recently estimated the market for off-grid energy storage at $3 billion by 2022. This will present huge opportunities for local as well as global players to enter the burgeoning Indian market at the right time in order to give storage solutions. A unique example of energy storage helping remote and rural areas is Promethean Power systems that originated in Boston in 2007 but works primarily in India. The company is trying different means of thermal storage to help rural milk collection centres, where grid connectivity is difficult. They have put in place a thermal battery that provides steady energy at a stable temperature. The company views solar as a possible hybrid solution for vegetables and fruits, where the temperature range is less critical and may help India's cold storage woes to some extent.

In fact, SoftBank envisages the storage market becoming affordable in the country in another three to four years, which in turn should instill confidence amongst lenders who could provide long-term financing to energy-storage players.

Another reputed think tank, The Energy and Resources Institute, had suggested that India may not need newer coal plants until 2026 due to rapid surge in renewables, existing plans to set up coal-fired plants in the country along with an improved energy storage. This demonstrates the inherent belief in the possibilities.

Oil-major Royal Dutch Shell opened a new technology centre in Bengaluru where it is looking at designing solutions for renewable energy, especially in next-gen battery technology. Suzlon Energy, one of the earliest wind power developers in the country, recently announced its intent to become a player in integrated energy storage.

Solar Energy Corporation of India, a government-owned entity, is looking to have 100 MW of storage capacity for the 750 MW solar park in Andhra Pradesh. One of the biggest independent wind power producers in the country, IL&FS, is looking at utility-scale integration of wind, solar, and storage in India for which it has roped in General Electric to help examine the feasibility. AES and Panasonic also declared a 10 MW Li-ion-based collaborative ESS project at the Panasonic white goods factory in Jhajjar, Haryana. The involvement of big players signals there is a market for energy storage and that the companies are trying in earnest. While Tesla may not have come to India, it has begun hiring for the storage division in another developing country, South Africa. The Indian Government of India has shown resolve in the adoption and implementation of renewables as a part of its vision to reduce emissions, but it will need to work faster for mass reduction in storage costs by devising sustainable policies. It can take its cue from more advanced countries, such as France, Germany, Britain, and the US, where the market is moving very swiftly.

For this, the government can make battery storage a part of the ambitious 'Make in India' programme and encourage international players to set up shop in the country. However, Indian companies may face tough competition from extremely cheap Lithium-ion batteries being manufactured on a mass scale in China, India's immediate neighbour, known for its ability to mass-produce at a low-cost; hence, positioning itself at the primary choice for a large number of companies internationally looking to curtailing its increasing cost. India faced a similar dilemma in the early stage of solar development when the threat of Chinese modules loomed large on Indian manufacturing. Currently, the energy storage market is dominated by Japanese and Korean manufacturers, such as Panasonic, Samsung, and LG. It is anticipated that China will overtake them by 2020.

The importance of renewable energy storage is augmented by the fact that over 15%–20% of India's renewable energy generation goes waste due to a lack of adequate electricity storage facility. While this number may be higher in some states as the grid cannot manage the kind of variation from solar and wind, this can be a sour reality that the Indian Government may need to address.

In order to promote research and development and bring in best technologies for storage adoptions, the NISE (National Institute of Solar Energy), an autonomous entity under the Ministry of New and Renewable Energy, and Tiger Power of Belgium, recently entered a Memorandum of Understanding for the validation of technology combining solar panels, normal lead-acid battery, and hydrogen fuel cells for producing steady power. This is a part of India's attempt to use international technologies in order to provide consumers quality power solutions to flickering supply from battery storage or diesel generators in distant or off-grid locations.

However, it must be remembered that India's tryst with new flow battery technology has been cut short because of SunEdison's bankruptcy as there were plans of rolling out 1,000 vanadium flow batteries across the country. The solar major had partnered with Imergy Power Systems in a major rural electrification programme. Another instance of a big company announcing plans but not taking shape ultimately included GE, which made an initial investment of $100 million in 2009 and opened a factory in 2011 for $170 million but finally lead to closure of the energy storage explorations in 2015.

A revolution in energy storage will be critical for the country now that solar power has almost reached grid parity. The announcement of initiatives, such as developing smart cities, will help in giving the necessary impetus to off-grid solutions and simultaneously to energy storage in the near future. EF

Viraj Desai, a former banker and journalist, has had stints with Citibank and The Economic Times. He currently works with an NGO and loves to travel and read on diverse things especially energy, environment, and technology. E-mail: virajd29@gmail.com.

Direct Torque Control Based Permanent Magnet Synchronous Motor Drives for Wind Energy Applications

India has a target of installing 175 GW of renewable power by the year 2022 of which 60 GW is to be from wind. While progress has been made in last year, innovation is required and will play an essential role in achieving the target. In this article, **Arun Shankar V K**, **Umashankar S**, and **Dr D P Kothari** talk about design innovation in wind turbine motors for enhancing efficiency.

Direct Torque Control (DTC) is capable of providing dynamic torque response and optimization in energy utilization. The whole idea of DTC is based on hysteresis control of torque and flux. Using the proposed scheme, permanent magnet synchronous motor (PMSM) can be operated at maximum efficiency at load condition by varying the amplitude of stator flux. The PMSM and variable frequency drives with DTC control are modelled and simulated in the MATLAB environment.

The PMSMs are replacing induction motors in many applications. PMSMs have high-power density, which means PMSM of the same kilo-Watt rating are smaller than that of induction motor since rotor flux is provided by permanent magnets and rotating at synchronous speed, rotor copper and core loss are almost nil.[1] Therefore, induction motors have high efficiency as

1 Zhong L, Rahman MF, Hu WY, Lim KW, and Rahman MA. 1999. A direct torque controller for permanent magnet synchronous motor drives. *IEEE Transactions on Energy Conversion* 14(3): 637–642.

compared to induction motor. PMSMs are adapted in electric automobiles due to their compact size and efficiency. Compared to synchronous reluctance motor PMSM has high power.[2]

Even though DTC (i.e., direct torque control) technique has been developed three decades back, it has gained importance only recently. In DTC, control makes use of two hysteresis controllers, one for torque and other for flux. Both torque and flux are maintained within the desired limit by selecting the optimum switching sequence for the inverter. Moreover, motor can be operated at maximum efficiency by controlling the magnitude of flux at steady state. Compared to some other vector control schemes, such as field oriented control (FOC), DTC is simple and provides superior performance. Unlike the FOC scheme, DTC does not need a position sensor. Since we do not need complex transformation as in FOC control, implementing DTC is computationally easy.

Modelling of PMSM

The dynamics of PMSM are governed by Equations (1) and (2). The Equation (1) represents the electrical model of PMSM in d–q rotating frame.[3] The instantaneous stator voltages equation are expressed in Equation (1).

$$\begin{bmatrix} V_d \\ V_q \end{bmatrix} = \begin{bmatrix} r_s + L_d \frac{d}{dt} & -p.\omega_{m}.L_q \\ p.\omega_{m}.L_d r_s + L_q \frac{d}{dt} \end{bmatrix} \begin{bmatrix} I_d \\ I_q \end{bmatrix} + \begin{bmatrix} 0 \\ p.\omega_{m}.\Phi_{Pm} \end{bmatrix} \quad (1)$$

In the Equation (1), V_d and V_q are the d–q axis stator currents represents stator resistance, Φ_{pm} is the flux linkage rotor magnet with stator p is the number of pairs of pole, L_d and L_q are the d–q axis stator inductance, and are the d–q axis stator currents, represents rotor shaft speed. The equivalent circuit of PMSM is illustrated in Figure 1.

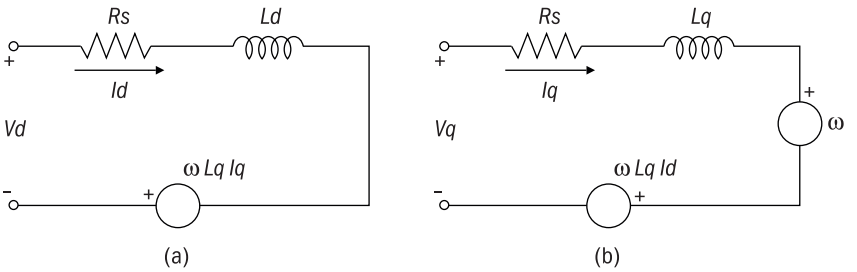


Figure 1 Equivalent circuit of PMSM (a) d axis (b) q axis

The mechanical dynamics of PMSM is defined by Equation (2).

$$J\frac{d\omega_m}{dt} = T_e - T_L - B.\omega_m \quad (2)$$

Where J, moment of inertia; B, coefficient of viscous damping; T_e, electromagnetic torque developed; T_L, load toque; ω_m, rotor shaft speed.

Direct Torque Control (DTC)

The concept DTC was first introduced about three decades back. DTC is a vector control technique for controlling the torque, thereby the motor speed.[4]

In DTC control, stator currents and voltages of any two phases are measured and converted to d–q axis quantities using park transformation. The d–q axis stator current and voltage thus obtained are used to estimate stator flux and electromechanical torque using Equations (4) and (5) Stator voltage is given by

$$V_s = r_s I_s + \frac{d\Phi_s}{dt} \quad (3)$$

From Equation (3)

$$\Phi_s = \int_0^t (V_s - r_s I_s)dt \quad (4)$$

Torque developed is given by

$$T_e = \frac{3}{2}p(\Phi_{pm} I_q + (L_d - L_Q) I_q I_d) \quad (5)$$

The error for torque and stator flux is calculated with estimated and reference values of stator flux and electromagnetic torque.[5,6] Estimated torque is compared using a three-level comparator as shown in Figure 2. The value is then assigned depending on the torque error as shown in Table 1. The error in flux is given to a hysteresis controller with the limits assigned between the values 1 and 0. After assigning value for error in torque

Table 1 Block diagram of DTC for PMSM

$T_e^* - T_e < \frac{-dT_e}{2}$	-1
$\frac{-dT_e}{2} < T_e^* - T_e \frac{-dT_e}{2}$	0
$T_e^* - T_e < \frac{dT_e}{2}$	1

2 Bose BK. 2002. *Modern Power Electronics and AC Drives*. New Jersy: Prentice Hall.

3 Soliman HF and Elbuluk ME. 2008. Improving the torque ripple in DTC of PMSM using fuzzy logic. In *Industry Applications Society Annual Meeting*, October 5, 2008, pp. 1–8. The Institute of Electrical and Electronics Engineers: Canada.

4 Abassi M, Khlaief A, Saadaoui O, Chaari A, and Boussak M. Performance analysis of FOC and DTC for PMSM drives using SVPWM technique. In *Sciences and Techniques of Automatic Control and Computer Engineering* (STA), 2015 16th International Conference on Dec 21, 2015. pp. 228–233. The Institute of Electrical and Electronics Engineers: Tunisia.

5 Rahman MF, Zhong L, Haque ME, and Rahman MA. 2003. A direct torque-controlled interior permanent-magnet synchronous motor drive without a speed sensor. *IEEE Transactions on Energy Conversion* 18(1): 17–22.

6 Faiz J, Mohseni-Zonoozi SH. 2003. A novel technique for estimation and control of stator flux of a salient-pole PMSM in DTC method based on MTPF. *IEEE Transactions on Industrial Electronics* 50(2): 262–271.

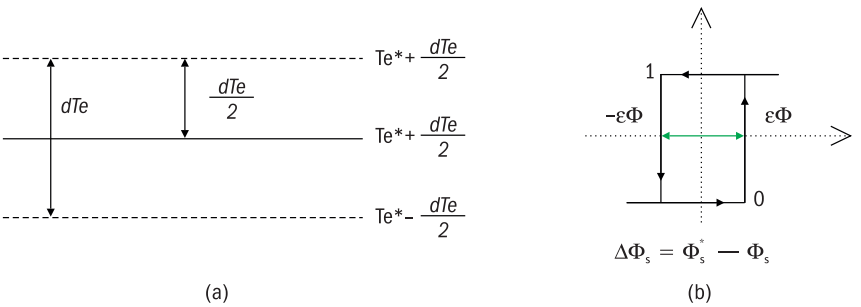


Figure 2 Hysteresis band for (a) torque, (b) flux

with the various simulation, results of which are discussed in this section. The simulation parameters and the power ratings considered for the simulation are provided in Table 3. PMSM with the power rating of 2.2 kW is selected for the modelling and analysis. The flux contour and stator current of the DTC-based PMSM is shown in Figures 3 and 4, respectively.

and flux, the sector in which flux resides is estimated and an optimum switching sequence for the inverter is selected from Table 2.

Table 2 Optimum switching sequence for inverter

		Sector						
	Torque	1	2	3	4	5	6	
1	-1	V2	V3	V4	V5	V6	V1	Switching states
1	0	V7	V0	V7	V0	V7	V0	
1	1	V6	V1	V2	V3	V4	V5	
0	-1	V3	V4	V5	V6	V1	V2	
0	0	V0	V7	V0	V7	V0	V7	
0	1	V5	V6	V1	V2	V3	V4	

Table 3 System parameters

Parameter	Value	Parameter	Value
Rated Voltage	415 V	Stator Resistance	1.3172 Ω
Rated Frequency	200 Hz	Rotor Resistance	1.6755 Ω
Ploe pair	4	d-axis Inductance	12.8 mH
DC Voltage	380 V	q-axis Inductance	10.0 mH
Moment of Inertia	1.2 kg-m^2	Back emf @1,000 rpm	90 V

Simulation Results

The modelling of PMSM and DTC are done in the MATLAB environment

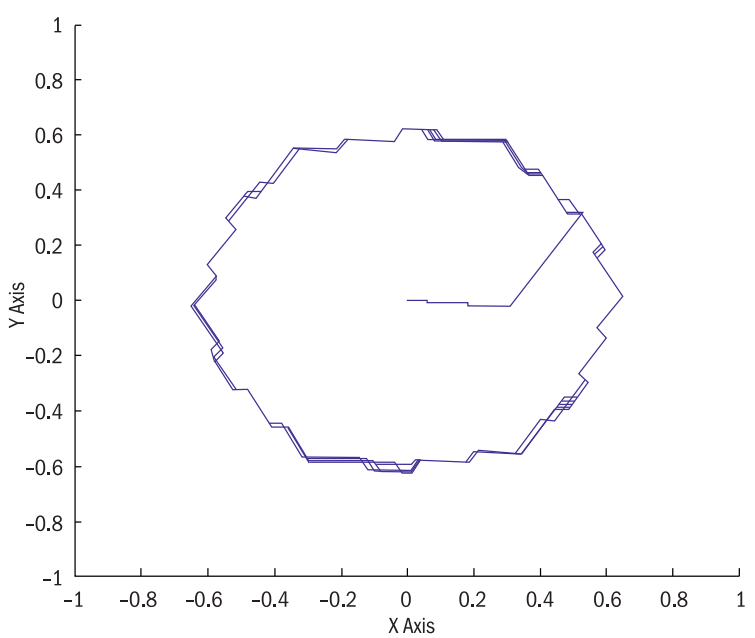


Figure 3 Flux contour

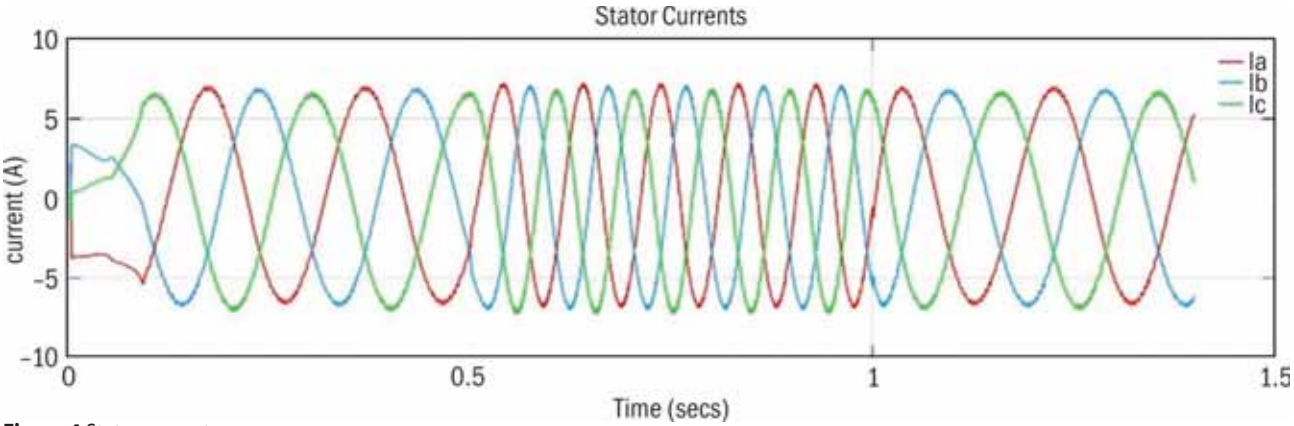


Figure 4 Stator currents

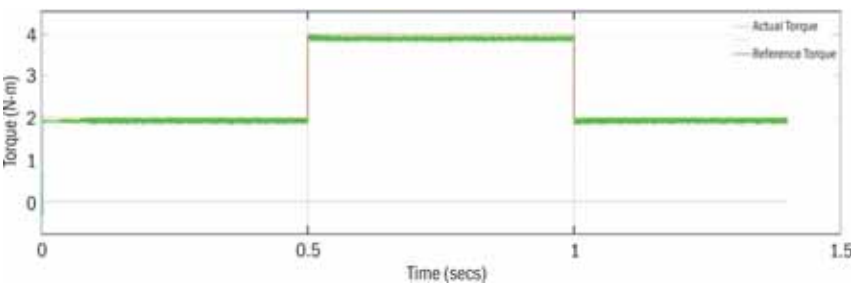


Figure 5 Actual torque and reference torque

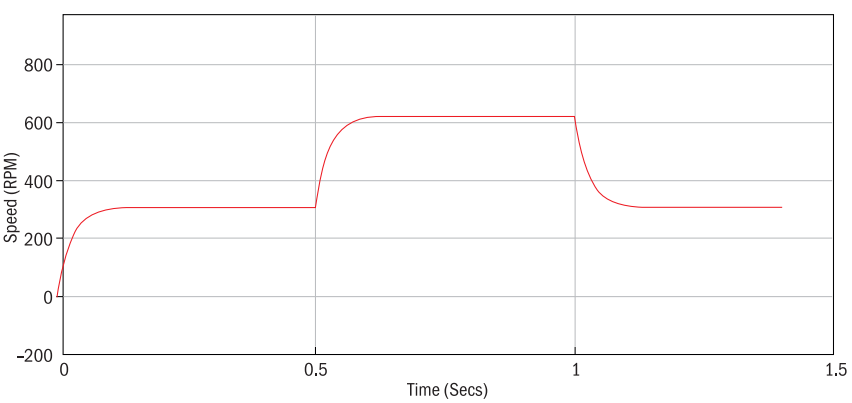


Figure 6 Speed of PMSM in RPM

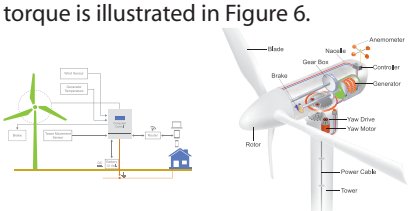
The calculation of ripple in torque and flux is done with the Equations (6) and (7).

$$T_{ripple} = \sqrt{\left(\frac{1}{N_m}\sum_{i=1}^{N_m}(T_e(i) - T_e^*)^2\right)} \quad (6)$$

$$\varphi_{ripple} = \sqrt{\left(\frac{1}{N_m}\sum_{i=1}^{N_m}(\varphi_s(i) - \varphi_s^*)^2\right)} \quad (7)$$

The number of samples taken for the ripple calculation is denoted by 'm'.[7]

Torque response for transient and steady-state applications shows the set point tracking capability of DTC control. For a given torque set point of 2 Nm and for the step change, the steady-state torque response is observed as shown in Figure 5. The corresponding change in speed with respect to change in the torque is illustrated in Figure 6.



Conclusion

The DTC of PMSM is simulated in the MATLAB environment. With DTC control, a better control of flux and torque is achieved for the PMSM. The torque exhibits minimal oscillations and follows the reference torque. The speed response for the defined torque is also illustrated for the better understandings. The torque fluctuations while using DTC can be further minimized by incorporating fuzzy logic and artificial neural networks. EF

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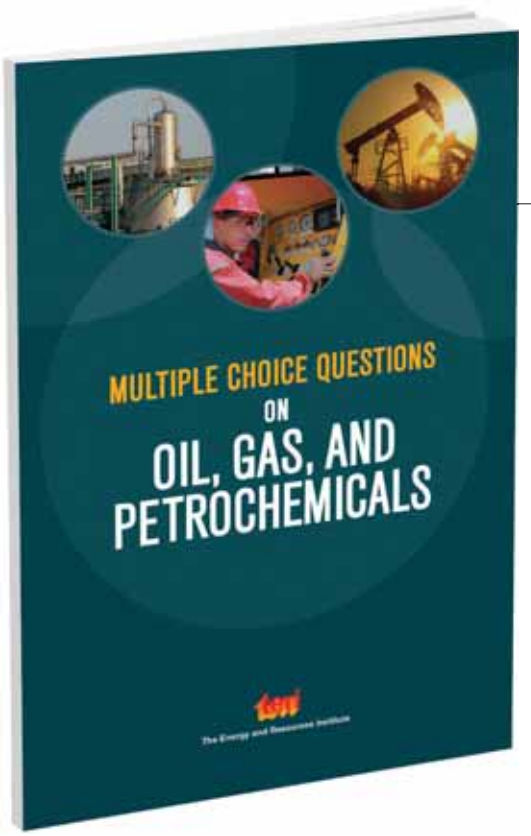
7 Arun Shankar V K, Umashankar S, Paramasivam S. 2016. Performance Evaluation of Fuzzy DTC based PMSM for Pumping Applications *Indian Journal of Science and Technology* 9(38).

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



Highlights

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AN ENERGY EFFICIENT POWER GENERATION TECHNIQUE FOR GREEN BUILDINGS

Hybrid Models to Make Clean Solar City

An important part of India's renewable target is to harness 40 GW from rooftop solar energy systems. Environmental conditions vary during the day and year, which interferes with power generation. Though this article, **Radhey Shyam Meena** and **Dilip Nigam** try to endorse energy efficient solar–wind hybrid power generation strategy using the wind and infrared plastic solar cell on roofs of buildings.

Energy crisis is one of the vital problems faced by our country since many decades. Major cities of India consume a lot of power and their requirements are increasing day by day. In order to satisfy the energy requirement and to promote pollution free energy production, renewable energy resources are promoted and used instead of conventional energy resources. A green building requires minimum amount of energy, consumes less water, conserves natural resources, reduces carbon footprint, and creates a space for healthy and comfortable living.

Today, essential requirements of the society are to minimize the levelized cost of energy and emission of the CO_2. Several methodologies were developed for reducing carbon footprint and to meet energy requirement, in which renewable energy-based solution is one of the easiest ways towards green energy development. In general, infrared plastic solar cell is the nexus of nanotechnology and material science, which plays a vital role in harnessing energy from the infrared energy band of the sun rays. They are more effective when compared to the conventional solar cell. Further, they are compact and are able to operate effectively even on cloudy days. Furthermore, in major cities, wind speed is low when compared to rural areas as tall buildings block the wind flow.

Small-scale solar works great for generating renewable energy from rooftop. The technology is mature, the cost is dropping, and panel efficiencies are rising, even though the sun isn't shining half of the time; when it is shining, solar panels will produce clean power dependably and silently for many decades, with minimal maintenance. Small-scale wind power generation isn't nearly as predictable, especially in the urban environment, such as placing a turbine on a rooftop, where low wind speeds and variable wind directions may not be optimal for producing electricity.

However, an advantage that the wind has over solar power is that turbines

can continue to generate electricity even when the sun goes down, so one solution is to combine the two into a hybrid renewable energy system.

This article presents 1 kW fixed speed wind generation system fitted at rooftop and another 0.5 kW bladeless wind power generation strategy in ground level to yield energy from the wind. The bladeless wind power generation strategy is based on piezoelectric effect, that is, harnessing energy by vibration created by wind speed even in the range of 3 to 4.5 m/s. Furthermore, 1 kW infrared plastic solar cell-based photovoltaic (PV) power plant will be fitted at rooftop. This research for hybrid power generation works effectively during offgrid operation and can be promoted to supply power for offices, school, and colleges in urban and rural areas.

Need and Motivation

The main objective of study is to design and develop ongrid-cum-offgrid hybrid power generating system based on the wind and infrared plastic solar cell to provide continuous power supply for domestic consumers in urban or rural settings for increase in the efficiency of offgrid power generation using hybrid power generation strategy and to ensure our aim towards green buildings and making green zone for cities.

Wind, infrared plastic solar cell and piezoelectric effect-based bladeless power generation system are combined together to form a hybrid power generation system. The use of the piezoelectric effect-based bladeless wind power generation system is an adaptive technique that can harness energy from the wind in every environmental condition. Furthermore, use of infrared plastic solar cell is an effective way of extracting solar energy in visible as well as infrared spectrum. This combined hybrid power generation system has higher efficiency compared to conventional hybrid power generation system. From a commercial point of view, the capital cost is moderate, it is however maintenance free. By using the proposed hybrid power generation system, it would be possible to generate power in all environmental conditions and is most suitable and economical way of creating a micro grid power supply for rural areas, schools, colleges, as well as for residential users, which is the need of the hour.

The aim of this article is to motivate institutions, such as schools, colleges,

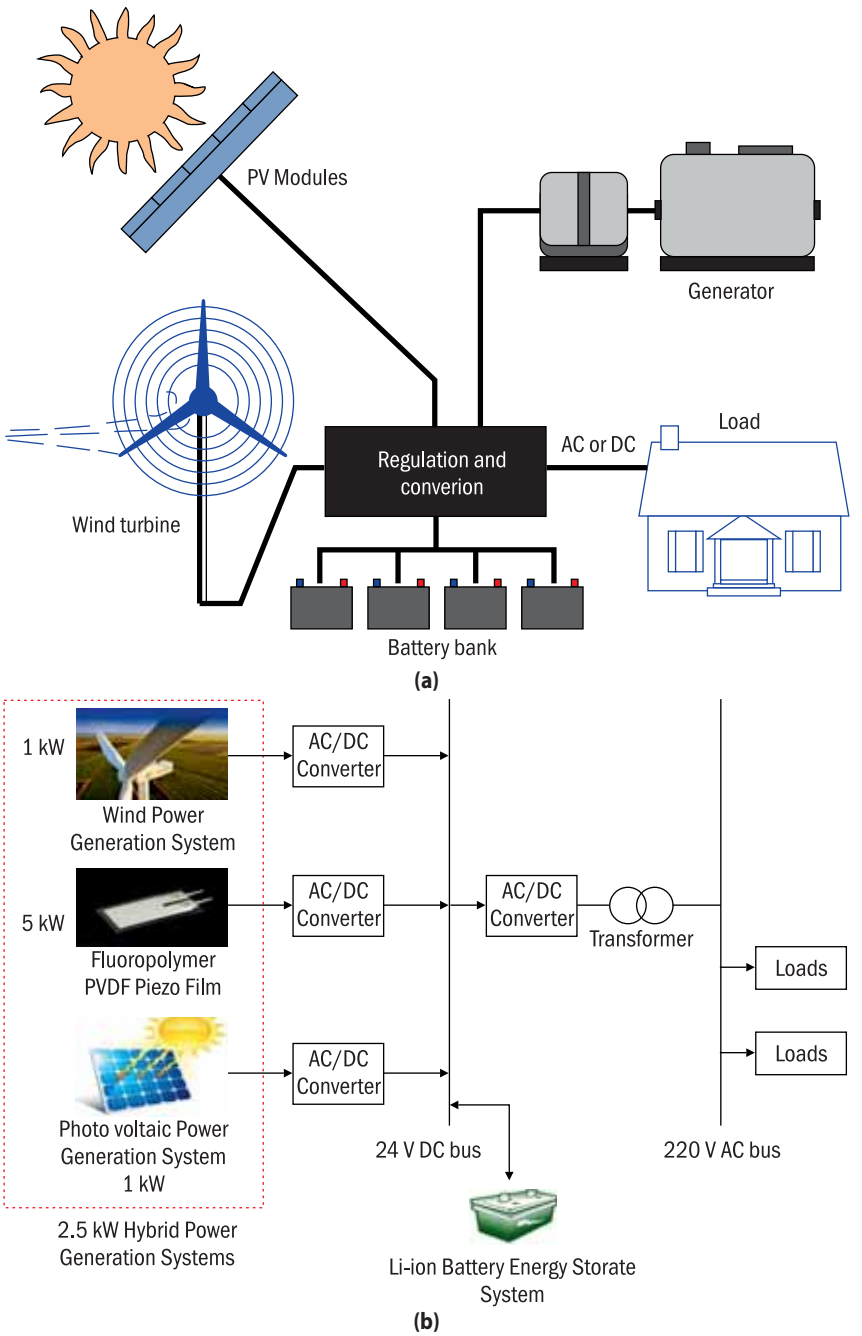
offices, and residential complexes, to generate power by installing their own energy generation equipment and, further, to promote the effectiveness of hybrid power generation systems for making a clean, green city.

System Design

In this work, we have planned to design 2.5 kW hybrid power generation system by combining 1 kW wind power generation system, 0.5 kW piezoelectric crystal-based bladeless wind power generation system, and 1 kW infrared plastic solar cell-based PV power generation system, as shown in Figure 1.

Design of the Wind Power Generation System

A 1 kW induction generator-based fixed speed horizontal axis wind turbine is employed. The schematic diagram of the wind turbine is shown in Figure 2. This induction generator produces 1 kW three-phase unregulated AC at 8 m/s wind speed with a maximum output of 1.3 kW at 11 m/s. The AC is converted to 24 V DC by the charge



S.No	Name of the Equipment	Value
1	Wind power generation system	1 kW
2	Polyvinylidene Fluoride thin film	230 no's
3	Piezoelectric power generation system (Supporting pole + controller + Amplifier + DC/DC controller & controller, etc.)	0.5 kW
4	Plastic solar cell	1 kW
5	Battery	130 Ah 6 no.s
6	DC/AC Inverter + Controller	1
7	Transformer	1

Figure 1 Block diagram of hybrid power generation systems for green buildings

controller to charge a 24 V battery bank. With a proper control of inverter, it is possible to get 220 V from the battery bank to power the domestic appliances or feed back to the grid. The control methodology planned is Elman Neural Network-based pulse width modulation (PWM) controller for controlling the converters. Therefore, overall efficiency can be optimized. This low cost and easy setup system is the most economical solution in reducing carbon footprint. Furthermore, the wind turbine is placed at a height of 20 feet by means of a pole and the pole is placed on the rooftop.

Design of Piezoelectric Crystal Based Wind Power Generation System

The method of harvesting electric energy from mechanical vibration is known as the piezoelectric effect. Further, it can also be defined as the ability of piezoelectric crystals to generate an electric charge in response to applied mechanical stress. Here, the wind energy is set to apply mechanical stress to the piezoelectric crystals. Consequently, the amount of energy obtained using this effect is known as piezoelectricity.

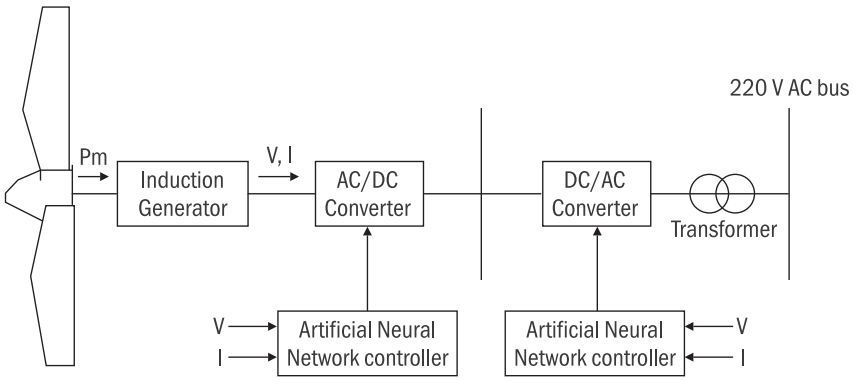


Figure 2 Wind power generation system

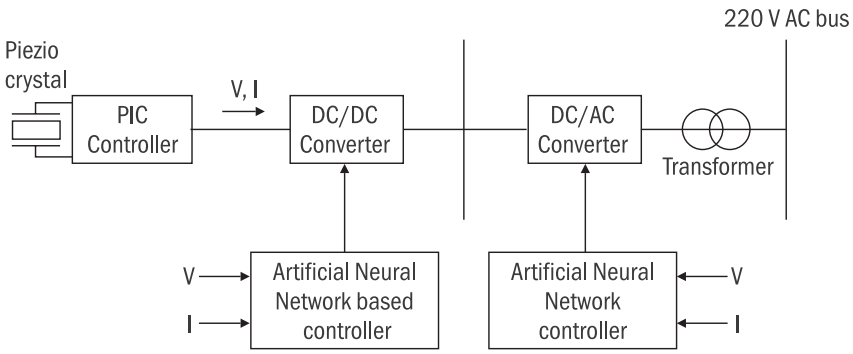


Figure 3 Piezoelectric crystal based bladeless wind power generation system

Fluro-polymer Polyvinylidene Fluoride (PVDF) thin film was planned to be used as the piezo crystal. A peripheral interface controller (PIC) controller was employed to derive power from the piezo crystal. The schematic diagram of Piezo power generation system is shown in Figure 3.

A total of 0.5 kW power was produced, each single piezo can generate 3 V, 0.3 mA. These piezo are set to vibrate by means of wind flow with a speed of 3–4 m/s. The power produced is extracted by PIC controller. The controller uses a current amplifier that amplifies the 0.3 mA to 20 mA which is then fed to DC/DC converter. The DC is boosted to 24 V by the charge controller to charge a 24 V battery bank. With proper control of the inverter, it is possible to get 220 V from the battery bank to power the appliances. The control methodology planned is Elman Neural Network-based PWM controller for controlling the converters.

Design of Plastic Solar Cell Power Generation System

The solar panel is placed on the rooftop of the building. It is designed to produce 1 kW by the means of roof-top PV power generation system. The schematic diagram of the PV system

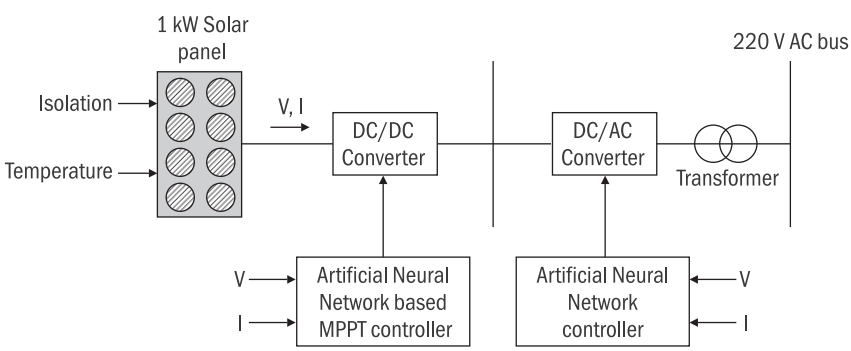


Figure 4 Solar power generation system

is shown in Figure 4. The DC power generated is converted to 24 V DC by the charge controller to charge a 24 V battery bank. With proper control of the inverter, you can get 220 V from the battery bank to power the appliances or feed back to the grid. The control methodology planned is Elman Neural Network-based MPPT controller and Elman Neural Network-based PWM controller for controlling the converters. Therefore by means of adaptive controlling, conversion losses can be

IN GENERAL, INFRARED PLASTIC SOLAR CELL IS THE NEXUS OF NANOTECHNOLOGY AND MATERIAL SCIENCE, WHICH PLAYS A VITAL ROLE IN HARNESSING ENERGY FROM THE INFRARED ENERGY BAND OF THE SUN RAYS. THEY ARE MORE EFFECTIVE WHEN COMPARED TO THE CONVENTIONAL SOLAR CELL.

reduced and overall efficiency can be improved for both ongrid and offgrid system.

World's First Integrated Hybrid Technology

The SolarMill Hybrid Energy System, from Windstream, integrates solar panels and vertical axis wind turbines into modular units that can be installed on rooftops or other appropriate locations, promising to be an easy-to-install 'highly efficient, low-cost, renewable energy hybrid device for any environment.'

The company supplied 50 of their SolarMill modules to what was billed as 'the world's largest hybrid renewable energy project' on the roof of a building in Kingston, Jamaica. The installation, which is on the roof of a law firm, is expected to generate 106,000 kWh of renewable energy per year (25 kW from wind and 55 kW from solar) and to pay for itself in just four years. This hybrid energy installation is expected to deliver over $2 million in energy cost savings to the owners over its expected 25 years lifespan.

BY USING THE PROPOSED HYBRID POWER GENERATION SYSTEM, IT WOULD BE POSSIBLE TO GENERATE POWER IN ALL ENVIRONMENTAL CONDITIONS AND IS MOST SUITABLE AND ECONOMICAL WAY OF CREATING A MICRO GRID POWER SUPPLY FOR RURAL AREAS, SCHOOLS, COLLEGES, AS WELL AS FOR RESIDENTIAL USERS, WHICH IS THE NEED OF THE HOUR.

Future Scope

In general, ongrid system has 98% efficiency and the offgrid system has only 60% to 65% efficiency due to conversion losses. There are two main methodologies (i) Neural Network-based PWM controller for DC to DC converter, through which optimal power can be extracted. (ii) Neural network-based PWM controller for DC to AC converter in order to rationalize the converter efficiency and reduce switching losses. By using above steps in near future, it will enable improvement in the performance efficiency of overall system during offgrid operation and reduce dependency on other sources. For the times when neither the wind nor the solar system is producing, hybrid systems provide power through batteries. EF

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A Necessary Switch

India's Only Women's Mosque Goes Completely Solar

In an exemplary initiative to reduce air pollution, the Ambar Mosque in Lucknow confirms how gender and environment are closely knit and how positive an impact on each has on the other. Acknowledging the adverse effects of climate change on society, Shaista Ambar spearheads a one-of-a-kind switch to solar power and achieves the dual purpose of preserving the environment while situating women at the centre of sustainable energy solutions. In this article, **Sapna Gopal** talks about how this revolutionary move that combats the formidable environmental crises as well as demonstrates how clean energy is fed back into the grid so as to contribute to the country's energy target.

For a country blessed with abundant solar power, India, to its credit, has had many notable firsts in the solar power sector. First, it was the airport in Kochi that made headlines in 2015, for being the first in the world to adopt solar, followed by the inauguration of the 648 MW solar project at Kamuthi, Tamil Nadu (the largest in the world) in September 2016. In February 2017, a woman's mosque switching to solar is likely to be an exemplary instance for others to follow.

The move could not have come at a better time, since the Ambar Mosque in Lucknow, Uttar Pradesh, the only women's mosque in the country, established in February 1997 by Shaista Ambar in defiance against patriarchy, also commemorated its twentieth anniversary this year.

On what prompted the decision, Shaista Ambar said in a public message, "Over the last few years, air quality in the city has worsened and rural areas of Uttar Pradesh have been suffering from frequent power cuts. We all are to

be blamed for it and we must all do our bit to improve the air quality and access to electricity. Electricity produced from solar energy does not cause air pollution like coal power plants do. If everyone starts using solar energy, Lucknow's air quality will start to improve and reduce power cuts."

Adding further, Dr Seema Javed, an independent journalist and communications expert, told *Energy Future* that she has known Shaista as a social activist for a long time. "She does a lot of community service, such as encouraging women activists and honouring them on Women's Day. Moreover, she provides shelter at the mosque to those who come for treatment at the Sanjay Gandhi Post Graduate Institute of Medical Sciences. Most of them are not only from Lucknow but also from Rae Bareli, Allahabad, Varanasi, Sultanpur, and suffering from chronic illnesses. Since they cannot afford to stay in a guest house or hotel, she provides them accommodation free of cost."

It was during one of their conversations that Dr Seema told Shaista how the mosque consumes energy, which comes from burning coal and in turn causes air pollution. Also, since the negative health impacts it has on others, she advised her to use an energy source that does not pollute. "This prompted her to think and she asked me to help her find the right solution and experts

to implement this. I went back to my team and asked them to connect her with the right people who can solve this issue. That's how we got her in touch with 8minutes, a company which helps homes and businesses reduce their energy spending by installing solar on their rooftop."

By switching to solar, the mosque saves ₹6,998 or more than 70% of its annual electricity expenditure. Moreover, it will offset 1 MT of carbon dioxide every year, the equivalent to driving a car for 3,810 km, to 965 kg of coal being burnt and carbon stored by 26 tree seedlings for 10 years, Arjun Aditya SriHari, Head, Marketing and Strategic Alliances, 8minutes, told *Energy Future*. Sized 1 kW (with four panels of 250 Wp and a 1 kW solar inverter), the estimated annual production of the plant is 1,400 units per annum and this accounts for 75% of the mosque's energy consumption.

How it Works

The grid-synchronized or ongrid rooftop solar system installed by 8minutes for the Ambar Masjid is a 1 kW system. Since it is an ongrid system, there was no need to install batteries. The solar system and the connection with the distribution company (DISCOM) run parallel, wherein solar is the primary source. If solar can manage 100% of the load, there is no need for grid electricity, but should solar do less than 100%, then the differential comes from the grid or DISCOM. This is the work of the smart solar inverter that converts DC current into AC current but more importantly, it prioritizes how power is pulled as outlined earlier. Any excess energy that is produced via solar (that is when production from solar exceeds consumption), is fed back to the grid and the consumer is given solar credits, which are directly adjusted against the units used from the DISCOM in the month's electricity bill. It is a smooth and hassle-free process, explains Arjun Aditya.

Even though the aim was to make the mosque 100% solar, since the sanctioned load of the mosque is only 1 kW, we were limited by the regulation that states one cannot exceed sanctioned load or contracted demand. However, the mosque plans to build another building and will apply for an increase on its meter then," he adds.

Dr Seema believes this initiative by Ambar Mosque is socially and environmentally progressive. "Moreover,

not only will solar energy power the mosque, it will also be able to make a small contribution towards Lucknow's electricity supply."

Clean Energy Gets a Thumbs Up

Contrary to general perception, there is a heightened awareness among the populace in Lucknow on clean energy and how pollution can be tackled. This came to the fore following a telephonic survey conducted by FourthLion Technologies, a provider of public opinion polling, and *IndiaSpend*.

The survey reported that 87% of voters in Uttar Pradesh would opt for solar energy if it helps improve air quality and reduce pollution. Almost 94% said they would use buses or other public transport if better amenities were available. It also revealed that power cuts remain the single biggest problem concerning both urban and rural voters. While 38% of UP voters face power cuts every day, 54% voters face power cuts every week, including 58% women, 59% rural voters, and 61% Dalits.

"Eighty-seven per cent of our sample of registered voters in UP said they would use solar energy if it helped reduce pollution. That is good news not only for climate campaigners and organizations, but it also demonstrates a healthy appetite for more solar power projects," Samar Halarnkar, Editor, *IndiaSpend*, was quoted saying.

Furthermore, a report prepared by Equitorials, a financial analysis firm, highlights that UP has a target of installing 1.8 GW of solar power by March 2017. In comparison, the state has added 239 MW capacity—a mere 13.1% of the target. While there is 271 MW of additional solar power capacity that is expected to come on stream over January 2017 to March 2017. Even with that capacity addition, the overall installed capacity would only reach 510 MW, which is about 28% of the target.

"UP is also one of the states that are expected to be power deficit in 2016/17 by the Central Electricity Authority. There is a clear need to significantly increase the rate of solar power capacity addition for the state to meet its power requirements, as well as the renewable power capacity targets" as was mentioned by Jai Sharda, Managing Partner, Equitorials.

Of the overall target, ground-mounted solar capacity target for March 2017 is 1,290 MW. Tables 1 and

Table 1 State-wise progress in installed ground-mounted solar capacity

State	Target till March 2017	Capacity Expected till March 2017	Target Achievement
Andhra Pradesh	600.0	965.2	161%
Bihar	300.0	95.0	32%
Chhattisgarh	210.0	111.8	53%
Delhi	330.0	6.8	2%
Gujarat	960.0	1,147.8	120%
Haryana	480.0	18.3	4%
Himachal Pradesh	96.0	0.3	0%
J&K	135.0	0.0	0%
Jharkhand	240.0	12.5	5%
Karnataka	690.0	633.6	92%
Kerala	240.0	14.9	6%
Madhya Pradesh	660.0	1,135.4	172%
Maharashtra	1,410.0	380.5	27%
Odisha	300.0	75.6	25%
Punjab	600.0	1,006.4	168%
Rajasthan	690.0	1,301.6	189%
Tamil Nadu	1,050.0	1,504.0	143%
Telangana	600.0	949.4	158%
Uttar Pradesh	1,290.0	410.3	32%
West Bengal	630.0	0.1	0%
Others/MoR/PSU	384.0	79.1	
Total	12,000.0	9,902.4	83%

Source: Ministry of New and Renewable Energy, Government of India

Table 2 State-wise progress in installed rooftop solar capacity

State	Installed Rooftop Solar Target by March 2017	Capacity Expected till March 2017	Target Achievement
Andhra Pradesh	250.0	39.5	16%
Bihar	125.0	0.9	1%
Chhattisgarh	87.5	34.4	39%
Delhi	137.5	92.0	67%
Gujarat	400.0	61.8	15%
Haryana	200.0	75.0	38%
Himachal Pradesh	40.0	10.0	25%
J&K	56.3	7.0	12%
Jharkhand	100.0	55.0	55%
Karnataka	287.5	10.9	4%
Kerala	100.0	15.0	15%
Madhya Pradesh	275.0	115.0	42%
Maharashtra	587.5	100.0	17%
Odisha	125.0	4.0	3%
Punjab	250.0	69.0	28%
Rajasthan	287.5	31.0	11%
Tamil Nadu	437.5	312.0	71%
Telangana	250.0	74.0	30%
Uttar Pradesh	537.5	100.0	19%
Uttarakhand	43.8	51.0	117%
West Bengal	262.5	30.0	11%
Others/MoR/PSU	160.0	200.0	
Total	5000	1487.5	30%

Source: Ministry of New and Renewable Energy, Government of India

2 show ground-mounted and rooftop solar capacities of different states in the country. Of that UP is expected to install only 410 MW of capacity. The problem is even more acute in the rooftop solar domain. Of the 538 MW target, UP is expected to commission only 100 MW by March 2017, thereby missing its target by over 80%.

On her part, Shaista is positive that the momentum to install solar will gather steam. "Communities in Lucknow

BY SWITCHING TO SOLAR, THE MOSQUE SAVES ₹6,998 OR MORE THAN 70% OF ITS ANNUAL ELECTRICITY EXPENDITURE.

have begun taking action to address the issue of air pollution and power cuts. Leaders from various faiths such as Diviya Giri Mahant of Mankameshwar Mandir and Rajinder Singh Bagga, president of Gurudwara, Pastor David and Buddhist priest Bhante Pragya Nandfrom have [come together] for talking up renewable energy to help save the environment."

Combating Pollution with Renewable Energy

Dr Seema is of the opinion that the battle against air pollution and climate change requires participation from all sides and should not just be the government's responsibility. "Religious leaders, educational institutions, residential co-operatives, private business, all need to do their bit to improve our environment and in that regard, the initiative by Ambar Mosque is a step in the right direction."

Increasing carbon emissions and dust has become a major health hazard for India. In fact, some of the cities in India have been dealing with air pollution throughout the year. While last winter it was vehicle emissions that contributed to Delhi's air pollution problem, this year it was crop burning.

There have been studies that reveal that a mix of vehicular emission, dust, crop burning, industrial activities, and coal-fired thermal power plants contribute to the air pollution problem in northern India. While there have been measures to reduce vehicular emissions through the odd–even scheme and stopping the burning of crops, nothing has been done to restrict emission from coal-fired power plants. The emission-control regulation for the existing and new coal-fired thermal power plants announced in 2016 has still not been planned or implemented, states Dr Seema.

In such a scenario, increasing the focus on renewable energy for domestic usage and encouraging rooftop solar can have significant contribution in reducing the dependence on coal-fired thermal plants. This will also help reduce carbon emission and improve the quality of air, she adds.

On April 10, 2017, the Minister of State for Power, Coal, New and Renewable Energy and Mines, Shri Piyush Goyal said in Rajya Sabha that India has plans to add 5,000 MW of rooftop solar and 10,000 MW from large-scale solar power projects in the current fiscal. This move is sure to bolster the industry to newer heights. EF

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WINDERGY INDIA 2017

The first-of-its kind event for and by the wind industry witnessed the participation of the industry experts

The Indian Wind Turbines Manufacturers Association (IWTMA) in association with Global Wind Energy Council (GWEC) hosted Windergy India, the largest annual conference and exhibition on Wind Energy in India, on April 25–27, 2017, in The Ashok, New Delhi. The two-day international conference and three-day international exhibition witnessed the enthusiastic participation of the leaders from the wind industry. Created by the industry and for the industry, Windergy India brought together key government authorities, international and national wind energy players, service providers,

cutting-edge innovators, financial entities, and other stakeholders on a single platform.

The first-of-its kind exhibition observed an active presence of over 150 exhibitors representing over 10 countries. The exhibition showcased the phenomenal prospects available in the wind energy sector. Many eminent personalities came together to contribute and make the first edition of Windergy India a remarkable platform for the wind industry. The event was graced by game-changing personalities, such as Mr Sumant Sinha, Chairman & CEO-ReNew Power; Mr Tulsi R Tanti, CMD, Suzlon Group; Mr Ramesh Kymal, CMD, Gamesa Renewables Pvt. Ltd; Mr Madhusudan Khemka, MD, ReGen PowerTech Pvt. Ltd; Mr Sarvesh Kumar, President & COO, RRB Energy Limited & Chairman, IWTMA; Mr Chintan Shah, President SBU, Suzlon Group & Vice Chairman, IWTMA; and Mr Steve Sawyer, the GWEC Secretary General.

The exhibition displayed the latest products and services by the leaders of the wind industry across the globe. Latest technological advancements in the sector were also demonstrated at the exhibition. It provided global networking and business opportunities as well as facilitated partnerships and investments through meetings between government officials and industry.

During the event, 'Indian Wind Energy Outlook' was released jointly by IWTMA and GWEC and the Global Wind Energy Outlook by GWEC. The release coincided with the inaugural of the conference.

The marquee event provided a platform for experts to exchange views and best practices to help grow the sector. During the conference, experts and delegates from across the country and the world presented their thoughts on a wide range of topics, such as policy, technology and emerging models, with accent on networking participation, panel discussion to get total support

of central and state governments, and participation of non-Wind States in their Wind Power Portfolio obligation.

Over 800 delegates from different parts of the world and within the country participated. Some of the important takeaways from the sessions were the as follows:

» Wind energy has a significant portfolio of 32 GW and can reach a target of 60 GW by 2022. This target can only be achieved with successful grid integration of wind power.
» In sync with the 'Make in India' initiative, manufacturing locally has reduced the costs by nearly 75% to 90%.
» Indian wind energy goods are accepted worldwide. With low project cost and support provided by the Department of Commerce, Indian wind industry can look at export options.

The session "Indian Power Horizon Enriched by Wind" discussed how wind power has proven to be scalable and cost-effective source for power generation as well as its rightful place in the overall power mix. The regulatory challenges, such as renewable purchase obligation (RPO) and the other is procurement tariff and methodology, was the theme of the session called "Regulatory Round-Up and Legal Landscape—What Needs to Change?"

The event came to an end with Valedictory session, for which Mr Sarvesh Kumar delivered the welcome address. He thanked the participants saying "We are overwhelmed with the response that we have received for Windergy India 2017. All the key players from the wind industry participated in the mega event. We look forward to welcoming Windergy India in its next edition." Shri Suresh Prabhu, Hon'ble Minister for Railways and Chief Guest for this session said, "It has been a great journey for wind energy industry in the country, achieving milestones over the past few decades. Wind is one of the major drivers that catered a lot in the industry while benefitting people immensely by creating multiple job opportunities, is Make in India, a vision and mission set by the Hon'ble Prime Minister, Shri Narendra Modi. I know the industry has been facing many issues as well as challenges, such as evacuation, opportunities for exports, and mainstreaming of wind. Indian Railways would like to contribute towards renewable power in every aspect. In this context, the Railways Ministry has chalked out a macro and a micro plan envisaging majority of power contribution coming from the wind sector." He further appealed the leaders of the wind sector to come forward and support the sector to fulfil the micro and macro objectives.

Dr Ajay Mathur, DG, TERI; and Chairman, Organizing Committee, Windergy India 2017, summed up the event saying "Events like these take the wind sector of the country a notch higher. I am happy to be a part of such an event."

Domain experts from premier research institutions, such as National Institute of Wind Energy, TERI, and the IITs, also participated at Windergy India 2017. EF

LVRT to "Help Make the World Safer, Smarter, and Greener"

A concern that has plagued installation and operation of renewable energy assets is their susceptibility towards faults. For stable energy supply through renewable assets, such as wind, innovation is required towards their stability. **Mathias Steck** in a conversation with **Spandana Chatterjee** inform readers about low-voltage ride through testing developed by DNV GL to test wind turbines for stability.

Could you tell us about DNV GL and about your role within DNV GL?

DNV GL is a 150-year-old company that started as a ship testing organization but today it has diversified to maritime oil and gas, energy, business assurances, and software. Through the merger, GL brought renewables generation—onshore wind, offshore wind, and solar—while DNV brought transmission, distribution, and sustainable use of energy and consultation services as well in these industries. It has over 14,000 people in about 100 countries across the world—hundreds around the world which makes it quite big. The energy part, which we are focussing on here, has about 2,500 people. For the energy part in the Asia Pacific region, we have about 150 people of which about 30 are in India.

In 2008, the company sent me to India to start operations in that region. Three years later, I moved to China. I am the Regional Manager for the Asia Pacific region looking at the combined energy parts of DNV GL. My role is to get the operations going. We provide technical advisory to our clients. Our clients are financial institutions, such as banks, developers, owners, governments, turbine manufacturers, utilities, etc.—basically the entire range of stakeholders in a renewables project. I am myself a civil engineer by training and was initially bringing foundations, tower expertise, etc. to India. But now, the team is much bigger and has varied expertise and we are bringing the entire portfolio.

Please tell us about DNV GL's presence in India so far.

Our first job was back in 1996 for the World Bank in renewables. And then, we set up shop with the local staff in 2008. Back then it was a small team of just three people that has now grown to 30 people and is continuing to grow with the market because around 2003 wind energy became a serious topic in India. Up until now, there is 34 GW [installed capacity], and in the next 5 years, its 26 GW. So, we have lot to do.

Could you tell us a bit about low-voltage ride through (LVRT)?

Let me explain LVRT through a story from China in 2010. They had a big generation asset for renewables in the west of the country, and then they had a fault in the grid which can be called a low-voltage fault. What happened is that the voltage levels dropped due to something happening, this could have been a short circuit. Then the problem was that the fleet of operating turbines were not capable of dealing with this low-voltage problem, and they considered this as fault and switch off to protect themselves. Suddenly, gigawatts of generation assets fall off the grid which already had issues. The problem here is that something else caused the fault event but the turbines didn't stay up long enough and the whole thing went down. A similar incident has happened in south Australia as well.

India has understood this and now wants to prevent a similar thing from happening because of the very ambitious installation targets, that is, 60 GW by 2022, which is about doubling the resources that we have here today. What is now required is that somebody has to verify that the turbines have the capability to withstand [voltage problems] and this kind of verification/testing is what we bring to India.

Is LVRT specific to wind energy or can it be applied to other resources as well?

The issue itself is a general issue. But different generators respond differently to such an event happening. The conventional ones are very robust; they just go on producing [energy]. But, the interactions of a wind turbine are different from others, say a nuclear power plant. They are more, I would say, at risk to trip-off because they have much smaller generators. So, you can say LVRT is special to them.

Every wind turbine can meet the LVRT requirement; it just needs to be ensured that it is set up correctly. What happens in this test is that the equipment—of the size of about two 40-feet containers—is connected between the rear grid and the wind turbine and then we simulate the grid faults through the turbine according to the Indian grid code. The Indian Grid Code—which is a new thing—is now requesting that turbines need to be able to handle these units and they give the scenarios that the turbines need to be able to handle. So, we will simulate the scenario (and I mean physically simulate) and then we will measure how the turbine responds. In this process, the manufacturer also has the opportunity or the possibility of updating his turbine. This gives him the ability to tweak his product, which in turn is better for the Indian grid.

Is LVRT functional with mini grids or independent grids that cater to small areas?

Yes it is important because it ensures that no blackouts happen and power doesn't get cut-off. LVRT itself doesn't generate any power; what it does is that it ensures that generators stay online. It can provide stability, especially if the grids are smaller.

What are the challenges that LVRT faces?

From our side, there are no challenges as such as this is a very established test. From our potential competitors side, it's not the easiest thing to do. We designed,

build, and operate these ourselves; so there is a lot of experience we collected over more than a decade. So from competitors' point of view, there is a challenge to get into this.

Also, this is a bit of a seasonal business which makes it hard for people who are not already into it to invest in this. Now there is a huge gap in India because they want new turbines and grid-connected turbines to be tested. And, this will go on for the next few years and then will flatten out again. So, for us it is good because we have an international fleet. We just bring our containers here and train the local team and get into this.

Operationally, the challenges we face are with the infrastructure as it takes much longer than anticipated to get these containers to reach their respective destinations.

How does LVRT help to address DNV GL's mission statement, that is, help customers make the world safer, smarter, and greener?

Safe, as I explained, because it makes the grid safer. Greener as it allows renewable energy to be deployed in big numbers. India plans to do this and will probably have to do this to meet the targets of CoP21. LVRT alone doesn't make anything smarter. But to have smart grids, and with heavy penetration of renewables needs, these assets to be able to interact intelligently with the grid and support it. This is the first step: first we need to make sure that the assets stay connected and do not harm anything and then we can go forward.

This is one piece of the puzzle needed to get to the big picture. But it doesn't solve every problem. EF

CURRENT R&D SOLAR

A Modified Impulse-Response Representation of the Global Near-Surface Air Temperature and Atmospheric Concentration Response to Carbon Dioxide Emissions

Atmospheric Chemistry and Physics, Volume 17, 2017, Pages 7213–7228

R J Millar, Z R Nicholls, P Friedlingstein, M R Allen

Projections of the response to anthropogenic emission scenarios, evaluation of some greenhouse gas metrics, and estimates of the social cost of carbon often require a simple model that links emissions of carbon dioxide (CO_2) to atmospheric concentrations and global temperature changes. An essential requirement of such a model is to reproduce typical global surface temperature and atmospheric CO_2 responses displayed by more complex Earth system models (ESMs) under a range of emission scenarios, as well as ability to sample the range of ESM response in a transparent, accessible, and reproducible form. Here, the simple model of the Intergovernmental Panel on Climate Change 5th Assessment Report (IPCC AR5) to explicitly represent the state dependence of the CO_2 airborne fraction is adapted. The adapted model (FAIR) reproduces the range of behaviour shown in full and intermediate complexity ESMs under several idealized carbon pulse and exponential concentration increase experiments. The study finds that the inclusion of a linear increase in 100-year integrated airborne fraction with cumulative carbon uptake and global temperature change substantially improves the representation of the response of the climate system to CO_2 on a range of timescales and under a range of experimental designs. EF

Production of Syngas from Biomass Using a Downdraft Gasifier

International Journal of Engineering Research and Applications, Volume 7, Issue 6 (Part 2), June 2017, Pages 61–71

Hassan Golpour, Teja Boravelli, Joseph D Smith, Hamid R Safarpour

The role of biomass in energy and fuel production as an alternative to fossil fuel is vitally important considering carbon dioxide production versus secure energy. Sustainable, renewable and reliable resources of domestically produced biomass together with wind and solar energy are sensible options to support small-scale power generation to meet local electricity demand plus provide heat for rural development. The present work focuses on (1) Design, build, and operate a vertical downdraft biomass gasifier with tar removal; (2) Establishing the optimum operating methodology and parameters to maximize syngas production in biomass gasification through process testing. The one ton per day biomass gasification process unit designed in this work included a downdraft biomass thermochemical conversion gasifier, gas transportation line with tar removal, and an enclosed combustion chamber. The reactor used internal heat transfer surfaces to enhance intra-bed heat and mass transfer inside the reactor. Three different woody biomass feedstock including pellets, picks, and flakes were examined in this work. Specific results described in this paper include identifying and characterizing the key operating factors (i.e., temperature profile, feed stock carbon/hydrogen mass ratio, and air flow rate) required to optimize reactor yield. To achieve the maximum syngas production yield, experiments carried out using classical experimental design methodology. EF

Mainstreaming Ecosystem Services Based Climate Change Adaptation (EbA) in Bangladesh: Status, Challenges and Opportunities

Sustainability, Volume 9, Issue 6, 2017,
Nazmul Huq, Antje Bruns, Lars Ribbe, and Saleemul Huq

The paper aims to analyse the extent of Ecosystem Service (ESS) based Adaptation (EbA) to climate change in the policy-making process of Bangladesh. The paper is based on a three stage hybrid policy-making cycle: (i) agenda setting; (ii) policy formulation; and (iii) policy implementation stage, where the contributions of EbA can horizontally (on the ground) or vertically (strategic stage) be mainstreamed and integrated. A total of nine national and sectoral development and climate change policies, and 329 climate change adaptation projects are examined belonging to different policy-making stages. The major findings include that the role of ESS is marginally considered as an adaptation component in most of the reviewed policies, especially at the top strategic level (vertical mainstreaming). However, at the policy formulation and implementation stage (horizontal mainstreaming), they are largely ignored and priority is given to structural adaptation policies and projects, for example, large-scale concrete dams and embankments. For example, ESS's roles to adapt sectors, such as urban planning, biodiversity management, and disaster risk reduction, are left unchecked, and the implementation stage receives overwhelming priorities and investments to undertake hard adaptation measures such that only 38 projects are related to EbA. The paper argues that (i) dominant structural adaptation ideologies; (ii) expert- and bureaucracy-dependent policy-making process; and (iii) lack of adaptive and integration capacities at institutional level are considerably offsetting the EbA mainstreaming process that need to be adequately addressed for climate change adaptation EF

Efficiency of Livestock Residue Treatment in Geomembrane Digesters

Agrisost, Volume 22, Issue 3, 2016, 51–59
Yanet Pérez González, Milagros C. Mata Varela

The efficiency of twelve 10 m^3 geomembrane biodigesters to treat swine and cattle residuals was assessed. The study took place at the Cooperative of Credits and Services (CCS) of the Municipality of Cumanayagua, Cienfuegos, Cuba. Its goal was to evaluate feasibility of technology implementation in Cuba. The effluent physical and chemical indicators were determined at entry and exit from biodigesters. The biodigesters charged with pig manure were able to remove 75.88% COD and up to 66–44% SS. Besides, 64.79% of the contaminating organic load was converted into volatile products during biofermentation. Meanwhile, the biodigesters charged with cattle manure removed 60.42% of COD and up to 67.67% of SS; 61.51% of the organic contaminating load was converted in volatile products. It was concluded that the biodigesters had acceptable efficiency values, and that the technology can be applied in Cuba. EF

Environmental Sustainability of Agriculture Stressed by Changing Extremes of Drought and Excess Moisture: A Conceptual Review

Sustainability, Volume 9, Issue 6, 2017
Elaine Wheaton, Suren Kulshreshtha

As the climate changes, the effects of agriculture on the environment may change. In the future, an increasing frequency of climate extremes, such as droughts, heat waves, and excess moisture, is expected. Past research on the interaction between environment and resources has focussed on climate change effects on various sectors, including agricultural production (especially crop production), but research on the effects of climate change using agri-environmental indicators (AEI) of environmental sustainability of agriculture is limited. The aim of this paper was to begin to address this knowledge gap by exploring the effects of future drought and excess moisture on environmental sustainability of agriculture. Methods included the use of a conceptual framework, literature reviews, and an examination of the climate sensitivities of the AEI models. The AEIs assessed were those for the themes of soil and water quality, and farmland management as developed by Agriculture and Agri-Food Canada. Additional indicators included one for desertification and another for water supply and demand. The study area was the agricultural region of the Canadian Prairie Provinces. We found that the performance of several indicators would likely decrease in a warming climate with more extremes. These indicators with declining performances included risks for soil erosion, soil salinization, desertification, water quality and quantity, and soil contamination. Preliminary trends of other indicators, such as farmland management, were not clear. AEIs are important tools for measuring climate impacts on the environmental sustainability of agriculture. They also

indicate the success of adaptation measures and suggest areas of operational and policy development. Therefore, continued reporting and enhancement of these indicators is recommended. EF

Development of a GIS Tool for High Precision PV Degradation Monitoring and Supervision: Feasibility Analysis in Large and Small PV Plants

Sustainability, Volume 9, Issue 6, 2017
Miguel de Simón-Martín, Ana-María Diez-Suárez, Laura Álvarez-de Prado, Alberto González-Martínez, Álvaro de la Puente-Gil, and Jorge Blanes-Peiró

It is well known that working photovoltaic (PV) plants show several maintenance needs due to wiring and module degradation, mismatches, dust, and PV cell defects, and faults. There are a wide range of theoretical studies as well as some laboratory tests that show how these circumstances may affect the PV production. Thus, it is mandatory to evaluate the whole PV plant performance and, then, its payback time, profitability, and environmental impact or carbon footprint. However, very few studies include a systematic procedure to quantify and supervise the real degradation effects and fault impacts on the field. In this paper, the authors first conducted a brief review of the most frequent PV faults and the degradation that can be found under real conditions of operation of PV plants. Then, they proposed and developed an innovative Geographic Information System application to locate and supervise them. The designed tool was applied to both a large PV plant of 108 kWp and a small PV plant of 9 kWp installed on a home rooftop. For the large PV plant, 24 strings of PV modules were modelized and introduced into the GIS application and every module in the power plant was studied, including voltage, current, power, series and parallel resistances, fill factor, normalized PV curve to standard test conditions, thermography, and visual analysis. For the small PV installation, three strings of PV panels were studied identically. It must be noted that PV modules in this case included power optimizers. The precision of the study enabled the researchers to locate and supervise up to a third part of every PV cell in the system, which can be adequately geo-referenced. The developed tool allows both the researchers and the investors to increase control of the PV plant performance, to lead to better planning of maintenance actuations, and to evaluate several PV module replacement strategies in a preventive maintenance programme. The PV faults found include hot spots, snail tracks, ethylene vinyl acetate discoloration, PV cell fractures, busbar discoloration, bubbles, and Si discoloration.

Sustainable Land-Use Planning to Improve the Coastal Resilience of the Social-Ecological Landscape

Sustainability, Volume 9, Issue 7 2017
Min Kim, Soojin You, Jinhyung Chon, and Junga Lee

The dynamics of land-use transitions decrease the coastal resilience of the social–ecological landscape (SEL), particularly in light of the fact that it is necessary to analyse the causal relationship between the two systems because operations of the social system and the ecological system are correlated. The purpose of this study is to analyse the dynamics of the coastal SEL and create a sustainable land-use planning (SLUP) strategy to enhance coastal resilience. The selected study site was Shindu-ri, South Korea, where land-use transitions are increasing and coastal resilience is, therefore, decreasing. Systems thinking was used to analyse the study which was performed in four steps. First, the issues affecting the coastal area in Shindu-ri were defined as coastal landscape management, the agricultural structure, and the tourism industry structure. Second, the main variables for each issue were defined, and causal relationships between the main variables were created. Third, a holistic, causal-loop diagram was built based on both dynamic thinking and causal thinking. Fourth, five land uses, including those of the coastal forest, the coastal grassland, the coastal dune, the agricultural area, and developed sites, were selected as leverage points for developing SLUP strategies to increase coastal resilience. The results show that 'decrease in the size of the coastal forest', 'decrease in the size of the coastal dune', and 'increase in the size of the coastal grasslands' were considered parts of a land-use plan to enhance the resilience of the Shindu-ri SEL. This study developed integrated coastal land-use planning strategies that may provide effective solutions for complex and dynamic issues in the coastal SEL. Additionally, the results may be utilized as basic data to build and implement coastal land-use planning strategies. EF

SOLAR-POWERED AUTO RICKSHAW

Environment-Friendly Transportation Option

A substantial part of carbon dioxide emissions to the environment comes from the transport sector. In order to reduce carbon emissions from vehicles, electric vehicles are being promoted. However, the electricity needed for recharging these automobiles mostly comes from fossil fuels. An important innovation in this regard is a solar vehicle or solar-powered vehicle. Marine Navaids and Solar Auto Pvt. Ltd is amongst the first companies in India to design, develop, and put into production solar-powered vehicles such as Solar Auto Rickshaws.

Originally, the company was set up in Delhi in 1974 as Asia Navigation Aids. In recent years, the company diversified to developing solar supply system and solar-operated vehicles. To better incorporate their changed profile, a new company was reorganized under the name Marine Navaids and Solar Auto Pvt. Ltd.

High-efficiency solar cells are used in the solar panels used for converting sunshine into electricity. The solar-powered rickshaw is registered for 4 + 1 passengers up to a distance of 125–130 km, on a sunny day which is powered by a single solar panel of 48 V/300W and 48 V/100 AH batteries. The mileage covered by the Solar Powered Vehicle is more than 50% against electric vehicle. With the solar panel, the batteries are charged continuously and it gets automatically cut-off once the batteries are fully charged, which in turn prolongs the life of batteries and reduces replacement cost of the batteries.

Environmental Benefits of Solar Auto Rickshaws

Description of Saving	Quantification of Savings	Units
Solar array output	4,125,000	kWh
CO_2 offsets	1,975	Tonnes of carbon annually
CO_2 offsets	3,950,100	Kilograms of carbon annually eliminated
Cars off the road	513 no.	Cars taken off the road for one year
Gasoline equivalent	1,234,406 no.	Litres of diesel
Tree equivalent	180,921 no.	Trees cleansing the air for one year
Tree planting equivalent	9,919 no.	Trees panted for life of tree
Average homes powered	463 no.	Homes powered for one year
Average light bulbs powered	35,317 no.	Light bulbs powered for one year

Under the standard sunshine, the batteries can be charged in a short period of time, which saves on electricity costs through mains. The carbon emission saved is nearly 2,000 tonnes annually. It is estimated that 10,000 solar auto rickshaws have the capacity to replace over 500 cars, saving 1,234,406 L of diesel annually. This would help the country in its contribution to reduce climate change impacts through mitigation measures.

These vehicles are basically hybrid in nature; there are two sources of power:

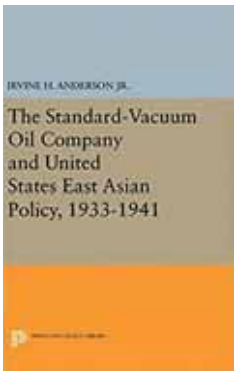
a. The batteries can be charged like any other electric vehicle in case of extreme rain or cloudy weather through grid-supplied electricity.
b. By solar panels that convert sunshine to electricity.

Auto rickshaw provides important connectivity in semi-urban areas providing transportation facility at affordable cost as well last-mile connectivity to mass transit. In transiting from conventional fuel to solar-powered, these would continue to serve the connectivity needs of the public but would substantially reduce environmental impact. EF

Source: http://www.asianavigation.net/

The Standard–Vacuum Oil Company and United States East Asian Policy, 1933–1941 (Princeton Legacy Library)

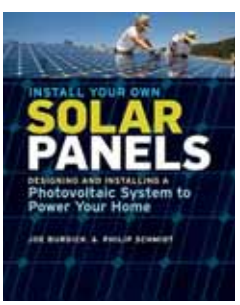
Oil was a basic source of conflict between the United States and Japan. This book examines the role played by the Standard-Vacuum Oil Company in the crisis that led to Pearl Harbor. "Stanvac" was the largest American supplier of oil to Japan and represented the single largest American direct investment in Asia before the war. In the context of Stanvac's relations with various governments, the author examines the ways in which United States petroleum policy was formulated and the arrangements by which Japan sought to increase its oil reserves. He provides new insight into the impact of the financial freeze of July 1941, the origins of the Pacific War, and the complexities of oil diplomacy. Originally published in 1975, the Princeton Legacy Library uses the latest print-on-demand technology to again make available previously out-of-print books from the distinguished backlist of Princeton University Press. These editions preserve the original texts of these important books while presenting them in durable paperback and hardcover editions. The goal of the Princeton Legacy Library is to vastly increase access to the rich scholarly heritage found in the thousands of books published by Princeton University Press since its founding in 1905. EF



Author: Irvine H. Anderson
Publisher: Princeton University Press
Year: 2017

Install Your Own Solar Panels: Designing and Installing a Photovoltaic System to Power Your Home (Kindle Edition)

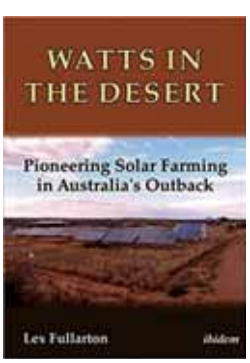
Labour and related costs account for more than half of the price of the average home solar installation. But homeowners can save thousands of dollars with this user-friendly manual, which follows the same process professional contractors use. Through detailed directions and step-by-step photographs, veteran solar installer Joseph Burdick and seasoned builder Philip Schmidt teach you how to determine the size, placement, and type of installation you'll need. This comprehensive DIY guide covers everything from assembling rooftop racking or building a ground-mount structure to setting up the electrical connections and making a battery bank for offgrid systems. EF



Authors: Joseph Burdick, Philip Schmidt
Publisher: Storey Publishing, LLC
Year: 2017

Watts in the Desert—Pioneering Solar Farming in Australia's Outback

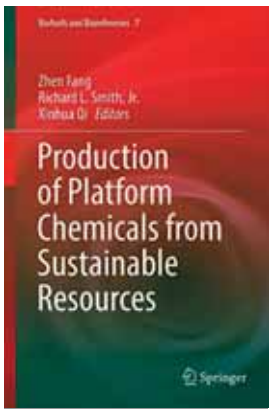
Solar power has taken a journey from what was once considered the lunatic fringe to mainstream society and industry. Looking specifically at the Solex project in Carnarvon, Western Australia, which pioneered the harvest of solar energy, this book offers an introduction to the development of renewable energy and the rise of dispersed, embedded solar energy systems in Australia in the early 2000s. Fullarton shows how a practical demonstration of innovative existing technology can have an incredible impact on a national scale. The ideas behind the Solex project were adopted by the broader community and were eventually taken up enthusiastically by the general population of Australia. Analysing government and utility policies throughout the 2000s, the book traces how ambivalence was followed by wholehearted incentives to the roll-out of alternative energy and then by active opposition to alternative energy in favour of traditional fossil fuel as government philosophies changed. EF



Authors: Lex Fullarton
Publisher: Columbia University Press
Year: 2017

Production of Platform Chemicals from Sustainable Resources (Biofuels and Biorefineries Book 7) (Kindle Edition)

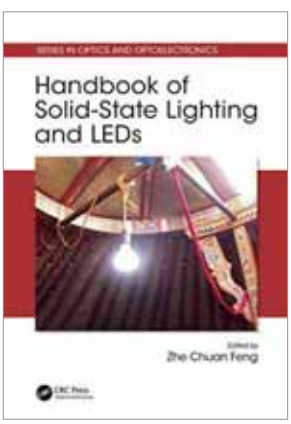
This book provides state-of-the-art reviews, the latest research, prospects, and challenges of production of platform chemicals such as C6 sugars, 5-hydroxymethylfurfural, furfural, gamma-valerolactone, xylitol, 2,5-furandicarboxylic acid, levulinic acid, ethanol, and others from sustainable biomass resources using processes that include heterogeneous catalysis, ionic liquids, hydrothermal/solvothermal, and electrochemical and fermentation methods. It also discusses the application of these chemicals and their derivatives for synthesizing commodity chemicals via various routes. Intended as a reference resource for researchers, academicians, and industrialists in the area of energy, chemical engineering, and biomass conversion, it provides a wealth of information essential for assessing the production and application of various biomass-derived platform chemicals using biological, chemical, and electrochemical techniques. EF



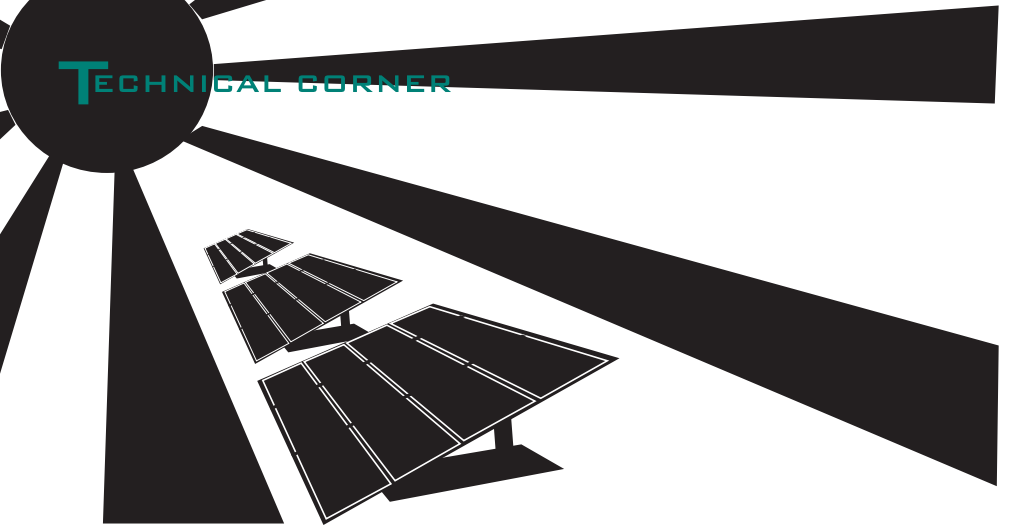
Authors: Zhen Fang, Jr., Richard L. Smith, Xinhua Qi
Publisher: Springer
Year: 2017

Handbook of Solid-State Lighting and LEDs (Series in Optics and Optoelectronics) (Kindle Edition)

This handbook addresses the development of energy-efficient, environment-friendly solid-state light sources, in particular semiconductor light emitting diodes (LEDs) and other solid-state lighting devices. It reflects the vast growth of this field and impacts in diverse industries, from lighting to communications, biotechnology, imaging, and medicine. The chapters include coverage of nanoscale processing, fabrication of LEDs, light diodes, photodetectors and nanodevices, characterization techniques, application, and recent advances. Readers will obtain an understanding of the key properties of solid-state lighting and LED devices, an overview of current technologies, and appreciation for the challenges remaining. The handbook will be useful to material growers and evaluators, device design and processing engineers, newcomers, students, and professionals in the field. EF



Editor: Zhe Chuan Feng
Publisher: CRC Press
Year: 2017



RENEWABLE ENERGY TECHNOLOGY DEVELOPMENT

Biofuel matchmaker: Finding the perfect algae for renewable energy

A dozen glass cylinders containing a potential payload of bright green algae are exposed to hundreds of multi-coloured lights, which provide all of sunlight's natural hues. The tiny LEDs brighten and dim to mimic the outdoors' constantly changing conditions. To further simulate a virtual cloud passing overhead, chillers kick in and nudge the algae a little cooler.

A new, approximately $6 million collaborative project is using this unique climate-simulating laboratory system as part of a new streamlined process to quickly pare down heaps of algae species into just a few that hold the most promise for renewable fuels.

Discovering which algae species is best suited to make biofuel is no small task. Researchers have tried to evaluate algae in test tubes but often find lab results don't always mirror what happens when green goo is grown in outdoor ponds.

The Algae DISCOVR Project—short for Development of Integrated Screening, Cultivar Optimization and Validation Research—is trying out a new approach that could reduce the cost and the time needed to move promising algal strains from the laboratory and into production. At the end of the three-year pilot project, scientists hope to identify four promising strains from at least 30 initial candidates.

The project started this fall and is led by PNNL, out of its Marine Sciences Laboratory in Sequim, Washington. The project team includes three other DOE labs—Los Alamos National Laboratory, National Renewable Energy Laboratory, and Sandia National Laboratories—as well as Arizona State University's Arizona Center for Algae Technology and Innovation.

Step by Step

The project's early work relies on PNNL's Laboratory Environmental Algae Pond Simulator mini-photobioreactors, also known as LEAPS. The system mimics the frequently shifting water temperatures and lighting conditions that occur in outdoor ponds at any given place on earth. The system consists of glass column photobioreactors that act like small ponds and are placed in rows to allow scientists to simultaneously grow multiple different types of algae strains. Each row of LEAPS mini-photobioreactors is exposed to unique temperature and lighting regimens thanks to heaters, chillers, and heat exchangers, as well as coloured lights simulating the sunlight spectrum—all of which can be changed every second.

The first phase of the team's multi-step screening process uses PNNL's photobioreactors to cultivate all 30 strains under consideration and evaluate their growth rates. Algae strains with suitable growth will be studied further to measure their oil, protein, and carbohydrate content, all of which could be used to make biofuels. The algae will also be tested for valuable co-products, such as the food dye phycocyanin, which could make algae biofuel production more cost effective. The first phase will also involve evaluating how resistant strains are to harmful bacteria and predators that can kill algae.

Next, the team will look for strains that produce 20% more biomass, or organic matter used to make biofuel, than two well-studied algae strains. The top-performing strains will then be sorted to find individual cells best suited for biofuel production, such as those that contain more oil. Those strains will also be exposed to various stresses to encourage rapid evolution so they can, for example, survive in the higher temperatures outdoor ponds experience in the summer.

Outside the Box

After passing those tests, the remaining strains will be grown in large outdoor ponds in Arizona. Researchers will examine how algae growth in the outdoor ponds compares with the algal biomass output predicted in earlier steps. Biomass will also be harvested from outdoor-grown algae for future studies.

Finally, the team will further study the final algae strains that fare best outdoors to understand how fast they grow in different lighting and temperature conditions. That data will then be entered into PNNL's Biomass Assessment Tool, which uses detailed data from weather stations and other sources

to identify the best possible locations to grow algae. The tool will crunch numbers to help the team generate maps that illustrate the expected biomass productivity of each algae species grown in outdoor ponds at any location in the US.

Data and strains will be made public in the hope that algae companies and other researchers will consider growing the most productive strains identified by the project.

Potential future work not included in the current project could include converting harvested algae into biofuels; examining operational changes, such as crop rotation to further increase biomass growth; and assessing the technical feasibility and economic costs of making biofuel from algae selected through this process.

https://www.sciencedaily.com/releases/2017/01/170113133049.htm

Renewable energy obtained from wastewater

A team of researchers have devised an efficient way to obtain electrical energy and hydrogen by using a wastewater treatment process. The proposed system uses bacteria, which consumes the organic material and produces electricity, which produces hydrogen, the energetic vector of the future. The results point to further developments of this technology at industrial scale.

Currently, there are treatments in which wastewater can flow out to the river or sea without causing any environmental problems. These technologies however entail high energy costs, mainly in aeration and pumping, and an elevated economic cost in treating the sludge left over from the treatment process.

Wastewater contains an elevated amount of chemical energy in the form of organic contaminants. In order to make use of this energy, researchers from around the world study ways to recover it in the form of hydrogen, a process which efficiently eliminates organic matter from wastewater. It not only reduces the amount of energy needed during the process, it also obtains energy from the produced hydrogen. The key to achieve this is known as microbial electrolysis cells (MEC). It requires a very special type of bacteria known as exoelectrogenic bacteria, capable of oxidizing organic material and generating electricity which in turn produces hydrogen. These cells only need a bit of added voltage, much less than what is used for water electrolysis, which is recovered with the hydrogen, thereby generating clean energy.

The team of researchers have improved the energetic efficiency of the cells. The experimental results were very positive and demonstrated that these systems would have a market niche at industrial scale.

» The scientists used real wastewater instead of the biodegradable synthetic water used in most experiments and achieved a biological production of hydrogen and, to a large extent, the recovery of a good part of the energy contained in the residues.
» To achieve this, researchers selected a set of bacteria capable of transforming complex substrates, such as methanol, dairy waste, starch, and glycerol, into simpler compounds which could, in turn, be degraded by exoelectrogens.

The results were very positive and high hydrogen production and energy intensity was obtained through the wastewater treatment. In the long term, the MEC fed with dairy wastewater yielded the best results in terms of current intensity (150 Amps per cubic metre of reactor), in hydrogen production (0.94 cubic metres of hydrogen per cubic metre of reactor and day), and in recovery of electrons at the cathode (91%); all that with an applied voltage of only 0.8 V. These results are the basis for a potential industrial development of this technology and therefore for the creation of systems capable of producing hydrogen from wastewater treatment.

https://www.sciencedaily.com/releases/2015/02/150224083114.htm

Fish 'bio-waste' converted to piezoelectric energy harvesters

Large quantities of fish are consumed in India on a daily basis, which generates a huge amount of fish 'bio-waste' materials. In an attempt to do something positive with this bio-waste, a team of researchers at Jadavpur University in Kolkata, India, explored recycling the fish by-products into an energy harvester for self-powered electronics.

The basic premise behind the researchers' work is simple: Fish scales contain collagen fibres that possess a piezoelectric property, which means that an electric charge is generated in response to applying a mechanical stress.

» To do this, the researchers first "collected bio-waste in the form of hard, raw fish scales from a fish processing market, and then used a demineralization process to make them transparent and flexible. The collagens within the processed fish scales serve as an active piezoelectric element.
» According to one of the researchers, they were able to make a bio-piezoelectric Nano-generator or energy harvester—with electrodes on both sides, and then laminated it. While it's well known that a single collagen nanofibre exhibits piezoelectricity, until now no one had attempted to focus on hierarchically organizing the collagen nano-fibrils within the natural fish scales.
» They wanted to explore what happens to the piezoelectric yield when a bunch of collagen Nano-fibrils are

hierarchically well aligned and self-assembled in the fish scales and they discovered that the piezoelectricity of the fish scale collagen is quite large (~5 pC/N), which they were able to confirm via direct measurement.

Beyond that, the polarization-electric field hysteresis loop and resulting strain-electric field hysteresis loop—proof of a converse piezoelectric effect—caused by the 'nonlinear' electrostriction effect backed up their findings.

» The team's work is the first known demonstration of the direct piezoelectric effect of fish scales from electricity generated by a bio-piezoelectric Nano-generator under mechanical stimuli—without the need for any post-electrical poling treatments.

To explore the fish scale collagen's self-alignment phenomena, the researchers used near-edge X-ray absorption fine-structure spectroscopy, measured at the Raja Ramanna Centre for Advanced Technology in Indore, India.

Experimental and theoretical tests helped them clarify the energy scavenging performance of the bio-piezoelectric Nano-generator. It's capable of scavenging several types of ambient mechanical energies—including body movements, machine and sound vibrations, and wind flow. Even repeatedly touching the bio-piezoelectric Nano-generator with a finger can turn on more than 50 blue LEDs.

The group's work could potentially be for use in transparent electronics, biocompatible and biodegradable electronics, edible electronics, self-powered implantable medical devices, surgeries, e-healthcare monitoring, as well as *in vitro* and *in vivo* diagnostics, apart from its myriad uses for portable electronics.

https://publishing.aip.org/publishing/journal-highlights/fish-biowaste-converted-piezoelectric-energy-harvesters

Storing solar power increases energy consumption and emissions

Homes with solar panels do not require on-site storage to reap the biggest economic and environmental benefits of solar energy, according to researchers from the University of Texas. In fact, storing solar energy for night-time use actually increases both energy consumption and emissions compared with sending excess solar energy directly to the utility grid.

In a paper published in *Nature Energy*, researchers assessed the trade-offs of adding home energy storage to households with existing solar panels, shedding light on the benefits and drawbacks of adding storage considering today's full energy grid mix.

There is a growing interest in using energy storage to capture solar energy to reduce reliance on traditional utilities. But for now, few homes have on-site storage to hold their solar energy for later use in the home.

A team of researchers analysed the impact of home energy storage using electricity data from almost 100 Texas households that are part of a smart grid test bed managed by Pecan Street Inc., a renewable energy and smart technology company housed at UT Austin.

» They found that storing solar energy for night-time use increases a household's annual energy consumption in comparison with using solar panels without storage because storage consumes some energy every time it charges and discharges. The researchers estimated that adding energy storage to a household with solar panels increases its annual energy consumption by about 324 to 591 kilowatt-hours.

» The researchers also found that adding storage indirectly increases overall emissions of carbon dioxide, sulphur dioxide, and nitrogen dioxide based on Texas grid mix, which is primarily made up of fossil fuels. The increase in emissions is primarily due to the increase in energy consumption required to account for storage inefficiencies. Because storage affects what time of day a household draws electricity from the grid, it also influences emissions in that way.

For utility companies, the benefits are more clear. Solar energy storage reduces peak grid demand by 8% to 32% and the magnitude of solar power injections to the grid by 5% to 42%. This is good for the utility because it can reduce the amount of electricity generation and delivery capacity required.

In short, the analysis showed that storing solar energy today offers fewer environmental benefits than just sending it straight to the grid, because the energy lost to storage inefficiencies is ultimately made up with fossil-fuel electricity from the grid. One of the researchers in the team said that, these findings challenge the myth that storage is inherently clean, but that, in turn, offers useful insights for utility companies.

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RENEWABLE ENERGY AT A GLANCE

Ministry of New & Renewable Energy			
Programme/ Scheme wise Physical Progress in 2017/18 & cumulative up to the month of April, 2017			
Sector	**FY 2017–18**		**Cumulative Achievements (as on 30.04.2017)**
	Target	**Achievement (April–March, 2018)**	
I. GRID-INTERACTIVE POWER (CAPACITIES IN MW)			
Wind Power	4000.00	7.50	32287.27
Solar Power	10000.00	215.67	12504.50
Small Hydro Power	200.00	5.00	4384.85
BioPower (Biomass & Gasification and Bagasse Cogeneration) #	340.00	0.00	8181.70
Waste to Power	10.00	0.00	114.08
Total	**14550.00**	**228.17**	**57472.40**
II. OFF-GRID/ CAPTIVE POWER (CAPACITIES IN MWEQ)			
Waste to Energy	15.00	0.13	171.22
Biomass(non-bagasse) Cogeneration	60.00	0.00	651.91
Biomass Gasifiers	7.50	0.00	161.45
Aero-Generators/Hybrid systems	.50	0.00	3.15
SPV Systems	100.00	8.62	471.16
Water mills/micro hydel (Nos.)	150/25	0.00	18.81
Total	**183.00**	**8.75**	**1477.70**
III. OTHER RENEWABLE ENERGY SYSTEMS			
Family Biogas Plants (in Lakhs)	1.10	0.00	49.56*

Source: www.mnre.gov.in

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