/4th inch hole in a steam piping operating a pressure of 20.7 kg/cm^2 twice than that of when the system operates at 6.9 kg/cm^2.
- *Reduction in flash steam loss through high pressure condensate receiver and vents:* If the flash steam loss is not recovered by a vent condenser, then the energy can be saved when the working pressure of the process is reduced.
- *Reduced steam demand:* Steam demand is reduced by lowering system steam pressure because of the enthalpy savings effect and also by reducing the mass flow rate from steam leaks.
- *Enthalpy saving effect:* The energy supplied to steam loads comes from the latent energy in the steam and not from sensible energy. When steam pressure is reduced, sensible energy is reduced while latent energy is increased. Although total enthalpy decreases with lower pressure steam, heat transfer potential increases resulting in a lower mass flow rate of steam needed to meet the same heating load.

Providing Dry Steam to the Process

All heat transfer processes require only dry steam—neither wet nor superheated steam is suitable for the process heating application.

Super heated steam

- Poses problems in controlling the process temperature
- Poor heat transfer coefficient
- It takes time to give-up its superheat by conduction
- It transfers heat at a rate slower than that of condensation heat transfer rate of saturated steam.

Wet steam

- Reduction of total heat content of the steam (since carries no latent heat)
- Increases resistant film of water on heat transfer surfaces
- Overloads the steam trap and affects its proper functioning.

Dry steam

- Best heating steam for process application is the dry saturated steam
- Dry steam has the property of rapid heat transfer.

Industrial boiler at best can deliver around 95 per cent dry steam in the absence of super-heater. Dryness fraction of steam in boilers depends upon factors, such as water level in the

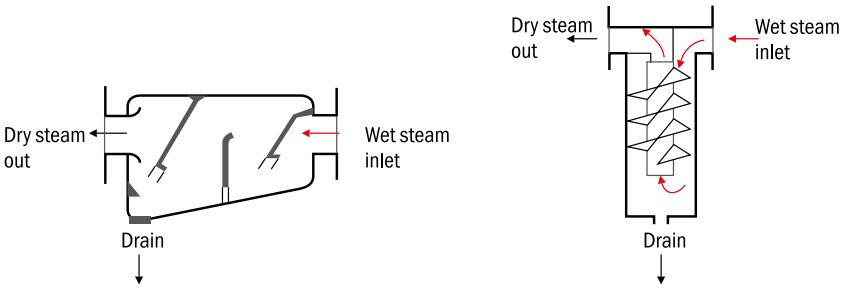

Figure 5: Steam separator

drum, boiler steam load, and pressure fluctuations.

A steam separator (Figure 5) is installed to reduce the wetness in steam and to improve its quality going to the process.

Utilizing Steam at the Lowest Acceptable Pressure for the Process

With the increase of steam pressure, latent heat in the steam starts reducing, but it is this very latent heat of steam that takes part in the in-direct heating process. The best practice is to keep the steam pressure low depending upon the equipment design with which the equipment can work satisfactorily without compromising on production rate or on steam consumption.

Insulation of Steam Pipelines and Hot Process Equipment

Bare steam pipelines, flanges, and hot process equipment releases heat to the atmosphere by radiation. Insulation helps in ensuring proper steam pressure for process and can reduce radiative heat loss from hot surfaces by 90 per cent. In industries on lagged steam pipes, it is common to see uncovered flanges, which is equivalent to leaving a 0.6 m of pipe length uncovered. The following table gives information about heat loss at different hot surface temperatures.

Difference in temperature between ambient and hot surfaces (°C)	Heat loss (kCal/m²/hr)
50	500
100	1,350
200	3,790
400	13,640

- A steam pipe 0.15 m in diameter with five uncovered flanges, is equivalent there to a heat loss equivalent to wasting five tonnes of coal or 3,000 L of oil a year
- Remedy is to provide removable prefabricated insulation covers, which can be easily removed when required
- A bare steam pipe of 150 mm diameter and 110 m length carrying a saturated steam at 8.0 kg/cm², i.e., equivalent to wasting of 24,000 L of furnace oil in one year
- Proper insulation helps in keeping these losses to minimum.

Reducing the Work to be Done by Steam

To reduce the work done by the steam, it is essential that all process equipments shall be supplied with dry saturated steam. There are some practices to be followed so that steam has no more work to do than is absolutely necessary. By reducing work done by steam, energy saving can be achieved by the following measures:

- Reduction in operating hours
- Reduction in steam quantity required per hour
- Use of more efficient technologies
- Avoiding part load operations
- Minimizing wastage.

Proper Utilization of Directly Injected Steam

Wherever feasible, the heating of a liquid by direct steam injection is desirable. The requirement of equipments is relatively simple, cheap, and easy to maintain. No condensate recovery system is necessary. This process of heating is quick, and the sensible heat of the steam is used up along with the latent heat, making the process thermally efficient.

Proper Air Venting

A 0.25 mm thick air film offers the same resistance to heat transfer as a 330 mm thick copper wall. The presence of air inside the process equipment will reduce the partial pressure of steam in the steam air mixture, thus dropping the overall temperature of the steam air mixture, which is the heating medium. The proper positioning of air vent is shown in Figure 6.

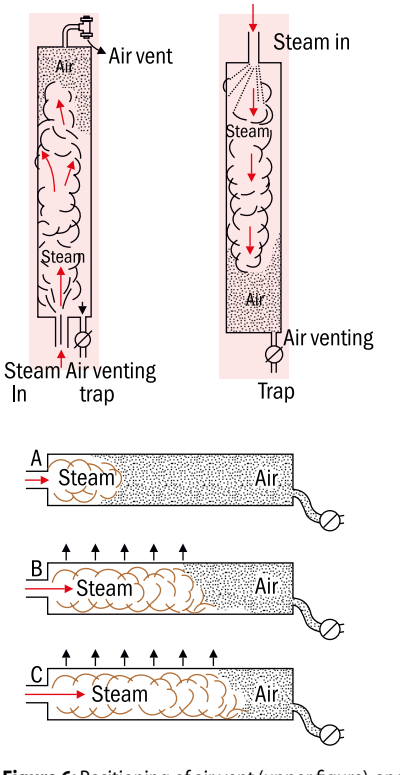

Figure 6: Positioning of air vent (upper figure); and behaviour of trapped air (lower figure)

However, it is impossible to avoid the entry of air into a steam system that is working intermittently. If the steam condenses during the shutdowns, air tends to be sucked in due to the partial vacuum created.

Adequate air venting provision should be made at appropriate positions (stagnant corner, remote from the steam inlet point) in the pipelines, to purge air as quickly as possible from the equipment, making heat transfer more efficient.

Minimizing Heat Transfer Barriers

Heat is transferred from steam to the material being heated in two ways:

- By direct contact, in which steam is directly injected into the material
- By indirect contact, through an intermediate heating surface which acts as a barrier between steam and material being heated.

In indirect heating, a temperature difference is required to overcome the resistance of barrier between steam and material. Figure 7 illustrates the barrier formed that impedes the flow of heat from steam to the material. Air is probably the best ever known heat insulator and is the most likely material to be trapped in all steam supplies, because when steam condenses, air will always try to take its place on account of partial vacuum created. Thus, adequate air venting provision should be made to purge out air quickly to make the heat transfer more efficient.

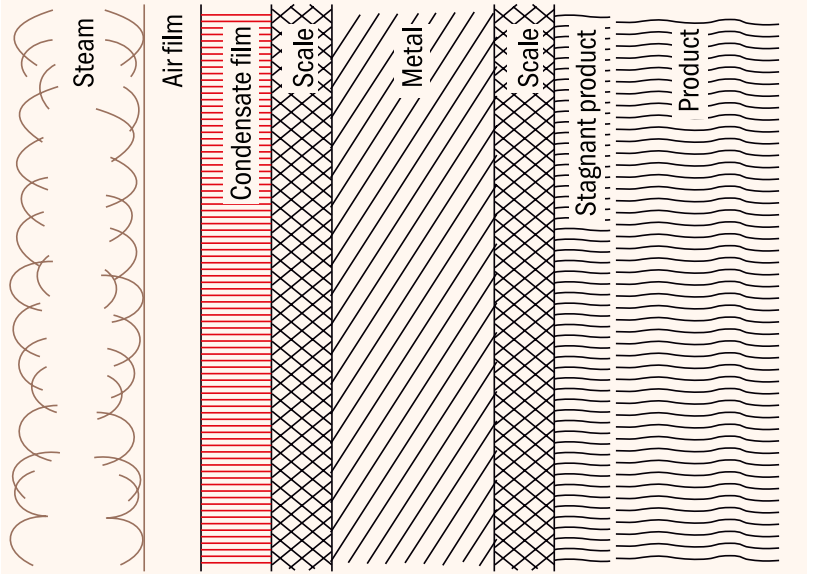

Figure 7: Obstacles in effective heat transfer

Minimize Vent Steam

Steam venting is different from the steam leaks. This happens due to steam imbalance on header due to disturbed process conditions. Plants having only back pressure turbines have more instances of steam venting than with plants having condensing turbines. Instances like peak demand scenario needs to be evaluated in detail where power generation is more beneficial than the marginal cost of vented steam.

Isolate Steam for Unused Lines/Headers

In process steam demand continuously varies and sometimes for a particular process or equipment steam is no longer required. So immediately the steam lines need to be isolated. The following are the benefits of isolating unused lines:

- Helps in eliminating steam leaks
- Helps in eliminating heat transfer losses
- Helps in reducing maintenance requirement of the steam system in that section
- Helps in eliminating insulation losses.

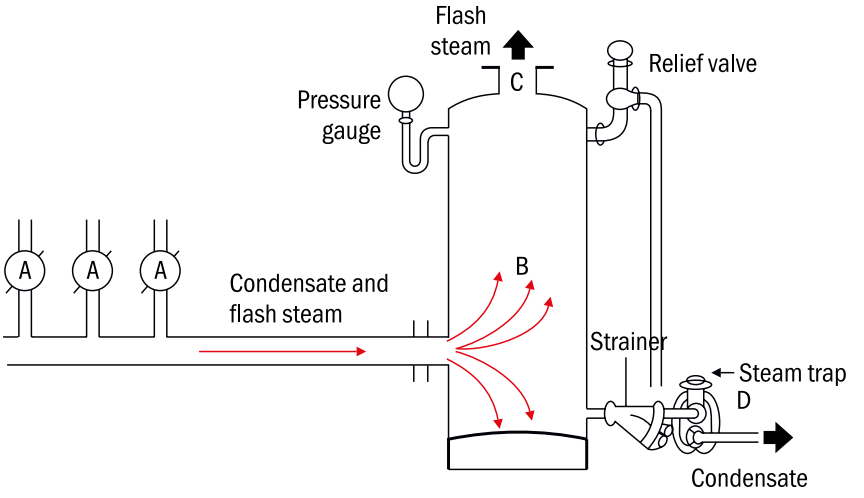

Figure 8: Flash vessel

Recover Flash Steam

Flash steam is produced when a condensate at high pressure is reduced to a lower pressure, then a portion of the liquid 'flashes' to steam at a lower pressure as shown in Figure 8 and the same can be used for low pressure direct heating applications and can easily replace the equal quantity of live steam that would be otherwise required.

The specially designed enclosure is called a flash vessel and flash steam contains around 10–40 per cent of the energy content of the original condensate depending on the pressures of the process condensate.

Emphasis on End-User Optimization

It is utmost essential to involve the end-user in order to improve the overall steam utilization for far-reaching benefits. The following are the areas where end-users can immensely contribute in optimizing steam usage:

- Eliminate or reduce the amount of steam used in a process
- By improving the process efficiency
- Steam usage at as low pressure as possible
- Shifting part of the steam demand to a waste heat source
- Upgrade low pressure steam to meet process demand that would otherwise require high pressure steam.

Conclusion

Industrial steam usage is and has been one of the important elements of the industrial revolution in a developing country like India and there are enough reasons to be optimistic in thinking that its usage will increase in the coming decades. The amount of fuel required to produce this industrial steam is substantial, and thus all our efforts towards reducing it results in reduction in fuel consumption and will result in substantial saving of money every year apart from lessening the burden on environment.

Strangely, many companies are moving slowly towards steam optimization though many of the steps that are needed are fairly, easy, simple, and inexpensive and can give quick paybacks. So, steam system optimization is a low hanging fruit and industries should reap the rewards of energy savings, reduced down times and maintenance crises, and also minimization of the safety hazards. EF

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BIOMIMICRY OF SUNFLOWER

Solar Tracking Technology Inspired by Nature

"Look deep into nature, and then you will understand everything better…" these profound words by the great physicist Albert Einstein are all the more relevant in today's world as we face a huge dilemma over the continuous availability of various energy resources. Is there any solution available in nature to meet the pressing energy and environmental challenges that humankind faces? Should we look towards the natural systems to solve the energy crisis? In this article, **Avipsa Dey** discusses how biomimicry of sunflower *(Helianthus)* plays a marvellous role in inspiring design of systems to harness solar energy not only efficiently but also effectively. Read on to know more…

The rampant use of conventional energy sources, such as coal, fossil fuels, and Uranium has created an uncertainty about the availability of these energy sources for the posterity. Not only the depletion of these energy reserves is an issue, the impact of these conventional energy sources on environment is also a matter of grave concern. The emission of CO_2 and other greenhouse gases (GHGs) results in global warming, and thus degrades the quality of life of living organisms on the earth. Therefore, using the conventional sources of energy incessantly is going to result in an alarming fate in the near future. Being finite and polluting are the reasons enough to warrant the shift to cleaner sources of energy, which have zero emissions and can be utilized to infinite volume. The long road is structured on harnessing the power of the sun, wind, oceans, and organic matter to generate electricity. With recent advancements in technology the world is changing and the latest change should be based on 'sustainability'. However, instead of patiently waiting for the next wave of advancement, scientists and engineers are in constant trail to design and develop energy efficient systems using the renewable sources of energy, which leads to the sustainable development of the world. But have you ever wondered that from where do they get the inspiration for developing such promising systems? The answer lies in 'mother nature'. Scientists and engineers along with architects are doing research in the field of biomimicry as how nature adapts itself to combat the harsh or unfavourable conditions of the environment.

With the present scenario, biomimicry holds promise for the next

frontier in energy for human beings. The word biomimicry originates from the Greek word *'bios'*—meaning life and *'mimesis',* which means—to imitate. Therefore, biomimicry is a process of using natural world mechanisms to inspire man-made designs and technological innovations. Designs and efficiencies of nature have evolved through billions of years of natural selection into intricate systems that can inspire novel thinking and energy efficient systems for long-term sustainable development. Biomimicry has been recognized as a field of study only recently, but researchers have drawn inspiration from nature for thousands of years. For instance, Leonardo da Vinci's sketches of a flying machine was inspired from the observation of birds and the Wright Brothers, who succeeded in creating the first airplane in 1903, apparently gained inspiration from observation of pigeons' flight. Modern biomimicry examples include the invention of Velcro, which emulates sticky plant cockleburs, observing water whorls and kelp to design a high efficient boat propeller; whale fins, tails, flippers inspired to design wind turbines, which turned out to be efficient in terms of speed and performance.

Remarkably, the sunflower uses a great mathematical marvel by optimal space utilization for its seed head by packing of the seeds in spirals of Fibonacci numbers. The head of the sunflower plant is not really a flower but a group of small flowers (called florets) crowded together. The ones on the outside hold the petals and the ones inside, which are called disc florets, develop seeds. The disc florets are arranged in spiral pattern that orient them at 137°—popularly known as the 'golden angle'. The angle produces a pattern of interconnected spirals that follow Fibonacci sequence (Figure 1). Let us discuss in detail about Fibonacci number, sequence and what makes them form a Fermat spiral and the importance of the 'golden angle' in all these formations.

Fibonacci Sequence and its Application

Fibonacci sequence of numbers is given below.

0, 1, 1, 2, 3, 5, 8, 13, 21, 34, 55, 89, 144, 233, 377, 610, 987, 1597, 2584, 4181.....

In mathematical terms, the sequence Fn of Fibonacci numbers is expressed as:

$$F_n = F_{n-1} + F_{n-2}$$

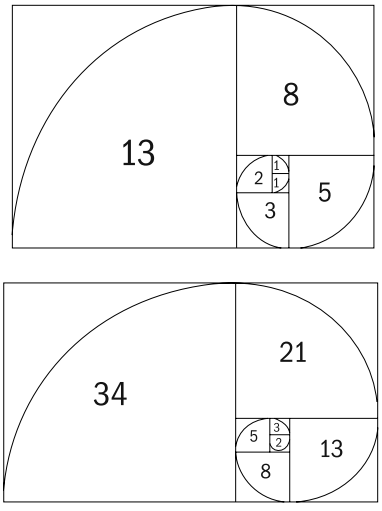

Figure 1: Pictorial representation of Fibonacci numbers forming the spirals

In geometry, the golden angle is the smaller of the two angles created by sectioning the circumference of a circle according to the golden section that is into two arcs, such that the ratio of the length of the larger arc to the length of the smaller arc is the same as the ratio of the full circumference to the length of the larger arc.

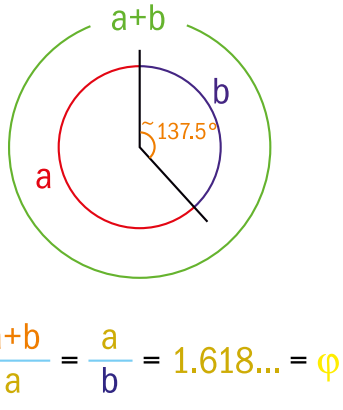

Figure 2: Circle depicting the concept of 'golden angle' and 'golden ratio'

The golden angle (Figure 2) is therefore the angle subtended by the smaller arc of length b. It measures approximately 137.50°. The ratio is known as the golden ratio, represented by 'phi'.

The Fermat spiral follows the equation:

$$r = c\sqrt{n},$$

$$\theta = n \times 137.508°$$

where,

r is the radius (distance from the centre)

θ is the angle

n is the index number of the floret

c is the constant scaling factor

Phyllotaxy refers to how leaves are arranged on a plant stem. The leaves, branches, and petals grow in Fermat spiral so that new leaves do not block the sun from older leaves or the maximum amount of rain or dew gets directed to the roots. Thus, the arrangement is structured in such a way to maximize the gains of the plant/flower to its surroundings.

Picture 1: Arrangement of sunflower floret in Fermat spiral

Biomimicry of Sunflower

The arrangement of the sunflower florets using the golden angle (Picture 1) plays a major contribution in designing the concentrated solar power (CSP) systems. In CSP systems, large mirrors or lenses are used to concentrate sunlight to drive a heat engine which goes to generate electricity. The field of

Picture 2: Heliostat with arrangement like sunflower floret

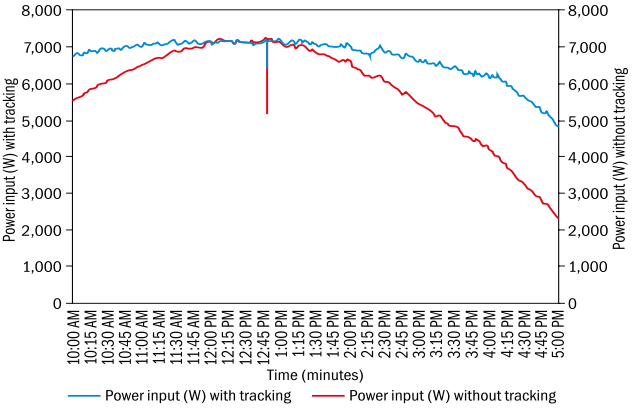

Figure 3: Graph representing the difference on the power input of a solar panel in tracking and stationary mode

mirrors or large lenses called heliostat (Picture 2) directs sunlight to the central receiver located at the top of a tower. The designers faced a huge difficulty in arranging the mirrors or the lenses because the spacing between mirrors is similar to the seats in a theatre, staggered so that every other row is aligned. However, this pattern resulted in shadowing and blocking throughout the day, reducing the reflection of light from mirrors to the tower, thus, there was a gradual reduction in the energy efficiency of the system. The sunflower-inspired pattern encouraged a more compact layout and minimized heliostat shading and blocking by neighbouring mirrors. The inspiration of Fermat spiral has resulted in a 10 per cent greater yield of energy and reduction in the amount of land used.

Sunflower also imparts a unique feature that is tracking the sun throughout the day. When the sun rises in the east, the sunflower head faces the sun and orients itself at a perpendicular direction to the sun rays, for maximizing the solar energy collection. As the day passes, it tracks the sun and always orients itself to 90° towards the sun. The tracking mechanism is known as heliotropism (Picture 3).

The Tracking Mechanism

This tracking mechanism is an inspiration for the manufacturing of solar trackers (Picture 4). The stationary panels are not very energy-efficient as they receive the sunlight only at noon timings perpendicular to them but when a tracking mechanism is installed to such panels they always remain perpendicular to the sunrays—maximizing the efficiency. The solar tracking mechanism can be broadly classified as timer-based solar trackers and sensor-based solar trackers. A stationary panel is equipped with a motor and gear drive mechanism. This entire arrangement is then programmed to follow the sun throughout the day and to increase the power collection efficiency.

Figure 3 shows the variation of power input with and without tracking. It can be seen that the power input because of tracking is higher than as compared to without tracking and in the evening time it can be noticed that the power input because of tracking remains consistent but the power input because of the fixed mode condition drops drastically. After 3 p.m. the drop in the power collection capacity is very high in the stationary (without tracking) mode. It is obvious that when the power collection is high, the power output will also increase at a directly proportional rate. The need of the hour is to implement tracking

Picture 3: Sunflower uses heliotropism for maintaining the solar power collection efficiency

mechanism in the existing stationary panels to maximize the efficiency of the installed systems from 20–30 per cent. As the power generation by renewable energy increases, it will decrease our dependency on the conventional utilities.

The Way Forward

If new technologies could harvest energy in a sustainable manner, then there would be no concerns associated with the increasing trend in global energy demands. However, the world's sources of energy today are far from being sustainable. The widespread use of fossil fuels increase greenhouse gases in the earth's atmosphere, exacerbating climate change and extreme weather that threatens the survival of living organisms and the human civilization. Our ideas are designed as a starting point for bio-inspired energy efforts. Encourage others to use and extend these ideas. An open source and collaborative approach to science and biomimicry innovation is the most preferred approach for attaining the goal of sustainable development, which is of utmost importance for the society in today's interdependent world with increasing energy demands. Identify the promising biomimicry research and ideas, as a novel way of thinking and encourage others to look at the energy world through the lenses of nature. EF

Picture 4: The solar tracker set-up for the direct alignment of the solar panels towards the sun

Courtesy: Sardar Patel Renewable Energy Research Institute (SPRERI), Anand, Gujarat, India

Ms Avipsa Dey, Assistant Professor, ITM Universe, Vadodara, Gujarat, India. Email: avipsadey@gmail.com.

PADDY STRAW–BASED POWER GENERATION FROM BIOGAS

Fazilka District in Punjab Leading the Way!

Punjab has taken the lead to explore possibilities to gainfully use excessive biomass, in the form of waste material of crops, with encouraging results. In this article, **Dr Ram Chandra, Prof. V K Vijay, Prof. P M V Subbarao, S Nagpal, A Trivedi, B Jha,** and **Vandit Vijay** discuss about a case study of 1.0 MW power generation at Fazilka district in Punjab. This is the first biogas-based power plant in India which is operating on paddy straw for large-scale production of green energy. It is a novel initiative wherein agricultural waste is used to generate clean energy using biogas produced from paddy straw. Read on to know more…

The deteriorating quality of life in urban hubs of India, especially in cities like Delhi, shackles our overall growth potential. "Delhi wakes up to air five times worse than the safe standard" as reported by a national daily, *The Times of India*, on Christmas in 2015. Delhi has been ranked poorly amongst the most polluted cities in the world. Furthermore, the case of paddy straw burning in Punjab and other northern parts of India causes serious concern over air pollution levels in Delhi and nearby areas, every year, during the paddy harvesting season. This burning causes a manifold increase in the pollution levels of the adjoining areas. The National Aeronautics and Space Administration (NASA), USA, had been alerting about the same since the past few years. This alarming increase in air pollution is a matter of great concern as we are aware that the air we are breathing is extremely unsafe and unhygienic for the current and future generations as well . We have become

so much helpless to the extent that the Government was forced to introduce the 'Odd–Even' formula for operation of private vehicles on roads so that the air pollution level of Delhi could be controlled to some extent.

The second generation of biofuels' production from renewable energy resources, 'plant biomass', refers particularly to the lignocellulosic biomass/materials, as this makes up the majority of the cheap and abundant non-food materials available from plants. Therefore, lignocellulosic feedstock can offer the potential to provide novel biofuels of the 'second generation of biofuels'. The production of biogas and bioethanol from renewable biomass has been the major research focus around the world with a view to supplement petroleum fuels and reduce environmental pollution as well.

The use of biogas being an environment-friendly, clean, cheap, and versatile fuel and its production from various available biomass resources is a viable option for our country. Harnessing such a resource will not only promote rural industries, agriculture, dairy, and animal farming in a sustainable way but will also help in regulating environmental cycles effectively, since nutrients, such as nitrogen, phosphorus, and potassium as well as micro-nutrients (zinc, iron, manganese, and copper) conserved in the process, in the slurry, can be returned to the soil. It has been observed that the use of slurry as a fertilizer has many advantages as compared to farm yard manure. Weed seeds in the substrates are destroyed completely during the digestion process and they are richer in nutrients when compared to farm yard manure.

Picture 2: Paddy straw bales being used for pulverization

Biogas after methane enrichment is as good as natural gas for powering the internal combustion engines used for various power generation applications and automobiles. Thus, biogas is a good substitute of the conventional compressed natural gas which is derived from crude petroleum. Moreover, biogas production from plant biomass being CO_2 neutral, its combustion again lowers the emissions in comparison to gasoline, diesel fuel, and even natural gas.

Picture 1: A view of paddy straw-based biogas plant installed at Fazilka, Punjab

Installation of Biogas-based 1.0 MW Power Generation System in Fazilka

This is the first biogas-based power plant in India which is operating on paddy straw for large-scale biogas production. Sampurn Agri Ventures Private Limited (SAVPL) is a private limited company established in 2006 to set up a Project for Cogeneration of Power and Bio-Fertilizer, at village Panchanwali in Fazilka district, Punjab, India. The project of SAVPL was sanctioned as a mega project by the Government of Punjab in the month of December 2011. The installed biogas production system is based on a 100 per cent usage of paddy straw as substrate for biogas production. The initial startup of anaerobic digester was carried out by using cattle dung. The established facilities were supposed to produce nearly 12,000 m^3/day of biogas from 40.0 tonnes of paddy straw to run power generation system for 24 hours to produce electricity at 1.0 MW scale. But due to low amount of biogas production power generation, the unit was not able to run beyond four hours. Thereafter, the Indian Institute of Technology (IIT)

Picture 3: Paddy straw pulverization unit using hammer mill

Delhi, was asked to provide technical help to improve the performance of the system. At present, the performance has been significantly improved to produce electricity for 6–8 hours though various level interventions carried out by IIT Delhi in order to increase biogas productivity. At present, the paddy straw processing capacity of the system is about 10.0 tonnes/day. Picture 1 shows the installed paddy straw-based biogas plant.

The system comprises the following sections—(i) Feed preparation unit; (ii) Substrate feeding unit; (iii) Biogas generation unit; (iv) Hydrogen sulphide scrubbing unit; (v) Power generation and grid feeding unit; and (vi) Biofertilizer production unit.

The brief details of individual units have been provided below.

Paddy Straw Feed Preparation Unit

The paddy straw received, in bales, from the entire region of Fazilka, Punjab, is stored in storage unit. Further, the paddy straw is manually spread over the width of the conveyer belt to be fed into the pulverization unit for its size reduction to a level of 3–5 mm. Picture 2 shows paddy straw being used for feed preparation. The average capacity of paddy straw pulverization unit is 1.0 tonnes/h. This unit is powered by an electric motor of 75.0 kW, which consumes nearly 94 kWh energy per hour of operation.

Picture 4: A visual of continuously stirred tank reactor digester of 2,000 m^3

This unit also consists of a pulverized paddy straw collection system followed by an aspirator system for the collection of dust generated during the pulverization process. The aspirator unit is powered through electrical power of 30 kW, which consumes 37.5 kWh energy per hour of operation. Picture 3 shows paddy straw pulverization unit.

Substrate Feeding Unit

The pulverized paddy straw is taken from conveyer belt to a blending tank where it is mixed with water obtained from solid–liquid separation of biogas spent slurry taken from digestate of biogas plant. In this tank, the total solids concentration is maintained at a level of 10–15 per cent. The blended substrate is fed to the anaerobic digesters through a pump comprising blended substrate handling capacity of 30 m^3/h. This pump is powered from an electrical motor of 18.65 kW, which consumes nearly 23 kWh energy per hour of operation.

Biogas Generation Unit

This unit consists of three anaerobic reactors wherein the water capacity of two reactors is 3,400 m^3 and for one reactor [continuously stirred tank reactor (CSTR type)] is 2,000 m^3. The prepared paddy straw substrate is first fed to two digesters through the feeding unit where substrate manages to hold for nearly 30 days of retention time to produce biogas. The digestate of these two reactors (leachates coming out) is thereafter sent to the CSTR reactor where it holds for nearly 10 days of retention time for further biogas production. Picture 4 shows the CSTR-type digester. These reactors operate nearly 10–15 per cent of total solids concentration at mesophilic temperature and are equipped with stirring mechanism to mix the substrate, occasionally, as per the requirement.

This anaerobic digester produces nearly 3,000 m^3 of biogas per day with methane and carbon dioxide content in the range of 50–55 per cent and

40–45 per cent, respectively. The hydrogen sulphide content in produced biogas varied from 500 to 800 ppm.

Hydrogen Sulphide Scrubbing Unit

This unit comprises a hydrogen sulphide scrubber. The biogas produced from anaerobic digesters is passed through

Picture 5: A visual of installed hydrogen sulphide biological scrubber

this scrubber at a flow rate of nearly 500 m^3/h to reduce the concentration of hydrogen sulphide gas from the biogas. It is an essential requirement to reduce hydrogen sulphide level below 50 ppm to use biogas as fuel to operate the engine. The engine is coupled with an alternator to generate electricity. The unit also consists of 5.5 kW electric motor to power a booster pump, which passes the raw biogas through the scrubber unit. An electric motor having 5.5 kW power is used to circulate the digested slurry in the scrubbing unit. The total power consumption in hydrogen sulphide scrubbing unit is 11 kW, which utilizes 13.75 kWh energy per hour of operation. Picture 5 shows hydrogen sulphide removal unit. In this unit, the conversion of hydrogen sulphide takes place into formation of ammonium sulphide and phosphoric acid with the help of DAP (di-ammonium phosphate) through recirculation of slurry. The product, thus obtained, has large potential application for rejuvenation of saline soils.

Power Generation and Grid Feeding Unit

The power generation unit consists of an MWM, German-make 100 per cent biogas engine generator (six cylinders) with a capacity to produce 1.2 MW per hour electrical energy through an alternator of three phase 415 V.
The consumption of biogas is nearly 500 m^3 biogas per hour. Picture 6 shows the installed power generation unit.
At present, the amount of available biogas enables to operate power generation unit for about six hours of operation which generates nearly 6,000 kWh of electrical energy per day. Picture 7 depicts the control panel readings for power generation values installed with the power generation unit. The electricity produced from the power generation unit (three phase, 415 V) is being fed to the national electricity grid through an 11 kV transformer and necessary power control systems.

Biofertilizer Production

Biofertilizer production unit comprises of slurry dehydration system (solid–liquid screw separator press). This unit has two horizontal solids–liquid separating machines with a slurry handling capacity of 8.0 m^3/h. The system is able to separate solids material that is nearly 600 kg/h with a moisture content of about 65 per cent.
The separated liquid is recycled to prepare paddy straw substrate in blending tank. The obtained biosolids are air dried and used as biofertilizer for land applications. The added advantage of biogas generation from paddy straw is production of silica rich biofertilizer. The silicon (Si) is a beneficial plant nutrient and yield responses to its application have been frequently demonstrated in Si-accumulator crops, such as rice and sugarcane. Increased crop yields are the result of simultaneous increases in plant tolerance to a wide range of stresses. The applied silica results in yield increase of up to 35 per cent.

Picture 6: A view of installed power generation unit

IN NORTHERN STATES OF INDIA, OPEN FIELD BURNING OF PADDY STRAW AND OTHER AGRO RESIDUES CAN BE AVOIDED THROUGH INSTALLATION OF COMMERCIAL BIOGAS PRODUCTION INDUSTRIES BY USING AGRO BIOMASS FOR BOTH POWER GENERATION AND BIOFERTILIZER PRODUCTION TO ENRICH SOIL HEALTH CONDITIONS. THE PRESENT LEVEL OF UTILIZATION OF PADDY STRAW AT FAZILKA, PUNJAB, SHOWED A SAVING OF 120.0 GJ/DAY ENERGY, WHICH OTHERWISE WOULD HAVE BEEN RELEASED INTO THE ATMOSPHERE BY THEIR DIRECT COMBUSTION IN FARMER'S FIELD ALONG WITH THE RELEASE OF ENORMOUS POLLUTANTS.

Picture 7: A view of control panel readings for power generation values

Environmental Benefits

In northern states of India, open field burning of paddy straw and other agro residues can be avoided through installation of commercial biogas production industries by using agro biomass for both power generation and biofertilizer production to enrich soil health conditions. The present level of utilization of paddy straw at Fazilka, Punjab, showed a saving of 120.0 GJ/day energy, which otherwise would have been released into the atmosphere by their direct combustion in farmer's field along with the release of enormous pollutants. In addition to the above daily savings in terms of various pollutants resulting from direct combustion of paddy straw, biomass amounts to 30 kg of particulate matter, 600 kg of carbon monoxide, 14.6 tonnes of carbon dioxide, and 20 kg of sulphur dioxide emissions, which has significant toxicological properties and are notably potential carcinogens.

In the present case, the overall thermal efficiency of power generation from biogas, produced from paddy straw, is nearly 20.0 per cent. The utilization of nearly 4,000 tonnes/year of paddy straw by this biogas-based power plant in Fazilka is the main reason for reporting of minimum burning of paddy straw in this region. The present productivity of biogas production from paddy straw is nearly 300 m^3/tonne. The installed system for biogas production has large scope for improvement in its performance for increasing biogas production, methane content in produced biogas, and operating hours of power generation unit.

The non-existence of any governmental standard for biogas spent slurry biofertilizer is a major hurdle in commercial sale of this organic fertilizer. However, there are standards for city compost, vermicompost, and phosphate-rich organic manure in the Fertilizer Control Order. Therefore, this requires urgent attention and needs to develop standards for biogas spent slurry biofertilizer by the Fertilizer Control Order in order to remove the barriers for its marketing and strengthen the biogas sector. EF

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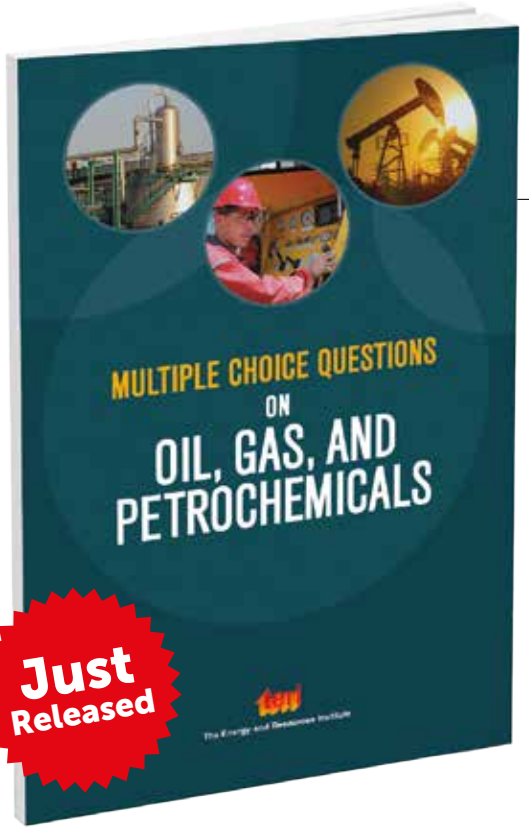
"Exploration of oil, gas, and petrochemical sectors in MCQ format"



Highlights

- Covers different forms of oil and gas sector
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LEADERSHIP SUMMIT FOR SUSTAINABLE DEVELOPMENT 2016

India Inc Deliberations on Roadmap to Align Business Goals with NDC

The Energy and Resources Institute (TERI) organized the 'Leadership Summit for Sustainable Development 2016' on June 7, 2016 in Mumbai. The high-profile event organized by the TERI Council for Business Sustainability (TERI-CBS) brought together corporate leaders and multiple stakeholder groups to debate and discuss the need for corporate organizations to usher in urgent commitments to the ongoing collaborative movement on climate change via a combination of interventions at the policy, financing, and technology levels. The Summit was attended by senior representatives from government organizations— the Ministry of Railways, NABARD, SIDBI and top Indian conglomerates, viz., Tata Group, Mahindra Group, NTPC, and GAIL, and deliberated on major areas of Moving towards Clean Energy (Renewable Energy and Energy Efficiency), Climate Financing, and the way forward for India post Paris Agreement. As the Summit came on the heels of Signing of the Paris Agreement by India in April this year, when over 160 nations committed to reduce

or moderate their greenhouse gas emissions—therefore, very appropriately, the theme of the event was 'Translating India's NDCs to Business Actions'. The Summit received an overwhelming response with participation from more than 100 delegates including CBS member companies.

The event commenced with a special video message by Shri Prakash Javadekar, Minister of State (IC) for Environment, Forest and Climate Change with his inaugural address on India's commitment to NDCs and the critical role that corporates could play in technology innovation and investments in order to achieve the set targets. Commending TERI's efforts Shri Prakash Javadekar, said, "The government has started walking the talk by initiating actions, such as coal cess which has contributed to the Clean Energy Fund. Businesses will now have to do the same. They need to invest and innovate in India, instead of importing expensive technology. There is a need to attract our technology manpower to capitalize on innovation opportunities in India. Working on improving energy, water, and emission efficiencies today present a huge business opportunity." Dr Jaco Cilliers, Country Director, UNDP in India at the inaugural session emphasized on the adoption of Sustainable Development Goals (SDGs) and need for SDGs to promote inclusive growth. He also highlighted the need of businesses to review their strategies and the impact they create and how companies can implement sustainability by using sustainable technologies, this will also bring down the cost of these technologies which is currently very high. Underlining the importance of organizing the Summit, Dr Ajay Mathur, Director General, TERI, took the discussions ahead and said, "There is an urgent need for the pace and scope of the clean energy activities of Indian corporates to highlight—Innovation, Investments, and Collaboration. These three factors need to work in sync for sustainable development. Secondly, the businesses need to review their strategies and the impact they create. Moreover, ambitious solar tendering programme and investment in tomorrow's technology is the focus. Energy, water, and urban development are the three areas where investments are most important."

In the session on 'Promoting Energy Efficiency' deliberations were done on the role of stakeholders, opportunities, and support required in the areas of policy, innovation, and financing to promote energy efficiency. Mr Damandeep Singh, Director, CDP India, discussed about Energy Efficiency (EE) specifically and said that India has taken commendable steps in energy efficiency, including PAT scheme. He also spoke about EP 100 initiative asking companies to double EE by 2030; they can achieve this only by increasing their EE by atleast 2 per cent per annum. Mr Sankar Bandyopadhyay, General Manager, CenPEEP, NTPC dwelled on the fact that energy sector works on a regulated model which needs to be enhanced and the key to sustainability is to manage the existing available resources.

In the RE plenary session on 'Expanding the Share of Renewable Energy in Energy Mix—Policy, Financing and Technology', discussions were done to identify support needed by the corporates in terms of policy, technology, and financing to power the non-fossil fuel energy programme. Mr Ardeshir Contractor, Managing Director and CEO, Kiran Energy, said that internationally, the share of renewable energy in many countries is around 75 per cent, therefore, India is lagging behind. India needs to include its private sector in order to fulfill its commitments. Dr Pawan Singh, Director—Finance, PTC India Financial Services Ltd, opined that biomass can help India in reducing or lowering the cost of energy imports. Dr Ajay Mathur highlighted a few take-away points of the session, such as appropriate business models need to be developed, justified financing is required, that is, there is need for risk management, and technology development is also required.

The deliberations of the event came to end with valedictory session chaired by Dr Ajay Mathur and special remarks by Mr Ashok Chawla, Chairman, TERI, with business thought leaders Mr Ulhas N Yargop, Director, Mahindra & Mahindra and Mr Venkatesh Valluri, Founder & Chairman, Valluri Technology Accelerators deliberated on 'Way Forward for India Inc. Post Paris Agreement'. The Summit was well received by the audience. The event was supported by Mahindra & Mahindra and the outreach partner All India Association of Industries (AIAI). The deliberations of the Summit lead to the Business Day of TERI's WSDS (World Sustainable Development Summit) wherein corporate India will come together to chart out the action plan. The WSDS is scheduled to be held in New Delhi on October 5–8, 2016. EF

GREEN BUILDING RATING SYSTEMS

Key to Save Environment and Push towards Smart Cities

LEED (Leadership in Energy and Environmental Design), is changing the way we think about how buildings and communities are planned, constructed, maintained and operated. Leaders around the world have made LEED the most widely used third-party verification for green buildings, with around 1.85 million square feet being certified daily. In an interview with ***Abhas Mukherjee*** for *Energy Future,* ***Corey Enck,*** Vice President, LEED Technical Development, presented his views on various facets of green and sustainable buildings in India as well as globally and LEED's overall role in the process.

Corey Enck is USGBC's Vice President of LEED Technical Development. In this role, Corey collaborates with volunteer technical committees and industry stakeholders to evolve and refine USGBC's LEED green building rating system. For the last few years, he has been focussed on the development and launch of LEED v4. Previous to his technical development work, Corey managed USGBC's certification team, where he was responsible for working with project teams and reviewers to ensure successful LEED reviews. Prior to joining USGBC, Corey worked at an engineering firm providing services in building system design and energy management. He holds a mechanical engineering degree from the University of Pennsylvania, USA, and is a LEED Accredited Professional.

How is GBCI related to USGBC and LEED?

Basically, GBCI, i.e., Green Business Certification Inc. is a powerful brand that has been synonymous with LEED and green building since it was founded in 2008. GBCI is the only brand to administer project certifications, professional credentials, and certificates within the framework of the US Green Building Council's LEED Green Building Rating System. GBCI also exclusively provides certification and credentialing services for EDGE rating in India, PEER, WELL, SITES, GRESB, and Parksmart.

The US Green Building Council (USGBC) believes that 'better buildings are our legacy'. What is your opinion on that?

Yes, that has been our tagline for the new version of the rating system and a lot of new products that we have launched. What it really means is that there is an urgency to act as we are currently facing environmental problems that are bigger than we have ever faced before and in order for us to solve these problems for the next generation, we need to act now. And, our legacy will depend on the decisions we make right now and green building is a solution to all of these problems and part of the solution to many of these environmental problems.

Leadership in Energy and Environmental Design (LEED) is a certification programme for buildings, homes, and communities that guides the design, construction, operation, and maintenance. Could you kindly elaborate more on that account and what has been LEED's contribution to the green building movement in the world?

LEED has been more successful than we would have ever imagined when we initiated it 20 years ago. I think LEED's contribution to all of this has really been to fuel the movement that has been happening even without the rating systems in place; LEED has been the facilitator in this conversation about sustainability and green buildings. LEED has provided a common framework, a common language for people to talk about green buildings and that has been really important. One of its biggest contributions is bringing people together with a shared goal and it does that through the rating system, it brings together project teams, brings together all sorts of specialists and tradesmen working on a specific project and working towards one common goal. Therefore, it is that common language which has been important and the shared goal of solving our environmental issues has been very helpful for the last 20 years.

With urbanization, urban areas are expected to house 40 per cent of India's population by 2030, which would require a comprehensive development of infrastructure in smart cities. So, how do you visualize the green building movement in India's smart cities of the future?

That's a really good question! As we know, 75 per cent of buildings in India will be new constructions by 2030; therefore, these buildings have not been built as yet. So, it really provides a huge opportunity for India as compared to many other countries, that are facing lower levels of development, it also provides a huge opportunity to get a jumpstart or head start on some of these problems and to really use green buildings as a way to push innovation, green buildings can really drive the infrastructure round these cities as well. So, green buildings will be the key over the next 15 years to meet some of our environmental targets and as we push towards smart cities, a bottom-up approach is really important. Therefore, communities are building green buildings so that we can then integrate the smart infrastructure around them. So, I think, bottom-up and top-down both will be important approaches for the next 15 years of urban development in India.

In 2014, the USGBC and TERI formed a strategic partnership to spread the development of green buildings in India. How fruitful has this association been over the last two years?

TERI's GRIHA (Green Rating for Integrated Habitat Assessment) and USGBC's LEED (Leadership in Energy and Environmental Design) have partnered to promote the best of global and

Indian practices to ensure efficiency of design, construction and operation of high performance buildings. GRIHA has created locally relevant and technologically advanced mechanisms, which is crucial in regionalizing LEED in India and Southeast Asia. We have alternative compliance paths (ACPs) that we have offered to different regions of the US. So, working with TERI has really helped us develop these ACPs for the Indian market and we have seen over the last 2 or 3 years that this strategy has helped us internationally grow our LEED certifications specifically around the existing buildings. Partnership with TERI was a large part of that success!

Please tell us in brief about the possible strategies related to the design and operations of indoor spaces to achieve the desired air quality and also tell us about how LEED and GRIHA are addressing the indoor environment quality issues.

One of the things that we are doing with our newest rating systems is really pushing our performance, that is, trying to understand how these green buildings are performing and one way of doing that is by metering energy and water and trying to quantify their performance. That does not necessarily take into consideration the indoor environment as well. Therefore, we have also started to implement some strategies for monitoring the air, so both monitoring the amount of outside air that one brings inside a building and also testing of the air quality inside the building are important. So, that has been a key strategy that we have been putting forth in our new rating systems but that is just part of the solution as well. I think many different markets will need different solutions to this indoor air quality problem. So, if you are in a region like India, or Asia, in general, there are air quality strategies that might be better suited for you. So, more filtration of the outside air is something that LEED promotes as part of the solution and I thought that might be something that the Indian market is looking for—how to both filter the air centrally or sort of locally in different spaces within a building to improve the air quality. So, one of the other things that we are working on with indoor air quality is really trying to survey occupants of the building and understand what their perceptions are regarding their indoor environment. That survey is helping us to also calibrate some of our indoor air quality solutions—whether that be testing for contaminants based on that survey or increasing the fresh air or just understanding what impact the indoor air quality is having on the occupants of the building. EF

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CURRENT R&D SOLAR

A Study of the Effect of Design Parameters on the Performance of Linear Solar Concentrator Based Thermal Power Plants in India

Renewable Energy, Volume 87, Part 1, March 2016, Pages 666–675
Chandan Sharma, Ashish K Sharma, Subhash C Mullick, and Tara C Kandpal

The sizing of a solar thermal power plant directly affects its cost and also the annual electricity output and hence its financial attractiveness. It involves deciding appropriate values of design DNI, solar multiple, and hours of thermal storage to achieve high annual capacity utilization factor (CUF) with the least cost of electricity delivered. An analysis of the impact of these design parameters on the performance of parabolic trough concentrator (PTC) and linear Fresnel reflector (LFR) based solar thermal power plants is presented using System Advisor Model for eight locations in India. Annual electricity output is estimated using radiation data source of SEC-NREL. Levelized unit cost of electricity (LUCE) is estimated using benchmark capital cost and other financial conditions specified by the Central Electricity Regulatory Commission of Government of India. For a design DNI of 950 W/m^2, LUCE is minimum in solar multiple range of 1.4–1.6 for PTC based plants and of 1.8–2.0 for LFR based plants. With a solar multiple of 1.0, LUCE is minimum in design DNI range of 550–700 W/m^2 for PTC based plants and 450–550 W/m^2 for LFR based plants.

A Comparative Review of China, India and Pakistan Renewable Energy Sectors and Sharing Opportunities

Renewable and Sustainable Energy Reviews, Volume 57, May 2016, Pages 216–225
Saeed Ahmed, Anzar Mahmood, Ahmad Hasan, Guftaar Ahmad Sardar Sidhu, and Muhammad Fasih Uddin Butt

China, India, and Pakistan (CIP) contain almost 40 per cent of the world population and constitute a developing region, which is desperately seeking energy resources to fulfill the growing economy requirements. CIP are the three main countries of Southeast Asia with nuclear capability and have greater potential of energy sharing for the regional prosperity and socio-economic development. The total energy consumption of China and India is 3,682.15 million tonnes of oil equivalent (MTOE) which is approximately 28 per cent of the world. The energy consumption of Pakistan is far less, i.e., 85.75 MTOE however, it can play a pivotal role by providing energy sharing opportunities in the region. This paper presents a comparative and comprehensive review of CIP renewable energy sectors and possible sharing opportunities. Cleaner and abundant Renewable Energy Sources (RES), such as hydro, solar, wind, biomass, nuclear, and geothermal have been discussed and compared in context of CIP energy requirements. CIP relations and energy sharing opportunities have also been elaborated in context of regional peace and security situation. Exploitation of the CIP energy potential and energy sharing opportunities might contribute to global peace and prosperity.

CA Geospatial Assessment of the Techno-Economic Wind Power Potential in India Using Geographical Restrictions

Renewable Energy, Volume 97, November 2016, Pages 77–88
Dimitrios Mentis, Shahid Hussain Siyal, Alexandros Korkovelos, and Mark Howells

India is a privileged country in terms of wind resource regime. However, most of it remains untapped at the same time as around 240 million people lack access to electricity in the country (19 per cent of the total population). This calls for a thorough estimation of the amount of wind energy that could be technically and economically seized to assess the potential penetration of wind power into the country's energy system. The utilization of wind energy is associated with a plethora of localization criteria and thus it should be systematically addressed by spatial assessments to guarantee its harmonization with socio-economic systems, infrastructure, and ecosystems. This study focusses on on-shore wind power and strives to provide with estimates of techno-economic potential based on state-of-the-art wind power technology. Socio-economic, geographical, and technical criteria regarding the localization of wind farms are outlined and implemented through a detailed Geographic Information Systems (GIS) analysis. The levelized cost of wind generated electricity is then calculated geospatially. According to this assessment there are several states that signify high yearly wind energy yield, such as Rajasthan, Andhra Pradesh and Gujarat, whilst Goa and other states indicate the least or negligible wind power potential. The levelized cost of generating electricity ranges between $57 and 100/MWh, which places wind power in a competitive position in the Indian electricity market.

A Review on Planning, Configurations, Modeling and Optimization Techniques of Hybrid Renewable Energy Systems for Off-Grid Applications

Renewable and Sustainable Energy Reviews, Volume 58, May 2016, Pages 376–396
Rajanna Siddaiah and R P Saini

Hybrid renewable energy (HRE) system based power generation is a cost-effective alternative where power grid extensions are expensive. This system utilizes two or more locally available renewable energy resources, such as wind, solar, biomass, biogas and small hydro power with or without conventional fossil fuel energy sources to create standalone mode to meet the energy needs in rural remote areas.
This study offers a comprehensive review of the research work carried out in planning, configurations, and modelling and optimization techniques of hybrid renewable energy systems for off-grid applications. Hybrid renewable system utilities today are more dependent on an optimal design to minimize the cost function. This paper presents a review of various mathematical models proposed by different researchers. These models have been developed based on objective functions, economics, and reliability studies involving design parameters. The present study will familiarize the reader with various optimization techniques of system modelling and enable them to compare these models on the basis of their cost functions. Researchers may consider the most suitable model from the various hybrid renewable system models proposed in this study to develop customized designs for optimizing system size while incurring least cost.

A Study of Existing Solar Power Policy Framework in India for Viability of the Solar Projects Perspective

Renewable and Sustainable Energy Reviews, Volume 56, April 2016, Pages 510–518
Nishant Rohankar, A K Jain, Om P Nangia, and Prasoom Dwivedi

A decade before, conversion of solar energy into electricity was quite expensive compared to other renewable energy or conventional fossil fired generated power. For making solar energy as a mainstream source of power generation the Indian government has taken several initiatives in the last 5–6 years. Presently, the deployment of the solar power project in India is governed by both Central and State governments under the various schemes. These schemes mainly include, Feed-in-Tariff (FiT), Renewable Purchase Obligation (RPO), long-term Power Purchase Agreements (PPAs), Renewable Energy Certificates (RECs), Accelerated Depreciation (AD) benefit and reverse bidding/auctions, etc. As an effect of this competitive market environment, the tariff of solar power has come down from ₹17 or $0.271 (year 2010) to less than ₹6 or $0.0922 (year 2015). This decremented solar tariff may achieve grid parity soon but also has raised the question of sustainability of the solar power project as well. Additionally, this multi-policy environment of both Central and State governments has created lots of confusion among the solar power project developers to select scheme and make their investment viable as per other power generation business. This paper summarizes various schemes under the current policy framework in terms of viability of the solar power projects in India. It also includes issues related with the sustainability of the solar power projects taken under the competitive bidding process with remarkable lowered tariff than benchmarked tariff (ceiling price) in India (i.e., ₹7 or $0.107). This study will help project developers and other stakeholders to understand the issues related with viability of

the project in current multi-policy environment for better planning before investing in the field of solar power business.

An Assessment on Performance of DC–DC Converters for Renewable Energy Applications

Renewable and Sustainable Energy Reviews, Volume 58, May 2016, Pages 1475–1485
S Sivakumar, M Jagabar Sathik, P S Manoj, and G Sundararajan

At present, power shortage has become a huge problem in many countries, due to cumulative load demand which cannot be met by Conventional Energy Power Generation. These challenging situations lead researchers to focus on non-conventional energy sources to extract electric power. In order to extract the electric power, DC–DC converters are adopted at the primary stage to increase the efficiency of power conversion. This paper presents an assessment of current and future trend of non-isolated DC–DC converters (Such as Buck–boost, Cuk, and Sepic) with various parameters and are analysed using MATLAB Simulink. Based on the simulation result, the performances of non-isolated converters are evaluated and are helpful to determine the suitable converter with a particular power rating for renewable energy based applications. In addition, the state space mathematical modelling of DC–DC converters are also presented which will be useful in the design of controllers for different non-isolated DC–DC converters.

Business Innovation and Diffusion of Off-Grid Solar Technologies in India

Energy for Sustainable Development, Volume 30, February 2016, Pages 1–13
Kartikeya Singh

India is a country where 300 million people still live without access to formal electricity, and where hundreds of millions more live with irregular supply through the existing grid network. This paper examines business innovation in the diffusion of off-grid solar technologies in India. An in-country survey of off-grid solar energy providers from across the nation was conducted and coupled with extensive field interviews. Findings reveal that most off-grid solar energy enterprises are not operating in the government subsidy market and that more than half are not offering any form of financing to their customers when selling their products. Also, more than half of the enterprises are selling their products in areas where the electric grid is present. Analysis of data collected suggests that an increase in product categories [lanterns, solar home lighting systems (SHS), micro-grids, etc.] negatively affects unit scaling for a firm but increases the likelihood that the firm is offering financing for its products. In areas without the electricity grid, the number of off-grid solar technology options decrease because the firms operating in the area have fewer categories of technology options. This study finds that off-grid solar technology enterprises that focus on fewer technology categories are more likely to achieve unit scaling. This finding must be balanced with the fact that the extent of the grid has not inhibited the market for off-grid solar technologies, but rather affects the number of categories of technologies that can be offered in those regions. Development programmes should thus recognize that those who need electricity access the most may be the ones with the most limited technology options.

CO_2 Emission Reduction Potential Assessment Using Renewable Energy in India

Energy, Volume 97, February 2016, Pages 273–282
Subhash Kumar, Reinhard Madlener

The Indian power sector is experiencing a lot of pressure to supply sustainable electricity at affordable cost due to heavy demand especially in the peak summer season. Most of India's electricity is produced by fossil fuelled power plants, which are the source of CO_2 emissions. In this case, renewable energy sources play a vital role in securing sustainable energy without environmental emissions. This paper examines the effects of renewable energy use in electricity supply systems and estimates the CO_2 emissions by developing various scenarios under the least cost approach. The LEAP energy model is used to develop these scenarios. The results show that in a ARET (accelerated renewable energy technology) scenario, 23 per cent of electricity is generated by renewables only, and 74 per cent of CO_2 reduction is possible by 2050. If the maximum energy savings potential is combined with the ARET scenario, the renewables share in electricity supply rises to 36 per cent as compared to the reference scenario, while the CO_2 emission reduction in this case remains at 74 per cent. EF

SOLAR DOMESTIC WATER PUMPS

An Apt Solution for Uninterrupted Water Supply

Surface solar pumps are best at drawing water from shallow wells, springs, ponds, rivers or tanks, and push it to a storage tank or reservoir. The ideal lift length for surface pumps is between 10 and 100 feet. The surface pumps, are designed for continuous, steady flow applications, and can be used with batteries. They are ideal to pressurize water for homes, cabins, or even for irrigation systems.

The solar water pump (Madhurisolar domestic pump — *ab baari hamari hai)* is an exact solution for the daily requirements of water for home, apartment, bungalows, small societies and for mini dual pump scheme (borewell hand pump). It works on solar energy and battery 24x7, which fulfills the need of water, as and when required. This solar water pump system has been designed by studying and calculating that how many litres of water is needed by each family or apartment and not by capacity or rating (HP) of pump. This system is totally automatic, which helps in providing 24 hours water to homes. Also, all types of protections and indications with LED and audio buzzer are provided in the system to make it user-friendly. Solar power generated by photovoltaic (PV) module is utilized directly when the pump is ON during daytime and when the pump is OFF. The energy generated is stored in battery and used as and when required, anytime during the day or night. This solar system is very economical and pocket-friendly as well. This domestic pump utilizes German technology and fulfills water requirement from 500–10,000 litres. Three different models have been designed to suit various customer requirements with head range from 20–230 feet. Picture 1 shows Model 1 (PES-12S, 12V surface pump). Figures 1 and 2 demonstrate the mechanism of the system.

Picture 1: Model 1 (PES-12S, 12V surface pump)

Key Features of the Solar Water Pump

- Fully automatic
- Round-the-clock operation
- Models as per capacity
- Economical
- Strong construction
- *Light weight:* 2.7 kg
- Internal bypass feature for pump protection
- Long life
- Streetlight/homelight from dusk to dawn with motion sensor.

Model-1: PES-12S, 12V surface pump

Total Vertical Lift (feets)	Flow Rate Per Hour (litres)
20	600
50	500

Model-2: PES-24S, 24V surface pump

Total Vertical Lift (feets)	Flow Rate Per Hour (litres)
50	900
100	800
125	700

Model-3: PES-24SU, 24V submersible pump

Total Vertical Lift (feets)	Flow Rate Per Hour (litres)
100	390
160	370
230	310

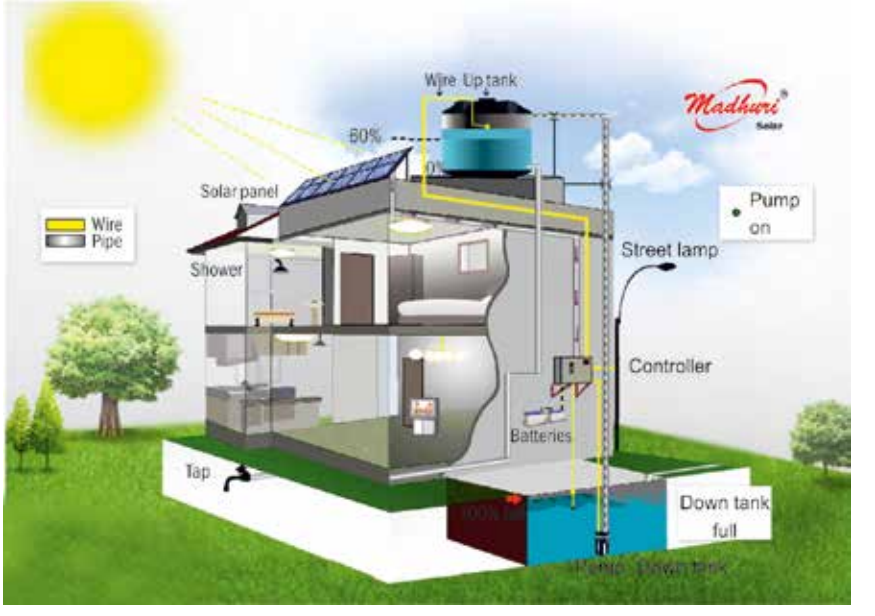


Figure 1: With sunrise the solar water pump gets 'ON' till tank is 100 per cent full

Figure 2: The pump remains 'OFF' till level of tank is reached 60 per cent and after that pump again automatically gets 'ON'

Model-3: Submersible Pump

The PES-24SU, 24V submersible pump (Picture 2) can be used for mini dual pump scheme. Submersible solar pumps are generally used for pumping from wells, and are designed to fit inside the well casing in a drilled hole. These kinds of pumps are great for applications in livestock watering, irrigation, ponds, islands, remote homes, and cabins. Madhurisolar has designed economical pump for mini solar dual pump schemes in which one can utilize the power of the sun during the day and act as a normal hand pump when the solar energy is not available, hence assuring uninterrupted water supply for drinking, sanitation, personal hygiene, etc.

Applications of the Solar Water Pump

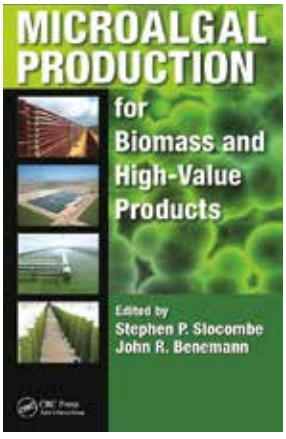
- Domestic solar pumps for residence / apartments
- Drinking water supply
- Water supply for remote domestic usage
- Water supply for solar thermal installation
- Water supply for animals
- Game parks and game farms
- Pond management
- Solar micro irrigation (small family's garden, small rural areas or green roof system)
- Irrigation of fields and greenhouses.

Pearl Enterprises is pioneer in manufacturing of solar photovoltaic products since the year 2003 under the brandname "Madhurisolar" and has come up with very innovative and economical solutions to meet water needs of society by introducing solar domestic water pumps for apartments, bungalows, toilets, schools, etc. For more information please visit the website www.madhurisolarpune.com

Picture 2: Model 3 is used as a submersible pump

Microalgal Production for Biomass and High-Value Products

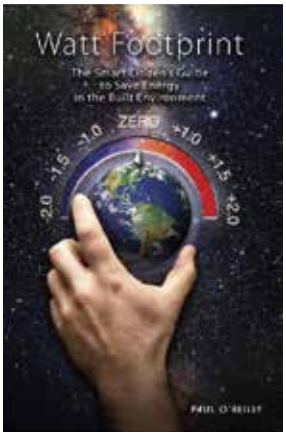
Microalgal Production for Biomass and High-Value Products gives in-depth analyses of the algal biomass industry, its products and processes, and economics. The book covers recent scientific developments, fundamental and applied, and future research directions and presents a wide diversity of viewpoints and experiences, both academic and industrial. The book also describes advances in gene technologies, synthetic biology, algal productivity, growth modelling, and crop protection. It reviews algal production systems, open ponds and photobioreactors, and the latest design innovations. It also includes specific case studies of cutting-edge technologies and industrial-scale production systems. This book brings together the latest advances of interest to those already working in the field while providing an introduction to those beginning to learn about the promise of microalgae as a sustainable source of both specialty and commodity products. It gives stimulating overviews from many different perspectives that describe how laboratory and applied research are creating advances in commercial microalgae production. EF



Edited by: Stephen P Slocombe, John R Benemann
Publisher: CRC Press; Year: 2016

Watt Footprint: The Smart Citizen's Guide to Save Energy in the Built Environment

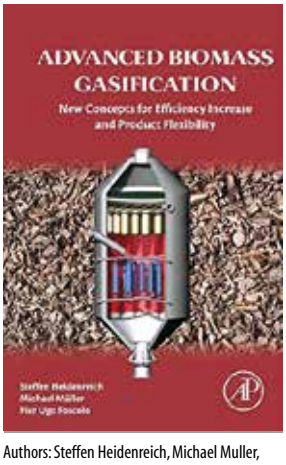
This inspiring and practical book presents a helpful seven-step guide to enable us make informed decisions about the type of energy we choose to power our modern lifestyles. The book also provides basic information to help us use energy more efficiently in our homes and workplaces. This book also aims to help you to navigate the rules, to understand the genesis of regulations governing energy efficiency in buildings, and to make sensible decisions about some very basic issues that significantly affect the quality of our modern lives. The book provides a seven-step guide, written in plain and simple language to help people understand such issues as energy measurement, energy efficiency, insulation, airtightness, temperature control and renewable energy generation and the part water efficiency has to play in climate change. EF



Author: Paul O'Reilly
Publisher: ePrint; Year: 2016

Advanced Biomass Gasification: New Concepts for Efficiency Increase and Product Flexibility

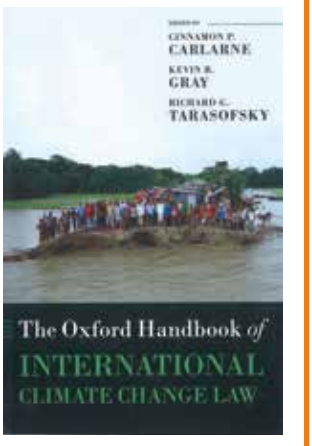
Advanced Biomass Gasification: New Concepts for Efficiency Increase and Product Flexibility provides a thorough overview on new concepts in biomass gasification and consolidated information on advances for process integration and combination, which could otherwise only be gained by reading a high number of journal publications. The authors start their exploration with the compact UNIQUE reactor, gasification and pyrolysis, gasification and combustion, and catalysts and membranes. The authors then examine biomass pre-treatment processes, taking into account the energy balance of the overall conversion process, and look into oxygen-steam gasification and solutions for air separation, including new options for integration of O_2-membranes into the gasifier. Several polygeneration strategies are covered, including combined heat and power (CHP) production with synthetic natural gas (SNG), biofuels and hydrogen, and new cutting-edge concepts, such as plasma gasification, supercritical water gasification, and catalytic gasification, which allows for insights on the future technological outlook of the area. This book is a valuable resource for industry and academia-based researchers, as well as graduate students in the energy and chemical sectors with interest in biomass gasification, especially in areas of power engineering, bioenergy, chemical engineering, and catalysis. EF



Authors: Steffen Heidenreich, Michael Muller, and Pier Ugo Foscolo
Publisher: Academic Press Inc; Year : 2016

The Oxford Handbook of International Climate Change Law

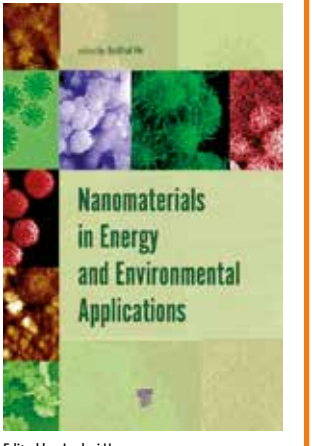
The Oxford Handbook of International Climate Change Law provides an unprecedented and authoritative overview of all aspects of international climate change law as it currently stands, with guidance for how it should develop in the future. Over forty leading scholars and practitioners set out a comprehensive understanding of the legal issues that surround this vitally important but still emerging area of international law. This book addresses the major legal dimensions of the problems caused by climate change: not only in the content and nature of the international legal frameworks, which need implementation at the national level, but also the development of carbon trading systems as a means of reducing the costs of meeting emission reduction targets. After an introduction to the field, the Handbook assesses the relevant institutions, the key applicable principles of international law, the international mitigation regime and its consequences, and climate change litigation, before providing perspectives focussed upon specific countries or regions. The Handbook will be an invaluable resource for scholars, students, and practitioners of international climate change law. It provides readers with diverse perspectives, bringing together interpretations from different disciplines, countries, and cultures. EF



Edited by: Cinnamon P Carlarne, Kevin R Gray, and Richard Tarasofsky
Publisher: OUP Oxford; Year: 2016

Nanomaterials in Energy and Environmental Applications

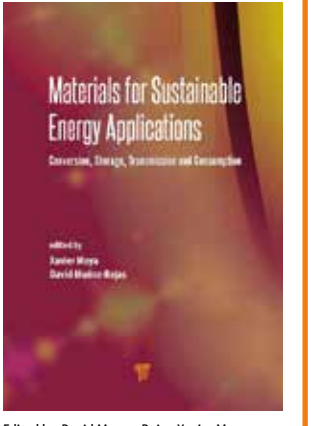
This book summarizes the recent efforts through nanoscience and nanotechnology towards meeting the pressing energy and environmental challenges that humankind faces. It examines future directions of nanomaterial development and encourages future efforts. It also presents contributions from world-renowned specialists in the fields of nanomaterials, energy, and environmental science. Among the current subjects in nanoscience and nanotechnology, nanomaterials are developing fast and explosively and attracting a huge amount of attention. They continue to show promising potential and have found application in solar cells, fuel cells, secondary batteries, supercapacitors, air and water purification, and removal of domestic and outdoor air pollutants. To summarize the past developments and encourage future efforts, this book presents contributions from world-renowned specialists in the fields of nanomaterials, energy, and environmental science. It discusses the design and fabrication of nanostructured materials and their energy and environmental applications. This book would be beneficial for graduate students of Physics, Chemistry, Materials Science, Biochemistry, Medicine and Engineering; researchers and engineers in nanoscience and nanotechnology. EF



Edited by: Junhui He
Publisher: Pan Stanford; Year: 2016

Materials for Sustainable Energy Applications: Conversion, Storage, Transmission, and Consumption

This book gives a unified and comprehensive presentation of the fundamentals and the use and design of novel materials for efficient sustainable energy applications, such as conversion, storage, transmission, and consumption. It presents general coverage of the use and design of advanced materials for sustainable energy applications. It also addresses all the relevant aspects, such as materials for energy conversion, storage, transmission, and consumption. The purpose of this book is to give a unified and comprehensive presentation of the fundamentals and the use and design of novel materials for efficient sustainable energy applications, such as conversion, storage, transmission, and consumption. Thus, the book addresses all the relevant aspects, such as materials for energy conversion, storage, transmission, and consumption. This book would be beneficial for Undergraduate and graduate students of Physics, Chemistry, and Materials Science and Engineering; Researchers in Physics, Chemistry and Materials Science; Engineers in sustainable energies. EF



Edited by: David Munoz-Rojas, Xavier Moya
Publisher: Pan Stanford; Year: 2016

RENEWABLE ENERGY TECHNOLOGY DEVELOPMENT

New 'Greenweb' Tools Aim to Create an Energy-Efficient Web

Researchers in the Cockrell School of Engineering at The University of Texas at Austin have developed a new, open-source computer programming framework that could make the web significantly more energy-efficient, allowing people to save more battery power while browsing on mobile devices. To help mobile device users maximize their limited battery storage, researchers have developed a 'Green Web', a set of web programming language extensions that enable web developers to have more flexibility and control than ever before over the energy consumption of a website.
The researchers have made the framework available to the public at <WattWiseWeb.org>.

The researchers integrated GreenWeb into Google Chrome and reported energy savings of 30–66 per cent over Android's default mode. Mobile device users spend nearly two-thirds of their time browsing the web, so that amount of energy savings could result in a 20–40 per cent battery life extension. GreenWeb more efficiently guides the web browser engine to save processor energy without sacrificing user experience. The language extensions, implemented as CSS style rules, allow developers to express hints to the browser, which in turn conserves power when excessive computational horsepower is not necessary.
The researchers also developed AutoGreen, an automatic tool within the GreenWeb framework to assist developers in automatically making webpages energy-friendly. The system continuously monitors hardware and browser execution behaviour to better understand how to maximize energy efficiency during interactive usage.

https://www.sciencedaily.com/releases/2016/06/160616110244.htm

Solar Power Home Storage Systems Put to Test

Home storage systems for electricity produced by photovoltaics' facilities are gaining attractiveness, as their costs are declining. However, standardized, verifiable criteria for the end client to assess their performance are still lacking. Now, scientists have launched the largest German study so far to analyse commercial systems with respect to safety, quality, and grid suitability and to derive recommendations for manufacturers, standardization bodies, and authorities. Thanks to their price-performance ratio, lithium-ion batteries are increasingly applied in these home storage systems. In operation, however, they differ from conventional lead batteries in some very important respects.

For the end clients and even for an expert electrician, it is difficult or even impossible to reliably assess the safety and quality of these home storage systems, as binding standards and inspection regulations exist for conventional battery technologies only. These test regulations cannot be applied to modern lithium-ion batteries. Laboratory tests carried out in 2013 revealed major safety deficiencies of home storage systems commercialized in Germany, including fires and explosions of the batteries.

https://www.sciencedaily.com/releases/2016/06/160613090726.htm

Novel Solar Absorber to Improve Efficiency of Concentrating Solar Power Technology

Faculty members of Masdar Institute are part of a collaborative team of researchers that has discovered a novel way to significantly increase the amount of sunlight that a solar absorber can convert into heat. By converting more of the solar energy that reaches the earth's surface into heat in a low-cost way, the solar absorber can help make sustainable technologies that rely on solar heat, like solar thermal technologies, more efficient and affordable. Researchers have developed a simple and cost-effective fabrication technique to create solar absorbers that can harness a greater share of the solar spectrum, thus increasing their efficiencies, while also maintaining low emission levels. The team's novel fabrication technique involves patterning a solar absorber with tiny holes with diameters less than 400 nanometres (that's roughly 200 times smaller than the width of a human hair), cut into the absorber at regular intervals.

The tiny holes penetrate the entire absorber greatly enhancing the range of solar energy that can be absorbed. Close to 90 per cent of all the wavelengths of light that reach the earth's surface are absorbed by the nano-hole patterned absorber. Unlike traditional solar absorbers, this absorber requires very little material and consists of only two layers: a semiconductor film and a reflective metallic layer, with a total thickness of 170 nanometres. This idea can be applied to most conventional solar absorbers. With this unique patterning, the absorbers can be boosted to harvest more solar energy from the ultraviolet and visible regions of the electromagnetic spectrum.

https://www.sciencedaily.com/releases/2016/06/160609064749.htm

Physicist Develops New Model for Speed, Motion of Solar Flares

A Montana State University physicist, who has developed a new model that predicts the speed of solar plasma during solar flares, likening it to the path travelled by a thrown baseball, presented his findings at the Solar Physics Division of the American Astronomical Society Conference in Boulder, Colorado. This physicist has developed the model that might help to define how solar flares evolve and provide better ways to predict them. His work could have applications on how to protect power grids and communication technology and aeronautics from the energy released by the flares.

He has used data from the NASA Interface Region Imaging Spectrograph satellite, also known as IRIS, which monitors a specific layer of the sun known as the transition region. The transition region is thin, but complex, and separates the sun's outermost layer, the corona, from an inner layer, the chromosphere. The corona, the chromosphere, and the transition region are of great interest and mystery to scientists. Temperatures in the corona can reach several million degrees Kelvin, far hotter—often by more than a factor of 100—than any other layer of the sun's atmosphere. A solar flare arcing through the corona can be more than 10 million degrees Kelvin. This is puzzling and seems counterintuitive since the corona is the furthest layer from the sun and, therefore, should arguably be the coolest. He has used IRIS's data to look at the sun's solar flare process. During a solar flare, plasma from the sun can heat up to millions of degrees Kelvin and evaporate into the corona. There it fills or is funneled into powerful magnetic fields that give it an arcing, loop-like shape. The prediction of large solar flares is important because they can emit vast amounts of energy that can disrupt power grids, satellites, communication technology, and aeronautics. For example, in March 1989, a powerful solar flare left millions of Canadians without electricity for about 12 hours, according to NASA.

https://www.sciencedaily.com/releases/2016/06/160603092851.htm

Harnessing Solar and Wind Energy in One Device Could Power the 'Internet of Things'

The 'Internet of Things' could make cities 'smarter' by connecting an extensive network of tiny communications devices to make life more efficient. But all these machines will require a lot of energy. Rather than adding to the global reliance on fossil fuels to power the network, researchers say they have a new solution. Their report on a single device that harvests wind and solar energy appears in the journal ACS Nano. Computer industry experts predict that tens of billions of gadgets will make up the Internet of Things within just five years, according to news reports. They will be in homes, syncing coffee makers to alarm clocks. They will be in buildings, managing lights and air temperature. But they will also require energy to run. Sustainably generating more energy in cities close to where the devices will be used is challenging. Cities do not have much space for towering wind turbines.
For the first time, the researchers have integrated two energy harvesting technologies in one: a silicon solar cell and a nanogenerator that can convert wind energy into electrical output. The solar cell component of the system delivers 8 milliwatts (mW) of power output (1 mW can light up 100 small LEDs). The wind harvesting component delivers up to 26 mW. Together, under simulated sun and wind conditions, four devices on the roof of a model home could turn on the LEDs inside and power a temperature-humidity sensor. Installed in large numbers on real rooftops, the hybrid device could help enable smart cities.

https://www.sciencedaily.com/releases/2016/05/160525121225.htm

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INTERNATIONAL

World Congress and Exhibition on Wind & Renewable Energy

July 28–30, 2016

Berlin, Germany
Website: http://windenergy.omicsgroup.com

2016 Capital Region International New Energy Industry Exposition and Forum

August 6–8, 2016

Beijing, China
Website: http://www.bbs-summit.com

Energy Issues Summit

August 10–11, 2016

St. Cloud, USA
Website: http://10times.com

5th International Conference on Production, Energy and Reliability 2016 (ICPER2016)

August 15–17, 2016

Kuala Lumpur, Malaysia
Website: http://usite.utp.edu.my/icper2016

International Conference & Exhibition on Clean Energy

August 22–24, 2016

Montreal, Canada
Website: http://icce2016.iaemm.com

Intersolar South America 2016

August 23–25, 2016

São Paulo, Brazil
Website: www.intersolar.net.br

Brazil Windpower

August 30–September 1, 2016

Rio De Janeiro, Brazil
Website:
http://www.brazilwindpower.org

Intersolar Middle East 2016

September 19–21, 2016

Dubai, UAE
Website: www.intersolar.ae

International Conference on Power and Energy Engineering

September 29–30, 2016

London, UK
Website: http://power-energy.conferenceseries.com

All-Energy Australia 2016

October 4–5, 2016

Melbourne, Australia
Website: www.all-energy.com.au

NATIONAL

Renewable Invest Telangana

July 15, 2016

Hyderabad, India
Website: http://10times.com

World Renewable Energy Technology Congress & Expo

August 21–23, 2016

New Delhi, India
Website: wretc.in

Coal Summit Expo

September 5–7, 2016

New Delhi, India
Website:
http://www.coalsummitnexpo.com/

Renewable Energy India Expo 2016

September 7–9, 2016

Greater Noida, India
Website:
www.ubmindia.in/renewable_energy

Regulators & Policymakers Retreat

September 22–25, 2016

Goa, India
Website: http://ippairetreat.com

Electrical Building Technology India

October 5–7, 2016

New Delhi, India
Website: http://10times.com

World Sustainable Development Summit 2016

October 5–8, 2016

New Delhi, India
Website: http://wsds.teriin.org

Green Building Congress 2016

October 6–8, 2016

Mumbai, India
Website: http://www.greenbuildingcongress.com

Intersolar India 2016

October 19–21, 2016

Mumbai, India
Website: www.intersolar.in

Powerelec India

October 24–26, 2016

Mumbai, India
Website: http://www.powerelec.co.in

RENEWABLE ENERGY AT A GLANCE

Programme/Scheme wise Physical Progress in 2016–17 (& during the month of May 2016)			
Sector	**FY 2016–17**		**Cumulative Achievements**
	Target	**Achievement**	**(as on 31.05.2016)**
I. GRID-INTERACTIVE POWER (CAPACITIES IN MW)			
Wind Power	4,000.00	106.40	26,932.30
Solar Power	12,000.00	559.78	7,568.64
Small Hydro Power	250.00	1.80	4,280.25
Bio-Power (Biomass & Gasification and Bagasse Cogeneration)	400.00	0.00	4,831.33
Waste to Power	10.00	0.00	115.08
Total	**16,660.00**	**670.98**	**43,727.60**
II. OFF-GRID/ CAPTIVE POWER (CAPACITIES IN MW_{EQ})			
Waste to Energy	15.00	0.00	160.16
Biomass(non-bagasse) Cogeneration	60.00	0.00	651.91
Biomass Gasifiers	2.00	0.00	18.15
—Rural —Industrial	8.00	0.0	164.24
Aero-Generators/Hybrid systems	0.30	0.00	2.69
SPV Systems	100.00	2.07	325.40
Water mills/Micro hydel	1.00	0.00	18.71
Total	**186.30**	**2.07**	**1,341.26**
III. OTHER RENEWABLE ENERGY SYSTEMS			
Family Biogas Plants (numbers in lakh)	1.10	0.00	48.55

Source: www.mnre.gov.in

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Three issues	171,000	142,500	142,500	114,000	57,000	34,200	19,950
Four issues	228,000	190,000	190,000	151,000	76,000	45,600	26,600

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