Agreement, but may be receding from the third prong of the Agreement. The country had pledged to create—through forest and tree cover—an additional 'carbon sink' of 2.5 to 3 billion tonnes of CO_2 equivalent by 2030. The goal of a 'carbon sink' is to enhance forest cover, thereby locking into the soil the CO_2 that otherwise would add to global warming.

The country is more focused on another issue—reducing transmission and distribution (T&D) losses, much of which are attributed to theft. In 2012, total losses were estimated at $12.6 billion per year.[5] With installed transmission capacity at only about 13% of generation capacity, a leisurely upgrade of the T&D network could stress the entire power sector. In fact, lack of proper T&D infrastructure was responsible for the slower-than-expected growth in renewable energy in 2018. Such situations dent the confidence of investors in this sector as well.

However, as India continues its emphasis on reducing emissions and increasing capacity, advances in technology can be big game changers. For instance, technological advancement in solar panels has resulted in a greater than 60% price drop in the last 10 years, and industry experts believe such advancements will continue to reduce the price of panels or enhance their longevity, making solar plants even more competitive and viable.

A number of other technological advances could make for big changes in India:

» Development of energy storage systems would reduce the need for additional power sources when utilizing renewables. No backup power would be needed, even if the sun was not shining or the wind was not blowing.
» A stable grid, too, would directly impact India's ability to leverage a higher percentage of renewables, thereby reducing emissions and cutting import dependency in the oil and gas space.
» Smart grids and smart metering systems will improve controlling and monitoring in the T&D sector.

[5] Nuclear Power in India, World Nuclear Association, February 2019, details available at http://www.world-nuclear.org/information-library/country-profiles/countries-g-n/india.aspx

» Advanced lighting systems can be developed and adopted too as they are already being used in homes and industries extensively. In addition, the advanced lighting systems help cut up to 50% of operational costs which is driven primarily by their high efficiency levels.
» Finally, digitalization will help provide smart networks that can deliver better energy management, for quicker—and sometimes proactive—outage detection, as well as restoration solutions.

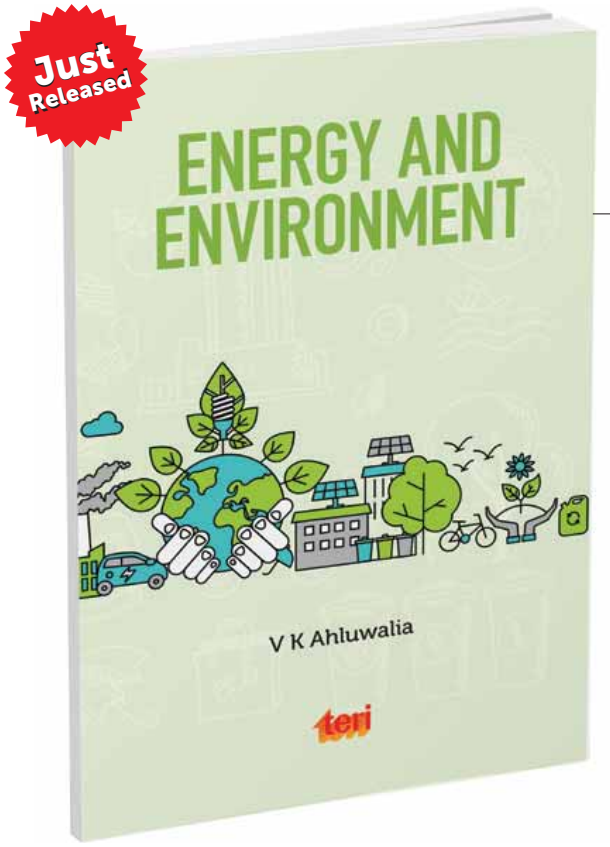
All of these technological advances are not without their pitfalls. Cybersecurity will be a major challenge, especially because some plants in India use outdated SCADA systems, making them increasingly vulnerable to cyberattacks. In fact, some utility and interconnected companies have reported thousands of cybersecurity attacks on their firewalls by hackers. The threat to power plants will continue to increase as the sector becomes more reliant on technology and networking. In order to address this issue, utilities must start with a complete cyber security assessment. The 'defense-in-depth' cybersecurity protocol, which uses a series of layered defense mechanisms, can help ensure the security of the plant. For example, utilities can enhance their supply chain management programme by integrating cybersecurity protections and, at the same time, prevent hackers from bypassing critical controls. Guarding the security of cyber assets security is a concern for every power producer, and developing a comprehensive strategy that fills the security gaps will have to come from industry ingenuity.

Staying the Course

Favourable political and social forces are increasing the pace of renewables growth in India, and the country appears to be on track to comply by 2030 with two out of three goals established in the Paris Agreement. Additionally, if the country continues to work on reducing T&D losses and embraces future technological advances, it could see results even sooner. By staying on the course of its commitment to combat climate change, India can help set an example for other countries to follow. EF

Mr. Suresh Nagarowth is Associate Vice President and Delivery Head at IENR Cyient.

RENEWABLES: GLOBAL SOLUTION TO ENERGY AND POLLUTION



Major topics covered

- Types of Alternative Fuels
- Storage of Energy in Chemicals
- Energy from Coal
- Geothermal Energy
- Greenhouse Gases
- Fuel Cells
- Nuclear Fusion
- Energy Sources

ISBN: 9789386536610 • Price: `195.00

Energy and Environment discusses various forms of energy. It examines environmental impacts of energy generation and how non-renewable sources of energy contributes significantly to environmental pollution. In the book the role of renewable energy sources in mitigating global problem of environmental pollution is also discussed at length. It also elaborates on storage of energy, an important subject, in the context of rising energy demands of the present world.

The Energy and Resources Institute
Attn: TERI Press
Darbari Seth Block
IHC Complex, Lodhi Road
New Delhi – 110 003/India

Tel. 2468 2100
Fax: 2468 2144
India +91 • Delhi (0)11
Email: teripress@teri.res.in
Web: http://bookstore.teri.res.in

To purchase the book, visit our online bookstore at http://bookstore.teri.res.in or send us your demand draft or cheque in favour of TERI, payable at New Delhi (outstation cheques are not accepted).

DUST FREE SOLAR PANEL
For Efficient Electricity Production

Most areas of our country are blessed with beautiful warm sunshine and have a lot to gain in terms of solar energy. Solar power is one of the most environmentally friendly renewable energy sources. There is a huge potential and scope for generating power using shadow-free rooftop space of various buildings, solar parks, agriculture farms for solar pumps, canal top, and large industrial roofs. It is widely recognized that people depend on the sustainable urban environment for a variety of benefits. **Suresh Dodia** evaluates the potential of solar energy.

As energy prices continue to rise, every unit of electricity saving matters. A solar cell or photovoltaic cell is a device that generates electricity directly from visible light. The innovation and efforts steadily brought incremental upgradation in crucial solar energy conversion into electricity and heat that is renewable and sustainable. The solar energy continues to play a predominant role in meeting energy needs.

Moreover, PV (photovoltaic) solar prices are dropping and panel manufacturers are offering good quality at a very competitive price. Hence, the solar photovoltaic panels get cheaper than before and more people are using them to harvest sunlight. People not only achieve reduction in their electricity bills but are also able to sell surplus units to Discoms. The electricity produced from solar and wind has almost reached the stage of grid parity. The price of fossil fuel based electricity generation is increasing day by day and renewable power is becoming cheaper and more affordable. The cost of solar power is as much as 20–25% less than that of diesel generators.

Owing to depletion of fossil fuels and hike in energy price, more and more attention is given towards accessible and affordable solar and wind power. The additional bonus of using solar power is the phenomenal reduction in air and noise pollution as well as transmission losses. The solar energy decreases carbon dioxide emissions, the primary greenhouse gas in the atmosphere. This will help a great deal in combating the effects of climate change. India is gradually making a shift towards cleaner and renewable energy.

The MNRE (Ministry of New and Renewable Energy) and state governments are playing an increasingly active role in promoting the adoption of rooftop solar by offering various incentives and subsidies. The electricity prices are very high in India compared to the United States. The Gujarat State has made it mandatory to install rooftop solar power units in all new buildings coming up in six municipal corporations.

However, the power production from solar panel will depend on several identified factors, such as cloud cover,

sun intensity, relative humidity, and heat build-up. The efficiency is associated with the ability of the solar cell to produce the maximum amount of electricity from a light energy source. A photovoltaic (PV) system performs best when there is completely unobstructed access to the sun's rays for most or all of the day.

The fixed type solar panel, completely stationary, needs very little maintenance. Despite all this, there is a problem of dust accumulation on solar panels. Even something as seemingly inconsequential as a residue layer can affect the performance of solar panels. It is evident that the presence of dust particles in air in Indian cities is more than the specified limits. The dust on the panel can reduce the performance of the panel, resulting in the production of less amount of power and can even deteriorate the performance of modules. Since most solar panels are mounted on a slope facing the equator in open sky, dust, debris and other foreign matters can form a non-transparent layer on the surface of the panel, impacting over time the amount of electricity generated by a module.

The efficiency of solar panels drops significantly if the surface of panels is not clean. This results in decline of the output. The PV solar panel manufacturers should warn buyers about the bad impact of dust and dirt on the PV solar panel output or efficiency. After the new installation of PV (photovoltaic) panel, there is sharp drop in power output of the solar panel within just a week due to dirt in our cities and towns. As a result, PV solar panel can lose up to about 25% energy output in few weeks of installation.

A good analogy is a car windscreen. If a car is parked outdoors for a few days, a layer may build up on the glass that would make it difficult to see through without cleaning it. The PV panels are in open like a car. The solar panels should be kept quite clean to gain optimum benefit of its efficiency in generation of electric power. A hosepipe with a suitable nozzle should be used to allow stream of pressurized water to reach panels. A permanent water supply connection for connecting hosepipe should be provided near panels' installation.

A good quality soft brush and a squeegee with a plastic blade on one side and a cloth covered sponge on the other coupled with a long extension should be used to clean the whole area of the solar panel. Detergents should be avoided as these may streak the glass of the panel. The use of abrasive powders should also be avoided to reduce the risk of scratching the panel glass. Solar panels should be cleaned on an overcast day, early in the morning, or in the evening. If the sun is beating down on panels, any water used can quickly evaporate and dirt will become smeared. In public places, the structure of panel is not accessible without ladders and no one is bothered to clean or check the panel, and thus the efficiency of panel is ultimately reduced.

It is recommended that cleaning is performed three times a week and washing twice a month is essential in most locations in India. Cleaning and inspection at regular intervals prevent build-up of residue and keep panels operating optimally at all times. Automatic robotic system of panel cleaning is available in other countries, but manual cleaning is a far more inexpensive option. EF

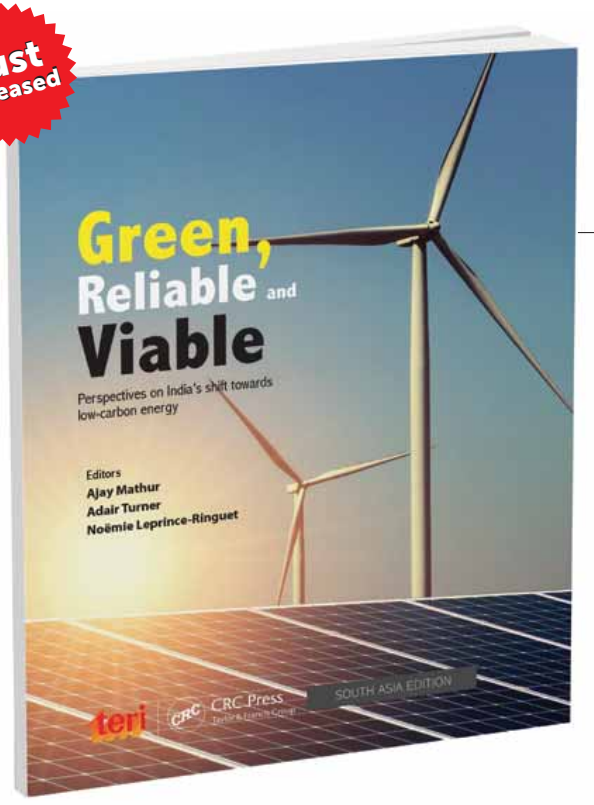
Suresh Dodia is an ex-manager, Indian Oil Corporation Ltd., Pipelines Division, Rajkot, Gujarat

CRC Press
Taylor & Francis Group

teri

"PROVIDING RELIABLE AND AFFORDABLE ENERGY FOR ALL"

Just Released



Major topics covered

- Managing India's Renewables Target
- Financing Clean Energy
- The Future of Mobility is Electric
- Powering the Powerhouse
- Energy Mix
- Bridging the Last Mile

ISBN: 9789386530882 • Price: `595.00

This book brings together the valued perspectives from key stakeholders in these transitions. Experts and practitioners from the mobility, clean energy, agriculture and energy efficiency sectors, amongst others, have shared their outlook on challenges that lie in the way of energy transitions in India, and offered solutions and next steps to move the country forward on the decarbonisation pathway. The overarching message is clear: the Indian energy sector of the future will be noticeably different from what it is today.

The Energy and Resources Institute
Attn: TERI Press
Darbari Seth Block
IHC Complex, Lodhi Road
New Delhi – 110 003/India

Tel. 2468 2100
Fax: 2468 2144
India +91 • Delhi (0)11
Email: teripress@teri.res.in
Web: http://bookstore.teri.res.in

To purchase the book, visit our online bookstore at http://bookstore.teri.res.in or send us your demand draft or cheque in favour of TERI, payable at New Delhi (outstation cheques are not accepted).

INSIGHTS ON PAT SCHEME

Perform Achieve and Trade (PAT) Scheme

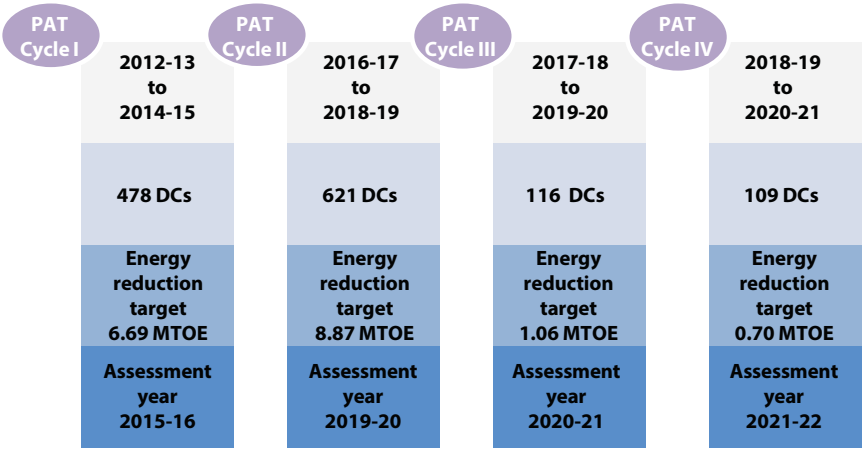
From the success of PAT Cycle I, there are many lessons to be learnt. A huge number of overachievers of the target in comparison to underachievers led to the belief that the target was not strict. Thus, in the subsequent cycles, more stringent energy reduction target would be envisaged. Through this article, **Rudhi Sundar Pradhan** provides an overview of the PAT scheme.

Introduction

Perform Achieve and Trade Scheme (PAT) falls under National Mission for Enhanced Energy Efficiency (NMEEE), which is one of the eight missions under the National Action Plan on Climate Change (NAPCC). It is a regulatory framework to reduce specific energy consumption in energy intensive industries, with an associated market-based mechanism to enhance the cost-effectiveness through certification of excess energy saving that can be traded.

Under the PAT scheme, reductions in specific energy saving targets are assigned to designated consumers (DCs) for a 3-year cycle. The target reduction of each DC is determined based on their current energy efficiency level through conducting 'Baseline Data Collection and Verification Audit for PAT Scheme', so that energy-efficient DCs will have a lower target of percentage reduction as compared to less energy-efficient DCs that will have higher targets.

As of now, PAT I has been concluded, with PAT II and PAT III going on with a total of 737 DCs participating under the PAT scheme. To widen and deepen



the PAT scheme, PAT IV has also been initiated by BEE, with identification of 109 new industrial units.

The first cycle of PAT was completed in March 2015. The achievement of PAT Cycle I is 8.67 MTOE (million tonnes of oil equivalent), which is an overachievement of about 30% in comparison to the assigned target (i.e. 6.69 MTOE). This energy saving is equivalent to 31 million tonnes of CO_2 emission reduction.

Thereafter, the Ministry of Power issued 38.24 lakh (approx.) ESCerts (Energy Saving Certificates) to 306 DCs on 16th February 2017. 110 DCs have been entitled to purchase 14.23 lakh (approx.) ESCerts to meet their compliance. ESCerts could be traded at two energy exchanges – Indian Energy Exchange (IEX) and Power Exchange India Limited (PXIL).

Synopsis of ESCerts trading

ESCerts trading for PAT Cycle I commenced on September 26, 2017 in IEX. Market clearing price (MCP) of ESCerts for the first trading session was

Table1: ESCerts trading details

Trading date	Sell Bid (No. of ESCerts)	Purchase Bid (ESCerts)	Trade Volume (ESCerts)	Price Discovered (`/ESCert)	No. of Participants
26-09-2017	239,644	50,904	10,904	1200	39
03-10-2017	236,031	51,925	23,295	1200	40
10-10-2017	348,587	64,459	43,078	1000	52
17-10-2017	381,443	40,538	40,148	800	45
24-10-2017	349,806	42,271	41,455	600	52
31-10-2017	383,379	21,037	19,359	500	51
07-11-2017	436,394	11,521	10,351	350	61
14-11-2017	319,810	12,241	12,125	200	45
21-11-2017	336,121	10,963	7,513	200	53
28-11-2017	368,361	117,514	36,580	250	64
05-12-2017	355,226	262,331	46,928	350	73
12-12-2017	433,769	495,553	123,520	525	85
19-12-2017	831,224	730,885	449,818	1000	112
26-12-2017	1,094,568	365,980	220,791	899	126
02-01-2018	777,567	145,150	28,983	500	78
09-01-2018	824,707	152,195	74,895	501	79
16-01-2018	894,445	110,511	109,161	450	81

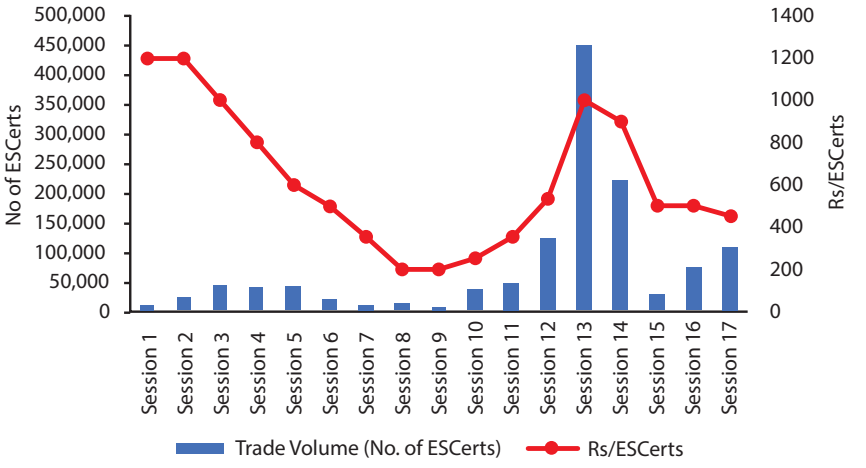


Figure1: ESCerts price versus No. of ESCerts

at `1200, which was highest among the total 17 trading sessions held. Thereafter, the MCP subsequently fell down to `200 over the 8th and 9th trading sessions. In the 17th session of ESCerts trading held on January 16, 2018, the total cumulative cleared volume for ESCerts was 12.99 lakh ESCerts, which amounts to the total transaction amount of `99.82 crore.

Facts of PAT Cycle IV

PAT scheme is currently proposed to be implemented on the rolling basis, that is, annual inclusion of new DCs. In this context, the Gazette notification of energy reduction targets for new DCs under PAT Cycle IV was published on March 28, 2018. Deepening of PAT cycle IV to reduce the specific energy consumption in the existing six sectors, namely, Cement, Chlor-Alkali, Iron & Steel, Paper & Pulp, Textile, Thermal Power Plant, and widening are done by including Petrochemical and Commercial Building (Hotels).

In total, 109 DCs were given a target to achieve 0.7004 MTOE of energy reduction.

Figure 2: Energy reduction target in PAT IV

In PAT cycle IV, two new sectors are identified in PAT scheme, namely, Petrochemical and Commercial Building (Hotels).

Total 45 DCs are notified under Petrochemical and Commercial Building (Hotels) sectors in PAT cycle IV.

Maximum 37 DCs are identified in Commercial Building (Hotels) sectors. Thirty-five new DCs are identified in Iron & Steel sector.

No new DCs from Aluminium, DISCOM, Fertilizer, and Railways are added in PAT cycle IV.

Table 2: Sector-wise no of DC in PAT IV

Sl No	Sector	Nos of DC
1	Cement	1
2	Chlor-Alkali	2
3	Iron & Steel	35
4	Pulp & Paper	2
5	Textile	7
6	Thermal Power Plant	17
7	Commercial Buildings (Hotels)	37
8	Petrochemical	8
	Total	**109**

Timeline for PAT Cycle IV

PAT cycle IV will span over a period of 3 years. Here is a sneak peek into the timelines related to PAT cycle IV.

Baseline year: 2016–17

Mandatory energy audit, energy conservation, and recommendations: Mandatory energy audit has to be concluded by September 2019 as per the Bureau of Energy Efficiency (Manner and Intervals of Time for Conduct of Energy Audit) Regulations, 2010.

Implementation years: 2017–18 to 2019–20

The recommendations of the energy audit are to be implemented within the implementation years, which will enable the designated consumers to reduce their energy consumptions by the assessment year.

Assessment year: 2020–21

Comparison with the specific energy consumption (SEC) with the baseline and the assessment year to be made to deduce the quantum of energy reduction.

PAT M&V audit to be conducted in the 1st quarter of 2021–22.

Table 3: State-wise no. of DC in PAT IV

Sl No	State	Nos of DC State Wise
1	Andhra Pradesh	5
2	Assam	3
3	Chhattisgarh	11
4	Goa	3
5	Gujarat	7
6	Haryana	3
7	Jharkhand	5
8	Karnataka	10
9	Maharashtra	16
10	Meghalaya	1
11	Madhya Pradesh	4
12	New Delhi	10
13	Odisha	3
14	Punjab	2
15	Rajasthan	2
16	Tamil Nadu	8
17	Telangana	3
18	Tripura	1
19	Uttar Pradesh	1
20	West Bengal	11
	Total	**109**

Energy Reduction – Sectoral Analysis

Baseline and verification audit of 109 DCs reveals about 24.064 MTOE of energy consumed by the industries in the baseline year 2016–17, and they are assigned energy saving target of 0.7004 MTOE by the end of the assessment year 2020–21.

Thermal power plant is assigned a maximum share of energy savings of 34% approx. (0.237 MTOE) and minimum target is given to Chlor-Alkali sector (i.e., 0.43%). PAT cycle I commenced in the year 2012 with 478 DCs notified and assigned an energy saving target of 6.69 MTOE by the assessment year 2014–15. Subsequently, in PAT II, 8.87 MTOE of energy saving target was assigned to 627 Industries.Since PAT cycle III, the scheme became rolling cycle with inclusion of new DCs every year. PAT cycle III and PAT IV cycle visualized the entry of 116 and 109 industries with the target to reduce the energy by 1.06 and 0.7 MTOE, respectively.

Maximum percentage of energy reduction target notified for the Commercial Building sector is about 15.43%. One of the Thermal Power Plant units is assigned with zero target.

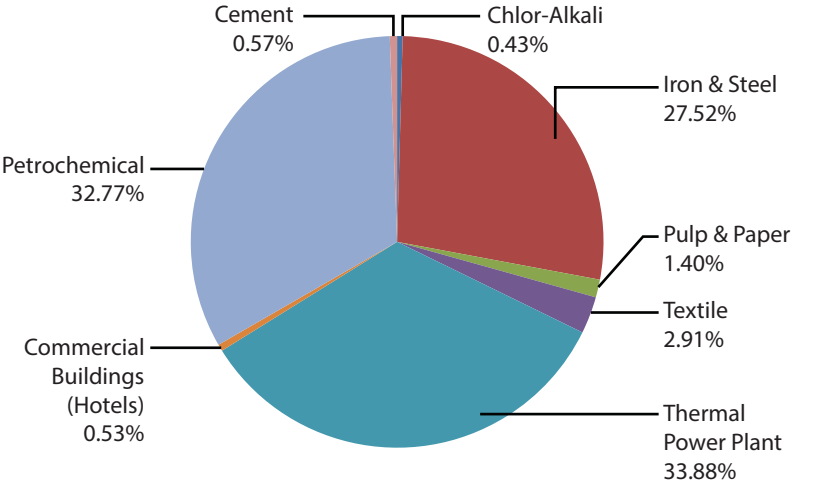


Figure 3: Percentage share of reduction target

Table 4: Sector-wise reduction target

Sl No	Sector	Reduction Target (MTOE)
1	Cement	0.0040
2	Chlor-Alkali	0.0030
3	Iron & Steel	0.1927
4	Pulp & Paper	0.0098
5	Textile	0.0204
6	Thermal Power Plant	0.2373
7	Commercial Buildings (Hotels)	0.0037
8	Petrochemical	0.2295
	Total	**0.7004**

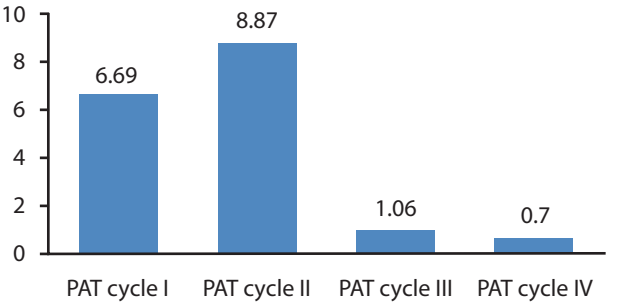


Figure 4: Energy reduction target in different PAT cycles (Million ToE)

Conclusion

From the success of PAT cycle I, there are many lessons to be learnt. A huge number of overachievers of the target in comparison to underachievers led to the belief that the target was not strict. Thus, in the subsequent cycles, more stringent energy reduction target would be envisaged.

The amended Energy Conservation Act, 2010 provides the legal backup to this scheme. Insertion of new sections 14 A and 14 B throws light on the sale and purchase of Energy Saving Certificates in order to comply with the energy consumption norms and standards. The penalty clause 26 is revised by encompassing hefty charges in case of non-compliance.

Further, we believe the results of PAT 2 and PAT 3 would provide more inputs for paving the way forward for this scheme. EF

Rudhi Sundar Pradhan, Associate Fellow, Industrial Energy Efficiency, TERI, New Delhi.

Table 5: Variance of energy reduction target in different sectors

Sector	Avg % of Reduction	Max % of Reduction	Min % of Reduction
Cement	5.42	5.42	5.42
Chlor-Alkali	5.97	5.97	5.97
Iron & Steel	5.97	9.06	3.73
Pulp & Paper	5.96	5.96	5.96
Textile	5.97	5.97	5.97
Thermal Power Plant	1.45	4.34	0.00
Commercial Buildings	5.97	15.44	2.79
Petrochemical	6.00	7.42	4.83

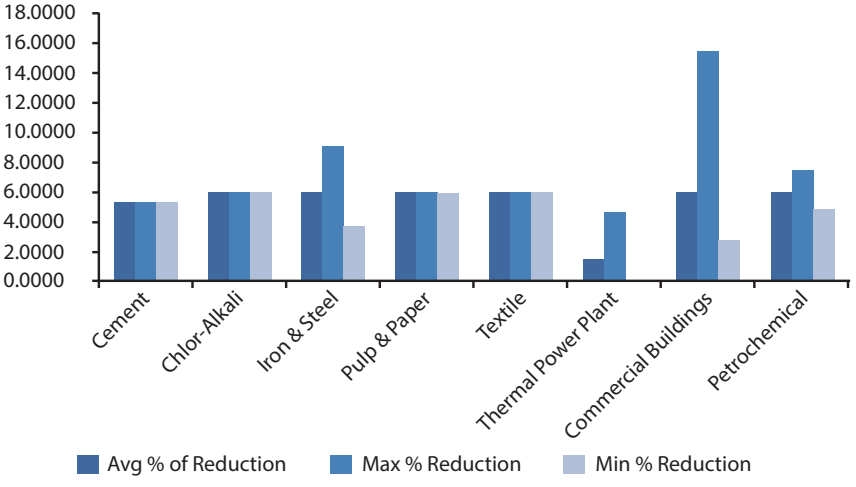
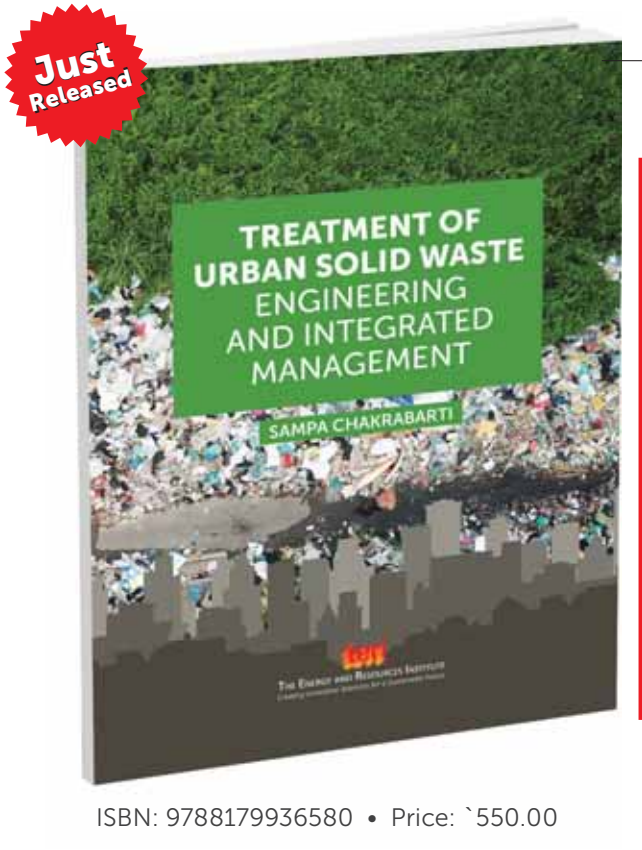


Figure 5 : Variance of energy reduction target in different sectors

CHALLENGES AND SOLUTIONS OF URBAN SOLID WASTE MANAGEMENT



Major topics covered

- Engineering and management practices for treating urban solid waste including municipal, biomedical, construction and development, plastic, e-waste
- Problems and opportunities of municipal solid waste management, including separation, collection and transportation
- Environmental and public health issues of managing various types of solid wastes

ISBN: 9788179936580 • Price: `550.00

Treatment of Urban Solid Waste: engineering and integrated management describes the principles or steps of integrated solid waste management, especially in the Indian context. The Indian scenario of generating and treating urban solid waste is explained in the backdrop of international status. Latest technologies as well as current rules and regulations applicable in India are compiled for ready reference. It will be useful for the postgraduate students as well as for the practising environmental engineers engaged in the management of municipal solid waste.

The Energy and Resources Institute
Attn: TERI Press
Darbari Seth Block
IHC Complex, Lodhi Road
New Delhi – 110 003/India

Tel. 2468 2100
Fax: 2468 2144
India +91 • Delhi (0)11
Email: teripress@teri.res.in
Web: http://bookstore.teri.res.in

To purchase the book, visit our online bookstore at http://bookstore.teri.res.in or send us your demand draft or cheque in favour of TERI, payable at New Delhi (outstation cheques are not accepted).

Higher Integration of SPV Systems
Issues and Challenges

Since photovoltaic (PV) systems have variable power generation because of variable parameters, it would be more challenging to manage distributed voltage, increasing wear and tear in electromechanical utility equipment, and configure protection system with larger distributed generation PV (DGPV) systems. **Deepak Kumar Yadav** and **Dr Brijesh Singh** highlight some of the major issues and their impacts on integrating DGPV in this article.

Photovoltaic (PV) systems have variable power generation because of variable parameters (day/night, angle of the panel, clouds, etc.); therefore, it is more challenging to manage distributed voltage, increasing wear and tear in electromechanical utility equipment, and configure protection system with larger distributed generation PV (DGPV) systems. Some of the major issues and their impacts of integrating DGPV are discussed next.

Voltage Regulation

The voltage level of different nodes of distribution system rises locally beyond the acceptable range due to integration of more and more distributed generation PV (DGPV) systems, wind, micro-turbine, and so on. The value of voltage rise depends on feeder characteristics, voltage rating, overhead or underground lines, size of the wire, etc.; the location of solar PV; and load pattern. Advanced inverters can be used to mitigate and eliminate undesirable voltage by shifting the phase angle of

sinusoidal current output to absorb or inject reactive power. Advanced inverters can provide capabilities that can benefit the power system, external controllability, real power curtailment in response to excess generation, voltage and frequency ride-through, and so on.

Reverse Power Flow

Conventional power flows are unidirectional, but the higher deployment of DGPV can reverse the power flow, which can be supplied to loads of neighbouring feeders or injected back into transmission lines. Tap-changing transformers are used for voltage regulations that use recirculation schemes to avoid arcing and other issues when changing voltage ratios under load and these can limit reverse power rating for tap-changing transformers. Some older units in system may ignore the reverse power flow and may sense it as an overload in the system and cause voltage droop and the regulators will increase the voltages, which is exact opposite behaviour required to mitigate the DGPV voltage rise. The bigger challenge about reverse power flow is distribution–transmission interface. This interface may require the approval of many parties and it also needs research on market exchanges and guidelines to support bulk level of penetration of DGPV. This is often known as frequency-watt control because an increase in grid frequency is the first measurable change of excess generation compared to load.

Overgeneration

During mid-day, the PV generations reach the peak and the demands are low. It can create a situation of overgeneration by variable generators (VGs). Without intercession, generators and motors connected to the network would increase rotational speed, which can cause damage. To prevent overgeneration, system operators may curtail DGs output by either inverters or disconnecting plants. This requires system operators to control generation resources, which is not easy with large power plants and abnormal for smaller systems (distributed or rooftop PVs). The curtailment of the output of VGs will reduce economic and environmental benefits. As curtailment increases, at a point, the additional installments of PVs are not worth the cost. Other technical challenges of increased/overgeneration of PV or any other DGs that limit the resilience of system include contractual and institutional restrictions on plant operation, including long-term 'must take' contracts, self-scheduling, and combined heat and power plants.

Unintentional Islanding

Islanding is a portion of a distributed system that continues to run even when the larger power system is disconnected by a protection device (Figure 1). Although this is sounding like a desirable state, unintentional islanding may result in damage of equipment and safety concerns. To avoid these problems, grid-connected inverters have anti-islanding features and must be certified by IEEE-1547-2003 to detect and drop offline within 2 s after an island forms. The complexities of distributed system, the placement of PVs and traditional rotating-machine based distributed generators may slow down the detection time or resulting risks:

- Equipment damage due to operation beyond constraints (e.g. voltage bound, frequency/phase synchronization with the grid)
- Safety risks to crews working on circuit

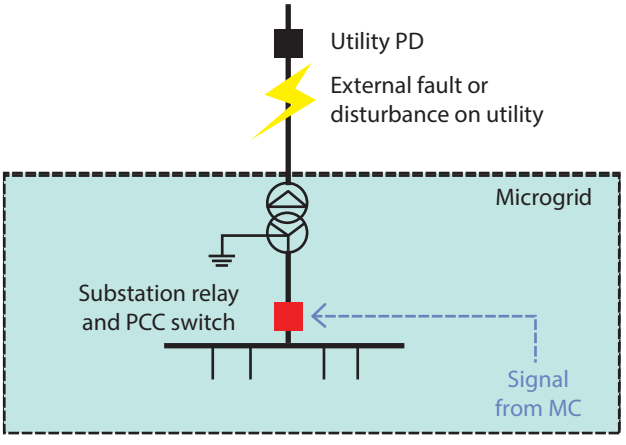


Figure 1 Representation of unintentional islanding due to external fault or disturbance on utility

Protection

The protection systems are designed to prevent power flow during a fault, such as a line to ground short or a line to line short. Distributed protection equipment generally depends on detecting an increase in current flowing during a fault to isolate the faulty part and healthy part while allowing the rest of the system to continue the operations. Since the PV power is highly reliable on sunlight and due to routine changes in operating conditions within the distribution system, it becomes complicated for the protection system to detect and locate the faults, particularly high-impedance faults. The expansion of any distributed generators, including DGPV, can make further difficulties in detecting and locating faults because this expansion of DGs could increase or decrease fault current flows through protection devices on a system that confuse current measurements and force them to not operate on the optimal way.

One such issue is relay desensitization (Figure 2), wherein current from PV decreases the fault current that would otherwise be observed by existing protection devices such as substation breakers, fuses, and reclosers. This could cause the

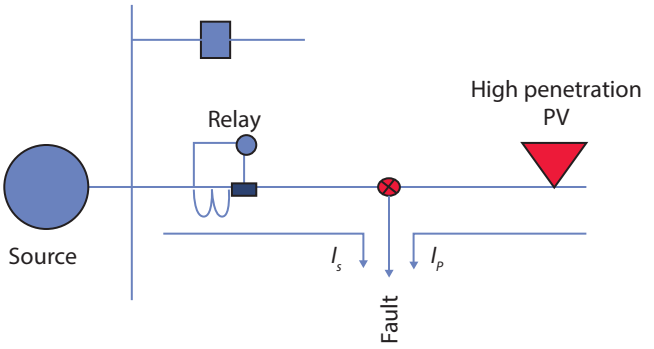


Figure 2 Relay desensitization due to PV integration

protection system to operate more slowly or not at all during the fault and potentially damage utility and customer equipment.

Equipment Wear and Tear

Notwithstanding the challenges in directing the voltage at the consumer level as described, DGPV can also affect the wear and tear on existing utility-owned equipment used to help regulate these voltages to be specific load tap-changing transformers situated at the substation, tap-changing line controllers, and capacitors. Although these devices may already operate many times per day, with high penetrations of DGPV increased power flow variation can cause increased wear and tear on these electromechanical actuators and potentially require untimely replacement. With the help of advanced inverters, the DGPV could possibly diminish the number of actuations and improve the life of the equipment.

The presence of voltage regulators and switched capacitors is generally an indication of a circuit with relatively higher impedance and the presence of voltage-sensitive customers on the circuit. Thus, circuits that have these types of equipment are generally more challenging cases of DGPV integration because of characteristics of the circuit more than the specific use of the voltage regulators and switched capacitors. The presence of voltage controllers or potentially switched capacitors is commonly a sign of a circuit with generally higher impedance as well as the presence of voltage-sensitive consumers on the circuit. In this way, circuits have these kinds of equipment that are more challenging cases of DGPV penetration because of the circuit.

Secondary Network Distribution System

In the present scenario, most of the distribution network systems are operated radially with a non-looping, tree-like structure of customers connected to only one point. Many dense, urban areas employ secondary networks wherein customers are connected to a large, meshed, low-voltage network that is fed by multiple points. Connecting PV to these systems has a limitation on reverse power flow for each customer and so it has been strongly limited to integrate PV. The systems get disconnected when electric power (both real and reactive power) flow back towards the utility by incorporating special protective devices, called 'network protectors,' at each network transformer. These devices are part of the design to ensure much higher service reliability to customers, especially to urban customers, compared to suburban and rural consumers. However, network protectors may hinder PV interconnection because routine excess power generation from DGPV may cause reverse-current flow through the network protector and thus cause the device to open unnecessarily. Due to this and related challenges, utilities with networks do not permit their customers to interconnect a PV system (or any other distributed generators). The latest combination of advanced inverters and utility-grade relays has demonstrated the ability to create a low-cost, locally controlled system that lets higher levels of PV (other distributed generators) to be installed on networks with very low risk of back-feeding into the network protector.

Cloud-driven Photovoltaic Variation

Solar irradiance variability majorly relies on cloud patterns and hence solar energy production variability. In clear weather, the solar energy generation profile varies slowly, smoothly, and with predictability. The variability of solar PV generation depends on the local climate. And India's climate is the most diverse climate on Earth. Some locations have many small clouds and fast wind speed (e.g. Tamil Nadu, Karnataka, Rajasthan, Gujarat, Maharashtra, and many other northern states of India) and some locations have unpredictable weather, which is mostly cloudy and with highly variable wind speed profile (e.g. Meghalaya, Kerala, and other north-eastern states of India).

Large PV plants or distributed PVs spread throughout a multi-mile extent of a distribution feeder that can considerably reduce the overall variability. When aggregated, some of the modules may be covered by clouds, while others experience clear skies. The amount of variability smoothing due to spatial diversity depends on the arrangement of PV modules, the daily cloud speed, and the timescale considered.

System Reconfiguration

In all except the most remote distribution circuits, utilities often introduce switches or generally provide restricted reconfiguration to connect adjacent distribution circuits. Reconfiguration is a significant tool that utilities use to manage changes

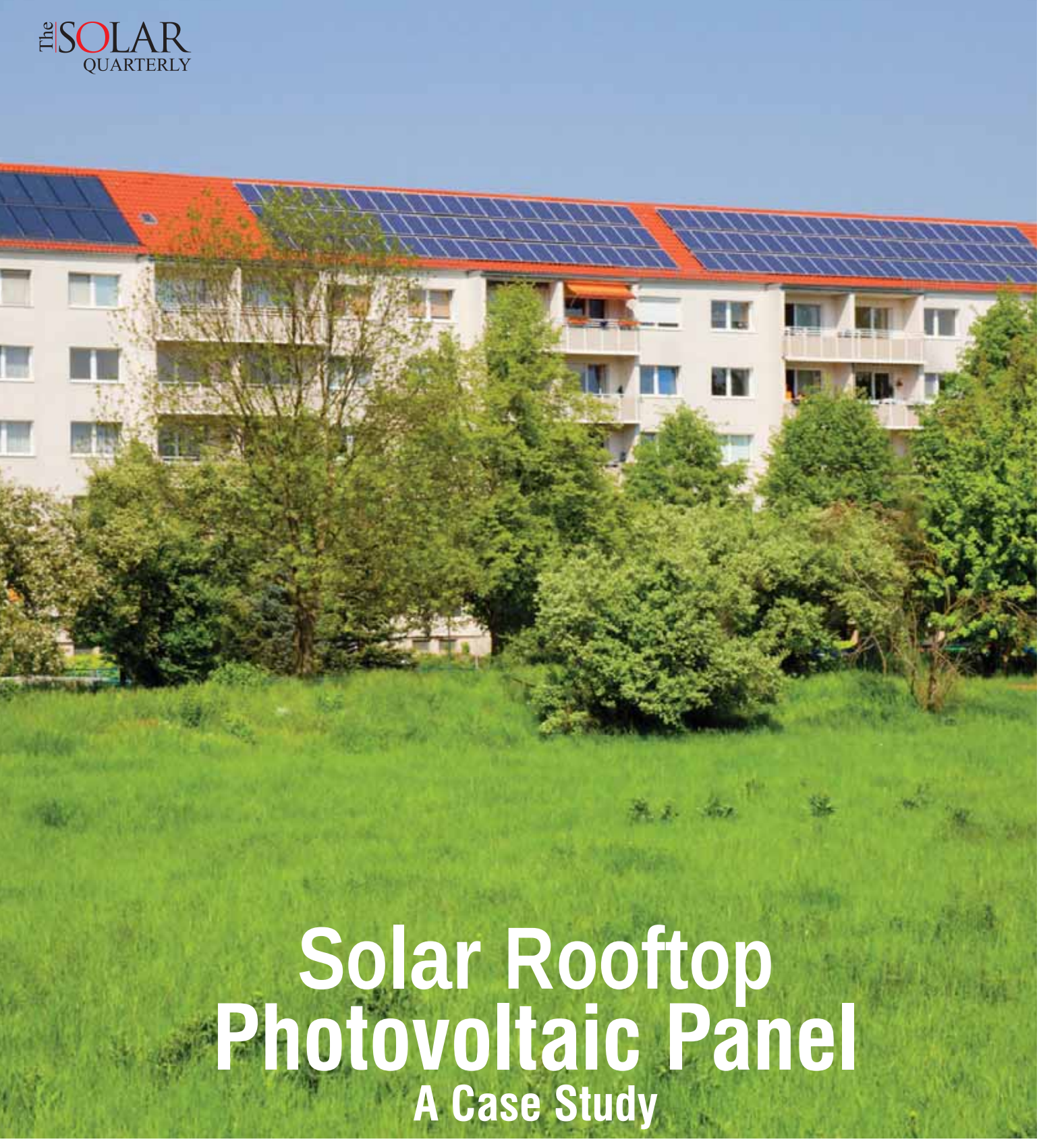
in circuit loading and circuit blackouts (both planned and contingent). Integrating DGs, including PV, on certain circuits or certain portions of a circuit can confound the switch sequencing, protection settings and control configurations needed to ensure reliable operation during reconfiguration. At a minimum, reconfiguration with PV interconnection makes the studies more complex and time consuming.

Hosting Capacity

One of the major challenges in integration of higher distributed generators, including PV, is 'hosting capacity' of feeder or system. The hosting capacity refers to the quantity of distributed generators that can be interconnected without imposing any changes to the existing infrastructure and without untimely wearing out equipment, such as that used for voltage control. In today's scenario, up until this level, PV plants are easily interconnected and could be subject to accelerated approval. It is feasible and often practical and inexpensive to install more PV systems than currently installed by allowing some small changes in system operations, adjusting controller set points, or upgrading or installing additional equipment. To go beyond the hosting capacity, the changes require more extensive analysis of expansion of existing infrastructure and their constraints. Typically, the hosting capacity is expressed in megawatt of PV spread across any location on feeder or system that causes the first violation of operating constraints.

Although specific criteria and standards were defined by various national and international organizations to deal with these mentioned issues, some of the other technical issues also affect the reliability and security of Indian DGPV systems, such as primary system overvoltage/undervoltage, primary system voltage deviation, regulator voltage deviation, secondary system voltage deviation, secondary system overvoltage/undervoltage, sympathetic breaker tripping, breaker reduction of reach, breaker/fuse coordination, element fault current, thermal overload, and so on. A number of solution methodologies were reported in last decades on these issues. In upcoming years, some advanced technologies will be introduced in DGPV systems that will smartly cater to the mentioned problems, such as smart inverters, advance controls using artificial intelligence, efficient and user-friendly information communication technologies, and so on. EF

Mr Deepak Kumar Yadav and Dr Brijesh Singh, SMIEEE, Centre of Excellence for Power Engineering Technologies and Clean Energy Integration, KIET Group of Institutions, Ghaziabad, Uttar Pradesh.



Solar Rooftop Photovoltaic Panel

A Case Study

The present case study by **Dr P Venkatesh** presents the installation procedure of a 2 kW grid-connected solar rooftop photovoltaic (PV) panel. How installation of a solar rooftop PV plant can reduce the electricity expenses is also discussed.

India is facing energy crisis and despite this the growth rate needs 9%–10% gain for a stable economy. On an average, India receives clear solar radiation for 300–330 days per year; this can be utilized for power generation through both ground and rooftop photovoltaic (PV) solar panels. With an aim to accelerate development and promotion of solar energy technologies in the country, Government of India launched Jawaharlal Nehru National Solar Mission (JNNSM) in January 2010. Both central and state governments give subsidy and loan for installation of solar rooftop plant to encourage people so that advantages associated with solar rooftop panels can be accrued. The key benefits of a rooftop solar plant are as follows:

- Savings in land requirements and costs
- Savings in development of new transmission infrastructure
- Creation of value from underutilized/ unutilized rooftops
- Good choice for distributed power generation system
- Generation of environmentally clean energy
- Consumer becomes generator for his own electricity requirements
- Reduction in electricity consumption from the grid
- Feeding excess power to the grid.

The present case study is supplemented with consumer energy consumption report and bimonthly bill (with and without solar rooftop plant) for better understanding of the benefits of solar rooftop PV system.

Selection of Rating of Solar Rooftop PV Plant in Home

The details of consumer's energy consumption and electricity bill (2016–18) are shown in the Table 1. This also forms the base for selection of a solar rating. The total energy consumption (in home) calculated for 1 year is considered for the study. A calculation is made for the installation of selection of a 2 kW solar rooftop panel with the solar energy produced and the corresponding savings on the bill. This is detailed in Table 1. Some assumptions are made, for example, tariff rate, the number of sunny days in a year. This study is very important for the selection of rating of a solar PV plant. Further, depending on the site availability and financial status of consumer, a slight deviation may occur in the selection of rating of the solar PV plant.

Selection of the solar panel, inverter, and other accessories mainly determines the investment cost. Generally, the cost of a good company's solar panel and the

Consumption of units/year for 2017–18	: 4350
Net current bill amount/year for 2017–18	: `19,575
Average cost/unit/year	: `4.5 paise
Solar capacity as per unit consumption	: 2 kW on grid
Required area for 2 kW on grid system	: 200 sq. ft
Solar generation units/year for 2 KW	: 9 x 275 days = 2,475 units
Solar generation units/year for 2 KW	: 6 x 90 days = 540 units
Total solar generation units/year	: 3015 units
Total revenue by solar generation	: `13,567/-
Net energy consumption/year	: 4350 – 3015 = 1335 units
Reduce government subsidy units	: 1335–360 = 975 units/6 month = 162.5 units
If install 2 kW solar, Average current bill to pay/month	: 162.5 x `4.5 paise = ` 731

Table 1 Solar energy produced and the savings in the electricity bill (2016–18)

Assessment Date	Assessment Entry Date	kWH Reading	kWAH Reading	Maximum Demand	Power Factor	Consumed Unit	CC Charge* (`.)
14/06/2018	18/06/2018	19750			1	880	4238
10/04/2018	11/04/2018	18870	20493	3	.92	710	3366
10/02/2018	10/02/2018	18160	19715	2.2	.89	570	2442
12/12/2017	13/12/2017	17590	19067	2.5	.91	690	3234
11/10/2017	11/10/2017	16300	18300	2.88	0.82	770	3862
09/08/2017	10/08/2017	16130	17478	2.77	0.82	730	3688
09/06/2017	10/06/2017	16400	16888	3.08	.4	1140	6304
10/04/2017	10/04/2017	14260	16430	3.64	.91	760	3730
09/02/2017	10/02/2017	13610	14410	2.74	.91	620	2872
10/12/2016	12/12/2016	12820	13630	8.43	.9	680	2874
11/10/2016	12/10/2016	12300	12760	2.28	.84	670	2862
08/08/2016	08/08/2016	11630	12680	3.24	.83	640	1964

inverter is approximately `60,000 per kW. The decision of installing a particular solar rooftop PV plant, of 1 kW or 2 kW capacity, is taken, based on the choice made by the customer.

Installation Procedure

After selection of rating of solar rooftop PV plant (involving the rating of solar panel and inverter), a site survey is needed for determining the location for installing solar panel, inverter, and accessories. A site survey for installation of a solar rooftop PV plant, ideal for a home set-up, is illustrated in Figure 1. From the site location, the number of solar panels (in this case six panels), and their placement with the dimension and tilt angle are also to be evaluated (Figure 2). The figure also shows side view of mounting-type structure arrangement. Before erecting the structure, the foundation with the dimension is required. This is also clearly depicted in Figure 3.

The selection of the number and the rating of solar panels are also based on the site location. In this case, 200 sq. ft is available (as a thumb rule: 1 kW for 100 sq. ft). Solar panels with different ratings are available. In the present case, six solar panels with the rating of 320 Wp are selected for installation. The arrangement plan for installing the PV module with the six panels is outlined in Figure 3.

The I-V and PV characteristics of solar PV panel (make: Kirloskar) and the test results with the important parameters of solar panel (V_{oc} = 45.8 V, I_{sc} = 9.18 A, V_m = 37.8 V, I_m =8.68 A, fill factor = 0.782) are shown in the Figure 4.

Materials Required for 2 kW Solar Rooftop PV Plant

The materials required for developing 2 kW solar rooftop plant with specifications are listed in the Table 2.

The procedure of mounting structures is summarized below:

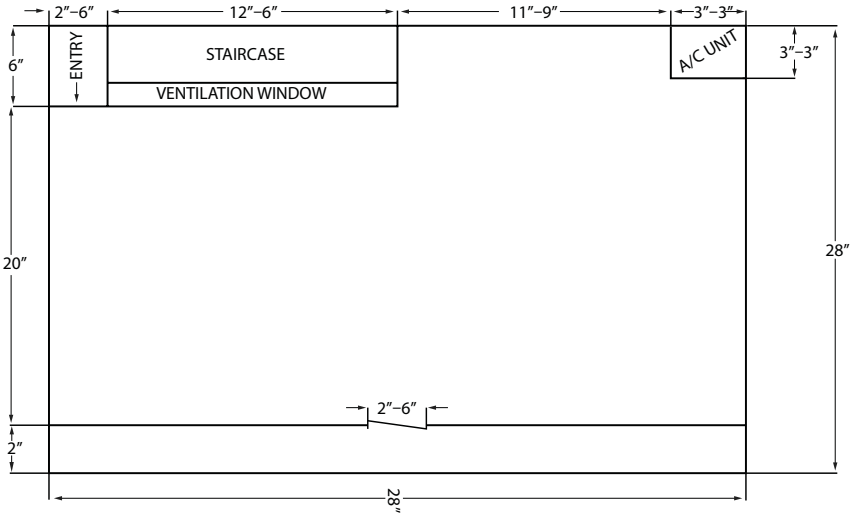


Figure 1 Site survey

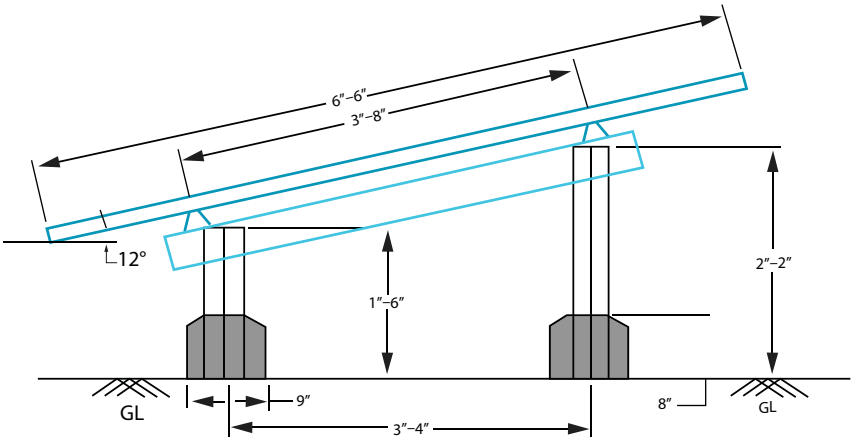


Figure 2 Side view of mounting-type structure arrangement

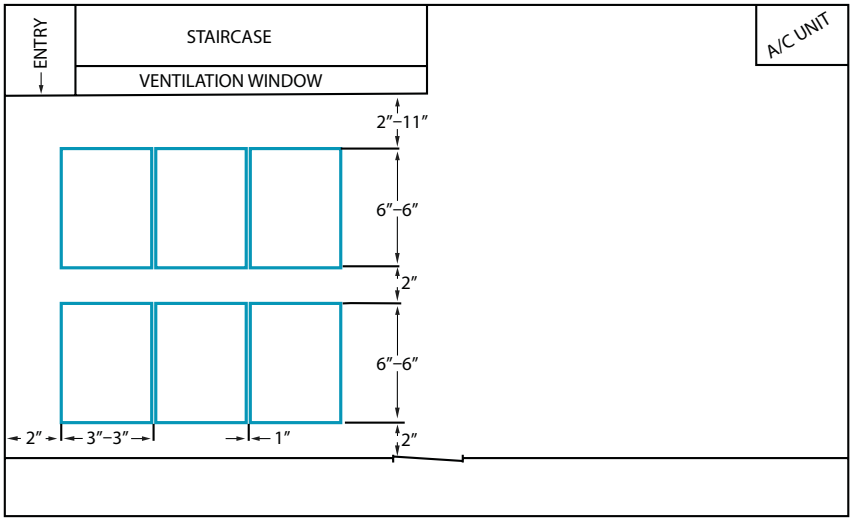


Figure 3 PV module arrangement plan

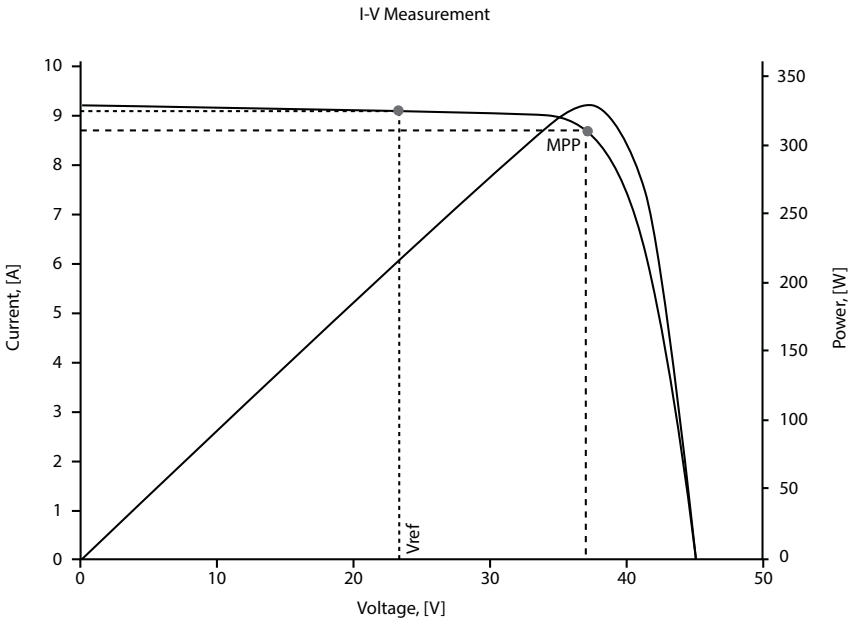


Figure 4 I-V and PV characteristics of a Kirloskar solar panel

Table 2 Materials required for 2 kW solar rooftop PV plant

S. No.	Description	Material
1	Solar PV modules 320 W, 6 in number	PV power tech polycrystalline
2	Module mounting structures	Pre-galvanized iron MMS
3	Solar string inverter with on-line monitoring system	Zever/Growatt/Kirloskar
4	Wireless monitoring accessory	1
5	DC cables	1C × 4 sq. mm
6	AC cables	4C × 2.5 CU
7	AC DB box with MCB and surge protection	1
8	DC DB Box with fuses and surge protection device	1
9	MC4 connectors, fittings, pipes, bend and accessories	Required quantity

- Panels shall be mounted on galvanized frames based on the place of installation.
- The structure should be designed in such a manner that module can be replaced easily and in line with site requirements. Such a design will also help in carrying out service and repair in the future.
- The frames will be supported by angle legs of suitable lengths to provide the pre-determined inclination.
- The structures are designed to withstand wind speeds up to 150 km/h and panel load.

Salient features of the cables (AC and DC) are summarized below:

- AC and DC cables should confirm to IS 694 and be of 650 V/1.1 kV grade.
- Interconnections, array to junction boxes, junction boxes to DCDB, DCDB to PCU, etc. will be selected to keep voltage drop and losses to the minimum.
- Use of bright annealed 99.97% pure bare copper conductors results in lower heating, thereby increasing cable life and efficiency.
- Wires are insulated with a special grade PVC compound formulated and manufactured in-house.

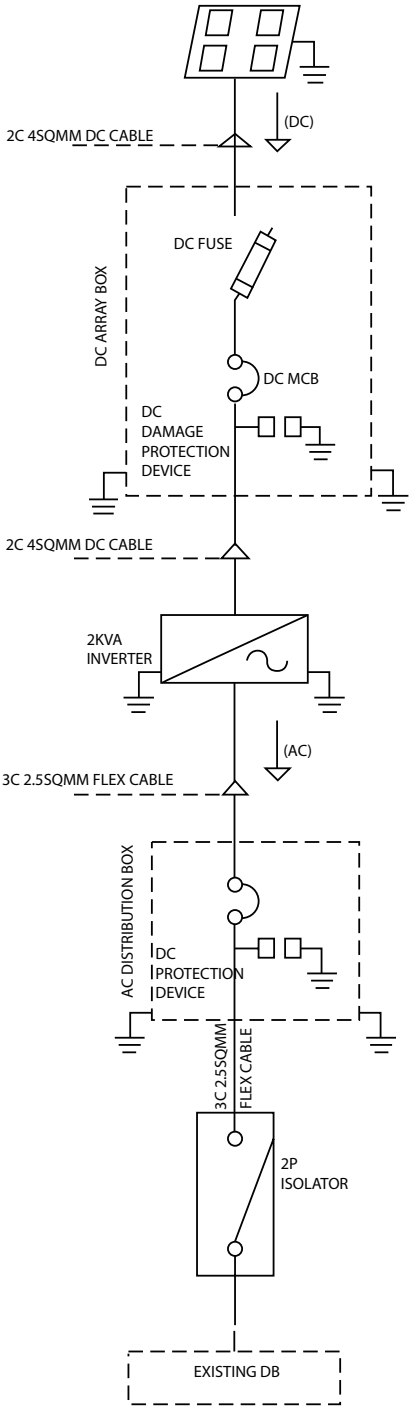


Figure 5 Single-line diagram of a 2 kW solar rooftop PV plant

- Working voltage: 1.1 kV
- Temperature range: –15°C to 70°C
- Color codes: Red, Yellow, Black, Blue, Green
- Cable: UV resistant

ACDB/ DCDB boxes with the specifications are summarized below:

- The ACDB and DCDB boxes are made of thermoplastic.
- ACDB is provided with MCB of required capacity and surge protection device.
- A separate changeover switch of required capacity is provided in the ACDB to isolate the existing connected load from the solar system and switch it over to the existing convention power (mains).
- In case of emergency, DCDB box is provided with fuse of rated capacity and surge protection device.

Placement of ACDB, DCDB, and 2 kVA inverter of a 2 kW solar rooftop PV plant is shown in Figure 6, while Figure 7 shows the solar panels of a rooftop plant.

The inverter is provided with the wifi facility, which makes convenient for the consumer to know the total solar generation, per day solar generation, and so on.

Net Metering Facility Procedure

Based on the selection of solar panel and inverter, it is necessary to submit the details (Net Metering Connection Application) in order to get the net metering facility from the distribution company. In addition, Net Metering Connection Application should be accompanied with the prescribed fee. As stated earlier, both central and state governments provide subsidy

Figure 6 DCDB, ACDB, and 2 kVA inverter

Figure 7 A 2 kW solar rooftop plant

for the installation of a solar rooftop PV plant. Normally the installation company is authorized to get subsidy (in percentage) for installation and then effectively the investment cost of the solar rooftop PV plant gets reduced.

After the complete installation of solar rooftop plant, representatives from the concerned DISCOM inspect the site as per the specifications and grant permission for the facility of the net meter. Then the payment is made for the cost of net meter and other accessories to the respective Discoms. Finally, the conventional meter gets replaced with a net meter. Figure 8 shows a three-phase net meter.

Results and Discussion

Figure 9 shows the display of a 2 kW wifi-enabled solar rooftop PV plant. If a 2 kW solar rooftop plant is operating from 1 January 2019 onwards, it means that it is generating power from that day onwards. The other features that are both recorded and displayed are

Figure 8 A net meter

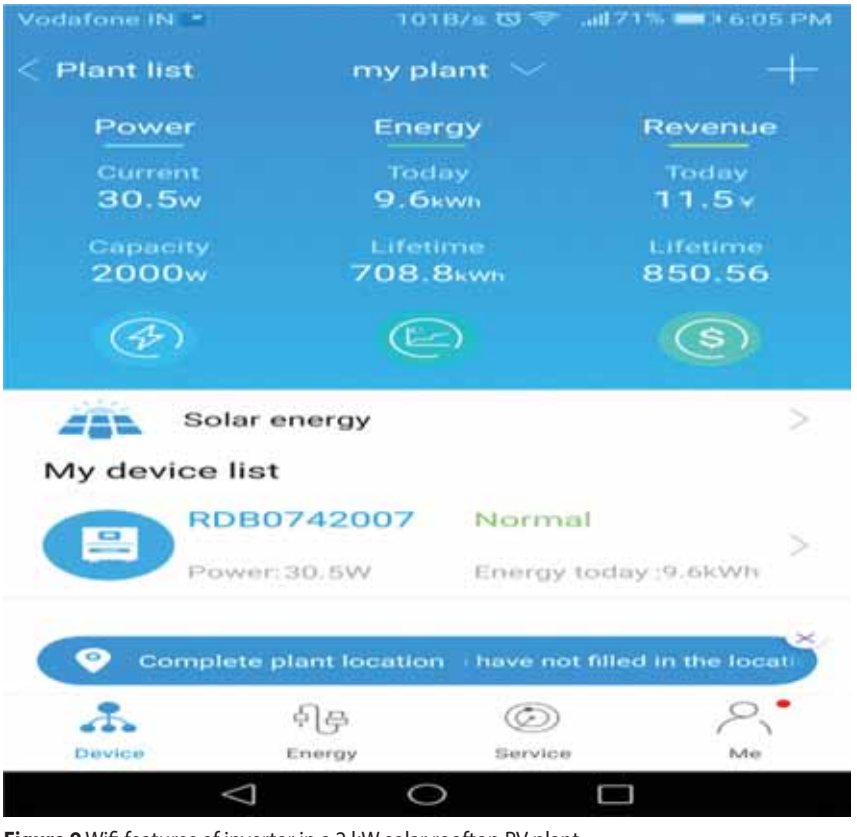


Figure 9 Wifi features of inverter in a 2 kW solar rooftop PV plant

Figure 10 Solar energy produced in the month of January (2019)

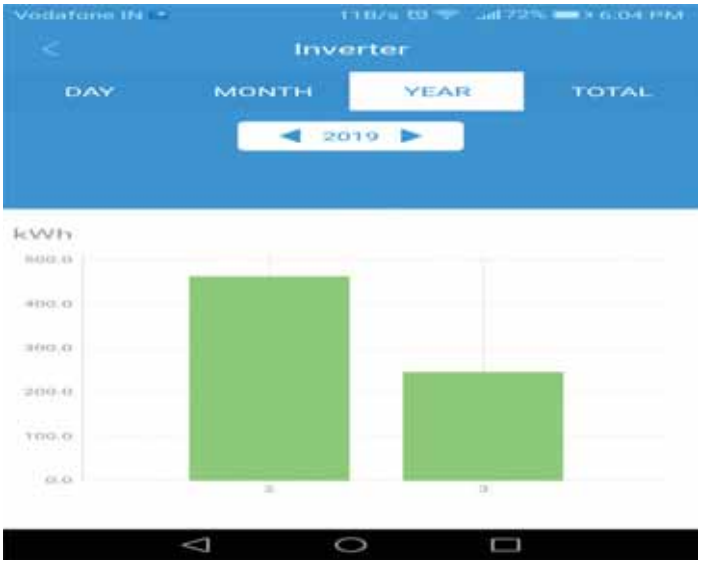


Figure 11 Cumulative solar energy produced for the two months of year 2019

capacity (2000 W), instantaneous power, energy and cumulative energy (708.8 kWh). Solar energy produced in the month of January is shown in Figure 10. The cumulative energy produced is shown in Figure 11. From the figures, it can be inferred that approximately 8 kWh is generated per day. The bill shown in Table 3 confirms that after installation of 2 kW solar rooftop PV plant, the electricity expenses of the consumers get reduced. EF

Dr P Venkatesh, BOYSCAST Fellow
Professor, Department of Electrical and Electronics Engineering, Thiagarajar College of Engineering, Madurai-625 015

Table 3 Bimonthly electricity bill with consumption, including the four months of the year 2019

Assessment Date	Assessment Entry Date	kWAH Reading	kWAH Reading	Maximum Demand	Power Factor	Consumed Unit	CC Charge* (`)
4/16/2019	4/20/2019	1050	1160	3.23	0.91	290	470
2/15/2019	2/10/2019	350	390	2.21	0.02	249	347
12/17/2018	12/19/2018	21750		2.32		610	2456
10/16/2018	10/16/2018	21140		2.54		610	2456
8/15/2018	8/21/2018	20530				780	3578
6/14/2018	6/18/2018	19750			1	880	4238
4/10/2018	4/11/2018	18870	20493	3	0.92	710	3366
2/10/2018	2/10/2018	18160	19715	2.2	0.89	570	2442
12/12/2017	12/13/2017	17590	19067	2.5	0.91	690	3234
10/11/2017	10/11/2017	16900	18307	2.86	0.92	770	3862
8/9/2017	8/10/2017	16130	17473	2.72	0.92	730	3598
6/9/2017	6/10/2017	15400	16683	3.08	0.9	1140	6304

An Imprint of TERI

WHY SHOULD I RECYCLE?

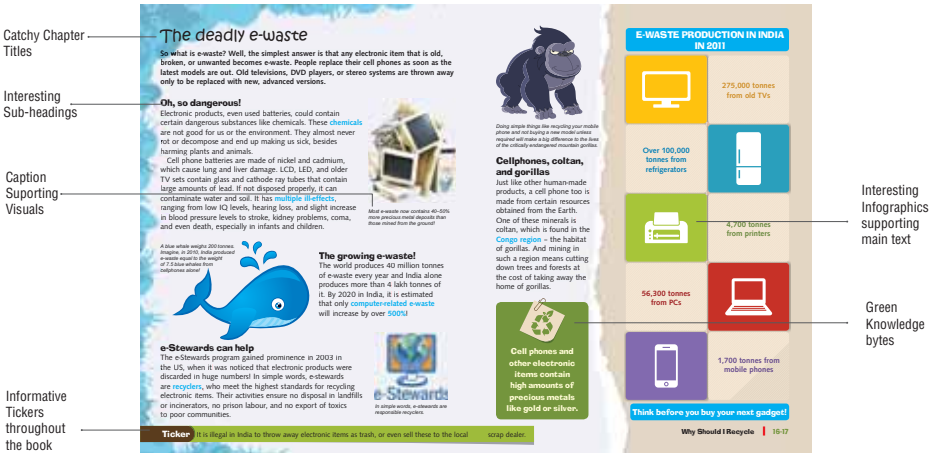
A smart kid's guide to a green world

Aanchal Broca Kumar

Do you know that the amount of waste generated everyday on Earth, in cities alone, is enough to fill a fleet of trucks covering 5,000 kilometres? We have been creating and dumping waste into the environment for far too long. Well, all this waste is destroying the environment and the world we live in. The time has come when we must sit up and make amends. Small and consistent efforts will go a long way in dealing with this mounting issue. *Why Should I Recycle*? helps us understand the principle of Reduce, Reuse, and Recycle to ensure that we play our part in making the world a cleaner, healthier, and better place.

About the Author

Aanchal Broca Kumar has done journalism from Lady Sriram College. She has been writing and editing for the past 10 years and has developed content for many publishing houses, magazines, and newspapers. Her body of work is richly diverse, spanning travel and tourism, health and wellness, and education. Anchal has co-authored two coffee table books and authored six children's books. Also to make learning rich, involving, and fun for children, she has converted many NCERT curriculum chapters into comics.



SPECIFICATIONS Size: 210 × 280mm • 50 pages • Hardback • Ages: 8 years and above • Price: `225.00

For orders and enquiries, please contact:

The Energy and Resources Institute

Attn: TERI Press, Darbari Seth Block, IHC Complex, Lodhi Road, New Delhi – 110 003
Tel.: 24682100/41504900, Fax: 24682144, E-mail: teripress@teri.res.in
Visit the TERI Bookstore at http://bookstore.teriin.org

KNOWLEDGE BOOKS ON ENVIRONMENT, WHICH SUPPLEMENT THE ENVIRONMENT EDUCATION CURRICULUM

Transformation Strategies for Built Environment

Collaborative Efforts of GRIHA Council and Public Works Department, Government of Maharashtra

GRIHA Council[1] and Public Works Department, Government of Maharashtra (PWD, GoM) signed a Memorandum of Understanding (MoU) on December 10, 2018 to envision and mainstream green building practices in the existing government building stock.

PWD-GRIHA Green Building Initiative

The sole objective was to encourage all the government and semi-government buildings to move towards resource efficiency and eventually vet the performance of the building based on the framework developed for rating buildings under the Existing Building (EB) variant of GRIHA – the national green building rating system. Subsequently, an agreement was signed on January 16, 2019 to decode the transformative strategies into robust implementation plan to sustainably retrofit 300 government buildings pan Maharashtra as first phase of the collaborative effort titled 'PWD-GRIHA Green Building Initiative'. The top-down approach espoused in this new partnership has also offered opportunities like training and capacity building of PWD officers at all levels to become GRIHA evaluators and certified professionals and to promote the initiative and its outcome at larger forums and deliberations.

The 10th Regional GRIHA Summit – Commemorating the Success of 1st Phase of the Initiative

The 10th Regional GRIHA Summit in Nagpur, co-created with PWD, GoM, with the theme 'Transformation strategies for built environment' was aligned to focus on rational approaches towards incorporating sustainability initiatives into functional public buildings and to rejoice the successful closure of the first phase of the PWD-GRIHA green building initiative by awarding the final rating to the eligible projects. The day-long summit created an opportunity to embark on multi-stakeholder partnerships served as a platform for knowledge sharing amongst different domains of the green building industry and facilitated networking opportunities amongst over 230 participants representing the government, academia, civil society organizations, architecture, engineering, and the construction management sector.

The event was preceded by a detailed three-day technical training programme and a workshop organized to publicize the benefits of utilizing 'Bamboo' as

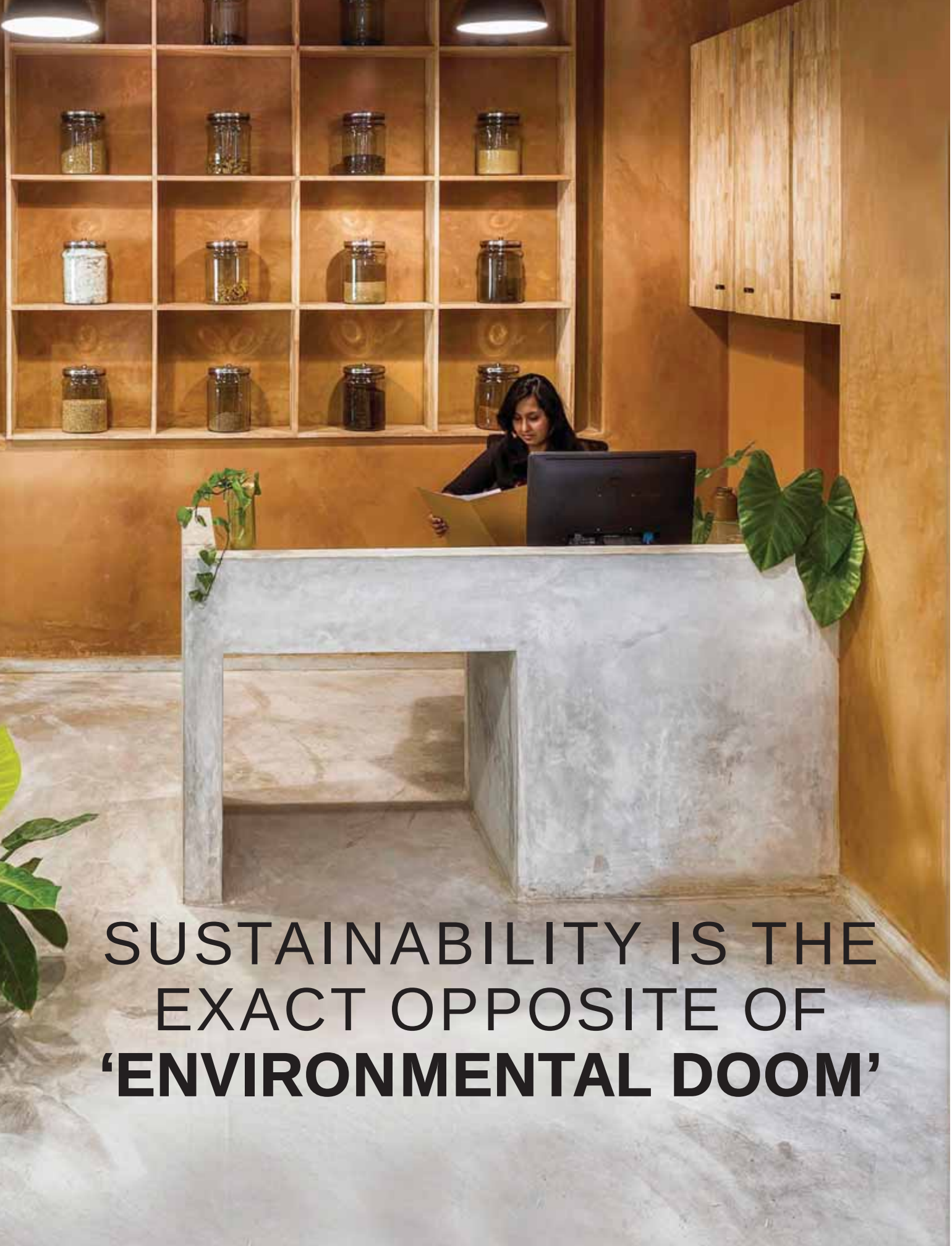
[1] GRIHA Council is an independent, not-for-profit society jointly set up by The Energy and Resources Institute (TERI) and the Ministry of New and Renewable Energy (MNRE), Government of India, to promote and administer GRIHA, the indigenous rating system developed by TERI, which was adopted by MNRE as the national rating system for green buildings in India. The tool measures the performance and environmental impact of a building based on a set of predefined criteria and assigns a rating between one and five stars. GRIHA is a part of the mitigation strategy for combating climate change in India's "Nationally Determined Contributions" submitted to United Nations Framework Convention on Climate Change (UNFCCC) by the Ministry of Environment, Forest and Climate Change, Government of India. More details are available at https://www.grihaindia.org/

an alternative construction material to make green buildings. On June 14, 2019, Shri Nitin Gadkari, Hon'ble Union Minister for Road Transportation and Highways and Minister of Micro, Small and Medium Enterprises, Government of India, inaugurated the summit and presented awards to rated projects and individuals who had displayed exceptional efforts towards the successful completion of the first phase of the initiative. In addition to delivering a powerful address reiterating his commitment towards sustainable development goals, the Hon'ble Minister interacted with students of the Institute of Design Education and Architectural Studies and representatives of product manufactures who had exhibited their work and products as a part of the exhibition set-up. The main event, held on June 15, hosted distinguished representatives of Bureau of Energy Efficiency (BEE), Smart Cities Council of India, Maharashtra Energy Development Agency (MEDA), and the Public Works Department of Maharashtra. Other eminent speakers at the event included representatives from renowned architecture and construction companies and exceptional individuals working towards alternative sustainable materials and technologies.

The summit also witnessed the launch of policy brief, encompassing a set of policy statements framed predominantly for PWD, GoM pertaining to environment-friendly procurement of low volatile organic compound (VOC) materials in building interiors and cleaning and pest control products for housekeeping, purchase of BEE star labelled products and use of low global warming potential refrigerants, insulations and fire retardants, provision of infrastructure at source for waste management and segregation and water performance index for demand and supply side management. The policy brief was an outcome of the experiences and challenges encountered during the implementation of the ongoing 1st phase of the initiative. Additionally, seven Memorandum of Understanding (MoUs) were inked with the Regional Chief Engineers of the seven regions of Maharashtra – Aurangabad, Amravati, Nagpur, Nashik, Konkan, Pune, and Mumbai – to initiate the second phase of the PWD-GRIHA green building initiative. This would include rating of 525 existing government buildings on the parameters of GRIHA EB rating system, along with training and capacity building of PWD officials.

The summit concluded on a positive note, having created the opportunity for individuals representing a diverse spectrum of backgrounds to interact and share ideas on the theme of sustainability. Future commitments were voiced by the Public Works Department, GoM, to further the cause of increasing the green footprint in the state. The event provided a platform for alternative materials and technologies to be showcased and environment- friendly initiatives and policies to be discussed. As volunteers at the event, students of architecture were provided with exposure to the green building industry and were able to present their work to the speakers, participants, and dignitaries at the summit. As a whole, the 10th Regional GRIHA Summit paved the way for greater awareness and impact in the sphere of sustainability. EF

Contributed by Namrata Mahal, Fellow, Sustainable Habitat Division, The Energy and Resources Institute (TERI), Western Regional Center and Manager, GRIHA Council and Shabnam Bassi, Associate Director, Sustainable Habitat Division, TERI and Secretary, GRIHA Council.



SUSTAINABILITY IS THE EXACT OPPOSITE OF **‘ENVIRONMENTAL DOOM’**

An architecture studio and construction practice promoting a type of architecture with lesser environmental impact, Made In Earth emphasizes on creating distinctly contemporary expression with the elements of the earth. The people behind the initiative work with local, natural building materials and techniques, with a taste for experimentation. In their own words, Made In Earth stands for responsible and beautiful architecture that is simple and sensible; created with an understanding of the soil on which it exists; with an exploration of the materials from its place; and in collaboration with the skills and the imagination of its people. The architects behind the wonderfully novel venture, via an email interview with **Anushree Tiwari Sharma**, unravel their version of ecological architecture in a day and age when sustainability is the need of the hour.

Drawing from your team's diverse experiences and insights, we're curious to learn how 'Made in Earth' came into being.

Made In Earth is the collective practice of the four of us, Shruthi Ramakrishna, Jeremie Gaudin, Agnimitra Bachi, and Ajinkya Unhale. With our love for earth at the heart of it all, the studio is driven by our individual strengths and craziness in making buildings with natural materials desirable, durable, and accessible. All of us have followed different paths during our studies, work and volunteer experiences, and something became very clear when we met and started working together; there is nothing else than 'sustainable architecture' for us. We believe that a sustainable approach to creating buildings is no more an option – it is a necessity and also a joy; combine this with the sheer joy of trying to make things as meaningful and natural as possible. Instead of seeing the use of local and natural materials as a limitation to architecture, we look at it as an infinite realm of possibilities.

We like to see our design approach as a dialogue with natural materials, such as clay, lime, wood, straw, and stone. With a taste for experimentation and innovation, our practice is focused on creating contemporary expressions that are both elemental and eco-friendly. While the practice was started 4 years ago, I think the idea of Made In Earth had been brewing in us for quite some time. We officially started the studio in 2015 in Bengaluru. And ever since, much of our work and the way it has evolved has been shaped by this city and its people. We knew that we wanted our work to be rooted in an urban context, and we love the challenges of bringing natural materials closer to people – in our homes, in our schools, into our restaurants and cafes, into our offices and stores, our galleries and fablabs, rendering our traditional techniques to newer aspirations and lifestyles. One of the primary goals of our processes on-site is to build self-confidence in people, in builders, craftsmen, the local community or students. What drives us is to make these techniques both desirable and competitive culturally and economically for our clients and contractors alike.

The team's individual inspirations and motivations behind the idea of 'sustainable architecture' are spelt out in the following paragraphs.

Shruthi: The Auroville Earth Institute introduced me to earth architecture way back in 2008. Our office at the Auroville Earth Institute was a community – living, working, debating, breathing earth, quite literally. Satprem sir's deep dedication and years of his research work with this material is an encyclopedia of inspiration and information for the next generation of architects like us. The most fundamental aspect that I took away from him is that to build with earth, you must really 'know' your material and become friends with it. After my studies, I spent 2 years working in France. It was really through my work there that I understood the full potential of earth as a material, one that renders itself to diverse climates and contexts. Europe is a couple of steps ahead in terms of technological advancements in natural building techniques. With labour being very expensive, Chenelet Construction (where I worked) constantly innovated on traditional building techniques, introducing machinery to make the process faster and adapt it to diverse geographical and social conditions. We worked on public spaces, like schools and bus stops in Earth and wood. We built restaurants together with the unskilled support of local volunteers. We also worked on large-scale social housing projects in Paris, where we



explored the competitiveness of earth with building industry standards in terms of time, durability, and aesthetics. We innovated on the idea of how architecture can be created as a community and not just in the mind of one individual. So many of our building projects, from the design conception to the finishing stage, would be one large workshop! After all of the technology that I had worked with in France, there was a certain eagerness to shape and mould by hand. On returning back to India, I worked for 2 years with the artisans in Kutch. This dual learning, from the remarkable technical intelligences of earth building processes in France to the soulful approach of artisanal practices, culture and skills in Kutch, is today a strong inspiration for the kind of architecture promoted by the Made In Earth studio.

Jeremie: I have been working with various organizations in both India and Europe, always with a proximity to earth, sustainable practices, and entrepreneurship. Through the last decade, there has been so much inspiration from our learnings with the Auroville Earth Institute, the Touraterre Association, and Inventerre team in France, the Oficinas do Convento in Portugal and the rich network of organizations in Kutch like Khamir, Hunnarshala, and Sahjeevan. The hundreds of conversations with the artisans of Kutch really convinced me of the necessity to bring back some soul in our lives, at every level (food, construction, clothing, etc.), and where there is a soul, there is sustainability. I feel Made In Earth was born somewhere along the way and is a continuation of it all.

Ajinkya: Made in Earth is the brainchild of my friends Shruthi and Jeremie. I joined them a few years ago. The idea of working together as a collective is something that always excited us. When I first met Jeremie in Auroville 10 years ago, we discovered that we had similar ideas when it came to the way buildings function and the impact of smart design and right materials on the livability of spaces. There are some realizations that one just can't come back from. Sustainability to me was a sort of obvious solution to a problem that is staring at humanity in the face. The choice of earth or other alternate sustainable building materials was something that came out a very simple and blatant realization of what is good or bad for the environment. I have worked closely with Dharmesh Jadeja and Dhruv Bhasker at Dustudio in Auroville for 4 years where I was involved in the revival and re-adaption of both traditional and modern building systems to bring about a change in the way we perceive and experience our buildings. Our practice at Made In Earth today is informed strongly by these concerns.

Agnimitra: Of the three others, I am the relative stranger. While the others knew each other from their college days, I was to meet them on one of the first few workshops they organized. It was a workshop set in the Tiruvannamalai hills, at the edge of a forest, where volunteers from all over had poured in to build a forest school. It was here that I first experienced building with earth. In the two weeks together, we moulded bricks, mixed mortar, and built a forest school! The tactility and nuances of the material caught my imagination. Knee deep in a pit of earth mortar, I realized that there was no looking back. On returning to Bengaluru, Jeremie, Shruthi, and I were to realize how in sync our ideology and aspirations were. Over weeks of conversation, we built rapport so strong that it still seems too good to be true.

The collective: Our studio is the coming together of all our individual perspectives and aspirations that go into the making of a building. Being a small firm, each of us bag an array of responsibilities. While

most decisions are taken collectively, we do play on our individual strengths to handle different aspects of our work.

Equipped with an intuitive understanding of earth, Shruthi has a deep love for good design. She draws from her experiences of working as an illustrator, her experiences in working with textile and traditional art, and her thirst for innovation. She works closely with Ajinkya in the initial concept development of projects.

Ajinkya, who has worked closely in the building industry, has pragmatism as a strong suite. His knowledge on conventions and understanding of feasibility clubbed with his keen eye for details help him translate and resolve design into beautiful buildings that we strive to create everyday.

Jeremie has both an intrinsic and an empirical understanding of materiality. He loves exploring and is on the constant move to innovate and research new materials and techniques. The office regularly produces batches of new blocks, a variety of lime plasters, and much more under his guidance. Having been educated as an urban systems engineer, he is keen not only in setting up of processes and protocols for the site, but also works on the internal organization of the office.

Agnimitra's passion for natural materials bleeds into our building sites! He is the choreographer who brings together all the teams and the techniques we explore to ultimately translate a drawing into reality. His patience, humour, and care for others are essential to keep a good spirit and atmosphere on site and with the people we work with.

What have been the challenges in your quest towards accessing and optimally utilizing natural building materials and techniques?

There are several aspects to building with natural materials today, from working with clients who may not have been exposed to these techniques and materials to pursuing teams for the execution of the building.

Perhaps owing to the firm belief that a choice towards a more sustainable lifestyle cannot be imposed, we have only worked with clients who already had the urge to take a step towards a more sustainable environment. We have never taken on the task of convincing anybody about building with eco-friendly materials. It should be a desire that stems from a deeper understanding of sustainability. When our clients come to us, they do not necessarily understand how the idea of sustainability translates into a building, and so we usually take them through the different techniques, methodologies, and details of earth construction to build their capacity to understand, appreciate, and trust the material. However, fundamentally they come when they have already made the choice to move towards a sustainable lifestyle.

The relationship with a client who is in sync with these values acts as a central tenet around which we can work and implement our ideas on sustainability and earth.

Earth is often associated with a rural typology and a rustic aesthetic, but it is not limited to that. Through our work, we are constantly trying to innovate and engineer to create freshness to the way

earth buildings look and function. This is a continuous challenge.

Over the years of building with natural materials and alternative techniques, we have noticed that sources of basic materials, such as lime and linseed oil, are vanishing and the market is filled with more convenient, but more energy intensive, commercial replacements for each of these. Moving away from these readily available and trending solutions available in the market towards more traditional or alternatively engineered solutions is met with little resistance.

Additionally, as the years pass, the last generation of the masons who were traditionally trained in local building practices was on the verge of retirement. They are giving way to the 'cement and steel' generation of masons.

There is a need to reintroduce these techniques to the workforce and build their trust of the material and techniques by spending more time on site, training, interacting, and educating a workforce to execute the project. During this process, there is an inevitable knowledge exchange, empowerment, and an active dialogue about building practices with the team. It is always a more rewarding experience than a challenging one.

Tell us about your ecological building techniques and their use in your projects.

There are a large variety of natural building techniques available to us today. It is the assimilation of knowledge and reimagining of many traditional techniques that are engineered to suit the requirement of a project. The choice of the technique we use is dependent on many factors ranging from locally available materials, availability of manpower and skill, feasibility in the given project, budget, appropriateness of the technique to the building, aesthetic consideration, etc.

Rammed earth: The worldwide tradition of rammed earth construction has shown that it is possible to achieve

strong majestic buildings that have withstood the test of time. The grandeur of rammed earth has been expressed historically in houses, forts, and palaces; even the Great Wall of China is largely built in earth! Rammed earth is a load bearing technique where earth is compacted in successive layers within a formwork. It is rammed by hand or with a pneumatic rammer between wood and steel shuttering. The shuttering is moved up and the process is continued until the full wall height is achieved, giving it a strong monolithic character. Rammed earth architecture has deep roots in countries such as France, South America, Spain, Morocco, China, and all over the Himalayan area, where it has proved to be a durable construction material. The earth mix is slightly moistened, mixed with aggregate or used in its raw form if the right proportions naturally exist. Sturdy metal or wooden formwork is used for the sides and the ends of the wall. The mix is poured into formwork in thin layers and then rammed to increase its density. The increase of density increases the compressive strength and its water resistance.

Adobes: The tradition of making sun dried raw earth bricks, popularly known as adobes, goes back to the beginning of human society. Adobe is versatile and viable. Adobe buildings can be found across continents where these have been spontaneously and continuously adapted by people of different cultures for housing as well as monumental structures. Traditionally, adobes were shaped by hand using a raw clay-rich subsoil, aggregate and sometimes fibre/cow dung in a wooden mould. Recently, the use of machines for moulding is more widespread. After moulding, the bricks are laid out in the sun to dry. Sun dried adobes are laid in bonded courses to build a wall with either a mud or lime mortar. The wall is then usually lime plastered for waterproofing as it is an unstabilized technique. Adobe bricks are generally made on site so that transportation costs are minimal. The

masonry does not require much skill. Domes and vaults are easily constructed with adobe.

CSEB: A mix that is similar to that used in rammed earth with little or no moisture is filled into a press. The press is either mechanized or manually operated, compressing the earth and producing a block. These blocks have to be stacked in air and are allowed to dry. If stabilized, they are watered and allowed to cure. Walls are constructed with simple masonry bonding and usually exposed as CSEB are somewhat water resistant. However, a good foundation and overhang are necessary details.

Wattle and daub: A traditional walling system with a history of 6000 years, wattle and daub is a composite wall building technique using tightly woven wooden sticks or split bamboo. The wattle and daub is composed of tightly woven sticks or cane set within a framed panel. This lattice is then coated with a daub mixture, a thick clay-rich subsoil mixed with chopped straw or hair and sometimes animal dung for extra weather resistance and durability. This is squeezed into and placed between the sticks. The daub can either be finished with a lime wash or coated in a lime plaster/earth render for extra protection. Wattle and daub is a comparatively lighter structure that is flexible to use for both exterior and interior partition walls. This technique has been traditionally used for the first floor of homes in high seismic zones.

Natural plasters: A natural plaster refers to a wall plaster that is made using natural or minimally processed materials such as clay and lime. Many traditional building systems use plasters to cover the walls and protect them from the weather, mechanical damage, etc. Hundreds of plaster techniques have been traditionally developed across the world to match the tastes and requirements of its regions. Natural plasters are made by mixing carefully proportioned raw materials, such as clay, lime, and stone dust. Additives are then added for colour and sometimes to enhance certain properties of the plaster, such as thermal mass, texture, water repellency, hardness, plasticity, and glaze.

Considering that the world is headed towards environmental doom, do you agree that 'sustainability is the saviour'? If yes, in what way do you incorporate 'sustainability' in your work?

We understand the word 'sustainable' to be the exact opposite of 'environmental doom'. Broadly speaking, 'to sustain' would imply the careful use of our planet's limited resources and in a way that suffices the needs for a growing number of people.

The building industry is today one of the most energy-intensive industries. The logistical and material energy quotient of most buildings depends on

the architectural choice, placing a huge responsibility on architects to design with and use materials that are not energy intensive in their processing and to use materials that are available close by to reduce energy footprints.

Apart from the energy use of each material and technique, we believe it is important to acknowledge that one cannot buy sustainability as a product. It is not just limited to choosing the right technique or material. Sustainability extends into a lifestyle. Increased awareness of the choices that people make on an everyday basis is perhaps the only true way of approaching this – awareness of the extent of damage we are causing to our planet, awareness of the solution, and most importantly, awareness of the alternatives available.

Having said that, neither do we need to believe that to be sustainable one needs to be frugal, nor do we need to live sustainability as a task. Within the realm of alternatives, there are choices that can be celebrated, ranging from exquisite artisanal plastering techniques of Morocco to the more modest in-built cob furniture. Once there is conviction and the desire to be sustainable, we believe only your imagination and innovation will limit your expression in architecture.

Within Made In Earth, we have a habit of questioning every choice from the ground up, be it in systems and protocols followed on site or in building techniques and materials. It is essential to question the architectural norms that have been set over the years, to be more frugal in our energy consumptions, to be more modest in our waste generation, to be more innovative in our interpretation of tradition, and to have an outcome that makes natural materials more desirable and more mainstream.

Will it be right to say that your work is a merger between the earth (and its materials) and your imagination?
When we start drawing a new project, we ask ourselves a fundamental question: What is the most ecological way to make this happen? And design making is a process of answering this question. In many of our conversations, we always mention that earth is our fifth partner. In any design, earth as a material influences the design as much as any of those involved in the design. You see, you cannot force earth to be anything you want it to be, it already wants to be something.

While designing with natural materials, we believe that it is extremely important to know the intricacies of the material, insofar as an understanding of the properties of each material best suited for the specific functions and what property can be exploited to achieve the desired results. This is best illustrated through an example. Plasters are one of the most dynamic and interesting alternative building techniques we use. Let us for the sake of discussion assume that we want to use natural plaster in the dining area on a western wall. We will immediately have to consider both its aesthetic value addition and its functional value addition. But the choices are immense and we could use either a lime or clay plaster. Clay has a wonderful ability to regulate moisture and even control odours. We could use natural ochres or other pigments to render it the colour we want. One could meddle with the thermal mass of the wall by increasing its thickness, and this could be done using natural fibres such as rice husk or cut straw. Again we find the property of the plaster changing; if there is rice husk in the clay plaster, it makes it incredibly mouldable and can accommodate relief patterns and designs. It could be roughed off with a sponge to make it

prickly or smooth with the strokes of a metal float. It could be oiled to make waterproof or stain resistant. We could probably even add essential oils to make it smell sweet! So as long as you understand what each ingredient does and what possibilities lie in store, the possibilities are endless.

There are two fundamental directions that drive our studio. First, you must really 'know' your material and become friends with it. We are constantly experimenting with new materials and new techniques, especially with earth. For example, all of the natural finishes we propose for our projects go through an intensive sampling process. Second, you must get your hands dirty. Our work connects us intensely to our medium. The process of moulding with one's hands requires a strong understanding of the material and a deliberate intention for its use. We often dive into the construction site ourselves, both to try out new techniques and to train our mason teams. Both these directions feed into our design process, allowing us to constantly revise and reinterpret materials and techniques and personalize our projects.

We're happy to share that clay and lime bind our studio together, and quite literally so! Additionally, we often bring wood, stone, fly ash, straw, rice rusk, and thatch into our projects. We love to combine these materials together with concrete, steel, glass and ceramics. There is a place for all of these materials, and when applied with imagination, and in the right context, they come together to create an architecture that is both responsible and beautiful.

Please tell us about your experience of working and learning from the local artisans in Kutch, Gujarat.

Shruthi: Working together with them made me realize that their world is a more honest, simpler, and a happier one. It is a world driven by culture, environment, and tradition and it leaves a tiny footprint on the planet. And especially to an urban person like me, the poetry of it all speaks to everything that I wished to be, but I am uneasily aware that I am not. We question ourselves constantly; why, what, where, and how? How do we make this more exciting, more interesting, and more meaningful? But the artisans, they just do it. They don't ask themselves questions. Their craft is in their heart and in their habit.

One day when I was working with a textile block print artisan, I asked him about the price of a really beautiful piece of cloth lying in his workshop. "Price? I don't know about price my dear. All I know is that one afternoon, I was dyeing this piece when they served me chai. I asked them to leave it by my side. I was so consumed in my work that a couple of minutes later, I drank the small pot of dyed water instead! I cannot put a price on it. I put my soul in it." The artisans made me take a step back from a 'product' and take time to understand a 'process'. And that is what I am trying to bring into my work today.

We would love to know about some of your projects and their architectural intricacies.

In the realm of building with natural techniques and materials, there exists a closer bond between the drawing board and the site. This relationship has always resulted in a bounty of memories and anecdotes.

Of the early projects, the Cuckoo Forest School stands out in many ways. It was the coming together of more than thirty people for 15 days to build a library for the Cuckoo Forest School located in Tiruvannamalai. Being out of range of cellular network, away from the din of the city, being at the edge of a reserve forest and in the laps of the Javadi hills were just the base of what was to be a magical experience. The group was an eclectic mix of people from the software industry, designers, farmers, journalists, artists, architects, and many more. The group was to stay on the then barren farm, set up the first of the shelters for the volunteers to stay in, and proceed to design and build a small library structure with earth. The days of hard labour while the group built, the music, dance and theatre of the nights, sleeping in the open and waiting for the full moon to rise behind the hills were experiences that pulled the group closer in more ways than one. It was another beginning of a conversation with earth and the communities that we would engage with. It was an experience that served as a compass and guided us through the next stretch of winding roads through the world of earth architecture.

We have been fortunate to have clients

whose outlook and aspirations match ours to a large extent. While trying to match our aesthetics and spatial ideas with our clients is one small part of the design process, it is essential that our clients resonate our building and material values and ethics. In this regard, the design process for the college campus of the Samvada Baduku Community College stands distinctly in our memories. Samvada is a non-governmental organization that works with disadvantaged youth to help sensitize and empower them. The site is set on a beautiful hillock a few kilometres off Kanakapura Road. Through the many interactions with their team about the design and strategy of handling the project, it became evident that not only were they sensitive to the environmental and economical impacts of the project, but they were also keen to address social, health, and welfare aspects at the building site and construction process. While this encouraged and boosted our spirits, it also helped create avenues and opportunities for our design and site teams to address issues from the very beginning of the process. The relationship with a client who is in sync with our beliefs and values acts as a central tenet around which we can work and implement our ideas on sustainability and earth. (This is an ongoing project of which the construction has just begun.)

We are very thankful to all the people who have given us the opportunity to explore the possibilities of sustainable architecture and construction with them. One of our big projects at the moment is the Samvada College Campus (Samvada Baduku Community College, mentioned earlier). Apart from designing an office for a real estate developer, re-modelling a restaurant in an old bungalow, and a mixed use commercial building in the heart of the city, we are also working on a handful of private residences.

We look forward to building more and more public spaces, schools, colleges, hospitals, etc., as landmarks for people to discover these alternatives as a viable and desirable option for all. We hope to become a vector for reinforcing and nurturing the bold future of earth in architecture in India.

What has been your experience with organizing hands-on workshops and training for interested individuals and institutions?

Over the last 4 years, we have had the opportunity to host a variety of workshops with different groups, ranging from full design and build workshops to ones centred around just the possibilities with different natural building techniques.

Hands-on workshops, in essence, serve as an educational extension for architects. It allows for them to work with a material on their own terms and develop an understanding and hence a relationship with it. Be it natural or manufactured building materials, we believe it is crucial for architects to develop a strong bond with a material to intimately understand what it is capable or not capable of. In our workshops, we try and give the participants both the information required and also the space for them to engage physically with the material and building technique.

The workshops also serve as a platform for people with similar interests and beliefs in building practices to meet. Over the years, we have made great friends and alliances with people who have participated in our workshops. Each person interprets and understands the material in their own way. Watching people discover a new material and its wondrous qualities is an enriching and rewarding experience in many ways. EF

teri PERIODICALS

Bundle Offer Rs.12,200/-

TERI Information Digest on Energy and Environment*

TIDEE aims to keep policy-makers, scientists, and technologists abreast of the latest developments in the fields of energy, local and global environment, and sustainable development. More than 600 periodicals, several hundred other documents, indexing services and other electronic resources, such as CD-ROMs, World Wide Web, discussion groups, and mailing list, are scanned.

Editor: Dr. P K Bhattacharya, TERI, New Delhi
Frequency: Quarterly (4 issues per year—March, June, September, and December) • **Print ISSN:** 0972-6721 • **Online ISSN:** 0975-7589
Subscription rate: **Print –** `2300/$203 • **Online – Free**

World Digital Libraries: An International Journal

WDL is an international peer-reviewed biannual journal. It publishes quality research papers that present original theoretical approaches. It also publishes experimental case studies related to digital library developments and maintenance, and disseminates digital information focusing on research and integration of knowledge at the interface of resources and development.

Editor: Dr. P K Bhattacharya, TERI, New Delhi
Frequency: Bi-annual (2 issues per year—June and December) • **Print ISSN:** 0974-567-X • **Online ISSN:** 0975-7597
Subscription rate: **Print –** `1700/$191 • **Online – Free**

Journal of Resources, Energy, and Development*

JREaD focuses on research and integration of knowledge at the interface between resources and development. It provides a forum for comprehensive investigation, analysis, and review of issues in the fields of energy, environment, and natural resource management that confront decision-makers, planners, consultants, politicians, and researchers. It deals with theoretical and methodological subjects and explores sustainability issues and transitions and facilitates dialogue between the scientific community and the society at large.

Editor: Dr Nandini Kumar, TERI University, New Delhi
Frequency: Bi-annual (2 issues per year—March and September) • **Print ISSN:** 0975-7554 • **Online ISSN:** 0975-7562
Subscription rate: **Print –** `2100/$232 • **Online - Free**

Asian Journal of Water, Environment and Pollution*

Primarily due to high population density, many regions of the continent face severe problems of water pollution on local as well as regional scales and these have to be tackled with a pan-Asian approach. However, the available literature on the subject is generally based on research done in Europe and North America. Therefore, there is an urgent and strong need for an Asian journal with its focus on the region and wherein the region specific problems are addressed in an intelligent manner.

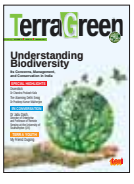
Exclusive distribution

Editor: Dr. V Subramanian, Jawaharlal Nehru University, New Delhi
Frequency: Quarterly (4 Issues per year—January, April, July, and October) • **Print ISSN:** 0972-9860
Subscription rate: **Print –** `4000 (Within India)

Mycorrhiza News

Mycorrhiza News provides a forum for the dissemination of scientific information on mycorrhiza research and activities; publishes state-of-the-art papers from eminent scientists; notes on important breakthroughs; provides brief accounts of new approaches and techniques; publishes papers compiled from its RIZA database; provides information on forthcoming events on mycorrhiza and related subjects; lists important research references published during the quarter; and highlights the activities of the Centre for Mycorrhizal Culture Collection.

Editor: Dr. Alok Adholeya, TERI, New Delhi.
Frequency: Quarterly (4 Issues per year—April, July, October, and January) • **Print ISSN:** 0970-695X
Subscription rate: **Print –** `500/$119 • **Online – Free**



TerraGreen

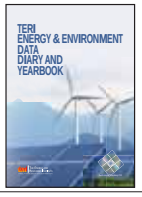
TerraGreen is India's most respected monthly magazine dedicated to informing and enlightening its readers on issues of environment, energy, and sustainable development. Launched in 2004, *TerraGreen* has made an indelible impression on the minds of readers, both in India and across the world. Today, it enjoys a readership of over 40,000 and a subscriber base of close to 10,000.

Frequency: Monthly (12 issues per year) **Print ISSN:** 0974-5688
Subscription rate: **Print –** `720/$122
Free online access to those subscribing for three years.

Energy Future

Energy Future draws from a deep well of expertise at TERI, 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.

Frequency: Quarterly (4 Issues per year) **Print ISSN:** 2278-7186
Subscription rate: **Print –** `800/$80 • **Online – Free**



TERI Energy & Environment Data Diary and Yearbook

(with complimentary CD) *A TERI Publication*

TERI Energy & Environment Data Diary and Yearbook, or *TEDDY*, is an annual publication brought out by TERI since 1986. *TEDDY* is often used as a reference in other peer-reviewed books and journals for energy and environment-related data. It gives an annual overview of the developments in the energy supplying and consuming sectors as well as the environment sector. It also provides a review of the government policies that have implications for these sectors of the Indian economy.

402 pages • Hardback • 220mm × 280mm • `1995/$129

* For subscriptions outside India, please contact: IOS Press Tel. +31 20 6883355 Nieuwe Hemweg 6B, 1013BG, The Netherlands
E-mail: order@iospress.nl,

The Energy and Resources Institute
Attn: TERI Press
Darbari Seth Block
IHC Complex, Lodhi Road
New Delhi – 110 003 / India

Tel. 2468 2100 or 4150 4900
Fax: 2468 2144 or 2468 2145
India +91 • Delhi (0)11
Email: teripress@teri.res.in
Web: http://bookstore.teri.res.in

To purchase online visit us at http://bookstore.teri.res.in or send us your demand draft or cheque in favour of TERI, payable at New Delhi.

CURRENT R&D RENEWABLE

Net-zero Energy Design and Energy Sharing Potential of Retail – Greenhouse Complex

Journal of Building Engineering, Volume 24, July 2019, 100736

Ali Muslim Syed and Caroline Hachem

The global projection of urban growth and increasing population densification creates new opportunities for an expanded role of greenhouse technology. Coupling a greenhouse with supermarket, as a method for energy sharing, has been identified as a promising method to increasing efficiency of the building operations while reducing dependency on transportation. This paper presents the results of a simulation study of an urban centric greenhouse-retail complex and explores optimal building design parameters, integrating renewable energy technologies and exploring energy sharing strategies within both buildings of the complex. The results show that with an integrated building design approach, cutting-edge technologies and high energy efficiency measures, a net reduction of 27% energy in the greenhouse-retail complex is achieved compared to design complying with the minimum requirement of the applicable energy codes. Additionally, by sharing waste heat recovered from retail refrigeration compressor racks, 21% of space and ventilation heating demand of the greenhouse and energy demand for irrigation water and service hot water for the complex can be met. By employing on-site renewable energy generation, net-zero energy performance of the greenhouse-retail complex can be achieved. It has been found that by feasible combination of buildings optimized to harness on-site energy and sharing energy between the individual buildings, dependence on utility grids can be reduced, in addition to having a local source of food growth for climate change resilient urban infrastructure. EF

Attaining the High-energy Orbit of Nonlinear Energy Harvesters by Load Perturbation

Energy Conversion and Management, Volume 192, 15 July 2019, Pages 30–36

Jiahua Wang and Wei-Hsin Liao

Energy harvesters, especially nonlinear systems with broad bandwidth, have made it possible for devices in IoT (Internet of Things) to extract energy from the ambient environment. However, due to the multi-stability feature of the nonlinear system, high and low energy orbits coexist in the system. It is critical to control the multi-stability so as to obtain high energy output. This paper proposes the load perturbation method to attain the high-energy orbit of nonlinear energy harvesters. Based on the electromechanical model, investigating the electrical load effects on the system shows that varying load results in different system states, which suggests that the load perturbation may trigger the transformation of system states. Therefore, a load perturbation by disconnecting the electrical load is employed to attain the high-energy orbit. Simulation and experiments reveal that the load perturbation can stimulate high-energy orbit oscillation for both monostable and bistable systems. The power output can be amplified for multifold times. The perturbation requires only one switch without additional mechanical structures. Furthermore, this method consumes little energy, and so no external electrical energy source is needed. The load perturbation method opens opportunities for wide applications of nonlinear energy harvesters. EF

The Role of Renewable Energy in the Global Energy Transformation

Energy Strategy Reviews, Volume 24, April 2019, Pages 38–50

Dolf Gielen, Francisco Boshell, Deger Saygin, Morgan D Bazilian, Nicholas Wagner, and Ricardo Gorini

This paper explores the technical and economic characteristics of an accelerated energy transition to 2050, using new datasets for renewable energy. The analysis indicates that energy efficiency and renewable energy technologies are the core elements of that transition, and their synergies are likewise important. Favourable economics, ubiquitous resources, scalable technology, and significant socio-economic benefits

underpin such a transition. Renewable energy can supply two-thirds of the total global energy demand and contribute to the bulk of the greenhouse gas emissions reduction that is needed between now and 2050 for limiting average global surface temperature increase below 2 °C. Enabling policy and regulatory frameworks will need to be adjusted to mobilize the sixfold acceleration of renewables growth that is needed, with the highest growth estimated for wind and solar PV technologies, complemented by a high level of energy efficiency. Still, to ensure the eventual elimination of carbon dioxide emissions will require new technology and innovation, notably for the transport and manufacturing sectors, which remain largely ignored in the international debate. More attention is needed for emerging infrastructure issues such as charging infrastructure and other sector coupling implications. EF

Energy from Closed Mines: Underground Energy Storage and Geothermal Applications

Renewable and Sustainable Energy Reviews, Volume 108, July 2019, Pages 498–512
Javier Menéndez, Almudena Ordóñez, Rodrigo Álvarez, and Jorge Loredo

In the current energy transition, there is a growing global market for innovative ways to generate clean energy. Storage technologies are potential and flexible solutions to deal with the intermittent nature of renewable resources. Closed mines can be used for the implementation of plants of energy generation with low environmental impact. This paper explores the use of abandoned mines for Underground Pumped Hydroelectric Energy Storage (UPHES), Compressed Air Energy Storage (CAES) plants and geothermal applications. A case study is presented in which the three uses are combined in just one mine. This preliminary study allows estimating an electrical energy generation of 153 and 197 GWh $year^{-1}$ at the UPHES and CAES systems, respectively, and a thermal energy generation of 0.41 GWh $year^{-1}$ at the geothermal system, with a total cost of 358 M€. An underground closed mine can be used to store energy for re-use and also for geothermal energy generation, providing competitive renewable energy with a low CO_2 footprint. These initiatives aid to ensure sustainable economic development of communities after mine closure. EF

Optimal Design of Renewable Energy Solution Sets for Net Zero Energy Buildings

Energy, Volume 179, 15 July 2019, Pages 1155–1175
Fatima Harkouss, Farouk Fardoun, and Pascal Henry Biwole

Net-zero energy buildings (NZEBs) have been considered as an efficient solution to limit the growing energy consumption and pollution emissions from buildings. The configurations and the capacities of the implemented renewable energy systems in NZEBs should be wisely selected to ensure the intended performance objective. This study aims to optimize, investigate, and compare six renewable energy solution sets for designing NZEBs in three different climates: Indore (cooling dominant), Tromso (heating dominant), and Beijing (mixed climate). The optimization is carried out using a multi-criteria decision-making methodology. The implemented methodology is composed of two phases. In the first phase, the optimal sizes of solution sets in each climate are derived and analysed. The effectiveness of optimal solution sets is evaluated with respect to economy, environment, energy, and grid stress. In the second phase, recommendations for each region are offered according to the overall performance evaluation results. The evaluation criteria include life cycle cost, payback period, levelized cost of energy, CO_2eq emissions, grid interaction index, load matching index, and total energy consumption. The analyses show that in Indore (hot climate), it is recommended to utilize the solution set composed of air source heat pump for cooling and flat plate solar collectors for domestic hot water (DHW) production. In Tromso (cold climate), the use of a biodiesel generator is promising to produce both electricity and hot steam for heating as well as DHW use. In Beijing (mixed climate), it is recommended to utilize electric chillers for cooling and natural gas condensing boiler for heating and DHW usage. EF

Renewable Energy Injustice: The Socio-environmental Implications of Renewable Energy Consumption

Energy Research & Social Science, Volume 56, October 2019, 101214

Julius Alexander McGee and Patrick Trent Greiner

The paper explores how national income inequality moderates the relationship between renewable energy consumption and CO_2 emissions per capita for a sample of 175 nations from 1990 to 2014. The researchers find that, independent of income inequality and other drivers of emissions, increases in renewable energy consumption reduce emissions. However, when national income inequality is considered, they find that as inequality increases renewable energy consumption is associated with a much larger decrease in emissions. They also find that when fossil fuel energy is controlled for, inequality does not significantly moderate the association between renewable energy and emissions. These results suggest that fossil fuel consumption is the main vector through which inequality moderates the relationship between renewable energy and emissions. Drawing on previous work from energy poverty scholars, the researchers theorize that national inequality influences the way renewables are deployed. Specifically, their findings suggest that renewable energy displaces more fossil fuel energy sources when inequality is increasing, while – conversely – fewer existing fossil fuel energy sources are displaced when inequality is decreasing. In additional analyses, they find that as the top 20% of income earners' share of income grows, the association between renewable energy consumption and emissions decreases in magnitude. They conclude by arguing that efforts aimed at increasing renewable energy consumption should adopt policies that ensure the effective displacement of fossil fuels and reduce inequality. EF

Co-simulation and Optimization of Building Geometry and Multi-energy Systems: Interdependencies in Energy Supply, Energy Demand and Solar Potentials

Applied Energy, Volume 242, 15 May 2019, Pages 1661–1682

Christoph Waibel, Ralph Evins, and Jan Carmeliet

This paper presents a co-simulation framework for the simultaneous optimization of building geometries and multi-energy systems using the energy hub approach. The rationale for such coupling is that building geometry has an impact on energy demands and solar potentials on roofs and façades, thus also altering the corresponding optimal energy system. As a demonstration of this approach, the researchers formulate bi-objective optimization problems for minimizing operational cost and carbon emissions, with decision variables for building geometry and for selection and sizing of energy system technologies. The methodology is applied to a case study in the city of Zurich, Switzerland, involving four office buildings. Different carbon emissions targets are studied to show the impact on cost, densities, sizing of the multi-energy system, and architectural design implications. Results for this case study show a clear relation between emissions targets and densities due to available solar potentials for renewable energy generation, with an optimal density in the strictest emissions target reaching only 10% of the optimal density without emissions target. This indicates that differentiated environmental targets should be defined depending on the location of a building, where rural sites could have stricter targets than dense urban sites to reflect the respective marginal costs for achieving the targets. This study shows that coupling multiple simulators into a common optimization and design workflow brings together architectural aspects, such as geometry, with engineering aspects, such as the energy system design, and microclimate conditions, such as local solar potentials. Thus, essential interdependencies between the energy supply and demand side can be captured in the design of energy efficient cities. EF

Women's Leadership in Renewable Transformation, Energy Justice and Energy Democracy: Redistributing Power

Energy Research & Social Science, Volume 57, November 2019, Pages 101–233

Elizabeth Allen, Hannah Lyons, and Jennie C Stephens

As women take on more leadership roles in the United States advancing social and political change, analysis of women's contributions to the transformation occurring within the energy sector is critically important. Grassroots movements focused on energy justice and energy democracy focus on: (1) resisting the power of large multinational fossil fuel energy companies that exacerbate inequities and disparities in energy, (2) reclaiming the energy sector with more community and public control to redistribute benefits and risks, and (3) restructuring the energy sector to prioritize equity and justice with

community ownership and distributed governance. This research analyses women's leadership by focusing on how two women-led, non-profit organizations are advancing the renewable energy transition, operationalizing the concept of energy democracy and contributing to the energy justice movement. The two organizations are Grid Alternatives, a solar installation and workforce training organization, and Mothers Out Front, an advocacy organization focused on addressing climate change by promoting a transition to renewable energy. These organizations differ in their mission and approaches, yet both intentionally link climate and energy action with other forms of social justice activism, by expanding community engagement, strengthening participation, and fundamentally redistributing power to promote a transition to more equitable, resilient, and sustainable energy systems. This paper contributes to the theoretical understanding of gender in energy justice and energy democracy movements, and to the practical consideration of the role that women's leadership is playing in accelerating energy system change and advancing the principles of energy justice and energy democracy. EF

Ecosystem Maintenance Energy and the Need for a Green EROI

Energy Policy, Volume 131, August 2019, Pages 229–234
Patrick Moriarty and Damon Honnery

A number of official energy forecasts—including those compatible with the aspirational 1.5 °C Paris Accord global temperature rise limit—see both global primary and net energy use continuing to rise, even out to 2100. Various technologies, including greatly increased use of renewable and nuclear energy, negative emission technologies such as direct air capture, and geoengineering are proposed as approaches for meeting the 1.5 °C target. In contrast, this paper argues that meeting this target and avoiding significant increases in extreme weather events will require marked reductions in future energy demand. The researchers argue that the combined fossil fuel and renewable net green energy production will fall in the coming decades, after subtraction of various energy costs essential for ecosystems maintenance, including those needed to stabilise climate. At best, nuclear energy will only fractionally increase its global energy share, because of its high capital costs and political opposition arising from accident risks, waste disposal, and proliferation concerns. Geoengineering will not solve fossil fuel depletion and has serious known—and perhaps unknown—risks. They conclude that global net energy produced in an ecologically sustainable manner will start falling in a decade or so and suggest the need to account for this at a policy level by introduction of a green EROI—EROIg. EF

Unveiling the Heterogeneous Effect of Energy Taxes and Income on Residential Energy Consumption

Energy Policy, Volume 129, June 2019, Pages 13–22
Djula Borozan

The paper investigates the effect of energy taxes in the European Union (EU) across different levels of residential final energy consumption (RFEC) in the period 2005–2016. The analysis is based on quantile panel regression models that directly and indirectly consider energy taxes. More precisely, the developed models provide a multivariate framework for evaluating their effects and, at the same time, for validating the existence of the energy environmental Kuznets curve (EKC) across the selected quantiles.
The results unveil significant heterogeneity in the RFEC responses across quantiles. Specifically, in less energy-consuming EU countries, an increase in energy taxes and energy prices influences stronger RFEC, and the rebound effect of real income and tertiary education is greater than in their more energy-consuming peers. Moreover, in the former, the energy EKC hypothesis holds, while in the latter its existence is not clear, as well as the rebound effect caused by highly educated people. Consequently, EU energy policy aiming at achieving energy and environmental targets has to consider the heterogeneity in RFEC since the outcomes might be different for different energy-consuming groups of countries. EF

BETTER PRODUCTS FOR BETTER LIVING

Though craftsmanship is abundant and diverse in India, it has not evolved over time in terms of design and aesthetics to suit the modern generation of consumers. A good design can sustain any craft in a long run. *Wallistry* bridges this gap and works with artisan communities to make thoughtful products that are functional, useful, and relevant to today's new age users. It designs everyday lifestyle products that have a positive impact on the user and the environment. It works with diverse artisan communities across Tamil Nadu to collaborate and make sustainable lifestyle products from natural materials that are non-toxic and biodegradable.

Bhumi – Terracotta Clay Water Bottle

This product is crafted to inspire a healthier lifestyle, reviving the traditional use of earthenware designed with a contemporary outlook. Made from clay, its porous nature keeps the water naturally cool all day without any

The coasters are finished with food safe beeswax, a natural polish that enhances the quality of wood. The natural form of the wood is unaltered, thus making each and every piece of the coaster unique in its shape, finish, and grain structure.

The selection of wood is thoughtfully made. As wood is a renewable and natural resource, it is to be made sure that its use should not affect the natural growth and the environment. The acacia trees are fast growing and capable of adapting to almost all soil conditions, from acidic to alkaline, from shallow to deep, from clay to sand, improving the same by adding nitrogen and organic matter at a fast rate. Naturally, this becomes a sustainable choice of wood in comparison to other materials that have a longer growth rate. This also helps the local wooden craftsmen to make small wooden products and sustain their livelihood.

refrigeration. Terracotta has been used by Indians for years for cooking and drinking water from matka pots to curd setters. Its natural properties have an overall positive impact on the health as opposed to other plastic bottles.

The Bhumi – Terracotta Water bottles are made from locally sourced natural clay by the potters in Tamil Nadu, which also makes it non-toxic and environmental-friendly. The water that becomes naturally cool is not harsh on the throat as opposed to the refrigerated water. An alternative to plastic water bottles, they come in three different capacities (1000 ml, 750 ml, and 500 ml) and two different designs that are ergonomically designed for everyday use at home and workspaces.

Vanna – Raw Wooden Coasters

Handcrafted from the acacia tree, the wooden coasters retain the original form, rings, and the colour.

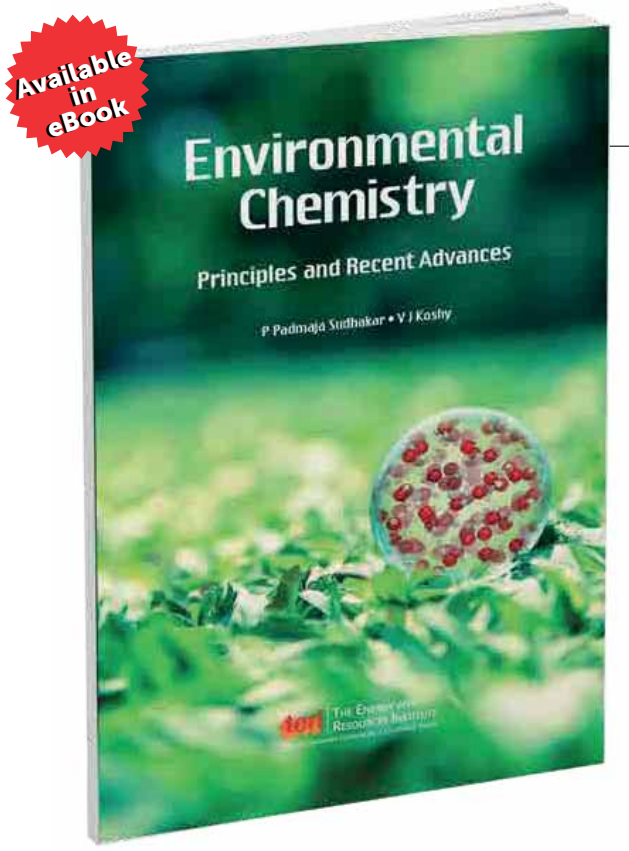
Ini and Adar Stoneware Davara Tumbler Sets

Stoneware is one type of ceramic that is made from a combination of different types of clays. Firing at a temperature higher than 1200°C results in a more durable material, with a denser, stone-like quality (compared to porcelain or earthenware). As stoneware is not porous as terracotta, the material can be used well for hot beverages, serveware, and other homeware products. The iconic davara or dabarah tumbler set is a cultural and everyday functional serveware used in most of the traditional homes in the coastal city of Chennai. This is usually made from brass metal.

That being said, the Ini and Adar Stoneware Davara tumbler sets are designed, retaining the nostalgic traditional form, with a conscious choice of the material and colours. They are crafted by artisans with years of material knowledge and craftsmanship in stoneware pottery. They are specifically made with non-toxic glazing materials. The choice of colours also plays a role in psychologically influencing the taste of the beverage. The brown colour enhances the strong essence of coffee, while the blue colour, being the contrast, induces a sense of sweetness to the drink.

Apart from the products, the packaging that goes with them is designed to be sustainable and reusable. In today's world, there is a need for conscious consumerism – be it food, fashion, and every other product. People have slowly started taking conscious choices in their everyday purchases. That being said, it is essential and necessary to understand the materials we use, the process it takes, and how much of an impact it has on the environment. Wallistry works on bringing thoughtful products for a better today and tomorrow. EF

A STUDY OF THE CHEMICAL PHENOMENA IN THE ENVIRONMENT



Major topics covered

- Fundamentals of chemical thermodynamics
- Atmospheric chemistry
- Hydrospheric chemistry
- Soil and soil pollution
- Solid and hazardous waste management
- Environmental toxicology
- Radiation pollution
- Global environmental disasters

ISBN: 9788179935224 • Price: `650.00

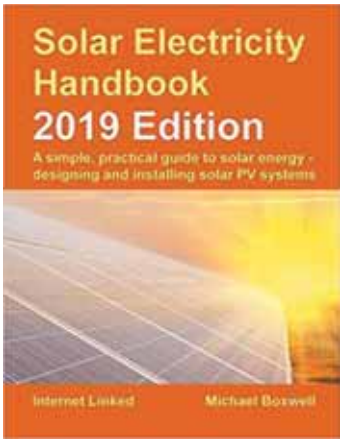
Environmental Chemistry: principles and recent advances discusses the various pollutants present in the atmosphere, including persistent and bioaccumulative chemicals, pesticides, nanoparticles, and chiral pollutants. Advances in treatment techniques and analysis and monitoring of pollutants are the other topics covered in detail. A chapter has been dedicated for a comprehensive discussion on green chemistry. The book also talks about the Best Available Techniques (BAT) adapted by industries for Preventing and Controlling Pollution and also provides information on the application of analytical techniques, such as GC, LC, IR, and MS for analysing and measuring aqueous, solid and atmospheric samples and for monitoring environmental pollutants.

The Energy and Resources Institute
Attn: TERI Press
Darbari Seth Block
IHC Complex, Lodhi Road
New Delhi – 110 003/India

Tel. 2468 2100
Fax: 2468 2144
India +91 • Delhi (0)11
Email: teripress@teri.res.in
Web: http://bookstore.teri.res.in

To purchase the book, visit our online bookstore at http://bookstore.teri.res.in or send us your demand draft or cheque in favour of TERI, payable at New Delhi (outstation cheques are not accepted).

The Solar Electricity Handbook – 2019 Edition: A Simple, Practical Guide to Solar Energy – Designing and Installing Solar Photovoltaic Systems



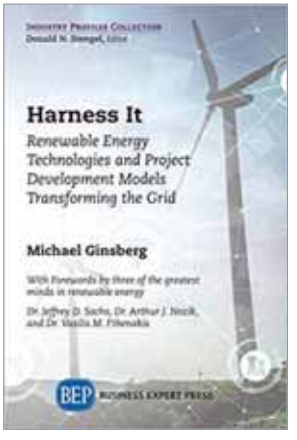
Author: Michael Boxwell
Publisher: Greenstream Publishing
Revised edition: 2019

Generating electricity from sunlight alone is a powerful resource, with applications and benefits throughout the world. But how does it work? What is it suitable for? How much does it cost? How do I install it? This best-selling internet-linked book answers all these questions and shows you how to use the power of the sun to generate electricity yourself.

Now in its thirteenth edition, this book assumes no previous knowledge. It explains the advantages of solar energy and the drawbacks you need to consider. As well as explaining the underlying principles, it provides a step-by-step guide so that you can successfully design and install a solar energy system from scratch.

The website that accompanies this book includes online solar calculators and tools to simplify your solar installation, ensuring that building your system is as straightforward and successful as possible. Readers can also get in touch directly with the author to ask questions and get further support with their solar projects. EF

Harness It: Renewable Energy Technologies and Project Development Models Transforming the Grid



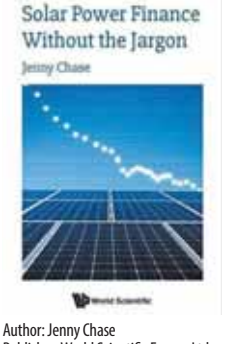
Author: Michael Ginsberg
Publisher: Business Expert Press
Year: 2019

Considering the increasing importance of renewable energy for climate change mitigation, this book provides an overview of how renewable energy sources are integrated into the grid to promote better understanding amongst students and business professionals in the utility sector and across industries.

Following an overview of the technical and historical development of the electric grid in the United States and Europe, this guide reviews hydropower, solar photovoltaics, wind energy, fuel cell, and battery technologies. The author also presents models for the connection of these renewable energy sources from large-scale to on-site and community power/microgrids. The models are explained through case studies in the developed and developing worlds that explore how technical evaluations are conducted, policy incentives implemented, and project finance applied.

Considering the increasing importance of renewable energy for climate change mitigation, this book provides an overview of how renewable energy sources are integrated into the grid to promote better understanding amongst students and business professionals in the utility sector and across industries. Literature on grid interconnection is highly technical, assuming an in-depth understanding of electrical engineering. With the rise of clean technologies and the diversity of interconnection models, this guide fills a gap in the existing literature by equipping non-technical business managers with the salient information they need to make critical decisions for their organizations. EF

Solar Power Finance Without The Jargon

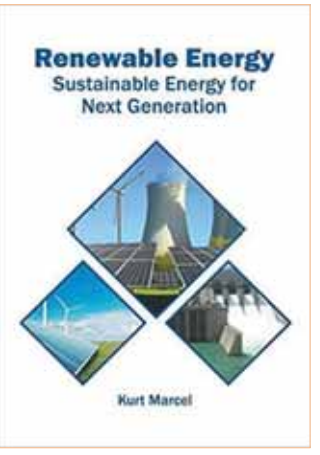


Author: Jenny Chase
Publisher: World Scientific Europe Ltd
Year: 2019

Solar power has become big business, with $131 billion invested in 2018, up from just $11.2 billion in 2004 but down from $171 billion in 2017 as unit costs fell. New installed capacity grew from 1.1 GW in 2004 to about 107 GW in 2018, a steady rise as solar begins to compete with fossil fuels on cost and to be built in nearly every country. This is a book for the solar workers of the future, a business book for those without a business or economics background and those simply curious about major shifts happening in the world energy economy. Key financial, economic, and technical concepts are interspersed with the history of the first decade of cheap solar power and the author's experience of being part of a successful start-up in the clean energy sector. EF

Renewable Energy: Sustainable Energy for Next Generation

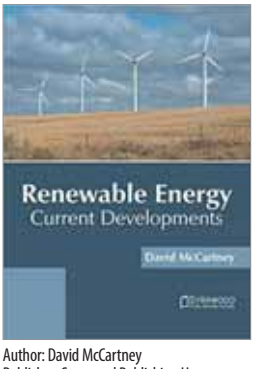
Renewable energy refers to the energy that is naturally replenished with time. Some of the sources of renewable energy include sunlight, wind, tides, rain and so on. Adoption of renewable energy has resulted in increased energy security, climate change mitigation, and economic benefits. The availability of energy is a major driver of human development. Renewable energy helps in facilitating this even in rural and remote areas of the world. Research is being done to develop newer and better energy sources like algal fuel or algal-derived biomass and artificial photosynthesis for energy storage using nanotechnology. This book presents the important theories and concepts that are central to the development of the technologies of renewable energy production. It further elucidates the cutting-edge technological innovations of recent years that have revolutionized this field. Students and researchers will benefit alike from an in-depth study of this book.



Author: Kurt Marcel
Publisher: Syrawood Publishing House
Year: 2019

Renewable Energy: Current Developments

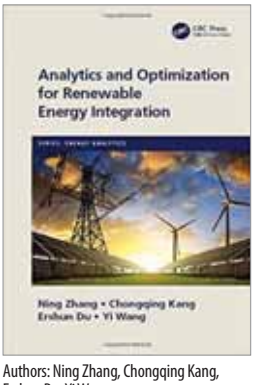
The energy derived from renewable sources such as sun, wind, rain, and tides is known as renewable energy. These sources are preferred over the conventional sources of petroleum and coal because they are naturally replenished in small timescales. They can be found in almost every geographical area unlike the conventional resources. Some of the most widely used renewable energy technologies include wind power, hydropower, geothermal energy, and solar power. They are primarily used for the purpose of electricity generation, apart from usage in the transportation industry. This book is a compilation of chapters that discuss the most vital concepts and emerging trends in this field. It includes some of the most significant pieces of work being conducted across the world on various topics related to renewable energy. Researchers and students actively engaged in this field will be assisted by this book.



Author: David McCartney
Publisher: Syrawood Publishing House
Year: 2019

Analytics and Optimization for Renewable Energy Integration (Energy Analytics)

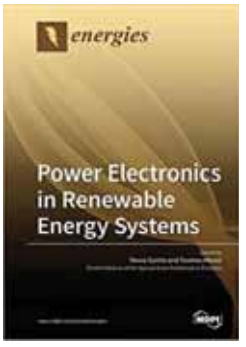
The scope of this book covers the modelling and forecast of renewable energy and operation and planning of power system with renewable energy integration. The first part presents mathematical theories of stochastic mathematics, the second presents modelling and analytic techniques for renewable energy generation, and the third provides solutions on how to handle the uncertainty of renewable energy in the power system operation. It includes advanced stochastic unit commitment models to acquire the optimal generation schedule under uncertainty, efficient algorithms to calculate the probabilistic power, and an efficient operation strategy for renewable power plants participating in electricity markets.



Authors: Ning Zhang, Chongqing Kang, Ershun Du, Yi Wang
Publisher: CRC Press
First edition 2019

Power Electronics in Renewable Energy Systems

This book offers a collection of 30 scientific papers that address the problems associated with the use of power electronic converters in renewable energy source-based systems. Relevant problems associated with the use of power electronic converters to integrate renewable energy systems to the power grid are presented. Some of the covered topics relate to the integration of photovoltaic and wind energy generators into the rest of the system, and to the use of energy storage to mitigate power fluctuations, which are a characteristic of renewable energy systems. The book provides a good overview of the above-mentioned topics. EF

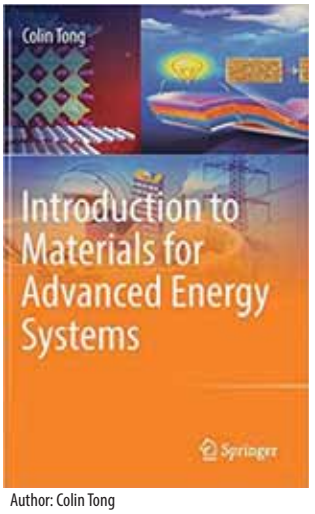


Authors/editors: Teuvo Suntio, Tuomas Messo
Publisher: MDPI AG
Year: 2019

Introduction to Materials for Advanced Energy Systems

This first-of-its-kind textbook enables today's students to understand current and future energy challenges, to acquire skills for selecting and using materials and manufacturing processes in the design of energy systems, and to develop a cross-functional approach to materials, mechanics, electronics, and processes of energy production. While taking economic and regulatory aspects into account, this textbook provides a comprehensive introduction to the range of materials used for advanced energy systems, including fossil, nuclear, solar, bio, wind, geothermal, ocean and hydropower, hydrogen, and nuclear, as well as thermal energy storage and electrochemical storage in fuel cells. A separate chapter is devoted to emerging energy harvesting systems.

Integrated coverage includes the application of scientific and engineering principles to materials that enable different types of energy systems. Properties, performance, modelling, fabrication, characterization and application of structural, functional, and hybrid materials are described for each energy system. Readers will appreciate the complex relationships amongst materials selection, optimizing design, and component operating conditions in each energy system. Research and development trends of novel emerging materials for future hybrid energy systems are also considered. Each chapter is basically a self-contained unit, easily enabling instructors to adapt the book for coursework.

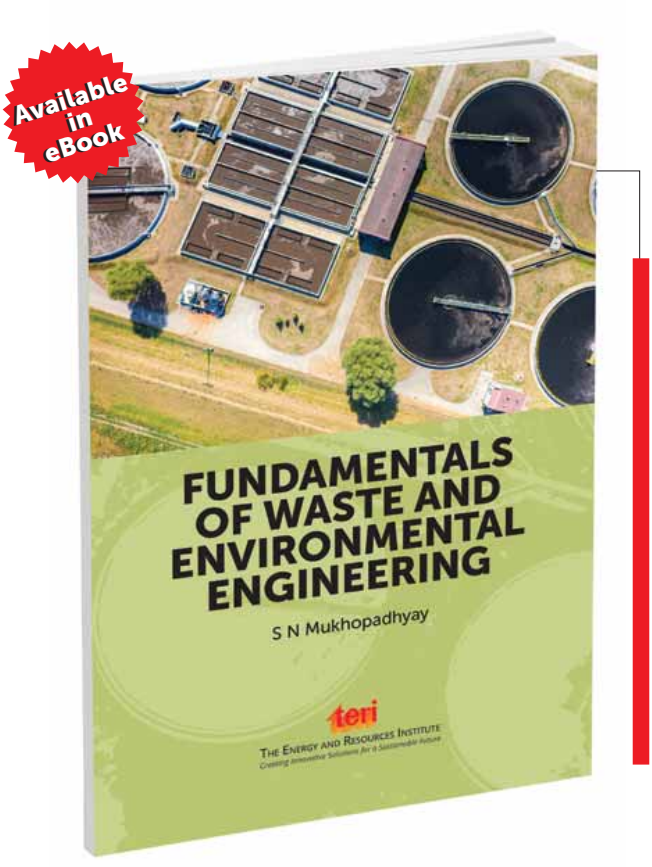


Author: Colin Tong
Publisher: Springer (first edition)
Year: 2019

This textbook is suitable for students in science and engineering who seek to obtain a comprehensive understanding of different energy processes and how materials enable energy harvesting, conversion, and storage. In setting forth the latest advances and new frontiers of research, the text also serves as a comprehensive reference on energy materials for experienced materials scientists, engineers, and physicists.

» Includes pedagogical features such as in-depth side bars, worked-out and end-of-chapter exercises, and many references to further reading
» Provides comprehensive coverage of materials-based solutions for major and emerging energy systems
» Brings together diverse subject matter by integrating theory with engaging insights. EF

ENVIRONMENTAL REMEDIATION THROUGH ENVIRONMENTAL ENGINEERING



Major topics covered

- Air Pollution and its Abatement
- Wastes to Value-added Products
- Water, Wastewater, and Non-aqueous Liquids
- Waste Heat Treatments and Utilizations
- Solid/Semisolid Waste Treatments/ Management for Business Developments
- Environmental Variance and Effects of Pollution on Humans.

ISBN: 9789386530103 • Price: `665.00

Fundamentals of Waste and Environmental Engineering deals with the global problem of waste generation. This book discusses the design and operation of engineering hardware and facilities for pollution control. It covers fundamentals of mesophillc and thermophilic bioprocessing of wastes. The book highlights the ways to control and minimize unwanted pollution and includes research-generated information and data. In order to make contents applicable, theoretical, multichoice, and practice tutorial numericals are also included in the book.

The Energy and Resources Institute
Attn: TERI Press
Darbari Seth Block
IHC Complex, Lodhi Road
New Delhi – 110 003/India

Tel. 2468 2100
Fax: 2468 2144
India +91 • Delhi (0)11
Email: teripress@teri.res.in
Web: http://bookstore.teri.res.in

To purchase the book, visit our online bookstore at http://bookstore.teri.res.in or send us your demand draft or cheque in favour of TERI, payable at New Delhi (outstation cheques are not accepted).

RENEWABLE ENERGY TECHNOLOGY DEVELOPMENT

Solar energy becomes biofuel without solar cells

Soon we will be able to replace fossil fuels with a carbon-neutral product created from solar energy, carbon dioxide and water.

A team of researchers at Uppsala University has successfully produced microorganisms that can efficiently produce the alcohol butanol using carbon dioxide and solar energy without needing to use solar cells.

As per the team, they have systematically designed and created a series of modified cyanobacteria that gradually produced increasing quantities of butanol in direct processes. When the best cells are used in long-term laboratory experiments, it is observed that the levels of production exceed the levels that have been reported in existing articles. Furthermore, it is comparable with indirect processes where bacteria are fed with sugar.

The knowledge and ability to modify cyanobacteria so that they can produce a variety of chemicals from carbon dioxide and solar energy is emerging in parallel with advances in technology, synthetic biology, genetically changing them. Through a combination of technical development, systematic methods and the discovery that as more products are removed from cyanobacteria, more butanol is formed, the study shows the way forward for realizing the concept.

It is possible to produce butanol using this process (proof-of-concept), but they have now been able to show that it is possible to achieve significantly

higher production, so high that it becomes possible to use in production. In practical terms, butanol can be used in the automotive industry as both an environmentally friendly vehicle fuel – fourth generation biofuels – and as an environmentally friendly component of rubber for tyres. In both cases, fossil fuels are replaced by a carbon-neutral product created from solar energy, carbon dioxide, and water.

Even larger industries, in all trades, that currently produce high greenhouse gas emissions from carbon dioxide will be able to use the process with cyanobacteria to bind carbon dioxide and consequently significantly reduce their emissions.

» Microscopic cyanobacteria are the most efficient photosynthetic organisms on earth. They utilize their ability to efficiently capture the sun's energy and bind to carbon dioxide in the air, alongside all the tools we have to modify cyanobacteria to produce desirable products.

» The results show that a direct production of carbon-neutral chemicals and fuels from solar energy will be a possibility in the future.

Research at Uppsala University is part of the larger EU Photofuel project being coordinated by vehicle manufacturer VW whose aim is to develop the next generation of techniques for sustainable manufacture of alternative fuels in the transport sector.

https://www.sciencedaily.com/releases/2019/07/190726094651.htm

Breakthrough in new material to harness solar power

The most affordable, efficient way to harness the cleanest, most abundant renewable energy source in the world is one step closer to reality.

Physicists from University of Toledo, pushing the performance of solar cells to levels never reached before, made a significant breakthrough in the chemical formula and process to make the new material.

Working in collaboration with the US Department of Energy's National Renewable Energy Lab and the University of Colorado, a team of researchers envision that the ultra-high efficiency material, called a tandem perovskite solar cell, will be ready to debut in full-sized solar panels in the consumer market in the near future.

» Perovskites, compound materials with a special crystal structure formed through chemistry, would replace silicon, which remains the solar cell material of choice for converting the sun's light into electrical energy.

As per one of the researchers, they are producing higher efficiency, lower cost solar cells that show great promise to help solve the world's energy crisis. The meaningful work will help protect our planet for our children and future generations. "They have a problem of consuming most of the fossil energies right now, and our collaborative team is focused on refining our innovative way to clean up the mess."

The new research paper on this topic outlines how the photovoltaics team is fine-tuning a mix of lead and tin to advance the technology closer to its maximum efficiency. Efforts have currently brought the efficiency of the new solar cell to about 23%. In comparison, silicon solar panels on the market today have around an 18% efficiency rating.

» Scientists used a chemical compound called guanidinium thiocyanate to dramatically improve the structural and optoelectronic properties of the lead-tin mixed perovskite films.

About 5 years ago, the team at University of Toledo identified the ideal properties of perovskites and has since focused on producing an all-perovskite tandem solar cell that brings together two different solar cells to increase the total electrical power generated by using two different parts of the sun's spectrum.

The University of Toledo research is ongoing to make cheaper and more efficient solar cells that could rival and even outperform the prevailing silicon photovoltaic technology. The tandem solar cells with two layers of perovskites deliver high power conversion efficiency and have the potential to bring down production cost of solar panels, which is an important advance in photovoltaics.

» The team has improved the quality of materials and the process to manufacture them at a low cost; more progress needs to be made.

» As per the team lead, the material cost is low and the fabrication cost is low, but the lifetime of the material is still unknown and they are working on the same. They are also planning to continue to increase efficiency and stability.

https://www.sciencedaily.com/releases/2019/05/190514081554.htm

Fossil fuels increasingly offer a poor return on energy investment

An evaluation of the global energy return on investment for fossil fuels and renewable sources reveals a much more level playing field than previously believed.

An enduring argument for the ongoing use of fossil fuels is their high energy return on energy investment. This refers to the ratio of how much energy a source such as coal or oil will produce compared to how much energy it takes to extract.

Previously, the estimated ratios for energy return on investment (EROI) favoured fossil fuels over renewable energy sources. Oil, coal, and gas are typically calculated to have ratios above 25:1; this means roughly one barrel of oil used yields 25 barrels to put back into the energy economy. Renewable energy sources often have much lower estimated ratios, which are below 10:1.

However, these fossil fuel ratios are measured at the extraction stage when oil, coal or gas is removed from the ground. These ratios do not take into account the energy required to transform oil, coal and gas into finished fuels, such as petrol used in cars or electricity used by households.

A new study, co-authored by scientists from the Sustainability Research Institute at the University of Leeds, has calculated the EROI for fossil fuels over a 16-year period and found that at the finished fuel stage, the ratios are much closer to those of renewable energy sources – roughly 6:1 and potentially as low as 3:1 in the case of electricity.

The study, undertaken as part of the UK Energy Research Centre programme and published in *Nature Energy*, warns that the increasing energy costs of extracting fossil fuels will cause the ratios to continue to decline, pushing energy resources towards a 'net energy cliff'. This is when net energy available to society declines rapidly due to the increasing amounts of 'parasitical' energy required in the energy production.

» The researchers emphasize that these findings make a strong case for rapidly stepping up investment in renewable energy sources and that the transition to renewables may actually halt or reverse the decline in global EROI at the finished fuel stage.

The member of the team stated that measuring energy return on investment of fossil fuels at the extraction stage gives the misleading impression that we have plenty of time for a renewable energy transition before energy constraints are a concern.

Those measurements are essentially predicating the potential energy output of newly extracted sources like crude

oil. But crude oil isn't used to heat our homes or power our cars. It makes more sense for calculations to consider where energy enters the economy, and that puts us much closer to the precipice.

» The ratios will only continue to decline because they are swiftly reaching the point where all the easily accessible fossil fuel sources are becoming exhausted.
» By stepping up investment in renewable energy sources, they can help ensure that they don't tip over the edge.

Co-author of this study, an expert in the social aspects of energy use on the Living Well within Limits (LiLi) project at Leeds, said: "There is too much focus on the initial economic costs of transitioning to renewable energy."

» Renewable infrastructure, such as wind farms and solar panels, do require a large initial investment, which is one of the reasons why their energy return on investment ratios have been so low until now.

https://www.sciencedaily.com/releases/2019/07/190711114846.htm

Caffeine gives solar cells an energy boost

Scientists from the University of California, Los Angeles (UCLA) and Solargiga Energy in China have discovered that caffeine can help make a promising alternative to traditional solar cells more efficient at converting light to electricity. Their research, published on April 25, 2019 in the journal *Joule*, may enable this cost-effective renewable energy technology to compete on the market with silicon solar cells.

The idea began as a joke over morning coffee. "One day, as we were discussing perovskite solar cells, our colleague Rui Wang said, 'If we need coffee to boost our energy, then what about perovskites? Would they need coffee to perform better?'", recalls Jingjing Xue, a PhD candidate in Professor Yang Yang's research group at the Department of Materials Science and Engineering at UCLA.

The offhand comment led the team to recall that the caffeine in coffee is an alkaloid compound containing molecular structures that could interact with the precursors of perovskite materials – compounds with a particular crystal structure that form the light-harvesting layer in a class of solar cells. Previous attempts to improve the thermal stability of these solar cells have included enhancing the perovskite layer by introducing compounds such as dimethyl sulphoxide, but researchers have struggled to boost cells' efficiency and long-term stability. No one had tried caffeine.

Realizing they might be onto something, the team set aside their coffee and began investigating further. They added caffeine to the perovskite layer of 40 solar cells and used infrared spectroscopy (which uses infrared radiation to identify chemical compounds) to determine whether the caffeine had successfully bonded with the material.

On conducting further infrared spectroscopy tests, they observed that the carbonyl groups (a carbon atom double bonded to an oxygen) in caffeine interacted with lead ions in the layer to create a 'molecular lock'. This interaction increased the minimum amount of energy required for the perovskite film to react, boosting the solar cell efficiency from 17% to over 20%. The molecular lock continued to occur when the material was heated, which could help prevent heat from breaking down the layer.

"We were surprised by the results," says Wang, who is also a PhD candidate in Yang's research group at UCLA. "During our first try incorporating caffeine, our perovskite solar cells already reached almost the highest efficiency we achieved in the paper."

But while caffeine appears to significantly improve the performance of cells that utilize perovskite to absorb sunlight, the researchers do not think it will be useful for other types of solar cells. The unique molecular structure of caffeine only allows it to interact with perovskite precursors, which may give this solar cell variety an edge on the market. Perovskite solar cells already have the advantage of being cheaper and more flexible than their silicon counterparts. They are also easier to manufacture – perovskite cells can be fabricated from solution-based precursors as opposed to solid crystal ingots. With further research, Wang believes caffeine may facilitate large-scale production of perovskite solar cells.

"Caffeine can help the perovskite achieve high crystallinity, low defects, and good stability," he says. "This means it can potentially play a role in the scalable production of perovskite solar cells."

In order to continue enhancing the solar cells' efficiency and stability, the team next plans to further investigate the chemical structure of the caffeine-incorporated perovskite material and to identify the best protective materials for perovskites.

https://www.sciencedaily.com/releases/2019/04/190425115639.htm

Novel thermoelectric nanoantenna design for use in solar energy harvesting

In an article published in the *SPIE Journal of Nanophotonics* (JNP), researchers from a collaboration of three labs in Mexico demonstrate an innovative nanodevice for harvesting solar energy. The paper 'thermoelectric efficiency optimization of nanoantennas for solar energy harvesting' reports that evolutive dipole nanoantennas (EDNs) generate a thermoelectric voltage three times larger than the classic dipole nanoantenna (CDN).

Capturing visible and infrared radiation using nanodevices is an essential aspect of collecting solar energy: solar cells and solar panels are common devices that utilize nanoantennas, which link electromagnetic radiation to specific

optical fields. The EDN antenna can be useful in many areas where high thermoelectric efficiency is needed from energy harvesting to applications across the aerospace industry.

"The paper reports on a novel design and demonstration of a nanoantenna for efficient thermoelectric energy harvesting," says Professor Ibrahim Abdulhalim, JNP associate editor, SPIE fellow and a professor in the Electrooptics and Photonics Engineering Department at Ben-Gurion University of the Negev. "They demonstrated thermoelectric voltage three times larger than a classical antenna. This type of antenna can be useful in many fields from harvesting of energy from waste heat, in sensing and solar thermal energy harvesting."

The nanoantennas are bimetallic, using nickel and platinum, and were fabricated using e-beam lithography. The nanoantenna design was optimized using simulations to determine the distance between elements. In comparing their thermoelectric voltage to the classic dipole nanoantenna, the EDNs were 1.3 times more efficient. The characterization was done using a solar simulator analysing the I–V curves. The results indicate that EDN nanoantenna arrays would be good candidates for the harvesting of waste heat energy.

https://sciencedaily.com/releases/2019/05/190503100804.htm

A new approach for the fast estimation of the solar energy potential in urban environments

TU Delft researchers have developed a new approach for fast and accurate calculation of the solar energy potential of surfaces in the urban environment. The new approach can significantly help architects and urban planners to incorporate photovoltaic (solar power) technology in their designs. The findings were presented in *Nature Energy*.

Buildings, trees, and other structures in urban areas cause shading of solar modules, which strongly affects the performance of a PV system. Accurate assessment of this performance, and the related price/performance of PV systems, will facilitate their integration in the urban environment.

Several tools are available for simulating the energy yield of PV systems. These tools are based on mathematical models that determine the irradiance incident on solar modules. By repeating the calculation of the incident irradiance throughout the year, the tools deliver an annual irradiation received by the modules. However, it is not easy to determine accurately how much electricity a PV system generates in an urban environment. Current simulations become computationally highly demanding as the dynamic shading of surrounding objects caused by the annual movement of the sun has to be taken into account.

Two parameters

A new approach simplifies the calculation and enables the user to carry out a quick assessment of the solar energy potential for large urban areas while keeping high accuracy. It is based on a correlation between a skyline profile and the annual irradiation received at a particular urban spot. This method is explained and validated in a study published in *Nature Energy* journal. The study demonstrates that the total annual solar irradiation received by a selected surface in an urban environment can be quantified using two parameters that are derived from the skyline profile: the sky view factor and the sun coverage factor. While the first parameter is used to estimate the irradiation from the diffuse sunlight component, the second one is indicative for the irradiation from the direct sunlight component. These two parameters can be easily and quickly obtained from the skyline profile. The study shows that the use of these two parameters significantly reduces the computational complexity of the problem.

Software toolbox

Andrés Calcabrini, PhD student in the department of Electrical Sustainable Energy, developed the new approach under supervision of Dr Olindo Isabella and Professor Miro Zeman. The Photovoltaic Materials and Devices (PVMD) group has already integrated the approach in a software toolbox that can accurately calculate the energy yield of PV systems at any location. Olindo Isabella, head of the PVMD group, stated: "Our fast approach integrated in software tools for calculating the solar energy potential can significantly facilitate design and distribution of buildings with integrated PV systems in urban planning frameworks. It will also help investors to take decisions on integrating PV systems in buildings and other urban locations."

This research has been carried out as a part of the Solar Urban programme of Delft University of Technology.

https://www.sciencedaily.com/releases/2019/02/190204114638.htm

A step for a promising new battery to store clean energy

Researchers have built a more efficient, more reliable potassium-oxygen battery, a step towards a potential solution for energy storage on the nation's power grid and longer lasting batteries in cell phones and laptops.

In a study published in the journal *Batteries and Supercaps*, researchers from The Ohio State University detailed their findings centering around the construction of the battery's cathode, which stores the energy produced by a chemical reaction in a metal-oxygen or metal-air battery. The finding, the researchers say, could make renewable energy sources like solar and wind more viable options for the power grid

through cheaper, more efficient energy storage.

"If you want to go to an all-renewable option for the power grid, you need economical energy storage devices that can store excess power and give that power back out when you don't have the source ready or working," said Vishnu-Baba Sundaresan, co-author of the study and professor of mechanical and aerospace engineering at Ohio State. "Technology like this is key, because it is cheap, it doesn't use any exotic materials, and it can be made anywhere and promote the local economy."

Renewable energy sources don't emit carbon dioxide, and so they don't contribute to global warming, but they provide energy only when the sun is shining or the wind is blowing. In order for them to be reliable sources of power for a region's energy grid, there needs to be a way to store excess energy gathered from sunshine and wind.

Companies, scientists, and governments around the world are working on storage solutions, ranging from lithium-ion batteries – bigger versions of those in many electric vehicles – to giant batteries of the size of a big-box store made using the metal vanadium.

Potassium-oxygen batteries have been a potential alternative for energy storage since they were invented in 2013. A team of researchers from Ohio State, led by chemistry professor Yiying Wu, showed that the batteries could be more efficient than lithium-oxygen batteries while simultaneously storing about twice the energy as existing lithium-ion batteries. But potassium-oxygen batteries have not been widely used for energy storage because, so far, they haven't been able to recharge enough times to be cost-effective.

As teams tried to create a potassium-oxygen battery that could be a viable storage solution, they kept running into a roadblock: The battery degraded with each charge, never lasting longer than 5 or 10 charging cycles – far from enough to make the battery a cost-effective solution for storing power. That degradation happened because oxygen crept into the battery's anode – the place that allows electrons to charge a device, be it a cell phone or a power grid. The oxygen caused the anode to break down, making it so the battery itself could no longer supply a charge.

Paul Gilmore, a doctoral candidate in Sundaresan's lab, began incorporating polymers into the cathode to see if he might be able to protect the anode from oxygen. If he could find a way to do that, he thought, it would give potassium-oxygen batteries a shot at longer lives. It turned out he was right: The team realized that swelling in the polymer played a vital role in its performance. The key, Gilmore said, was finding a way to bring oxygen into the battery – necessary for it to work – without allowing oxygen to seep into the anode.

This design works a bit like human lungs: Air comes into the battery through a fibrous carbon layer, then meets a second layer that is slightly less porous and finally ends at a third layer that is barely porous at all. That third layer, made of the conducting polymer, allows potassium ions to travel throughout the cathode, but restricts molecular oxygen from getting to the anode. The design means that the battery can be charged at least 125 times, giving potassium-oxygen batteries more than 12 times the longevity they previously had with low-cost electrolytes.

"The finding shows that this is possible, but the team's tests haven't proven that batteries can be made on the scale necessary for power grid storage," Sundaresan said. However, it does show potential.

Gilmore said that potential may also exist for potassium-oxygen batteries to be useful in other applications.

"Oxygen batteries have higher energy density, which means they can improve the range of electric vehicles and battery life of portable electronics, for example, though other challenges must be overcome before potassium-oxygen batteries are viable for these applications," he said.

And the finding offers an alternative to lithium-ion batteries and others that rely on cobalt, a material that has been called 'the blood diamond of batteries'. The mining of the material is so troubling that major companies, including TESLA, have announced their plans to eliminate it from batteries entirely.

"It is very important that batteries intended for large-scale applications do not use cobalt," Sundaresan said.

And it is also important that the battery can be made cheaply. Lithium-oxygen batteries – a possible energy storage solution that is widely considered one of the most viable options – can be expensive, and many rely on scarce resources, including cobalt. The lithium-ion batteries that power many electric cars cost around $100 per kilowatt hour at the materials level.

The researchers estimated that this potassium-oxygen battery will cost about $44 per kilowatt hour.

"When it comes to batteries, one size does not fit all," Sundaresan said. "For potassium-oxygen and lithium-oxygen batteries, the cost has been prohibitive to use them as grid power backup. But now that we've shown that we can make a battery this cheap and this stable, then it makes it compete with other technologies for grid power backup."

"If you have a smallish battery that is cheap, then you can talk about scaling it up. If you have a smallish battery that is $1,000 a pop, then scaling it up is just not possible. This opens the door for scaling it up."

This work was funded by a grant from the National Science Foundation. EF

https://www.sciencedaily.com/releases/2019/05/190513155656.htm

INDUSTRY REGISTRY

RTS CORPORATION

2-3-11 Shinkawa
Chuo-ku, Tokyo
Tel: +81/3/3551-6345
Email: info@rts-pv.com
Website: rts-pv.com

SCORPIUS TRACKERS PVT LTD

397/6 Senapati Bapat Road
Pune, Maharashtra, India
Tel: +91-20-25659413
Website: scorpiustrackers.com

MONDRAGON ASSEMBLY

Pol. Ind. Bainetxe, RAB 5-A
20550 Aretxabaleta, Spain
Tel: +34/943712080
Email: info@mondragon-assembly.com
Website: www.mondragon-assembly.com

STUDER INNOTEC SA

CH-1950 Sion
Tel: +41/27/2056080
Email: info@studer-innotec.com
Website: www.studer-innotec.com

PI BERLIN AG

Wrangelstrasse 100
D-10997 Berlin, Germany
Tel: +49/30/8145264-0
Email: info@pi-berlin.com
Website: www.pi-berlin.com

VOLTRONIC POWER TECHNOLOGY

5F, No. 151, Xinhu 1st road, Neihu dist.
Taipei, Taiwan
Tel: +886-2-27918296
Email: sales@voltronic.com.tw
Website: www.voltronicpower.com

MECO EQUIPMENT ENGINEERS

Marconilaan 2
NL-5151 DR Drunen, Netherlands
Tel: +31/416/384384
Email: meco.sales@besi.com
Website: www.meco.nl

WASHINGTON MILLS AS

N-7300 Orkanger, Norway
Tel: +47/72/483500
Email: wmas@washingtonmills.no
Website: www.washingtonmills.no

SOLARTRON PCL

1000/65-67 PB Tower, Sukhumvit 71 Rd.
Bangkok 101110, Thailand
Tel: +66/2/3920224
Website: support@solartron.co.th

SCHMID GROUP

Robert-Bosch-Str. 32-36
D-72250 Freudenstadt, Germany
Tel: +49/7441/538-0
Email: info@schmid-group.com
Website: www.schmid-group.com

NATIONAL AND INTERNATIONAL EVENTS

NATIONAL

SMART ASIA India Expo & Summit
October 17–19, 2019
Mumbai, Maharashtra
Website: https://www.smartasia.com/

International Conference on Advances in Renowned Renewable Energy Technologies
October 23–24, 2019
Vijayawada, Andhra Pradesh
Website: https://easychair.org/cfp/ICARRET2019

International Conference on New and Renewable Energy Resources for Sustainable Future
November 07–09, 2019
Jaipur, Rajasthan
Website: https://www.iconrer.skit.ac.in/

India Wind Energy Forum
November 14–15, 2019
New Delhi
Website: https://events.firstviewgroup.com/IndiaWindEnergyForum2019?lang=en

International Conference on Sustainable Energy & Environmental Challenges
November 27–29, 2019
Nagpur, Maharashtra
Website: http://www.seec2019.com/

INTERNATIONAL

American Wind Energy Association Offshore WINDPOWER Conference and Exhibition
October 22–23, 2019
Boston Park Plaza, Boston, USA
Website: https://www.awea.org/conferences/awea-offshore-windpower-2019-conference

Integration Renewables into Power Generation & Financing Conference
October 22–23, 2019
Dallas, Texas, USA
Website: https://lmnpower.com/event/integrating-renewables-into-power-generation-financing-conference/

US Power & Renewables Summit
October 29–30, 2019
Austin, Texas, USA
Website: https://www.greentechmedia.com/events/live/power-renewables-summit

Solar Asset Management Europe
October 30–31, 2019
Frankfurt, Germany
Website: https://europe.solar-asset.management

International Conference on Renewable Energy and Power Engineering (REPE)
November 2–4, 2019
Toronto, Canada
Website: http://www.repe.net/

RENEWABLE ENERGY AT A GLANCE

Ministry of New & Renewable Energy			
Programme/Scheme wise Physical Progress in 2019-20 & Cumulative up to July 2019			
Sector	**FY- 2019-20**		**Cumulative Achievements (as on 31.07.2019)**
	Target	**Achievements (April-July 2019)**	
I. GRID-INTERACTIVE POWER (CAPACITIES IN MW)			
Wind Power	3000.00	1060.86	36686.82
Solar Power - Ground Mounted	7500.00	1546.02	27930.32
Solar Power - Roof Top	1000.00	344.68	2141.03
Small Hydro Power	50.00	11.65	4604.80
Biomass (Bagasse) Cogeneration)	150.00	28.00	9131.50
Biomass (non-bagasse) Cogeneration)/ Captive Power	100.00	0.00	674.81
Waste to Power	2.00	0.00	138.30
Total	**11802.00**	**2991.21**	**81307.58**
I. OFF-GRID/ CAPTIVE POWER (CAPACITIES IN MWEQ)			
Waste to Energy	10.00	1.63	180.35
Biomass Gasifiers	1.00	0.00	166.17
SPV Systems	400.00	3.54	919.15
Total	**411.00**	**7.97**	**1265.67**
III. OTHER RENEWABLE ENERGY SYSTEMS			
Biogas Plants	86900.00	1680.00	5028340.00*

***Progress up to June 2019**

Source: www.mnre.gov.in

ADVERTISE IN...

TERRAGREEN

Circulation information

Industries, Ministries, PSUs, Corporates, Multi and Bilateral Agencies, Universities, Educational Institutions, and Research professionals. Readership of 40,000

General information

- Monthly
- All colour
- Matte paper
- Number of pages: 56

Technical specifications

Finished size:	20.5 cm × 26.5 cm
Non-bleed ad size:	17.5 cm × 23.5 cm
Half page ad size:	17.5 cm × 11.75 cm
Bleed size (3 mm bleed on all sides):	21 cm × 27.5 cm
Artwork preference:	Print ready, minimum 300 dpi (tiff, eps, pdf, or cdr) files with all fonts with high quality print proofs and progressives for colour reference.

Advertisement tariffs (₹)

Position	Card rate for single issue(INR)	quarter contract (3 issues) (INR)	bi-annual contract (6 issues) (INR)	annual contract (12 issues) (INR)
Advertorial (per page)	100,000	255,000	480,000	900,000
Back Cover	100,000	255,000	480,000	900,000
Inside Back Cover	75,000	191,250	360,000	675,000
Inside Front cover	75,000	191,250	360,000	675,000
Inside Full Page	50,000	127,500	240,000	450,000
Inside Half page	30,000	76500	144,000	270,000

GST & taxes additional as applicable

Subscription

One year `720 / $122 • Two years `1440 / $234 • Three years `2160 / $302 *(Free online access for those subscribing for three years)*

ENERGY FUTURE

Circulation information

Industries, Ministries, PSUs, Corporates, Multi and Bilateral Agencies, Universities, Educational Institutions, and Research professionals. Readership of 25,000.

General information

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

Technical specifications

Finished size:	20.5 cm × 26.5 cm
Non-bleed ad size:	17.5 cm × 23.5 cm
Half page ad size:	17.5 cm × 11.75 cm
Bleed size (3 mm bleed on all sides):	21 cm × 27.5 cm
Artwork preference:	Print ready, minimum 300 dpi (tiff, eps, pdf, or cdr) files with all fonts with high quality print proofs and progressives for colour reference.

Advertisement tariffs (₹)*

Ad location	Back cover	Inside back cover	Inside front cover	Inside full page	Inside half page	Inside quarter page	One-sixth page
Single issue	60,000	50,000	50,000	40,000	20,000	12,000	7,000
Two issues	114,000	95,000	95,000	76,000	38,000	22,800	13,300
Three issues	171,000	142,500	142,500	114,000	57,000	34,200	19,950
Four issues	228,000	190,000	190,000	151,000	76,000	45,600	26,600

Subscription

One year `800 / $80 • Two years `1600 / $160 • Three years `2400 / $240

Contact details

Gitesh Sinha
Email: gitesh.sinha@teri.res.in
<Extn 2733>

Sanjeev Sharmata
Email: sanjeev.sharma@teri.res.in
<Extn 2732>

Payment mode

Please send your advertisement material along with the accompanying advertisement release form and the payment in the form of cheque/DD favouring **TERI, payable at New Delhi** (no outstation cheques will be accepted)

Website:http://bookstore.teri.res.in/TerraGreen

The Energy and Resources Institute
Darbari Seth Block, IHC Complex
Lodhi Road, New Delhi - 110 003
Tel: 011 2468 2100 / 7110 2100
Fax: 011 2468 2144 / 2468 2145
Website:http://bookstore.teri.res.in

DELENG/2012/49326 ISSN 2278 – 7186

OPEN YOURSELF TO A WHOLE NEW WORLD OF ENVIRONMENT INTELLIGENCE!

PRESERVE • CONSERVE
INSPIRE • LEARN

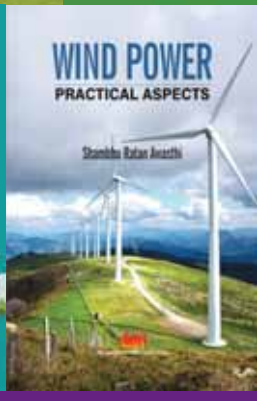
ORDER YOUR COPY TODAY

ENVIRONMENT STUDIES AND SUSTAINABLE DEVELOPMENT

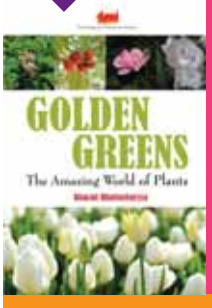
ECOLOGY, ENVIRONMENT, AND FORESTRY

SUSTAINABLE ARCHITECTURE

ENERGY



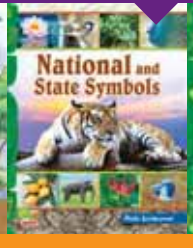
LIFE SCIENCES



ENVIRONMENT ENGINEERING

CLIMATE

CHILDREN BOOKS



TERI publications also available at

amazon.in flipkart.com GET IT ON Google play LEARNERLIBRARY mintbook Experience Reading

amazonkindle ShopClues.com infibeam.com paytm kopykitab

For more information, log on to http://bookstore.teri.res.in