Utilizing the Sustainable Solar Power Efficiently

Overcoming the Challenges

Solar power is one of the most promising renewable energy technologies, allowing the generation of electricity from free and inexhaustible sunlight. It is a safe, clean, and renewable energy resource that will no doubt play a pivotal role in powering our future. In this article, ***Dr S S Verma*** *points out that inspite of the advantages of solar energy, there are still a few challenges that we need to overcome. If the engineering challenges can be met for improving solar cells, reducing their costs, and providing efficient ways to use their electricity to create storable fuel, solar power will assert its superiority to fossil fuels as a sustainable energy source for many generations to come. Read on.*

Growing concern about the environmental degradation and depleting conventional energy resources with rising demand of energy due to increasing population and changing civilization style makes all of us realize the need to utilize solar power for its maximum use in all human endeavours that has been so far driven by conventional sources of energy. Various solar energy generation and utilization activities are taking place all over the world and India is putting its wholehearted efforts to catch up with the world's leading countries in solar power utilization. The Jawaharlal Nehru National Solar Mission (JNNSM) is an important paradigm in that direction. Solar power utilization has reached new horizons from street lighting, water heating, water cooling, and refrigeration to electricity generation. Solar devices, such as cookers, coolers, lanterns, filters, water heaters, pumps, electricity generators, solar-assisted vehicles, and planes are becoming very common in day-to-day life. Not only big solar plants are being set up at different locations all over the world but solar photovoltaic panels and solar reflectors/absorbers are becoming an integral part of a common man's life. Massive new solar power generation (state-wise list) in the country (Table 1) and major photovoltaic (PV) power plants all over India (Table 2) reflect a booming demand for solar power. Therefore, question definitely arises whether this mode of power is sustainable. This article briefly presents not only the growing applications of solar power but challenges towards its further use and sustainability.

Table 1: State-wise installed solar power

State	MWp
Arunachal Pradesh	0.025
Puducherry	0.025
Lakshadweep	0.75
Tripura	5
Uttarakhand	5
Chandigarh	5.041
Andaman & Nicobar Islands	5.1
Delhi	6.712
West Bengal	7.21
Chhattisgarh	10.28
Haryana	12.8
Jharkhand	16
Odisha	31.92
Telangana	62.75
Uttar Pradesh	71.26
Karnataka	88.22
Tamil Nadu	157.98
Punjab	195.27
Andhra Pradesh	268.46
Maharashtra	378.7
Madhya Pradesh	603.58
Gujarat	1,000.05
Rajasthan	1,163.7
Others	0.79
Total	**4,096.648**

(Source: https://en.wikipedia.org/wiki/Solar_power_in_India)

All the stakeholders in the country have plans to go for solar power utilization in a major way, therefore, homeowners, businesses, and energy companies boosted by a mix of federal tax credits, and state and local incentives are all expected to follow the use of solar power and install a number of plants.

DEVELOPMENT PLANS

Already, the sun's contribution to human energy needs is substantial—worldwide, solar electricity generation is a growing, multibillion dollar industry. But solar's share of the total energy market remains rather small, well below 1 per cent of total energy consumption, compared with roughly 85 per cent from oil, natural gas, and coal. There is probably need of vast amounts of solar power if we are going to avoid the more dire effects of climate change. Experts have calculated that roughly 50 per cent of the world's electricity will need to come from solar power by 2050, requiring about 12.5 TW of photovoltaic capacity. We have barely begun the difficult and expensive transformation. Eventually, it will take vastly improved solar materials and better storage options such as batteries, as well as a realistic price on carbon emissions. But meanwhile, we need policies that are more effective in helping to make solar power a significant contributor to our electricity supply. The plan to build the massive manufacturing facility comes at a time when demand for solar power is booming.

All the stakeholders in the country have plans to go for solar power utilization in a major way, therefore, homeowners, businesses, and energy companies boosted by a mix of federal tax credits, and state and local incentives are all expected to follow the use of solar power and install a number of plants. By offering innovative financing schemes, it has spurred strong demand for rooftop panels on homes and on land including agricultural land as the fastest-growing sector of the solar market. Instead of buying the expensive solar panels and paying for their installation, homeowners and landlords can lease the system on time bound payment basis. Presently, the Central and State governments in India have big plans to harness solar energy. India has set the ambitious target for installation of 175 GW renewable power by 2022. It includes 100 GW of grid connected solar power. India will have the world's largest—750 MW solar power plant in Rewa district of Madhya Pradesh. The policies formulated by the Central government and the states to boost clean power, will offer 'deemed industry' status to solar parks and standalone solar plants. Governments are planning net metering (process through which a solar power project is installed on the roof) policy for rooftop solar PV power plants.

Table 2: India's major photovoltaic (PV) power plants

Name of the Plant	DC Peak Power (MW)	Commissioned in
Jamuria Photovoltaic Plant, West Bengal	2	2009
Azure Power—Ahwan Photovoltaic Plant, Punjab	2	2009
M G M Minerals—Odisha	1	2010
NDPC Photovoltaic Plant, Delhi	1	2010
Itnal Photovoltaic Plant, Belgaum, Karnataka	3	2010
Thyagaraj Stadium Plant, Delhi	1	2010
Kolar Photovoltaic Plant, Yalesandra, Kolar District, Karnataka	3	2010
Sivaganga Photovoltaic Plant, Tamil Nadu	5	2010
Sunark Solar—Odisha	10	2011
Raajratna Energy Holdings—Bolangir Solar Power Project—Odisha	10	2011
Skygen Infrabuild—Odisha	5	2011
Konark Kranti Energy—Odisha	5	2011
Abacus Holdings—Odisha	3	2011
Orion Solar—Odisha	3	2011
Skygen Infrabuild—Odisha	5	2011
Raajratna Energy Holdings—Odisha	10	2011
Tata Power—Odisha	1	2011
Gandhinagar Solar Plant, Gujarat	1	2011
Tata Power—Mulshi, Maharashtra	3	2011
Azure Power—Sabarkantha, Khadoda village, Gujarat	10	2011
B&G Solar Pvt. Ltd—Mayiladuthurai, Tamil Nadu	1	2011
Tata Power—Osmanabad, Maharashtra	1	2011
IIT Bombay—Gual Pahari, Haryana	3	2011
Moser Baer—Patan, Gujarat	30	2011
Citra and Sepset Power Plants, Katol, Maharashtra	4	2011
Green Infra Solar Energy Limited—Rajkot, Gujarat	10	2011
Waa Solar Power Plant (Madhav Power)—Surendranagar, Gujarat	10	2011
Rasna Marketing Services LLP, Ahmedabad, Gujarat	1	2011
Tata Patapur—Odisha	9	2012
Bitta Solar Power Plant (Adani Power)—Bitta, Kutch, Gujarat	40	2012
Mahindra & Mahindra Solar Plant, Jodhpur, Rajasthan	5	2012
TAL Solar Power Plant—Barabanki, Uttar Pradesh	2	2012
Zynergy, Vannankulam village, Peraiyur, Madurai, TN	1	2012
Chandraleela Power Energy—Narnaul, Haryana	0.8	2012
Mithapur Solar Power Plant (Tata Power)—Mithapur, Gujarat	25	2012
Numeric Power Systems, Coimbatore, Tamil Nadu	1	2012
Amruth Solar Power Plant—Kadiri, Andhra Pradesh	1	2012
Charanka Solar Park—Charanka village, Patan district, Gujarat	221	2012
Dhirubhai Ambani Solar Park, Pokhran, Rajasthan	40	2012
Urja Global Limited—Jharkhand, Delhi	1	2012
Omega Renk Bearings Pvt. Ltd Solar Plant—Madhya Pradesh	1.5	2013
Mahagenco 125 MW Solar Project—Maharashtra	125	2013
Welspun Energy 50 MW Rajasthan Solar Project—Phalodhi, Rajasthan	50	2013
Azure Power—Rajasthan PV Plant, Rajasthan	35	2013
Ushodaya Project—Smarttrak Solar Systems, Midjil, Telangana	10	2013
Green Energy Development Corporation Ltd—Odisha	50	2014
Vivaan Solar—Madhya Pradesh	15	2014
NTPC Limited—Odisha	10	2014
Welspun Solar MP project 151 MW Neemuch, MP	151	2014
Tata Power Solar Systems Ltd—50 MW NTPC—Rajgarh, MP	50	2014
Tata Power Solar—Murugan Textiles, Palladam, Tamil Nadu	2	2014
DonBosco,Kurla, Omega Natural Polarity, Mumbai	0.1	2014
Sharda Construction—Latur, Maharashtra	10	2015
Welspun 34 MW, Bhatinda, Punjab	34	2015

(Source: https://en.wikipedia.org/wiki/Solar_power_in_India)

THE CHALLENGES AHEAD OF US

Solar power is a safe, clean, and renewable energy resource that will no doubt play a dynamic role in powering our future. On one single day, the sun sends 15,000 times more energy to the earth than we consume worldwide on a daily basis. That means such a large free supply is available in limitless quantities in contrast to fossil fuel-based energy sources. Harnessing the sun's power is accomplished through the use of a PV system. This new technology could be a very big deal to create jobs to workers, contractors, and suppliers. But, problems with solar energy, i.e., its intermittent nature, energy storage, solar cell efficiency, and solar energy infrastructure, have prevented it from becoming a more utilized energy source. The major issues which need attention to utilize sustainable solar power are highlighted in Table 3.

The challenges and obstacles that we must address for efficiently utilizing solar power are as follows:

- What is hampering solar power has everything to do with the cost of technology. It is five to eleven times more expensive to produce electricity from the sun than it is from coal, hydro, or nuclear sources. Solar panels use expensive semiconductor material to generate electricity directly from sunlight. Semiconductor factories need 'clean' manufacturing environments and are expensive to build and maintain.
- Companies supported with federal investment tax credit for solar power may be benefitted initially and the landowner may also be credited but the business is still unprofitable due to high cost of solar electricity. And rooftop solar is especially expensive. Subsidies and other government incentives are the reason the solar market is booming. If technologies were chosen purely on the basis of what it costs to produce power, there isn't a market for residential solar. With time, the federal tax credits for installation, generation, and utilization of solar power are due to drop for businesses and to disappear altogether for consumers who buy their own solar panels.
- Home/land leasing programme is proving attractive for homeowners/landowners—especially in locations with high electricity rates and lots of sunshine and with a lifestyle moving away from agriculture. But, the infrastructure of sprawling solar power plants when abandoned after use and beyond redevelopment state will be a great nuisance on the land.
- The cost of the PV module—the chunk of silicon or other semiconductors that convert sunlight to electricity—has dropped impressively over the years. But, it has been more difficult to cut the other expenses—the so-called balance of system (BOS) costs, which include hardware like the inverters that are necessary to connect the panels to the grid and, most crucially, the labour to install the equipment. Installing heavy solar panels on the roofs of houses is particularly expensive.
- There is a need to design more efficient solar cells than standard silicon cells in converting sunlight to electricity. Cost efficiency is also important. The efficiency of solar cells is only about 22 per cent. The rest of the sunlight that strikes the panel is wasted as heat. More efficient photovoltaic cells have been discovered (up to 43 per cent efficient) but these are still in their experimental phase and are expensive to manufacture. It will likely take decades to discover new materials and methods of making solar panels less expensive. How long it takes depends on how much time and money is invested into research both by government and private industry. Figure 1 illustrates PV system efficiency comparison over the years.

Table 3: Various challenges in using solar energy

Initial Cost	• Requirement of a large number of solar panels • Fitting
Recurring Costs	• Cleaning • Maintenance • Replacement of damaged panels
Location Problems	• No obstructions in terms of shadows cast by other buildings, trees and so on
Storage Challenges	• Need of sunny climates throughout the year • Today's power grid is not able to store energy
Space Constraints	• Large space requirement for installing enough solar panels to generate significant amounts of power
Inefficiency	• Most solar panels convert less than half of the sunlight beaming down on them into electricity • The best panels in the market only convert about 35 per cent of sunlight into energy and most models have an efficiency rate of only 15 per cent

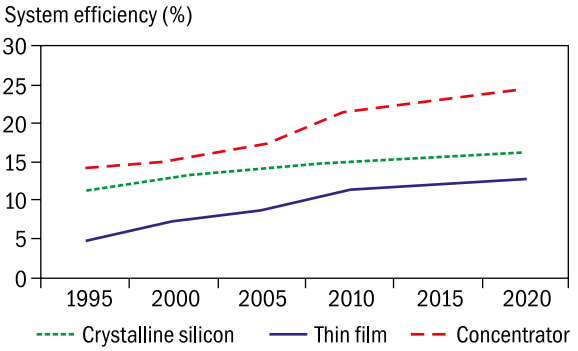

Figure 1: PV system efficiency comparison over the years

- Giant solar farms have been built in desert regions and have reduced the installation cost since a larger economy-of-scale is created (parts, material, and installation people are in one location). But these large, inexpensive tracts of lands are found far from cities where the power is needed. Expensive transmission lines are needed to bring the power to a distant market.
- Maintenance costs are high since every inch of a solar panel must be kept clean and clear of debris. Their efficiency drops drastically even when a small portion is blocked by a leaf or a thin film of dust.
- The main problem with solar power that has stifled its use is the fact that energy production only takes place when the sun is shining. Large storage systems need to be developed to provide a constant and reliable source of electricity when the sun is not shining at night or when it is a cloudy or rainy day. When solar panels are not producing energy, it takes longer to recoup their installation and maintenance cost.

POSSIBLE SOLUTIONS FOR THE SITUATION

A few of the possible solutions to overcome the challenges in utilizing solar power are discussed here. Large landscapes are needed to harvest solar power in large quantities, so in an agriculture-based economy, there is always a need to think to conserve land resources and innovate methods to install solar panels on buildings and in fields, with all scope of agriculture and some new designing concepts.

- To harvest more of this free energy, we need to discover new materials, develop new production techniques, and solve the problem of storing energy when the sun is not shining.
- Scientists need to discover more efficient semiconductors that are more efficient at electricity production. Doubling the efficiency of a panel will halve the size of the array which in turn means less space will be required to produce the same amount of power. New materials for solar cells may help reduce fabrication costs. This area is where breakthroughs in the science and technology of solar cell materials can have the greatest impact on the cost and widespread implementation of solar electricity. Current solar cell designs require high-purity, and are therefore expensive, because impurities block the flow of electric charge. That problem would be diminished if charges had to travel only a short distance, through a thin layer of material. But thin layers would not absorb as much sunlight to begin with. One way around that dilemma would be to use materials thick in one dimension, for absorbing sunlight, and thin in another direction, through which charges could travel. One such strategy envisions cells made with tiny cylinders, or nanorods. Light could be absorbed down the length of the rods, while charges could travel across the rods' narrow width. Another approach involves a combination of dye molecules to absorb sunlight with titanium dioxide molecules to collect electric charges. But, large improvements in efficiency will be needed to make such systems competitive.

Scientists need to discover more efficient semiconductors that are more efficient at electricity production. Doubling the efficiency of a panel will halve the size of the array which in turn means less space will be required to produce the same amount of power. New materials for solar cells may help reduce fabrication costs.

- Another idea for enhancing efficiency involves developments in nanotechnology. Recent experiments have reported intriguing advances in the use of nanocrystals made from the elements lead and selenium. In standard cells, the impact of a particle of light (a photon) releases an electron to carry electric charge, but it also produces some useless excess heat. Lead–selenium nanocrystals enhance the chance of releasing a second electron rather than the heat, boosting the electric current output. Other experiments suggest this phenomenon can occur in silicon as well. Theoretically, the nanocrystal approach could reach efficiencies of 60 per cent or higher, though it may be smaller in practice. Engineering advances will be required to find ways of integrating such nanocrystal cells into a system that can transmit the energy into a circuit.
- Engineers need to develop more efficient production techniques. Mass production of panels in efficient factories will help bring down production costs and make them cheaper for consumers to buy.
- New transmission technology is needed to bring the clean energy to market. Energy storage systems will also help smooth out the production bumps caused by climate and atmospheric interruptions.
- A major barrier to widespread use of the sun's energy remains—the need for storage. Cloudy weather and nighttime darkness interrupt the availability of solar energy. At times and locations where sunlight is plentiful, its energy must be captured and stored for use at other times and places. Many

technologies offer mass-storage opportunities. Pumping water (for recovery as hydroelectric power) or large banks of batteries are proven methods of energy storage, but they face serious problems when scaled up to power-grid proportions. New materials could greatly enhance the effectiveness of capacitors, superconducting magnets, or flyweels, all of which could provide convenient power storage in many applications. Another possible solution to the storage problem would mimic the biological capture of sunshine by photosynthesis in plants, which stores the sun's energy in the chemical bonds of molecules that can be used as food. The plant's way of using sunlight to produce food could be duplicated by people to produce fuel.

- Sunlight could power the electrolysis of water, generating hydrogen as a fuel. Hydrogen could then power fuel cells, electricity-generating devices that produce virtually no polluting byproducts, as the hydrogen combines with oxygen to produce water again. But, splitting water efficiently will require advances in chemical reaction efficiencies, perhaps through engineering new catalysts. Nature's catalysts, enzymes, can produce hydrogen from water with a much higher efficiency than current industrial catalysts. Developing catalysts that can match those found in living cells would dramatically enhance the attractiveness of a solar production-fuel cell storage system for a solar energy economy.

CONCLUSION

Solar power is one of the most promising renewable energy technologies, allowing the generation of electricity from free, inexhaustible sunlight. Many homeowners have already begun adopting solar electricity, and large-scale power generation facilities offer solar energy's advantage. The reality that the boom in solar power has depended on government subsidies does not mean such incentives should end. On the contrary, it makes it obvious just how important they are to achieving the goal that society cares about: an overall reduction of carbon dioxide emissions at the lowest possible cost. But, they must be carefully designed to be as fair as possible. This means that subsidies should not favour inefficient versions of clean-energy technologies, such as rooftop solar over utility-scale plants. If the engineering challenges can be met for improving solar cells, reducing their costs, and providing efficient ways to use their electricity to create storable fuel, solar power will assert its superiority to fossil fuels as a sustainable motive force for civilization's continued prosperity. Until all of these problems with solar energy are overcome, the promise of pollution-free energy from the sun will remain unfulfilled and marginally used in our society. EF

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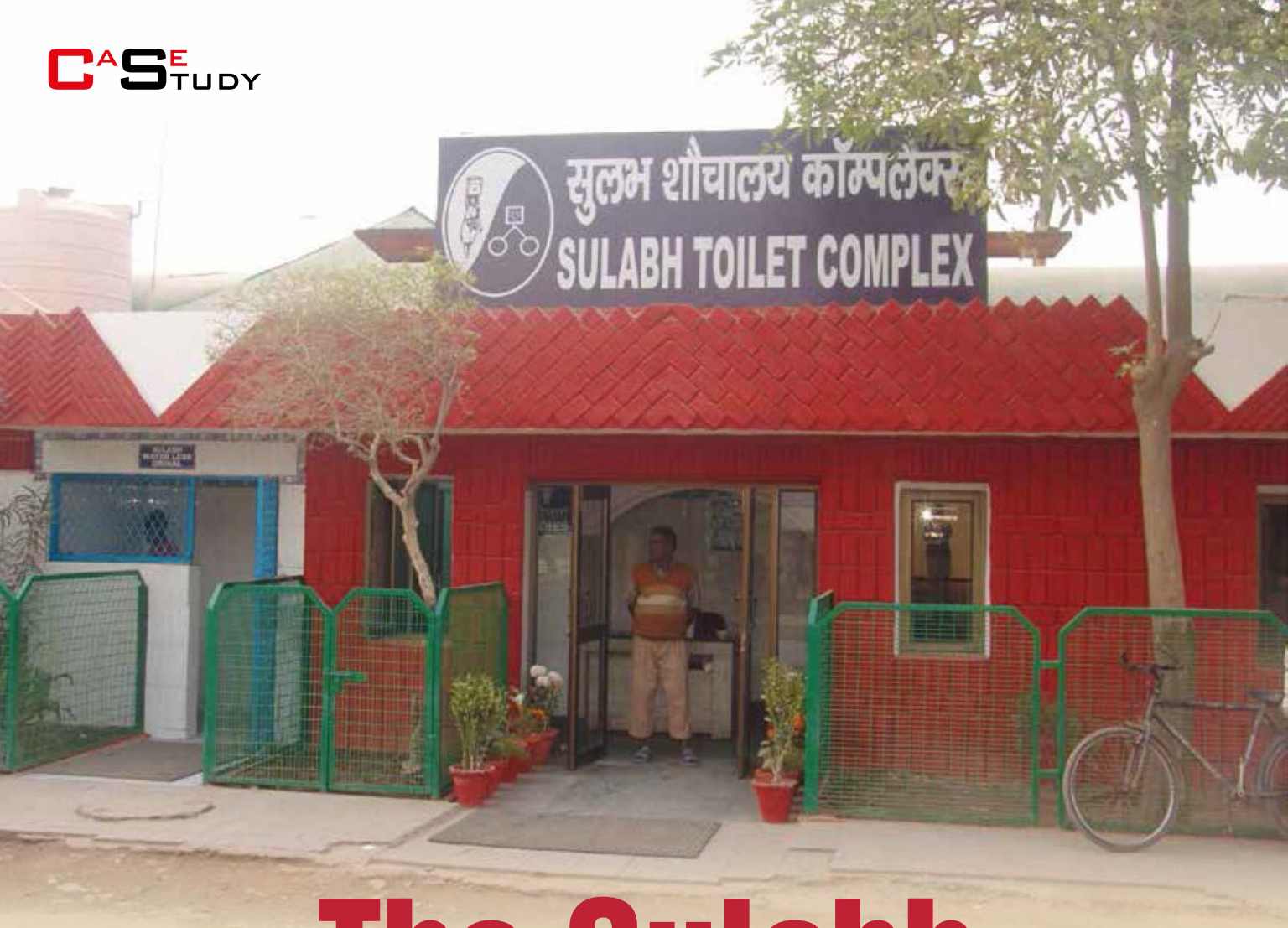

The Sulabh International Organization

Producing Biogas and Renewable Power from Public Toilets

Recycling and reuse of human excreta for biogas generation is an important way to get rid of health hazards posed by it. The Sulabh International Organization is the pioneering organization in the field of biogas generation from public toilet complexes. In this article, ***Sarita Brara*** *dwells on the benefits of utilizing human excreta as a renewable source of energy in the form of biogas and also examines in brief the technical processes adopted at the Sulabh Community Toilet Complex.*

A migrant from Mirabpur village in Bihar, Shyam Behari, stays in a rickshaw shed in Delhi, where he does not even have enough space to sleep, let alone other facilities. Fortunately for him he can access the Sulabh public toilets in Mahavir Enclave not far from the shed for easing himself, bathing, and for even washing his clothes. He is not the only one. Hundreds of people use over a dozen toilets constructed there separately for men and women. In the toilets meant for women, an incinerator has also been installed that takes just two minutes to destroy eight used sanitary napkins. The story does not end there. The excreta flushed from the toilets is recycled for generating biogas and electricity. The biogas plant set up in the complex produces 30 m^3 biogas every day, enough to generate 30 kW of electricity. This biogas is used for cooking lunch for 150–200 people every day and tea for as many people twice a day in the premises of the Sulabh International Social Service Organization located there. There is also a provision for lighting mantle lamps from the biogas as well as generation of electricity, whenever required. The modified genset installed there does not require diesel and runs completely on biogas. This has made electricity generation from biogas more sustainable. This is not all; the biogas is fed into a kind of container of stones and well, this serves as a body warmer in winters!

While the animal waste has been extensively used for manure and biogas production for long, generation of biogas from human excreta has been very limited in India. The foul smell associated with human excreta perhaps accounts for low response to using it for production of biogas and electricity. However, Sulabh International Organization is the pioneering organization in the field of generation and utilization of biogas from human excreta of Public Toilet Complexes. The model, first of all does not require manual handling of human excreta and also there is complete recycling and resource recovery from the waste.

PROCESS OF GENERATING BIOGAS AND ELECTRICITY FROM HUMAN EXCRETA

Firstly, the excreta from public toilets flows under gravity into a digester built underground. Inside the digester, biogas is produced by anaerobic fermentation with the help of methanogen bacteria. As specific bacteria feed on organic materials, various reactions and interactions take place in the methanogens, non-methanogens, and substrates fed into digester as inputs. The initial gas formation takes 2–3 days. To begin with, the volume of CO_2 exceeds that of methane. It takes approximately 25–28 days for an optimum stage to be reached when the volume of methane exceeds that of CO_2. Thereafter, the process of gas formation is continuous. The biogas, thus produced, is stored in inbuilt liquid displacement chamber. The gas then can be used by burning it for cooking purpose or to generate electricity or to light mantle lamps.

According to Sulabh International experts, one cubic foot (cft) biogas is produced from the human excreta of a person per day. Human excreta–based biogas contains 65–66 per cent methane, 32–34 per cent CO_2, and the rest is hydrogen sulphide and other gases in traces. Methane is the only combustible constituent, which is utilized in different forms of energy. Its calorific value is 24 MJ/m^3 or about 5,000 Kcal/m^3. One thousand cft (30 m^3) of biogas is equivalent to 600 cft of natural gas, 6.4 gallons of butane, 5.2 gallons of gasoline, or 4.6 gallons of diesel oil. Biogas can be utilized for cooking, lighting through mantle lamps, and electricity generation, and body warming. Figure 1 presents the process of complete recycling and reuse of human excreta adopted at the Sulabh Community Toilet Complex.

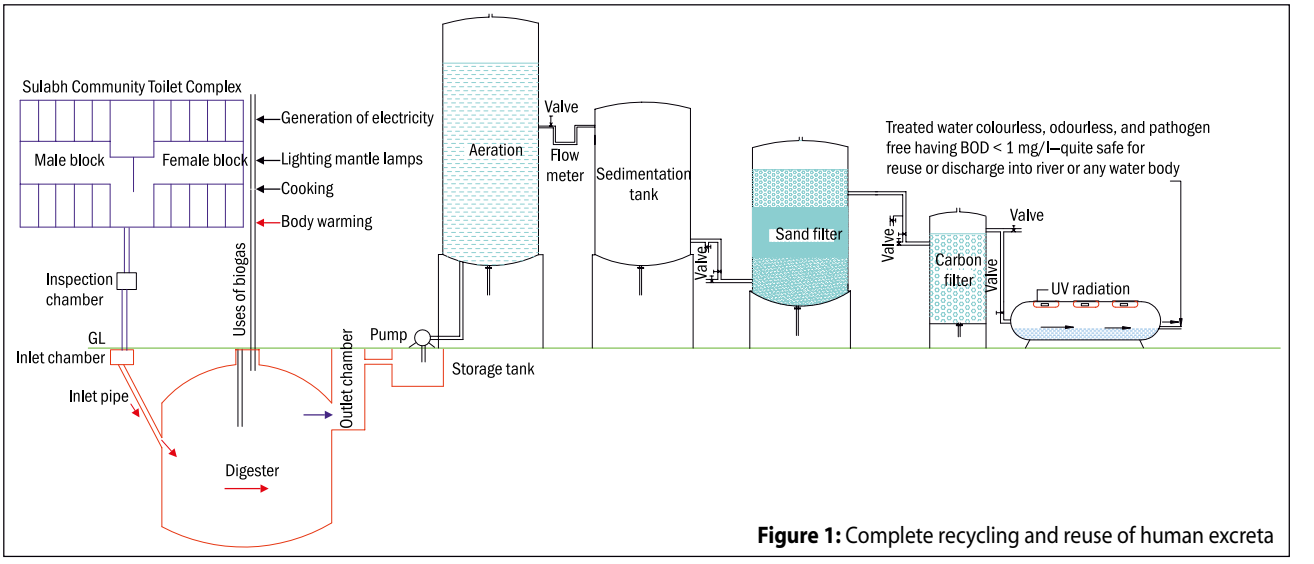

Figure 1: Complete recycling and reuse of human excreta

RECYCLING OF EFFLUENTS

The technology is based on sedimentation and filtration of effluents through sand, aeration tank, and activated charcoal followed by exposure to ultraviolet rays. The treated effluent is colourless, odourless, and pathogen free with Biochemical Oxygen Demand less than 10 mg/l. It is then safe for discharge into any water body without causing pollution. It can also be used for cleaning of floors of public toilets in water scarce areas.

As far as cooking from biogas is concerned for a family of four to five members, it requires 60 cft of biogas per day for their breakfast, lunch, and dinner. Cooking is the most efficient use of biogas. Biogas burners are available in a wide ranging capacity from 8 cft to 100 cft biogas consumption per hour. It burns with a blue flame and without soot and odour.

LIGHTING MANTLE LAMPS

Biogas can be utilized for mantle lamp lighting. A mantle lamp consumes 3–4 cft of biogas per hour. Its illumination capacity is equivalent to a 40 W bulb at 220 volts.

USE FOR ELECTRICITY GENERATION

Electricity generation is through dual fuel engine coupled with alternator that runs on 80 per cent biogas and 20 per cent diesel. Biogas consumption by engine is 15 ft/BHP/hour. A public convenience used by 1,000 people per day would produce approximately 30 m^3 of biogas, which can run a 5 KVA genset for eight hours, producing 30 units of power. However, Sulabh has modified the genset that does not require diesel, which means it can run completely on biogas.

SULABH TECHNOLOGY REDUCES GREENHOUSE GAS EFFECT

In addition to conserving and reusing water, the system has additional inbuilt advantage of reducing greenhouse gas effect arising out of CO_2 and methane production due to degradation of human waste. Due to design of leach pit of Sulabh toilet in households, the CO_2 produced is diffused in the soil through honey combs and does not escape in the atmosphere. Because of anaerobic digestion of human waste during biogas production, methane is produced that is used for different purposes and not left to escape in the atmosphere. Thus, both these technologies help in reducing greenhouse effect and consequently in protecting the environment.

Sulabh International Social Service Organization has set up 200 such community toilets cum biogas production units. Biogas generated from human excreta from these toilets varies from facility to facility, depending on the number of users. The biggest excreta-based biogas producing unit, set by Sulabh International, is in Shirdi, Maharashtra. An estimated 4,000 to 5,000 pilgrims use the toilet facilities there on a daily basis. The toilet-cum-biogas generation unit produces 105 m^3 of biogas on a daily basis. The unit has the capacity to provide electricity to the entire complex for illumination whenever required, for water heating, as well as for cooking purpose. The first Sulabh Toilet linked biogas plant was set up at Adalatganj, Patna, in 1980 that produced electricity supplied to the 3-km-long Bailey Road, Patna, for streetlight. Approximately 3,500–4,000 users use the 14-seat toilet complex. Not just in India, five community toilet cum biogas generation units were also set up in the war-ravaged Afghanistan in 2007. Sulabh International was assigned to implement these projects in collaboration with the Municipality of Kabul, funded by India's Ministry of External Affairs. Local persons were given training for the operation and maintenance of toilet complexes and biogas plants. Human waste from public toilets at all the five sites is being used for generating biogas, which is used for cooking, lighting, electricity generation, and warming oneself.

The toilets-cum-biogas–producing units have many advantages. It is a

free source of energy, the technology is quite simple and cheap, and does not require much time. Significantly, it serves the dual purpose of, firstly helping in meeting the energy needs of people in semi-urban areas, slums in cities, as well as rural areas; and secondly, it is a safe and hygienic way of disposal of human waste. Due to lack of sewage treatment systems in many town and cities, effluents from the septic tanks pass through covered or uncovered drains and finally flow into rivers or water bodies. Many rivers and water bodies in India are getting highly polluted as sewage of the towns and cities gets dumped into the waters affecting community health, hygiene, and environment.

Although harvesting biogas from human waste is not a new concept, the potential to simultaneously manage waste and generate power is gathering increasing attention in recent decades. China is already way ahead in turning human faeces into what is being described as 'black gold'. According to some estimates, in Beijing, 68,000 tonnes of human excreta are treated each day for fertilizers and biogas production. In Kenya, Umande Trust and the British charity 'Practical Action' are building biocentres—toilet facilities where human slurry is collected and put in a digester. The methane emitted from human excreta is sold back to the slum dwellers as biogas, used for cooking within the centres and elsewhere. Rwanda has installed 20 human waste–powered generating plants of 500 kW each at some of their big prisons. These provide about half of their electricity requirements. In fact, Rwanda was given the Ashden Award for Sustainable Energy in this regard. Researchers at the Bristol Robotics Laboratory were successful in charging a mobile phone using electricity generated from urine. In 2014, the story of a bus running on power generated from human waste in Britain made the headlines.

The realization is already dawning that human faeces or human waste could be the ultimate source of energy.

According to a research paper published by the *American Journal of Engineering Research (AJER)* in 2013, the seven billion people residing on the earth produce about 14 million tonnes of faeces every day and 25 per cent of this has the potential power to produce roughly 40,000 MW of energy. India with one-seventh of the world population could therefore add some 6,000 MW to her power capacity. The Founder of the Sulabh International Organization, Bindeshwar Pathak, rightly says that the resource of human excreta for energy is renewable and does not deplete. It should be utilized to save the conventional sources of energy that are non-renewable.

If Sulabh model of toilet-cum-biogas plants is replicated in hospitals and hostels or community toilets, it will not only save the conventional sources of energy but the problem of management of human waste too would be resolved in a manner which is not harmful and hazardous to health. What is unfortunate is that the government is yet to wake up to the enormous potential of tapping energy from human excreta, despite the way shown by the Sulabh Organization more than three decades back. EF

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Green Transport Initiative by the Mumbai Police

To Provide Extended Service Support

This article is an attempt to highlight the impact of transport in a non-green economy where the future investment in the sector is increasingly towards green processes and outcomes. It also focusses on how strategy can be used and implemented in improving the efficiency of all the modes of transport. ***Varun Vartak*** *highlights one such successful attempt made by the Mumbai Police and explores the challenges and opportunities faced by organizations of all sectors within the industry to shift to a greener transport system. It also tries to evaluate the various options for conditions that can enable actions and investments for the development of the globe as a whole. It is a successful model that ought to be replicated in other parts of the country as well.*

Transport is a medium that connects the lives of citizens across the world; still it is widely seen in today's scenario that the current patterns of transport, mainly by fossil fuel–driven motor vehicles, generate a range of environmental, social, and economic costs. It is estimated, for instance, that transport is responsible for nearly a quarter of the global energy–related carbon dioxide (CO_2).

Going 'green' is not just good for the environment; it is also good for business and the economy. It is the turning point in the business environment. Now more than ever, individuals are on the lookout for environment-friendly products and services so that they minimize the damage on the ecosystem. Significantly, the service providers are discovering that, going green generates significant cost savings on day-to-day operations. One simple way any business can go green is to encourage employees to formulate processes that ensure maximum usage of 'green transport'.

'Green transport' is hereby defined as the one that supports environmental sustainability through, for example, the protection of the global climate, ecosystems, public health, and natural resources. It also supports other pillars of sustainable development, namely economic (affordable, fair, and efficient transport that supports a sustainable competitive economy as well as balanced regional development and the creation of decent jobs) and social (e.g., allowing the basic access and development needs of individuals, companies, and society to be met safely and in a manner consistent with human and ecosystem health, and promoting poverty reduction and equity within and between successive generations). This definition was developed through extensive discussions with transport experts including those at the UN agencies and was based on a review of existing and well-acknowledged definitions such as ECMT (2004).

They came up with a unique solution of using a humble means of transport—a bicycle, which would be able to suit their needs. The bike (bicycle) was custom made and imported. It came in two variants, one for the roads with narrow tyres and one for the beaches which came in with thick tyres for better grip against the multi-terrain surface.

USE OF GREEN TRANSPORT BY THE MUMBAI POLICE

It has been a remarkable journey for the Mumbai Police who have evolved various techniques over the years to solve many issues related to crime management and maintaining law and order in the commercial capital city of India—Mumbai. Recently for better patrolling, the following operational features were considered as a part of their strategy by the Mumbai Police:

- To increase accessibility in areas where bikes and vans cannot enter such as congested by-lanes, station areas, narrow bridges, joggers' parks, footpaths, tourist spots, near some temples, and beaches
- To increase patrolling without affecting the ecosystem, that is, by using the green transport system for approach and getting better outcomes.

Thus, they came up with a unique solution of using a humble means of transport—a bicycle, which would be able to suit their needs. The bike (bicycle) was custom made and imported. It came in two variants, one for the roads with narrow tyres and one for the beaches which came in with thick tyres for better grip against the multi-terrain surface. Both the bicycle variants had a large and comfortable adjusted seat that ensured an effective ride. This initiative also saw to the fact that the usage of bicycles was considered as a complementary measure to the motorcycles, where the main aim was to increase police visibility and, thereby, extend availability and enforcement of law and order in all areas of the maximum parts of the city.

In June 2015, as a pilot project, a total of 24 bikes were imported and their break-up for usage was as follows:

- Eight bicycles for the beaches including areas like Marine Drive, Gateway of India, Dadar-Juhu-Aksa-Chowpatty, Shivaji Park, and Worli Seaface and Sea link
- Sixteen bicycles for the streets and footpaths in several crowded and lonely areas across Mumbai.

A beach bicycle would cost approximately ₹18,000 and a street bicycle would cost around ₹8,000. Aluminium grade material of construction was used to prevent bicycle parts from rusting. Table 1 presents the total expenditure done by the Mumbai Police in purchasing the two varieties of bicycles.

Each unit of the bicycle was accompanied by some additional gadgets including a walkie-talkie and a baton. It was seen as a feedback from the project that there were better outcomes in terms of the mission and the sole purpose of doing this project. Some of the benefits of this initiative were observed as follows:

Table 1: Total cost of the two variants of the bicycles

Item	Cost Per Unit (in ₹)	Total Units	Total Units Cost (in ₹)
Street Bicycle	8,000	16	128,000
Beach Bicycle	18,000	8	144,000
Total cost			**272,000**

- Because of these bicycles being used in many areas in Mumbai, it is expected that on the whole it is playing a significant contribution in reducing carbon emissions and in improving the quality of air.
- One significant outcome is the health benefits that the green transport strategy has given the Mumbai Police. The physical fitness levels of these police personnel riding the bicycles during duty hours have taken a healthy upward curve and may increase exponentially for the better of the whole ecosystem of the city.
- There has been a reduced number of crime incidents in the areas covered. Even in the areas of the city where the beaches are located, there was a significant decrease in illegal consumption of alcohol and drugs. In some cases, amorous couples were given warnings for attempting indecent behaviour on the beaches. In certain parks and in desolate and lonely stretches, the general population now feels safe to travel at odd hours due to the presence and patrolling of the police personnel.
- There has been an increase in the efficiency in operations of the Mumbai Police with a modest investment of ₹272,000; the intangible returns being seen can be estimated to be worth much more.

The whole notion of green transport as a concept and its application by the Mumbai Police for patrolling has proved to be a positive one and would certainly look to have better outcomes in crowd management during the festival seasons like Ganesh Chaturthi, which is one of the most celebrated events in the city as well as the nation.

Thus, taking a cue from this successful initiative, all business organizations must look forward to promote and use energy-efficient transport options. From a research done in the UK, it is seen that around 40 per cent companies are already encouraging their employees to use alternative transport to and from work. As a strategic approach for encouraging the employees to use car-pooling and other public transport systems, the organizations can introduce the following schemes:

- Tax benefits for employees who routinely use public transit or carpool to get to work
- Other monetary benefits from the cost savings done by employees from reduced use of fuel and other driving costs.

CONCLUSION

The initiative taken by the Mumbai Police in Maharashtra is no doubt a successful model but there is still a lot to be done in terms of getting a substantial impact of reduced carbon emissions on the ecosystem. The current global scenario of the inference on impact from a report on Certified Emission Reduction that comprises of similar initiatives, which include efforts to reduce on energy and fuel sources for reducing carbon footprint and also other alternative methods deployed along with their potential impact, carried out in several countries is shown in Figure 1.

The other factors that would assist in reducing carbon footprints are as follows:

- *Political:* The Indian government has pledged to cut carbon intensity—the amount of CO_2 emitted per unit of the economic output by 33 to 35 per cent by 2030.
- *Environmental:* Indian transport sector contributes around 11 per cent to carbon emissions. Within it, road transport accounted for nearly 90 per cent of transport emissions (the remaining 10 per cent coming from rail, aviation, and shipping).
- *Economic:* National Action Plan on Climate Change (NAPCC), released in 2008, includes a target to reduce the emissions intensity of India's economy (per unit of GDP) by 20 per cent from the year 2008–16.
- *Technical:* Every litre of petrol saved keeps 2.5 kg of CO_2 out of the atmosphere. Using radial tyres will help you save 3 to 7 per cent of fuel. You will save 1.5 kg CO_2 for every 5 km you do not drive.
- *Social:* One tree planted absorbs CO_2 of the order where it releases a volume of oxygen sufficient for two human beings. EF

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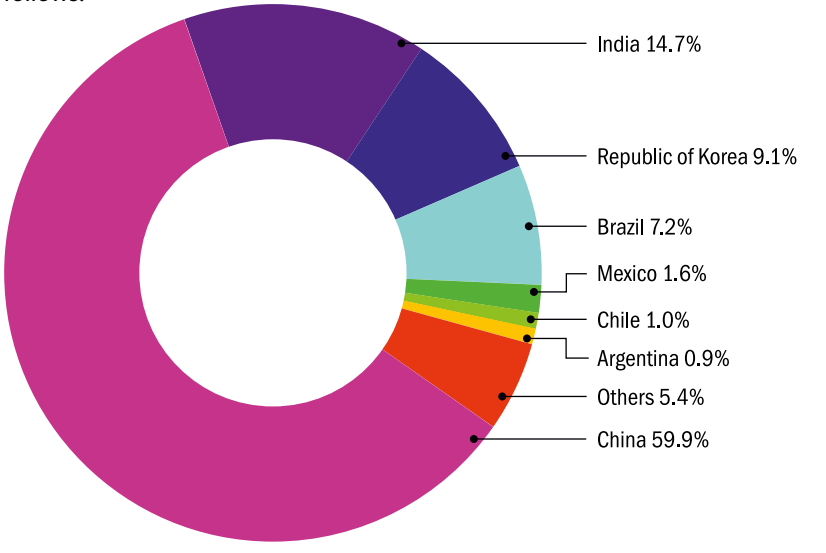


Figure 1: Certified emission reduction units by country
(*Source: http://cdm.unfcc.int*)

There has been a reduced number of crime incidents in the areas covered. Even in the areas of the city where the beaches are located, there was a significant decrease in illegal consumption of alcohol and drugs.

The 6th World Renewable Energy Technology Congress & Expo-2015

The 6th World Renewable Energy Technology Congress (WRETC) & Expo-2015 was held on August 21–23, 2015 at New Delhi, India, and was organized by the Energy and Environment Foundation and supported by the Ministry of New and Renewable Energy (MNRE), Government of India. The theme of the event was "Promoting Renewable Energy, Energy Efficiency & Sustainability for a Brighter Future". The event served as an excellent energy platform for the global renewable energy industry to address various industry issues including innovations, new technologies, investment opportunities, and project financing.

The Welcome address was delivered by Dr Satish Agnihotri, Former Secretary, MNRE, Govt of India and Chairman Steering Committee 6th WRETC-2015. Dr Agnihotri emphasized to take the stock of the progress made so far against the commitment made by the industry players to Hon'ble Prime Minister at the RE-Invest 2015. Mr Gireesh B Pradhan, Chairperson, Central Electricity Regulatory Commission delivered the inaugural address and highlighted the importance of promoting renewable energy, green technology for its sustainability.

During the conference, Energy and Environment Foundation awarded the prestigious 'Energy and Environment Foundation Global Excellence Awards 2015' in the Renewable Energy Sector to Mr K S Popli, CMD, IREDA; Mr Rana Kapoor, Managing Director & CEO, YES BANK Ltd; Mr Pashupathy Gopalan, Managing Director, SunEdison; Mr Vineet Mittal, Vice Chairman Welspun Renewables; Mr Ashish Khanna, CEO Tata Power Solar; Mr Sumant Sinha, Chairman & CEO ReNew Power; and Mr Anders Grundstromer, Managing Director, Scania CV India. Mr Gireesh B Pradhan was also honoured with the 'Energy and Environment Foundation Global Excellence Award 2015'. Mr Kerry Adler, President and CEO SkyPower, Canada announced while delivering the Plenary Address at the event, that the SkyPower will fund the creation of a new renewable energy scholarship programme to leading institutions such as—'NIMS University', 'EMPI Institute', and 'IIT Delhi'. SkyPower will provide 10 scholarships to these institutions per year for the next 25 years. The merit and needs-based scholarship programme will benefit 750 Indian students wanting to pursue higher education in renewable energy technology. The scholarship programme will help promote

innovation in solar technology and energy storage in India.

The 6th WRETC-2015 conference deliberated various issues related to Innovation in Renewable Energy, Renewable Energy 2030 and Beyond, Financing in RE Projects: A Way Forward, Renewable Regulatory Issues: Road Map, Smart Cities—Mission to Reality, Developing Solar Industry—Key Challenges to Make-in-India, Wind: New Technology & Offshore Wind Forming, Energy Storage and Microgrids, Bio-Energy—Biomass-Biofuels, Energy Efficiency & Conservation. The conference & expo was attended by 335 national and international delegates from Bhutan, Canada, France, Germany, Italy, Japan, Denmark, Switzerland, and the USA, apart from the host country India. The conference brought together leading international and domestic players, industry experts, policymakers, government officials, and technocrats on a common platform. The concurrent conference sessions comprised interesting workshops, interactive panel discussions on 'Solar Rooftop Policy and Emerging Opportunities (Achieving 40 GW of Rooftop Solar by 2022)', 'Renewable Energy: The Road Ahead' and Thought Leadership Summit on 'Skill Development & Capacity Building in Renewable Energy'. The conference served as an important gateway for worldwide new energy companies to access the Indian market to foster partnerships and collaborations with local players.

The 'Energy and Environment Foundation Global Sustainability Awards, 2015' were conferred in Platinum Category to 'Shree Cement Ltd', 'Windforce (Pvt.) Ltd, Sri Lanka' and in Gold Category was awarded to 'Etalin Hydro Electric Power Company Limited', and 'Bhushan Steel Limited'. The 'Global GreenBuilding Award 2015' was conferred in Platinum Category to 'National Buildings Construction Corporation Limited'.

The Valedictory Address was delivered by Ms Gauri Kumar, Secretary Coordination, Cabinet Secretariat, Government of India and she gave away the 'Energy and Environment Foundation Global Environment Awards 2015' in Platinum Category to 'Haldia Energy Limited', 'Bhushan Steel Limited', 'ONGC Mumbai High Asset', 'Jindal Steel & Power Limited' and in Gold Category to 'ReNew Power', 'ONGC Well Stimulation Services', 'ONGC Corporate Health Safety and Environment', 'NIMS University', 'Petronet LNG Limited', and 'Sardar Swaran Singh National Institute of Bio-Energy'. Dr Anil K Garg, President, WRETC-2015 congratulated all the award winners and proposed a vote of thanks to MNRE, The United Nations Educational, Scientific and Cultural Organization (UNESCO), dignitaries, all the sponsors, knowledge partner, media partners, delegates, and the participants.

Some of the key recommendations adopted in the 6th WRETC-2015, New Delhi by the Global Renewable Energy Industry Experts were:

- The Renewable Energy Policy Framework should be put in place at the earliest with a separate focus on grid-connected and off-grid applications. The economic and social advantages should be specifically included in the policy.
- The government should intensify green corridors with the conventional national grid to ensure smart evacuation of the energy generated.
- Continued policy and financial support for technology development in renewable energy remain necessary to bring down costs further.
- Affordable energy storage is a priority need to make decentralized RE systems attractive to the users. Strong R&D initiatives are needed in the energy storage area.
- Electric vehicles and biofuels, including methanol must be promoted to extend renewable energy applications in the transportation sector, all transportation modes should be considered. EF

San Francisco

Intersolar Conference 2015

The Intersolar Conference 2015 held at San Francisco in July was optimistic, as usual, but the atmosphere was guarded in comparison to past events, in spite of continued rapid growth.

KEY INDUSTRY CHALLENGES

- Investor capital for cutting edge solar startups is becoming scarcer. The cause is the loss of $4 billion by early stage solar investors in the last decade, spooking risk capital. This is a normal circumstance for disruptive technologies: In the early days of the auto industry, there were over 50 auto manufacturers in the United States. The competition is similarly fierce in the solar industry, as low cost manufacturers from Asia have continued to put pressure on pricing. The outcome has been to emphasize cost at the expense of proven durability.
- Transmission issues have been ongoing, since solar output is not smooth. This results in power supply spikes and the need for additional power in the 'duck curve' period of late afternoon/early evening, when both wind and solar power tend to be weak.
- As a result, storage technologies were front and centre at the convention. While all supplemental power is costly, whether from batteries or thermal solar molten salt storage, this effort is considered to be worthwhile if solar and wind are to achieve market domination.
- Solar subsidies have come and gone in Spain, Germany, Italy, and soon in California. Deployment volume directly tracks this government support, including in the downward direction when subsidies are removed or reduced.
- A German attendee told the author that Europe has the same issues as the US with respect to transmission. Europe's grid is similar to the United States', in being nominally integrated but still facing issues of connectivity, handling output spikes from wind and solar, and jurisdiction. Such an overhaul would cost trillions of dollars, requiring governments to step up, including smart grid development.

SOLAR INDUSTRY TRENDS FROM LEADING COMPANIES

'The Future of PV: Executive Panel' included top executives from SunPower, Canadian Solar, Singulus, and REC Power. SunPower and Canadian Solar are established firms with $3 billion apiece in annual sales. Key points of this discussion are as follows:

- Executives predict rapidly decreasing prices, as competition becomes more intense. Advances in panel efficiencies and scale are believed to be key drivers.
- Panellists agreed that the Investment Tax Credit cliff is steep in the US, going from 30 per cent to 10 per cent in only a few years. This is the strongest subsidy available in the US, especially for utility scale solar. Panelists believe that increased efficiencies and experience will allow continued rapid growth, but also pointed out that removal of subsidies in European countries resulted in sharp declines in solar deployment.
- Electricity sales represent the largest industry in the world. Utilities enjoy a rare combination of monopoly territories and guaranteed markets. In spite of public pronouncements, the actions of utility company management can contradict their public statements.

THE POSSIBLE RE-EMERGENCE OF THIN FILM SOLAR PANELS

Thin film panels are not made from crystalline photovoltaics (PV), but incorporate glass that is essentially painted over with 200 elements designed to convert sunlight to electricity. This surface is in turn covered by a framed glass cover to prevent damage from the elements. Due to lower panel cost, thin film reached close to 20 per cent market share by 2009, but that share has declined to 9 per cent, mostly due to aggressive pricing from crystalline PV manufacturers that closed the gap in price. Crystalline PV, with a longer and more established deployment record, is the technology of choice for most of the large companies. The other reason for market decline was short-term product failure some years back, issues that the thin film industry claims to have solved.

Two new thin film companies present at Intersolar this year were intriguing: Hulk Solar, from Taiwan, and Siva Power, from San Jose, California. Hulk has assembled an impressive technical team, and has strong financial backers. Their marketing presentation demonstrated thin film competitive advantages that are not apparent in a simple side by side comparison:

- Thin film panels capture considerably more solar energy than traditional PV during cloudy periods
- Thin film is more heat tolerant: crystalline performance declines more sharply at high temperatures, as in the California desert.

The second intriguing presentation was delivered by Brad Mattson, a Silicon Valley veteran as a principal in both solar and software companies. He promised thin film panel delivery at $.28 per watt, far less than those of competitors in either thin film or crystalline PV technologies. This cost is achieved by sophisticated automation, cutting edge design, and high speed manufacturing. The plant Siva proposes to build would be able to produce 300 MW of capacity annually in 10 per cent of the building space normally required for that volume. Should this technology be as viable as promised, the world could change. Solar is already being deployed at $.06/kWh in both Dubai and the United States. Reducing this figure further, in combination with better storage and a smarter grid, would render polluting fossil fuel power plants obsolete. EF

For questions about specific companies, along with company contact information, the reader may contact Mike Roddy at his email address: greenframe@aol.com

Investment in Clean Energy and Energy Access Businesses

For Accelerating Green Growth and Effective Knowledge Transfer

The Renewable Energy and Energy Efficiency Partnership (REEEP) is a market catalyst for clean energy in developing countries and emerging markets. In an interview with ***Pawan Garg*** *for* ***Energy Future****,* ***Martin Hiller*** *discusses the future plans and goals of REEEP, the role of SMEs in various countries, and REEEP's experience of association with TERI.*

Martin Hiller has been Director General of REEEP since December 2011. He has over 20 years of experience in environmental issues and sustainability, policy, specialized policy communications and campaigns, and in-depth knowledge of climate change and energy policy. Under his leadership, REEEP has sharpened its focus as a catalyst for up-scaling clean energy business models.

Prior to joining REEEP, Hiller had a distinguished career with the World Wide Fund for Nature (WWF) where he led campaigns and communications in the global climate and energy programme. Earlier, he established the first EU-specific campaign operation for any environmental NGO in Brussels, developed WWF's European communications operations, and created the first EU-specific policy campaigns.

What goals do you have for 2015–16 at REEEP?

We at REEEP have two main objectives for this year and next: first, to increase investment in clean energy and energy access businesses to accelerate green growth; second, to contribute to bringing the Climate Knowledge Brokers Group to the next level—this is a growing movement of organizations working together to improve knowledge transfer and communication about climate change and development issues, based on principles of transparency, openness, and collaboration.

When we talk about investment, what has been your experience with the public–private and especially private investment in renewable energy globally as well as specifically in India?

The space that we are looking at is the investment flow into small and medium enterprises (SMEs) in low and middle-income countries, and we are talking always about clean energy and energy efficiency business, so that is a space where it is still harder to raise private investment. Investment in larger scale projects, such as wind farms, large solar plants, etc., is a very rapidly developing market requiring reasonably big investments from 30–40 million dollars upwards. SME stimulation is more difficult: SMEs are important because in practically every country they deliver atleast half of the productivity of the country, and disproportionately high levels of employment. In many countries this is considerably more, both in developing and industrialized countries.

Could you please elaborate more on the important role that SMEs play for their respective countries and REEEP's perspective in this regard?

SMEs are hugely important for the economy of any country, crucial to dynamism and innovation, in addition to providing livelihoods for large percentages of most countries' populaces. SMEs are also very effective in distributing prosperity to those who do not have it. So they play a massive role, and at the same time are really being left behind in development cooperation and technology transfer.

The SME sectors of places like Germany or the US are highly developed and extremely well-organized and well-represented politically, and enjoy relatively unfettered access to financial services. In low and middle-income countries, these businesses are under intense pressure to survive, they are forced to do so amid difficult circumstances and maybe without political representation, and they are terribly under-banked. And because they are small, donors and development agencies often prefer to go for the big projects, from which SMEs are left out. This exacerbates the pressure.

In REEEP, we are trying to break this cycle by generating and spreading evidence for how successful business and investment models can look under specific circumstances. We do this by investing in high-potential SMEs—giving them grant funding or soft loans—and following what they do extremely closely, so we can learn what works, what doesn't, and maybe what needs to change to let these markets take off. Because the barrier is not lack of available investment, it's risk-aversion and lack of bankable projects. We're taking away this risk with better information and knowledge, and also working on creating bankable projects—and providing blueprints for replication.

We are quite specific in where we operate: right now, for instance, we are seeing tremendous potential in food-producing agricultural (or agrifood) value chains. These include everything from farming activities like irrigation and harvesting, to processing, storage and even distribution: farm-to-table. There are opportunities throughout these chains: you have cooling requirements that can be solved off-grid through solar, or you have waste that you could use to create biogas. We look for companies in that field that have a lot of promise and a solid, innovative idea that can disrupt the market; very often these companies are start-ups or medium-sized enterprises that branch out into a new field. We bring in a grant or a patient loan in order to support these entrepreneurs in their next steps, such as a creating a pilot or demonstration product, or developing a new marketing strategy or payment scheme. At the same time, our close partner PFAN provides business mentoring and helps them hone a business plan, and then sets them up with investors in the space who match the needs of the business. Together we aim at helping them find investors for investment levels of between half a million and 20 million dollars.

What is most important is that we also work with these companies as investigative partners. They provide us with data and information that helps us understand the sectors and subsectors better, and this improves our own work and that of bigger partners downstream from us.

What do you expect from the Indian government's aim of 175 GW of installed power by the year 2022 in the renewable energy sector?

I expect a strong focus on off-grid, both in very rural regions where the grid takes a long time to come, and also in on-grid areas, be it because the grid is unreliable, be it because often it is easier to use an off-grid solution. Street lighting is one of the examples but there are many others.

How can REEEP help in the projects that are being implemented in India for renewable energy and is there any arrangement between REEEP and the Indian government officially or unofficially or with any private player from Indian companies?

India is a partner to REEEP, but apart from that there is no official

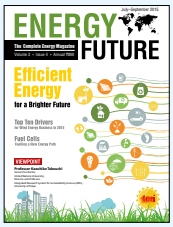
arrangement at the moment. We work with the private sector, funded by donor governments (and we do not expect India at this stage to become a donor government). We are interested to work in rural energy access and also in industrial energy efficiency where we have quite a lot of experience in India already in our work with The Energy and Resources Institute (TERI). Therefore, expectation will be that the government and also the State governments see the kind of offer that we have and see where they can use parts of that and vis-à-vis TERI, our main Indian partner and other Indian partners, we can bundle services that may be interested in rolling out the large off-grid component.

How has been your experience of association with TERI and what are REEEP and TERI doing together in the foreseeable future?

I think TERI has been a fantastic partner for REEEP: we very much value the partnership and are entering a phase now where we hope to make this partnership even more dynamic. We are looking at energy efficiency, access, but also at knowledge management. Both TERI and REEEP are also engaged in international initiatives, such as the *Climate Technology Center and Network*, a UN instrument to support technology transfer, and the initiative *Sustainable Energy for All*, so there are many opportunities. Watch this space! EF

ENERGY FUTURE

The Complete Energy Magazine



By looking at the technologies, policy decisions, and business ventures that have the potential to overcome energy shortage and our crippling dependence on depleting fossil fuels, Energy Future draws from a deep well of expertise at TERI (The Energy and Resources Institute), India's leading research institute on energy and green growth. Knowledge of energy security and development is a critical requirement in the modern global economy, and Energy Future aims to educate and inform you about the wide world of energy; its history, its future, how the energy industry works, how it has affected the world, and how it continues to affect you and me.

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Failure Mode Prediction and Energy Forecasting of PV Plants to Assist Dynamic Maintenance Tasks by ANN Based Models

Renewable Energy, Volume 81, September 2015, Pages 227–238

Fernando A Olivencia Polo, Jesús Ferrero Bermejo, Juan F Gómez Fernández, and Adolfo Crespo Márquez

In the field of renewable energy, reliability analysis techniques combining the operating time of the system with the observation of operational and environmental conditions, are gaining importance over time.

In this paper, reliability models are adapted to incorporate monitoring data on operating assets, as well as information on their environmental conditions, in their calculations. To that end, a logical decision tool based on two artificial neural networks models is presented. This tool allows updating assets' reliability analysis according to changes in operational and/or environmental conditions.

The proposed tool could easily be automated within a supervisory control and data acquisition system, where reference values and corresponding warnings and alarms could be now dynamically generated using the tool. Thanks to this capability, on-line diagnosis and/or potential asset degradation prediction can be certainly improved.

Reliability models in the tool presented are developed according to the available amount of failure data and are used for early detection of degradation in energy production due to power inverter and solar trackers' functional failures.

Another capability of the tool presented in the paper is to assess the economic risk associated with the system under existing conditions and for a certain period of time. This information can then also be used to trigger preventive maintenance activities.

Nitrogen Doped Hybrid Carbon-based Composite Dispersed Nano Fluids as Working Fluid for Low-temperature Direct Absorption Solar Collectors

Solar Energy Materials and Solar Cells, Volume 140, September 2015, Pages 9–16

Rashmi Shende and Ramaprabhu Sundara

Solar energy is the best source of renewable energy among all other natural resources. Due to the abundant availability of solar energy, it could be effectively used to fulfil the energy requirement of modern industrial society. Application of nanofluids in direct absorption solar collectors (DASC) can significantly increase its efficiency. Carbon nanotubes (CNTs) and graphene, which exhibit high thermal conductivity, unique optical properties, good mechanical strength, and large surface area, have been of great advantage in the field of nanofluids. In this present work, application of N-(rGO-MWNTs) (nitrogen doped hybrid structure of reduced graphene oxide (rGO) and multiwalled carbon nanotubes [MWNTs]) in DASC has been investigated. The absorption and transmittance studies have been carried out by UV–visible–NIR spectrophotometer. Furthermore, temperature dependent thermal conductivity study with different volume fractions has been carried out. A significant enhancement in thermal conductivity of 17.7 per cent is achieved with 0.02 per cent volume fraction in DI water and 15.1 per cent with 0.03 per cent volume fraction with EG.

Combining Wave Energy with Wind and Solar: Short-Term Forecasting

Renewable Energy, Volume 81, September 2015, Pages 442–456

Gordon Reikard, Bryson Robertson, and Jean-Raymond Bidlot

While wind and solar have been the leading sources of renewable energy up to now, waves are increasingly being recognized as a viable source of power for coastal regions. This study analyses integrating wave energy into the grid, in conjunction with wind and solar. The study was conducted in the Pacific Northwest in the United States which has a favourable mix of all the three sources. Load and wind power series are obtained from government databases. Solar power is calculated from 12 sites over five states. Wave energy is calculated using buoy data, simulations of the European Center for Medium-range Weather Forecasts model (ECMWF, 2015), and power matrices for three types of wave energy converters. At the short horizons required for planning, the properties of the load and renewable

energy are dissimilar. The load exhibits cycles at 24 hours and seven days, seasonality and long-term trending. Solar power is dominated by the diurnal cycle and by seasonality, but also exhibits nonlinear variability due to cloud cover, atmospheric turbidity, and precipitation. Wind power is dominated by large ramp events—irregular transitions between states of high and low power. Wave energy exhibits seasonal cycles and is generally smoother, although there are still some large transitions, particularly during winter months. Forecasting experiments are run over horizons of 1–4 h for the load and all three types of renewable energy. Waves are found to be more predictable than wind and solar. The forecast error at 1 h for the simulated wave farms is in the range of 5–7 per cent, while the forecast errors for solar and wind are 17 and 22 per cent. Geographic dispersal increases forecast accuracy.

Biomass Gasification Models for Downdraft Gasifier: A State-of-the-Art Review

Renewable and Sustainable Energy Reviews, Volume 50, October 2015, Pages 583–593
Tapas Kumar Patra and Pratik N Sheth

Among the different methods of energy production from biomass, gasification is considered as the most suitable option as it is a simple and economically viable process to produce thermal energy or decentralized electricity generation. Downdraft gasifiers are typically small-scale units having maximum power production capacity up to 5 MW. This feature makes it more suitable for decentralized power generation and distribution to the remote villages/islands deprived of grid electricity. Mathematical models can be helpful for the design of gasifiers, prediction of operational behaviour, emissions during normal conditions, startup, shutdown, change of fuel, change of loading, and to alleviate the type of problems mentioned above. It has been observed that although many researchers have developed models of various types and degrees of complexity, reviews of these modelling and simulation studies are scarce. Largely, it is observed that the review articles reported in the literature fail to address the basic understanding of each model type and their applicability to design different gasifiers for a certain feedstock and variation of operating parameters. This review article discusses different models available for downdraft gasifiers such as thermodynamic equilibrium, kinetic, CFD, ANN, and ASPEN Plus models. A comparative analysis of each model and its output is carried out. A critical analysis of the effect of different modelling parameters and finally, the advantages and disadvantages of each modelling technique is outlined.

An Assessment on the Sustainability of Lignocellulosic Biomass for Biorefining

Renewable and Sustainable Energy Reviews, Volume 50, October 2015, Pages 925–941
Sonil Nanda, Ramin Azargohar, Ajay K Dalai, and Janusz A Kozinski

Biofuels are promoted on a wide-scale as a means of achieving energy security and reducing greenhouse gas emissions. Biofuels derived from lignocellulosic biomass, particularly from agricultural crops are being massively supported worldwide for meeting multiple strategy objectives such as climate change mitigation, energy security, and development of the rural economy. Recently, the negative implications of using food crops for fuel have been realized to possess a significant threat towards global food security and competition for arable land. In contrast, lignocellulosic biomass in the form of waste residues from agriculture, forestry, and energy crop systems are geographically abundant worldwide and have the potential to support the sustainable production of liquid transportation fuels. This paper encompasses the improvement in biofuels sector in relation to revitalizing and restraining the rural economies across the globe, along with the global statistics for lignocellulosic biomass availability. In addition, the socio-environmental impacts of energy and greenhouse gas emissions from biomass conversion technologies have been addressed through highlights on life-cycle assessment of several biomasses.

Analysing Major Challenges of Wind and Solar Variability in Power Systems

Renewable Energy, Volume 81, September 2015, Pages 1–10
Falko Ueckerdt, Robert Brecha, and Gunnar Luderer

Ambitious policy targets together with current and projected high growth rates indicate that future power systems will likely show substantially increased generation from renewable energy sources. A large share will come from the Variable Renewable Energy (VRE) sources wind and solar photovoltaics (PV); however, integrating wind and solar causes challenges for existing power systems. This paper analyses three major integration challenges related to the structural matching of demand with the supply of wind and solar power: (i) low capacity credit, (ii) reduced utilization of dispatchable plants, (iii) and over-produced generation. Based on residual load duration curves the researchers define corresponding challenge variables and estimate their dependence on region (US Indiana and

Germany), penetration and mix of wind and solar generation. Results show that the impacts of increasing wind and solar shares can become substantial, and increase with penetration, independently of mix and region. Solar PV at low penetrations is much easier to integrate in many areas of the US than in Germany; however, some impacts (e.g., over-production) increase significantly with higher shares. For wind power, the impacts increase rather moderately and are fairly similar in US Indiana and Germany.

HARmonic–LINear (HarLin) Model for Solar Irradiation Estimation

Renewable Energy, Volume 81, September 2015, Pages 209–218
Yavuz Selim Güçlü, Smail Dabanlı, Eyüp Şişman, and Zekai Şen

The solar energy has potential future effectiveness in a variety of areas and it helps to decrease the dominance of fossil fuels, which cause atmospheric pollution, global warming, and climate change impacts. In the literature, there are different methodologies for its modelling, but this study suggests the harmonic analysis application to solar irradiation and sunshine duration data for more refined relevant prediction of solar irradiation. The basis of the methodology is combined application of the HARmonic and the classical LINear regression analyses, and therefore, it is referred to as the HarLin model. It isolates first the periodicity from the daily averages of records and then the linear regression analysis is applied elegantly to first order stationary data. The results are tested and compared with the Adaptive-Neuro Fuzzy Inference System (ANFIS) model based on the Sugeno fuzzy logic inference system and Angström–Prescott model in the form of a linear regression analysis. In the application, three solar irradiation sites are considered from different solar energy potential locations in Turkey, namely, at Adana, Gaziantep, and Silifke cities. The predictions by the HarLin model appear more successful than ANFIS and the classical Angström–Prescott approaches.

New Integrated Simulation Tool for the Optimum Design of Bifacial Solar Panel with Reflectors on a Specific Site

Renewable Energy, Volume 81, September 2015, Pages 293–307
Chin Kim Lo, Yun Seng Lim, and Faidz Abd Rahman

The use of a commonly available planar reflector such as a plane mirror can boost the energy output of a bifacial solar panel effectively without increasing much in the overall cost. However, the actual energy yield from the solar panel in this case is dependent on the light reflected from the reflector and surrounding objects to the rear surfaces of the solar cells. The design of the bifacial solar panel with the reflector has to be optimized in order to achieve the maximum yield on a specific site set-up. Therefore, a new simulation tool consisting of several open-source software packages with the bifacial solar cell model is developed to predict the yearly yield of the bifacial solar panel with the reflector accurately. The simulation tool includes the effects of the temperature changes in solar cells and the variation in solar irradiance incident on both front and rear sides at different times in a day, the manufacturing mismatch of the solar cells, and also the reflected light from the nearby objects.

Use of Encapsulated Zinc Particles in a Eutectic Chloride Salt to Enhance Thermal Energy Storage Capacity for Concentrated Solar Power

Renewable Energy, Volume 80, August 2015, Pages 508–516
Sreeram Cingarapu, Dileep Singh, Elena V Timofeeva, and Michael R Moravek

Concentrated Solar Power (CSP) is considered as a viable large-scale renewable energy source to produce electricity. However, current costs to produce electricity from CSP are not cost competitive as compared to the traditional energy generation technologies based on fossil fuels and nuclear. It is envisioned that development of high-efficiency and high heat capacity thermal storage fluids will increase system efficiency, reduce structural storage volume, and hence, contribute to reducing costs. Particularly, with respect to CSP, current high temperature energy storage fluids, such as molten salts, are relatively limited in terms of their thermal energy storage capacity and thermal conductivity. The current work explores possibility of boosting the thermal storage capacity of molten salts through latent heat of added phase change materials. The paper studied the advantage of adding coated Zn micron-sized particles to alkali chloride salt eutectic for enhanced thermal energy storage. Zinc particles (0.6 μm and 5 μm) obtained from commercial source were coated with an organo-phosphorus shell to improve chemical stability and to prevent individual particles from coalescing with one another during melt/freeze cycles. Thermal cycling tests (200 melt/freeze cycles) showed that coated Zn particles have good thermal stability and are chemically inert to alkali chloride salt eutectic in both N_2 and in air atmospheres. Elemental mapping of the cross-sectional view of coated Zn particles from the composite after thermal cycles showed no signs of oxidation, agglomeration or other type of particle degradation. EF

Solar Radios

Edutainment Powered by Sun

A solar powered radio is a portable radio receiver powered by photovoltaic panels. It is primarily used in remote areas where access to power sources is limited.

ADVANTAGES

Solar powered radios eliminate the need to replace batteries, which makes their operating cost much lesser. Since they do not require plugs, they can be used in areas where there is no electrical grid or generators. As a result, people in remote areas with little disposable income can have equal access to news and information. Informative radio programmes on human rights, women's rights, the importance of education (especially for girls), HIV and AIDS, animal husbandry, agriculture, food security, combined with solar powered radios, can be a powerful tool for improving the lives of people in remote areas. Not only this, solar radios are very useful for adventurers during their expeditions as they could easily depend on this renewable-energy powered gadget for entertainment and other utility purposes.

PRODUCT

Eton FR160 Microlink Radio

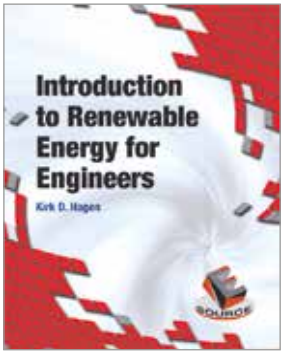
A utility item for emergency kit, bedside stand or car, this solar radio is compact and portable. The battery can be charged via solar or crank. The radio receives AM, FM and all other useful stations, and has a built-in cell phone charger and bright LED flashlight. Its casing is a polycarbonate resin with a metallic finish.

PRODUCT DESCRIPTION

- Convenient power options include full-time power via hand crank, solar panel, and rechargeable NiMH battery pack
- Built-in USB cell phone charger breathes life into most brands of cell phone batteries
- Internal rechargeable NiMH battery pack stores power generated from dynamo hand crank, solar panel, or USB port
- Handy flashlight features three bright white LEDs for a dependable source of light when the power is out
- 3.5 mm earphone jack allows easy private listening with headphones
- FM/AM radio receiver can tune in all 7 NOAA weather channels
- Telescoping antenna for FM reception; internal ferrite antenna for AM reception
- Analogue tuning knobs on side offer smooth dialling to zero in on finicky signals; full-range monophonic front speaker serves up clear sound reproduction. EF

Source: www.solartown.com

INTRODUCTION TO RENEWABLE ENERGY FOR ENGINEERS



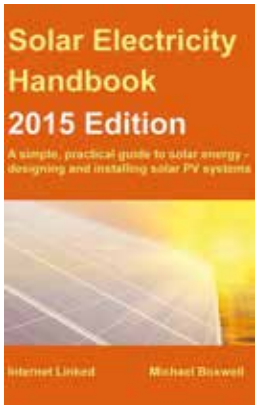
Author: Kirk D Hagen
Publisher: Prentice Hall; Year: 2015

The primary focus of this book is the application of renewable energy to electrical power generation. As each renewable energy technology is explained, the book shows how to do a basic energy analysis of the corresponding power-generation system.

Following an introductory chapter that covers the main types of renewable energy, the basics of energy and power calculations, and the fundamental economics of renewable energy systems, the book devotes a separate chapter to each renewable energy type: solar, wind, hydro, geothermal, marine, and biomass.

Introduction to Renewable Energy for Engineers is intended for engineering students at the beginner's level and students in other fields of study who want to learn the fundamental engineering principles of renewable energy. EF

SOLAR ELECTRICITY HANDBOOK: 2015 EDITION



Authors: Michael Boxwell
Publisher: Greenstream Publishing
Year: 2015

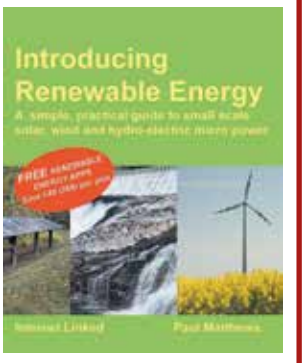
The book is a simple and practical guide to use electric solar panels and designing and installing photovoltaic (PV) systems. Now in its ninth edition, the book assumes no previous knowledge of solar electric systems. The book explains how solar panels work and how they can be used. It explains the advantages of solar energy and the drawbacks that you need to take into account when designing a solar power system. While explaining the underlying principles, the book provides a step-by-step guide so that you can successfully design and install a photovoltaic solar system from scratch. Unlike many guides, the book explains the principles behind the technology, allowing the reader to design solar energy systems with confidence. The book has been used all around the world, designing systems as diverse as providing entire African villages with electricity, powering vending machines, building grid-tied systems for housing, building a one-off solar electric car, and creating lighting for an allotment shed. Accompanying the book is a website that provides solar calculators and online tools to help simplify the solar design process, including a unique database of sunlight values for every major town and city in every country in the world that has been created specifically for this book in conjunction with NASA. Readers can also get in touch with the author directly to ask questions and get further support with their solar projects. EF

ECONOMIC AND ECOLOGICAL EVALUATION OF BIOGAS PLANT CONFIGURATIONS FOR A DEMAND ORIENTED BIOGAS SUPPLY FOR FLEXIBLE POWER GENERATION

Editors: Henning Hahn
Publisher: Fraunhofer IRB Verlag; Year: 2015

The transformation of the power supply towards renewable energy (RE) sources will depend on a large scale of fluctuating RE sources, primarily of wind energy and photovoltaics. However, the variable power generation of these renewable sources will lead to an increased need of flexible power producers in order to balance differences between energy generation and consumption. Among the different types of RE sources, biogas plants have the advantage that their input biomass and the produced biogas can be stored and electricity can consequently be generated on demand. Since electricity from biogas has not been used to balance fluctuations of intermittent RE in the past, new concepts are required. These concepts should be able to meet the requirements of highly renewable electricity systems and to supply biogas according to the varying demand for long- and short-term balance power generation. In this regard, this thesis focuses on the identification of biogas plant concepts for flexible power generation, as well as on ranking them with regard to their economic and life-cycle performance. EF

INTRODUCING RENEWABLE ENERGY

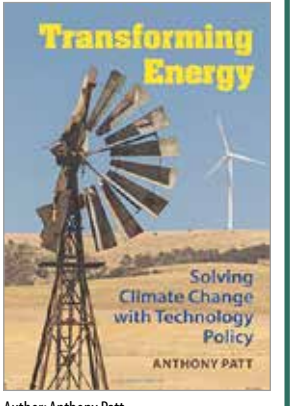


Authors: Paul Matthews
Publisher: Greenstream Publishing; Year: 2015

The book is about renewable energy that you can harness for a small scale 'micro power' project. It is designed to give the reader a view of what renewable energy is, how it works and what it can be used for. The book includes step-by-step instructions for two renewable energy projects—one solar photovoltaic (PV) and one wind project. However, it is not intended as a detailed 'how to' guide for installing all types of renewable energy systems. The book is an introductory guide on the subject that will give the reader enough grounding to extend his/her knowledge with more specialized information later on. Although this book focuses on small-scale renewable energy systems, it also covers larger scale systems at a high level as well. So, if you are interested in finding out about energy production in general, about wind farms, or wish to gain some insight into the emerging energy technology that promises to revolutionize the way we generate vast quantities of renewable energy in the future, this book will give you an understanding of what is possible with renewable energy, both now and in the near future.

Introducing Renewable Energy has been written for the enthusiastic amateur, or for students who want an easy-to-follow introduction to the subject. It is also a perfect introduction for people who are interested in finding out whether they can install their own solar or wind farm, or other industrial scale renewable energy systems, and wanting to get some basic understanding of the technology before they call in the professionals. EF

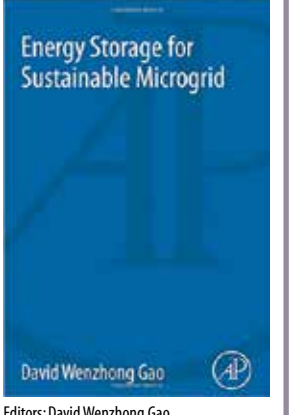
TRANSFORMING ENERGY: SOLVING CLIMATE CHANGE WITH TECHNOLOGY POLICY



Author: Anthony Patt
Publisher: Cambridge University Press; Year: 2015

Climate change will be an ecological and humanitarian catastrophe unless we move quickly to eliminate greenhouse gas emissions. Policy experts advise us that we need to make major changes to our lifestyles, and our governments need to agree to globally binding treaties and implement market instruments like carbon taxes. This advice is a mistake: it treats technological innovation as being at the periphery of the climate policy challenge, whereas it needs to be at its core; we will phase out emissions when and only when the technologies to replace fossil fuels are good enough, and policies need quickly to support these new technologies directly. Anyone with an interest in climate change and energy policy will find this book forward-thinking and invaluable. Professional policymakers, climate and energy policy researchers, and students of energy and public policy, economics, political science, environmental studies, and geography will especially find this book stimulating. EF

ENERGY STORAGE FOR SUSTAINABLE MICROGRID



Editors: David Wenzhong Gao
Publisher: Academic Press; Year: 2015

The book addresses the issues related to modelling, operation and control, steady-state and dynamic analysis of microgrids with energy storage system (ESS). It also discusses major electricity storage technologies in depth along with their efficiency, lifetime cycles, environmental benefits and capacity, so that readers can envisage which type of storage technology is best for a particular microgrid application. This book offers solutions to numerous difficulties such as choosing the right ESS for the particular microgrid application, proper sizing of ESS for microgrid, as well as design of ESS control systems for proper interfacing with the microgrid. The features:

- Explanations for major power electronic converters/technology required to achieve the desired interfacing
- Case studies on the major impacts of energy storage on microgrid
- Detailed solutions for choosing the right ESS for particular microgrid applications
- Valuable economics chapter to help evaluate entire systems. EF

RENEWABLE ENERGY TECHNOLOGY DEVELOPMENT

INNOVATIVE COMPONENTS PAVE WAY FOR CHEAPER WIND ENERGY

Even though energy distribution and management play a crucial role in wind energy uptake across Europe, reducing cost—by relying on research and development (R&D)—is of the challenge currently explored. For example, this is the aim of the European research consortium WINDTRUST.

The project plans to reduce costs by improving the reliability of key components of the turbine. One avenue of research has been the aim to improve the durability of turbine rotorblades. To achieve this, it has already begun to optimize the use of carbon fibre to increase rotorblade durability and reduce component weight. This will contribute to extending the overall life of the turbine to 20–30 years. Developments are also underway to enhance turbine control. At the same time, emphasis should be placed on developing control algorithms that should reduce extreme and fatigue loads of the turbine in order to maximize the balance between energy production and machine life.

http://www.sciencedaily.com/releases/2015/05/150528083826.htm

BOEING & EMBRAER BRAZIL AVIATION BIOFUELS RESEARCH CENTRE TO OPEN

Aircraft manufacturers Boeing and Embraer are to open a joint aviation biofuels research centre in Brazil. US aircraft firm Boeing and Brazil's Embraer have announced that they will open the research centre in city Sao Jose dos Campos to advance a sustainable aviation biofuel industry in the BRIC country.

The two companies will perform joint biofuel research, as well as fund and coordinate research with Brazilian universities and other institutions. Boeing said the research will focus on technologies that address gaps in a supply chain for sustainable aviation biofuel in Brazil, such as feedstock production and processing technologies. The biofuel research centre will be located in Sao Jose dos Campos Technology Park.

http://www.renewable-energy-technology.net

HUNDRED PER CENT CLEAN AND RENEWABLE WIND, WATER, AND SUNLIGHT (WWS) ALL-SECTOR ENERGY ROADMAPS FOR THE 50 UNITED STATES

This study presents roadmaps for each of the 50 United States to convert their all-purpose energy systems (for electricity, transportation, heating/cooling, and industry) to ones powered entirely by wind, water, and sunlight (WWS). The plans contemplate 80–85 per cent of existing energy replaced by 2030 and 100 per cent replaced by 2050. Conversion would reduce each state's end-use power demand by a mean of ~39.3 per cent with ~82.4 per cent of this due to the efficiency of electrification and the rest due to end-use energy efficiency improvements. By the year 2050 end-use, US all-purpose load would be met with ~30.9 per cent onshore wind, ~19.1 per cent offshore wind, ~30.7 per cent utility-scale photovoltaics (PV), ~7.2 per cent rooftop PV, ~7.3 per cent concentrated solar power (CSP) with storage, ~1.25 per cent geothermal power, ~0.37 per cent wave power, ~0.14 per cent tidal power, and ~3.01 per cent hydroelectric power. Based on a parallel grid integration study, an additional 4.4 per cent and 7.2 per cent of power beyond that needed for annual loads would be supplied by CSP with storage and solar thermal for heat, respectively, for peaking and grid stability. Over all 50 states, converting would provide ~3.9 million 40-year construction jobs and ~2.0 million 40-year operation jobs for the energy facilities alone, the sum of which would outweigh the ~3.9 million jobs lost in the conventional energy sector.

http://www.researchgate.net/publication

STABLE PEROVSKITE SOLAR CELLS DEVELOPED THROUGH STRUCTURAL SIMPLIFICATION

Lead-halide-based perovskite (hereinafter simply referred to as perovskite) has been used as a solar cell material since the last six years. Perovskite solar cells are promising low-cost and highly-efficient next-generation solar cells because they can be produced through low-temperature processes such as spin coating, and generate a large amount of electricity due to their high optical absorption together with the high open-circuit voltage. In order to identify the semiconducting properties of perovskites and formulate guidelines for the development of highly efficient solar cell materials, the National Institute for Material Science (NIMS) launched an ad-hoc team on perovskite PV cells—Global Research Center for Environment and Energy based on Nanomaterials Science (GREEN).

While the conventional perovskite solar cells have demonstrated high conversion efficiency, they were not sufficiently stable; plagued by their low reproducibility and the hysteresis in the current-voltage curves depending on the direction of the voltage sweeps. For this reason, the semiconducting properties of perovskites had not been identified. Researchers successfully created reproducible and stable perovskite solar cells as follows:

- They created perovskite solar cells with a simplified structure while strictly eliminating moisture and oxygen by employing the fabrication technique they had developed for the organic solar cells in the past.
- They found that the perovskite solar cells are stable and they observed no hysteresis in the current-voltage curve. Furthermore, they found that the perovskite solar cell material serves as an excellent semiconductor with ideal diode properties.

http://www.sciencedaily.com/releases/2015/06/150608081755.htm

SCALING UP NANOSCALE WATER-DRIVEN ENERGY CONVERSION INTO EVAPORATION-DRIVEN ENGINES AND GENERATORS

Evaporation is a ubiquitous phenomenon in the natural environment and a dominant form of energy transfer in the Earth's climate. Engineered systems rarely, if ever, use evaporation as a source of energy, despite myriad examples of such adaptations in the biological world. Here, Columbia University scientists report the development of two novel devices that derive power directly from evaporation—a floating, piston-driven engine that generates electricity causing a light to flash, and a rotary engine that drives a miniature car. The study reports evaporation-driven engines that can power common tasks, such as locomotion and electricity generation. These engines start and run autonomously when placed at air–water interfaces. They generate rotary and piston-like linear motion using specially designed, biologically based artificial muscles responsive to moisture fluctuations. Using these engines, the scientists demonstrate an electricity generator that rests on water while harvesting its evaporation to power a light source, and a miniature car (weighing 0.1 kg) that moves forward as the water in the car evaporates.

http://www.nature.com/ncomms/2015/150616/ncomms8346/full/ncomms8346.html

RENEWABLE ENERGY FROM MICROBES

Stanford University scientists have solved a long-standing mystery about methanogens, unique microorganisms that transform electricity and carbon dioxide into methane. In a new study, the Stanford team demonstrates for the first time how methanogens obtain electrons from solid surfaces. The discovery could help scientists design electrodes for microbial 'factories' that produce methane gas and other compounds sustainably. Methane is an important fuel for heating, transportation, cooking, and generating electricity. Most methane comes from natural gas, an abundant fossil fuel extracted from wells. However, burning natural gas emits carbon dioxide, which accelerates global warming. Methanogens offer a promising alternative.

Researchers are trying to develop large bioreactors where billions of methanogens crank out methane around the clock. These microbial colonies would be fed carbon dioxide from the atmosphere and clean electricity from electrodes.

http://www.sciencedaily.com/releases/2015/05/150518112029.htm

FINE-TUNED MOLECULAR ORIENTATION IS KEY TO MORE EFFICIENT POLYMER SOLAR CELLS

Polymer solar cells are a hot area of research due to both their strong future potential and the significant challenges they pose. It is believed that thanks to lower production costs, they could become a viable alternative to conventional solar cells with silicon substrates when they achieve power conversion efficiency—a measure that indicates how much electricity they can generate from a given amount of sunlight—between 10 and 15 per cent. Now, using carefully designed materials and an 'inverted' architecture, a team of scientists has achieved efficiency of 10 per cent, bringing these cells close to the threshold of commercial viability.

Improving the power conversion efficiency of polymer-based bulk-heterojunction solar cells is a critical issue. Here, the scientists show that high efficiencies of ~10 per cent can be obtained using the crystalline polymer PNTz4T in single-junction inverted cells with a thick active layer having a thickness of ~300 nm. The improved performance is probably due to the large population of polymer crystallites with a face-on orientation and the 'favourable' distribution of edge-on and face-on crystallites along the film thickness (revealed by in-depth studies of the blend films using grazing-incidence wide-angle X-ray diffraction), which results in a reduction in charge recombination and efficient charge transport. EF

http://www.sciencedaily.com/releases/2015/05/150525120309.htm

INDUSTRY REGISTRY

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Dow Corning Corporation
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Tel: +1-989-496600
Fax: +1-989-6952054
Email: solarsolutions@dowcorning.com
Website: www.dowcorning.com/solar

Evasol SAS
Evasol offers a turnkey photovoltaic solution. Evasol is the No. 1 solar company in France for photovoltaic systems destined for individual home owners and investors.
ZAC Sans-Souci 1111 Chem. La Bruyere, F-69760 Limonest, France
Tel: +33/437460300
Email: contact@evasol.fr
Website: www.evasol.fr

FLEXcon Company
FLEXcon Company is manufacturer of customized and standard multi-layer flexible composites for barrier protection of crystalline and thin-film photovoltaic modules.
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Juli New Energy Co., Ltd
Juli is a vertical production chain company specializing in manufacture and sales of crystalline silicon, silicon wafer, solar cells, solar modules. Juli also invests, develops, and operates PV power plants.
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Email: juli@julisolar.com
Website: www.julisolar.com

Mounting Systems GmbH
Manufacturer of mounting systems and components for Photovoltaic and SolarThermal.
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Tel: +49-33708-5290
Fax: +49-33708-199
Website: www.mounting-systems.com

ReneSola Ltd.
ReneSola is a leading Chinese manufacturer of both monocrystalline and multicrystalline solar wafers. ReneSola seeks continuous improvement in the wafer manufacturing process and technical innovation.
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Fax: +86-573-4773063
Email: sales@renesola.com
Website: www.renesola.com

SDN Company Ltd
SDN Company Ltd is total provider of all components of PVGS with several years of field records since 2003. It is the world's only Turn-Key System through SunDay Series (Module, Inverter, Structure, etc.).
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Fax: +82-2-34243818
Email: alma@sdn-i.com
Website: www.sdn-i.com

Titan Energy Systems Limited
An ISO 9001-2000 certified manufacturer of multi-technology Solar PV modules, crystalline modules up to 245 Wp, thin-film and CIGS modules up to 120 W as per IEC 61215:2005, IEC 61730-2.
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Email: info@titan-energy.com
Website: www. titan-energy.com

Websol Energy Systems Ltd.
Websol is a vertically integrated manufacturer of solar cells and modules (10 Wp to 280 Wp) with over 15 years' experience. All products are certified to UL 1703, IEC 61215 & 61730 Standards.
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Fax: +91-3340239011
Email: websol@webelsolar.com
Website: www.webelsolar.com

NATIONAL AND INTERNATIONAL EVENTS

INTERNATIONAL

South African International Renewable Energy Conference (SAIREC 2015)

Oct 4–7, 2015

Cape Town, South Africa
Website: http://www.ren21.net/irecs/sairec-2015

The Caribbean Renewable Energy Forum (CREF) 2015

Oct 19–21, 2015

Punta Cana, Dominican Republic
Website: http://www.caribbeanenergyforum.com

Ocean Energy Europe 2015 (OEE2015)

Oct 20–21, 2015

Dublin, Ireland
Website: http://oceanenergy-europe.eu

International Bioenergy Conference and Exhibition 2015

Oct 28–30, 2015

Shanghai, China
Website: http://www.ibsce.com

ISES Solar World Congress

Nov 8–12, 2015

Daegu, Korea
Website: www.swc2015.org

National Energy Efficiency Council

Nov 17–18, 2015

Melbourne, Australia
Website: http://www.eec.org.au/National-Energy-Efficiency-Conference-2015

7th Annual Conference & Exhibition, OWCI 2015

Dec 1–2, 2015

Hamburg, Germany
Website: http://www.windenergyupdate.com/offshore-construction

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The 2nd International Conference on Renewable Energy Technologies (ICRET 2015)

Dec 06–08, 2015

Abu Dhabi, UAE
Website: http://icret.org

Wind Operator Congress Europe

Dec 8–10, 2015

London, UK
Website: http://www.greenpowerconferences.com

World Future Energy Summit 2016

Jan 18–21, 2016

Abu Dhabi, UAE
Website: http://www.worldfutureenergysummit.com

6th International Conference on Ocean Energy (ICOE)

Feb 23–25, 2016

Edinburgh, UK
Website: http://www.renewableuk.com/icoe-2016

NATIONAL

Renewable Energy Chennai

Oct 07–09, 2015

Chennai, India
Website: http://10times.com/renewable-energy-chennai

Global Conference on Renewable Energy (GCRE)

Oct 19–21, 2015

Patna, Bihar, India
Website: https://www.weentech.co.uk/gcre2015

Thorium Energy Conference

Oct 19–22, 2015

Mumbai, India
Website: http://10times.com/thec-mumbai

Global Green Summit

Oct 31, 2015

Mumbai, India
Website: http://10times.com/global-green-summit

International Conference on Solid Waste Management

Nov 24–27, 2015

Bengaluru, India
Website: http://10times.com/solid-waste-management-bangalore

Biennial International Conference on Power and Energy Systems: Towards Sustainable Energy (PESTSE2016)

Jan 21–23, 2016

Bengaluru, India
Website: https://www.amrita.edu/site/pestse2016

Delhi Sustainable Development Summit 2016

Feb 01–04, 2016

New Delhi, India
Website: http://dsds.teriin.org/2016

RE-Invest 2016

Feb 18–20, 2016

New Delhi, India
Website: http://re-invest.in

Biofuels & Bioenergy: International Conference and Exhibition (BICE 2016)

Feb 23–25, 2016

Bhopal, India
Website: www.weentech.co.uk

Renewable Energy at a Glance

Programme/Scheme wise Physical Progress in 2015–16 (During the month of July, 2015)			
Sector	FY 2015–16		Cumulative Achievements
	Target	Achievement	(as on 31.07.2015)
I. GRID-INTERACTIVE POWER (CAPACITIES IN MW)			
Wind Power	2,400.00	421.30	23,864.91
Solar Power	1,400.00	357.68	4,101.68
Small Hydro Power	250.00	75.20	4,130.55
Bio-Power (Biomass & Gasification and Bagasse Cogeneration)	400.00	0.00	4,418.55
Waste to Power	10.00	12.00	127.08
Total	**4,460.00**	**866.18**	**36,642.77**
II. OFF-GRID/ CAPTIVE POWER (CAPACITIES IN MW_{EQ})			
Waste to Energy	10.00	0.50	146.51
Biomass (non-bagasse) Cogeneration	60.00	10.50	602.37
Biomass Gasifiers -Rural	2.00	0.00	17.95
-Industrial	6.00	0.00	152.05
Aero-Generators/Hybrid Systems	0.50	0.13	2.67
SPV Systems	50.00	0.00	234.35
Water Mills/Micro Hydel	2.00	0.00	17.21
Total	**130.50**	**11.13**	**1,173.11**
III. OTHER RENEWABLE ENERGY SYSTEMS			
Family Biogas Plants (numbers in lakh)	1.10	0.04	48.22
Solar Water Heating – Coll. Areas (million m^2)	-	0.00	8.90

Source: www.mnre.gov.in

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Twelve issues	684,000	570,000	570,000	342,000	205,200

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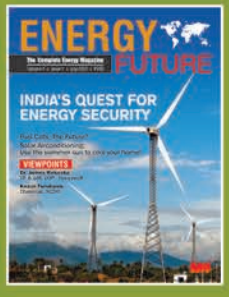

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