Each one of us likes to bask in the sunshine more so during the winter months. It goes to an easy extent of shifting our position the moment we feel any reduction in the availability of sunshine. This is what could be termed as tracking the sun in simplistic terms. In a way, most of us are familiar with the changing position of the sun as well as its intensity from the time of sunrise to sunset. If it is so, then where does the need arise to deliberate on the sun tracking issue? Well, there is more to it than what meets the eye in terms of a fixed type of solar photovoltaic (PV) array. We being live entities are able to move along with the sun but the array is incapable of moving by itself. The simple enough reason is that a PV array is a fixed type of ground/roof-mounted structure. The turning point is that the sun moves from east to west direction during the day. However, the assembly of solar modules, i.e., the array does not budge even an inch from its position. There is no reason to feel disheartened any more as a simple tracking solution is now available to align the PV array in the path of the moving sun. This raises a very pertinent question at this juncture—"If we are losing some amount of solar power by not adhering to the practice of sun tracking in case of large capacity (i.e., 1 MW and above) PV power plants, then what is the solution?"

THE UNDERLYING RATIONALE

As mentioned above, tracking can bring in some gain from within the same solar PV system. However, it means an additional cost liability too apart from the routine maintenance requirements. A typical solar power producing system whether big or small has no moving parts associated with it so much so that one fails to mark its existence even from a very close quarter. This will not be the case when a tracking unit finds its way into the PV system.

There is an added issue which merits the consideration of the project developers. This importantly concerns the land use as the tracking system puts an additional demand on land area availability. The solar modules incorporated in the system need to be spaced out in order to avoid shading one another as they track the sun.

Prior to understanding trackers at some length, it seems appropriate to take a quick look at a financial term or two. Take for example the levelized cost of energy or simply LCOE. The moot question is if, it makes good sense to lower the capital cost and operation and maintenance (O&M) cost of a solar power plant via a tracking feature? The immediate purpose at hand seems to be improving the LCOE. Here a 'tracker' is a generic term, which is used to describe such devices as can orient various payloads towards the sun.

UNDERSTANDING THE TRACKING REQUIREMENTS

Take a simple case of a solar PV system wherein the payload is the solar module. Seemingly, no other balance of system component other than a tracker can enhance the performance of a PV system. As per reliable estimates, use of trackers in a PV system can improve a PV system's output up to a maximum of 40 per cent in direct contrast to a fixed tilt array. The increment of production improvement over a fixed system would be much in accordance with the project's latitude and type of tracker. The benefits of trackers often vary between the different categories of trackers, i.e., one-axis, 1.5 axis, and dual-axis. These trackers generally incur an added cost relative to the fixed type of PV systems. In purely cost competitive terms, the enhanced energy harvest must be more than the added cost of installing and maintaining trackers over the lifetime of a PV system.

There is an added issue which merits the consideration of the project developers. This importantly concerns the land use as the tracking system puts an additional demand on land area availability. The solar modules incorporated in the system need to be spaced out in order to avoid shading one another as they track the sun. Simply put, it means that the modules must be spaced farther apart, thereby, possibly leading to enhanced land use and its associated cost for the project developer. There is an additional negative attribute of using tracker in terms of bringing in a higher O&M cost. This usually tends to be more for this type of system operation. With an expected system lifespan of around 25 years, the O&M cost could become a major cost component in the realm of overall system cost.

CHOOSING BETWEEN A FIXED AND MOVING TYPE PV SYSTEM

Solar PV technology has received accolades so far due to its distinct attributes of being clean, reliable, safe, and emission free—with no moving parts at all. However, when it comes to making a clear choice between the fixed and tracking type systems, several factors like the ones discussed below come into active consideration.

Land availability

The present era is that of large capacity megawatt scale PV power plants in the country. The tracking systems possess a larger area footprint per MW. It implies that the use of trackers is not favourable for those areas that have a very limited availability of land. In general, fixed-type PV systems require around 4–5 acres of land per MW as against a use of 4–7 acres for an equivalent

capacity under tracking conditions. Choice of a specific technology also has a bearing on the land requirements. Thin film modules being less efficient offer fewer prospects for tracker friendly utilization. The trackers need fewer modules for the same energy output. As such, the crucial comparison for evaluating trackers must account for the cost of modules and trackers.

System performance and cost

Quite clearly, trackers are intended to enhance the generation but due consideration needs to be given to the accompanying cost of trackers and modules. It would be preferable to consider the overall cost of a PV system. Taking two numbers of MW systems of 10 MWp capacity each into consideration, a fixed-tilt system would turn out to be a cheaper choice. However, a single-axis tracking system has witnessed a significant cost reduction in the recent times. Take a case specific example of Bakersfield in California, which demonstrates a 25 per cent enhancement in project performance within the sun soaked regions especially. Now to account for this variation in the performance, it may be useful to raise the capacity of a fixed-tilt project size to around 12.5 MW. Thus, a single-axis tracking project seems to be more attractive at the existing price range of solar modules. However, there may not be a striking difference between a fixed-tilt- and a single-axis tracking system in areas receiving little sunshine.

Solar module is the power producing part of both the off-grid and on-grid energy system. The energy made available by the solar system is directly proportional to the solar radiation incident on the module. Incidentally, the amount of solar radiation received is always changing at a particular orientation. This implies a clear need to orient the path in such a way so as to receive the maximum possible amount of radiation. The additional piece of equipment which does this trick is commonly known as a 'solar tracker'. Let us take a closer look at the solar to electric conversion efficiencies of commercially available solar modules. Actually, these normally range anywhere between 14–18 per cent in case of MW scale power plant installations. It means that these type of modules are capable of converting just 14–18 per cent of the available sunlight into useful electricity. The moot question is as to what extent such efficiency values can progress due to ongoing/future technology advancements? The readily available value is a natural limitation of around 26 per cent for single junction crystalline silicon modules.

CHOICING BETWEEN THE TRACKER TYPES

Presently, two types of trackers are

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Picture 1: 200-kW CPV modules on a dual-axis tracker in Qingdao, China

available in the marketplace. These are better known as the single-axis- and dual-axis tracking units. The single-axis tracker (SAT) tracks the sun's path in a day implying thereby that it compensates for the variation in solar radiation due to rotation. In contrast, the dual-axis trackers possess the capability to move over two axes (Picture 1). Thus, this tracker can compensate both for the rotation and revolution of the earth. This article deals specifically with the single-axis trackers for a variety of end-use considerations. It is a system designer's guess to include or exclude the choice of a single-axis tracker in a MW capacity facility. In financial terms, it is the Internal Rate of Return (IRR) which matters the most in deciding the worthiness of a solar PV power plant. Thus, it is of interest to determine the sheer ability of trackers in exercising any noticeable impact on this key financial parameter, i.e., the IRR. It has a strong bearing on the following few parameters besides the spatial coordinates of the project:

- Cost of land/modules
- Cost of the tracking structures
- Actual gain in radiation.

Thus, it is quite important to collate all these factors from the viewpoint of their financial analysis too for deciding on the suitability of incorporating a solar tracker in the existing scheme of things.

THE MODELLED NUMBERS

The era of MW scale power plants in India owes its origin to the Jawaharlal Nehru National Solar Mission (JNNSM) in 2010. A limited amount of field data, which needs to be analysed for the specified purpose, is currently available. Sun Power Corporation has put in place a LCOE model for cost–benefit estimation. The major assumptions flowing into this model are based on the guidelines provided by the Central Electricity Regulatory Commission (CERC), India. Lanco—a premier EPC solar company, has included its own field experiences. As per which, the following few assumptions came into being:

- Debt-equity ratio: 80 per cent
- Rate of interest: 11 per cent
- Return of equity rate: 16 per cent
- Expected lifespan: 25 years.

The O&M costs were assumed to be ₹9 lakh per MWp. It involved annual escalation rate of 5 per cent in case of fixed-tilt based system. For the single-axis tracker, this amount was placed at ₹9.90 lakh per MWp with an equivalent rate of escalation. The degradation concerning the performance of a multi-crystalline silicon module was duly considered.

KEY FACTORS AFFECTING THE TRACKING DECISION

Yield: It is basically related to the number of units produced per kWp of the system installation. It is expected to go up with the use of a single-axis tracker. The amount of enhancement in this yield is mainly the benefit a system derives from a technological improvement. The system yield is influenced by several factors, such as: (i) Latitude; (ii) Distance from large water body; and (iii) Dust that can disperse radiation within a specific location. As per the study done by Lanco, six locations were considered. These included: (i) Askandra (Rajasthan); (ii) Bhatradra (Gujarat); (iii) Gulbarga (Karnataka); (iv) Anantpur (Andhra Pradesh); (v) Puducherry; and (vi) Kovilpatti (Tamil Nadu).

Land utilization

Solar PV power plants place a sizeable demand on the availability of land. As more and more number of such plants are being put up, the land cost is going up strongly even within the far off parts of the country. Table 1 presents the comparative land cost for the above said locations.

Table 1: Comparative land costs at the considered locations

Location	Cost per acre (₹)
Askandra	200,000
Bhatradra	500,000
Gulbarga	350,000
Anantpur	300,000
Kovilpatti	500,000
Puducherry	3,000,000

Importantly, the system design should be in a manner so as to ensure its utilization in the most efficient manner. Solar modules are placed in a number of rows taking sufficient care not to cast any shadow on the adjacent rows. As is well known, the formation of any such shadows can lead to module damage, thereby, affecting the power generation values. Practically, a specific inter row spacing is needed to avoid any shadow formation. However, it essentially depends on the latitude of a plant location. This specific consideration is more commonly referred to as the ground coverage ratio (GCR). Such a number goes up as one moves towards the equator. Take the case of Puducherry in southern part of India, within which, GCR figure could be as high as 90 per cent. There is no change in the GCR value vis-à-vis the single-axis tracking, no matter what the latitude value is. Such a figure is about 45 per cent for the single-axis tracking. It implies that the trackers would use double the land area in Puducherry as compared to the fixed-tilt systems. There could be no impact in case of very cheap availability of land. Assume for a moment any small increase in the land cost. It could be offset by a good enough increase in the plant yield with the use of a single-axis tracker.

This increased utilization of the land at varying price, i.e., from one geographical region to the other could be deemed suitable only if, there is some sizeable increase in the number of units generated per year via single-axis tracking. Table 2 gives a figurative comparison of the percentage increase in yield for: (i) Fixed-tracking system and (ii) Single-axis tracking.

It is quite clear from Table 2 that the GCR remains constant in case of single-axis tracking systems, no matter what their latitude may be.

Solar module as a key determinant

Till few years back, the cost of solar module used to be prohibitively high. However, it did not cost much to put up a module mounting structure in relation to the overall cost contribution of solar modules. Today, that scenario has changed for good with module prices having declined significantly. Thus in the renewed cost, the cost contribution of mounting structures seems to be significant when viewed in overall system cost terms. Let us now take the role of solar to electric conversion efficiency of the solar modules into account. The best commercially available modules of today are not more than 22 per cent efficient, with majority of modules deployed under the actual field operating conditions being just about 15–17 per cent efficient. Assuming that efficiencies of solar modules touch their uppermost limit of 27 per cent in future, the need for single-axis tracking may not be a catchy one for more reasons than one.

TRACKING THE DEVELOPMENTS INTERNATIONALLY

The tracking technology applicable to large capacity solar PV power systems have undergone several path breaking improvements more so since the last few years. This has transformed into reduced cost for equipment as well as routine operation cum maintenance. Simultaneously, more number of projects incorporating the tracker technology have come up, which is a marked departure from the previous times. An encouraging example is that of First Solar, which despite being a thin film module (CdTe) producer, acquired Ray Tracker in 2011. It can be explained by a revealing fact that First Solar develops its solar project in areas with little concern for land area. More recently, few more European companies, namely DEGERenergie and Mecasolar have attempted to make forays into the North American tracker market. The simple idea is to take advantage of low competition and growing demand.

As per the available market information, single-tracking units seem to edge past the double-axis trackers at least for now. A core issue with dual-axis is basically that the added generation from upgrading from single- to dual-axis does not economically pan out in terms of the extra materials and costs. Currently, there is a marked preference for a single-axis tracking rather than

Table 2: A figurative comparison of the percentage increase in yield for: (i) Fixed-tracking system and (ii) Single-axis tracking

Location	Ground Coverage Ratio (Fixed Tracking) (%)	Ground Coverage Ratio (Single-Axis Tracking) (%)	Percentage Increase in Yield
Askandra	39.90	45.0	14.36
Bhatradra	60.0	45.0	15.88
KA (Gulbarga)	63.2	45	18.52
AP (Anantpur)	78.9	45.0	20.95
Puducherry	90.10	45.0	20.89
Tamil Nadu (Kovilpatti)	92.30	45	20.76

Source: Lanco

dual-axis trackers. The dual-axis market players have proved more successful in smaller-scale markets. Such trackers are finding their way into residential systems as well as in the large capacity solar farms. It is equally true that trackers have proved their worthiness in quite hostile, i.e., harsh conditions. The dual-axis trackers are more attractive in areas with production-based incentives like the feed-in tariffs. There is yet another type of dual-axis tracker namely—QBotix, which is promising to be a pathbreaking development indeed. Its key attributes being in terms of offering increased margins and ease of installation.

Key technical features of QBotix tracker

It is mainly comprised of about 200 trackers, which total around 300 kW. The tracker has two robots one primary and the other one serving as a backup. These move on a steel monorail to each tracker. In turn, the monorails also contain two charging points for the robots. Further, a robot moves along the rail every 40 minutes so as to adjust each tracker individually throughout the day. Besides, the rail also carries the wiring of the system thus dispensing with any need for trenching. Importantly, the QBotix system makes use of less steel, which normally is regarded as a major price driver for the tracking systems. In cost terms, this unique design is available for almost half the cost of a dual-axis tracker. In conclusive terms, this tracker enables to achieve a LCOE reduction of up to 20 per cent as compared with the fixed-type systems. Additionally, the robot is made of water- and dust-resistant components and is thus weather-resistant.

This novel design of this tracker is such that the robot collects performance and reliability data thus allowing it to optimize the performance of each tracker and thereby the full system. It also has built-in GPS sensors, memory capabilities,

Importantly, the system design should be in a manner so as to ensure its utilization in the most efficient manner. Solar modules are placed in a number of rows taking sufficient care not to cast any shadow on the adjacent rows. As is well known, the formation of any such shadows can lead to module damage, thereby, affecting the power generation values. Practically, a specific inter-row spacing is needed to avoid any shadow formation.

Table 3: The key specifications and operational characteristics of single-axis tracking units of Scorpius make

Tracker type	Single-axis—automatic
Tilt angle	± 45 degrees from Zenith
Block size in kW per motor/drive/controller set	200 kW/250 kW/300 kW/500 kW or more
Motors per MW	2–5 (depends on the configuration)
Tracker height	1 m above ground
Module mounting	Both in landscape and portrait modes
Welding during installation	None needed
Linear actuators and drives	Lubrication required once per year
Energy gain	Up to 25 per cent much in accordance with the site-specific conditions
Land needed per MW	5–7 acres per MW (design cum location dependent)
Performance monitoring	Cloud-based preventive maintenance
Average power consumption	Less than 0.02 per cent of the energy generation of the plant
Limited Financial (estimated)	
Payback on tracker investment	Around 3 years
Internal rate of return increase	➢ 3 per cent
Reduction of LCOR power generation cost	➢ 10 per cent

and wireless communications. On a bigger note, nearly 50 per cent cost of the solar system even today is for balance of system alone. Thus, it is amply clear that the use of trackers in growing numbers may play a pivotal part in cutting costs.

Tracking at an indigenous level

Selective few tracking variants are currently available in the country, such as a Pune-based company namely Scorpius Trackers Private Limited, which was set up in 2012 to provide tracking solutions for solar PV applications. It has so far deployed more than 300 trackers for applications as varied as solar water pumping, rooftop systems, and other distributed system applications. Table 3 presents the key specifications and operational characteristics of single-axis tracking units of Scorpius make.

The Scorpius make single-axis tracking units have been deployed in a solar park at Raichur and earns the distinction of being India's first fully tracked park.

THE TRACKING WAY FORWARD

Solar PV technology is expected to incorporate several new design, engineering, and cost-cutting features in its resolve to become a really cost-competitive energy option. At current prices, it is being seen as trailing behind the cost of conventional power supply cost by a mere 15 per cent. This makes it amply clear that solar power can draw still closer by taking a sizeable recourse to the solar tracking path. Why not when the gains likely to accrue from it are so visible? The need of the hour is to track for a gainful purpose of extra power generation, wherever feasible. It would not be a misplaced notion to point out that solar PV technology and associated programme are in a stage of continuous evolution. However, cost alone should not be the key determinant to gauge its true success under the actual field operating conditions. EF

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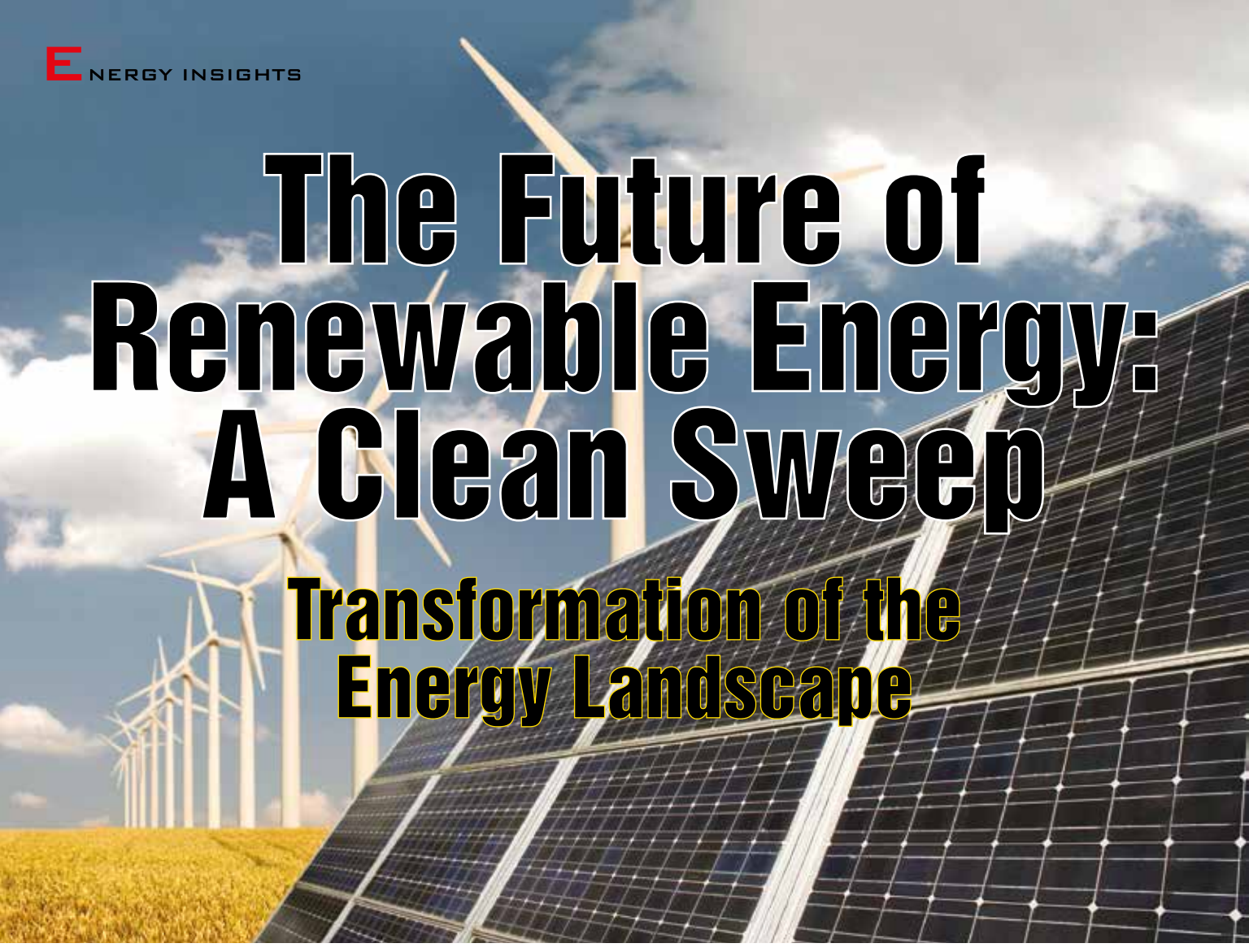

The Future of Renewable Energy: A Clean Sweep

Transformation of the Energy Landscape

The Paris agreement has set a goal of keeping the global warming well below 2°C and also for the first time agrees to pursue efforts to limit the increase in temperatures to 1.5°C. In this article, ***Ramakrishnan M*** *highlights that despite the debate on the provisions and enforceability of the agreement, there is a discernible global trend towards less reliance on fossil fuels, prevention of climate change, and efforts to create a sustainable society. Read further to know more…*

Never has a discussion on renewable energy been more relevant than in the wake of the 21st session of the Conference of the Parties (COP21) in Paris during November–December 2015. The conference resulted in the adoption of the Paris Agreement. Some of the key clauses of this agreement are to limit global warming to less than 2°C compared with pre-industrial levels and to achieve emissions neutrality during the second half of the twenty-first century. In fact, by 2030, the share of low-carbon power generation is expected to grow to almost 45 per cent, which would help contain power emissions and cater to an expected 40 per cent rise in global energy demand. The International Energy Agency's *World Energy Outlook 2015* predicts a cumulative $7.4 trillion global investment in renewable energy by 2040. This colossal spend is likely to lead to seismic shifts in the global energy mix over 2014–2040 (Table 1). Renewable energy is expected to surpass coal as the largest source of electricity by 2040, as well as account for 51 per cent of the total increase in electricity generated over 2014–2040.

TECHNOLOGY MIX

Solar power is generated through several technologies—solar photovoltaic (PV), solar thermal, concentrated solar thermal power (CSP), and concentrated PV. Among these, solar PV holds the largest share of the solar power market

Table 1: Global Electricity Generation—by source (TWh, 2014–40)

Type	2014	% Share	2040	% Share	Growth (% between 2014–40)
Renewables	5,440	*23*	13,400	*34*	146
Hydro	3,961	*17*	6,191	*16*	56
Wind	740	*3*	3,570	*9*	383
Solar	239	*1*	1,839	*5*	671
Others	500	*2*	1,800	*5*	259
Coal	9,610	*41*	11,900	*30*	24
Gas	5,100	*21*	9,000	*23*	76
Nuclear	2,520	*11*	4,580	*12*	82
Oil	1,030	*4*	515	*1*	-50
Total	**23,700**		**39,395**		**66**

Source: "World Energy Outlook 2015", International Energy Agency (November 2015); "Renewables 2015 Global Status Report", REN21 (June 2015); TSC Analysis

(98 per cent in 2014), followed by CSP (2 per cent in 2014), with the rest of the technologies having negligible market share by value. Currently, the market for solar PV is larger than CSP due to substantial investment and R&D initiatives undertaken by various national governments and multiple projects in the pipeline. However, CSP technologies are expected to grow at a faster rate in the future, as new markets, such as China, India, Brazil, Canada, Germany, and France look to invest in them. Innovations will bring down the cost of air-cooling systems, and this will help CSP plants ramp up, as well as reduce their dependence on water resources. Apart from this broad technological development, several bubble trends with the potential to transform the solar power industry have emerged in recent times. Two of these have been discussed below.

- *Monocrystalline technology*: A monocrystalline PV solar panel module is made from a single silicon crystal. Though expensive, it is more efficient than multicrystalline and thin-film PV technologies.
- *Ongoing innovations*: In August 2015, Solar Window Technologies unveiled a revolutionary solar window technology that can turn any glass pane into a solar panel.

GLOBAL COLLABORATIONS TO FOSTER GROWTH

The Intended Nationally Determined Contributions (INDCs) submitted by countries to the United Nations Framework Convention on Climate Change (UNFCCC) prior to the COP21 summit have formed the core of collective and increasingly ambitious climate action; COP21 has facilitated several other important collaborations to accelerate the clean energy revolution. Two of the prominent ones are as follows:

- *The International Solar Alliance (ISA)* was launched at the COP21 climate conference, with 121 countries (between the Tropic of Cancer and the Tropic of Capricorn) supporting it to pursue cooperation in the areas of training, institution building, regulatory issues, common standards, and investments, including joint ventures. This could prove to be instrumental for India to realize its target to establish 100 GW of solar capacity by 2022, and provide 24×7 power to all households across the country by 2019.
- *The Global Solar Council* is a business-backed council formed at the COP21 summit to bring together regional and national solar associations in a bid to support innovations

in the energy market. It aims to unify the solar power sector at an international level and encourage wide-scale adoption of solar energy through cooperation.

UTILITIES AND NON-UTILITIES TO EMBRACE RENEWABLES

Advances in residential solar power generation and storage have led to customer churn and trimmed down the margins of utility providers. Utilities are thus partnering with renewable energy startups. This has also helped companies, such as SolarCity, Nest, C3, and EnerNOC to achieve a larger scale of operations. A few such partnerships are as follows:

- In May 2015, US-based utility company MidAmerican Energy announced plans to invest $900 million more into wind energy over May 2015–December 2016, bringing the company's total wind investment to $6.7 billion.
- Duke Energy acquired a majority stake in commercial solar developer REC Solar for $225 million in February 2015.

Utilities are set to be the major customers for the energy storage industry as well, as they invested approximately $90 billion in new technologies and services in 2015 in the USA. Most of this investment is aimed at enhancing the energy distribution and transmission network, of which storage is a major component. Non-utility corporations are also actively procuring renewable energy to mitigate the financial and environmental impact of climate change. In February 2015, Apple entered into an agreement with US-based solar PV provider, First Solar, to procure 130 MW of solar energy over 25 years for $84 million. The energy will power its California operations. Fellow technology giants Amazon, Facebook, Google, and Microsoft have all made similar investments in various forms of renewable energy.

ENERGY STORAGE: THE GAME CHANGER

While fossil fuels provide a steady supply of energy throughout the day, clean energy is intermittent, fluctuating along with atmospheric conditions. As a result, storing clean energy during peak generation periods, in order to manage power volatility, will be crucial to closing the price and performance gap versus fossil fuels.

Growing energy storage options

Energy storage market is poised for growth with state legislation and regulations being the key drivers. 'Lithium batteries' can store electricity from the sun for use at night or on a cloudy day. Large-scale manufacturing plants are being built worldwide by companies including BYD, LG Chem, Samsung SDI, and Tesla Motors. Some other important points are:

- 'Flow batteries' turn electric energy into chemical energy and back again to electric energy. They are scalable and work like rechargeable batteries.
- 'Liquid cooling' is a good choice for fast action and large-scale energy needs. In 2014, GE made an investment in Highview Power Storage, a startup that uses liquid air to store energy. When air is cooled to –196°C, it turns into a liquid and 700 litres of air can be stored in 1 litre of space. The advantage is that this does not require complex chemicals for storage—just insulated stainless steel tanks. When the energy is needed, it is warmed and expands, powering a turbine to produce electricity.
- 'Hydrogen' is a great energy storage medium. It is benign if it leaks, it is readily available, and it is fairly easy to turn water to hydrogen and then hydrogen to electricity. Energy storage company ITM Power converts wind energy into hydrogen for vehicle fuelling and energy storage.

RISE OF PROSUMERS: A NEW CATEGORY

The arrival of small-scale decentralized energy installations has led to the emergence of prosumers—energy customers with the ability to generate and store their own electricity. The steady growth of both residential and commercial 'prosumers' in the energy market can be attributed to solar and wind power (the most popular forms of non-hydro renewable energy) reaching grid parity in various countries. This is when the cost of energy from renewable sources is less than or equal to the price of purchasing energy from the electricity grid. Self-consumption not only provides cheap electricity to people, it also guards them against energy price volatility.

Changing relationship between utilities and customers

In the near future, the relationship of utility providers with their end customers is expected to gain importance. Industry experts predict that by 2020, there will be approximately 20 million residential prosumers in North America.

The age of the prosumer presents challenges for utility providers accustomed to thinking of customers in terms of kilowatt hours consumed. Prosumers will be the new business partners that will

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trigger many disruptions in the utilities business model and will eventually transform the historical dependency of electricity consumers on utilities into new relationships of interdependency. As per the Capgemini Report (released in October 2015), new business models are expected to emerge that increase accessibility to on-site energy generation tools for a large number of consumers.

Consumers as active participants in energy transition

Prosumers will support the transition towards a sustainable energy mix; distributed renewable generation systems give consumers the access to resilient and competitive power systems that are cleaner than conventional sources of energy. This is supported by the successful business models of PV systems suppliers, such as SolarCity and SunPower. These companies offer solar panel installation at the customer's rooftop and sell electricity back to the customer at reduced rates while generating revenue by trading renewable energy credits.

It is important to note that the prosumer model attracts private capital from consumers that have lower expectations in terms of the rate of return than pure financial investors, thereby reducing the cost of global transition towards cleaner forms of energy.

Demand-side flexibility

To make the best use of on-site generation and reap concrete economic benefits, prosumers will drive the development of solutions, such as storage, smart appliances, and flexible contracts for consumers. These developments will reduce the peaks of production and consumption, congestion issues, and bottlenecks for the benefit of grid operators.

Schneider Electric is one of the companies working towards solutions in this area. In April 2015, the company introduced a solution that predicts the load profile for industrial and commercial buildings by tracking energy-relevant inputs. It then cuts down energy bill using demand management techniques.

Prosumers to shape the next generation of renewable electricity policy

The following are important channels through which the rise of prosumers will foster new policy frameworks:

- *Prosumer-friendly regulations*: This includes leniency in terms of obligations to inject electricity into the grid, minimum installation sizes, and taxation policies for prosumers.
- *Ease of accessibility to grid*: Arrangements, such as purchasing programmes or leasing models are likely to be introduced.
- *Facilitation of peak reduction and demand-side flexibility*: Specific programmes to bring new technologies to the market and facilitate the deployment of smart appliances will be formulated.
- *Design of new grid tariff models and market rules*: This includes ensuring the return of excess power to the grid and proper remuneration for the same, and access to aggregation services for prosumers.

THE OUTLOOK FOR RENEWABLES

While it is fairly clear that renewables are going to dominate the energy landscape in the years to come, there are several factors that will impact the trajectory that this industry will take. The efficiency and cost-effectiveness of renewable power are continuously improving, but policies continue to determine the adoption of renewable power. Legislations that favour renewable energy will be crucial drivers for growth. Varied energy storage devices and innovations will result in easier and efficient energy management, stable electricity, and improved customer satisfaction. Moreover, new entrants from the utility, non-utility, and residential sectors will change the landscape of investment, electricity production, transmission, and consumption. EF

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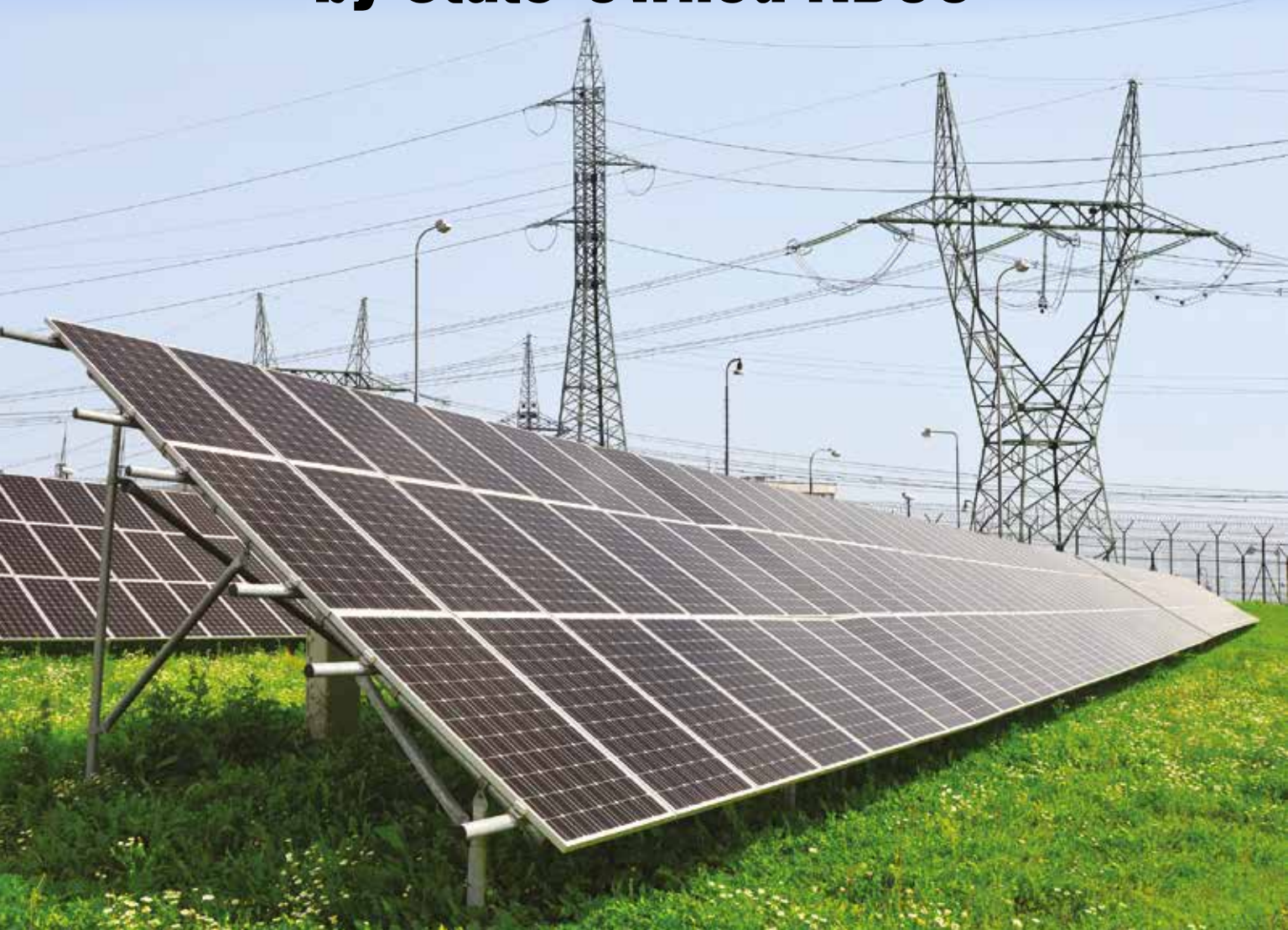
Harnessing Solar Energy for Niche Real Estate

A Success Story Chartered by State-Owned NBCC



The renewable sources of energy provide a visible and viable option to harness non-polluting and sustainable energy that does not cause greenhouse effects. Of late the large scale use of solar energy for generation of clean power having zero emissions, is receiving impetus from governments all over the world, especially in the wake of the recently concluded Paris Agreement (reached at the end of COP21) that calls for surface temperature increases to be limited to 2°C. The Indian government is also largely promoting mega solar energy programmes in the country involving huge investments. In this article, ***Dr Om Prakash Nangia*** *provides salient details about a success story chartered by state-owned The National Buildings Construction Corporation Ltd (NBCC) in a first-of-its-kind initiative by harnessing solar energy for its real estate business. The technical highlights presented about the prevailing environmental friendly carbon free solar energy technologies, are simple and brief for general awareness of readers and especially for the younger generation.*

India is a solar-resource rich country and receives abundant amount of solar insolation (an average radiation of 4–7 kWh per m^2 per day with approximately 300 sunny days annually). The abundant solar energy in India has demonstrated a durable and efficient potential by its direct conversion into electricity through the use of solar photovoltaic and thermal technologies. The Jawaharlal Nehru National Solar Mission (JNNSM) launched in January 2010 by the Indian government , has been set up to promote the development and use of solar energy for power generation and other uses with the ultimate objective of making solar energy competitive to fossil-fuel based energy options. The Ministry of New and Renewable Energy (MNRE), Government of India has been widely promoting development and deployment of large number of renewable energy solar systems with a view to accelerate promotion of solar energy technologies and for country's energy security. With downward trend in the cost of solar energy, large multi-megawatt grid connected solar power projects are being installed all over the country. The solar power systems (in various capacities of kWs to MWs) are also being installed for electrification needs where the grid connectivity is neither feasible nor cost-effective and also on the rooftop of industrial, commercial, institutional, and residential buildings involving net-metering. With energy demands only set to increase in emerging and developing countries, solar is the primary and affordable form of energy. Also for climate change mitigation, the energy transition through the use of carbon free solar technology is going to be the key factor.

INTRODUCTION TO NBCC

The National Buildings Construction Corporation Ltd (NBCC), a construction business company in India, is a blue-chip Government of India Navratna Enterprise under the Ministry of Urban Development. The company was set up in 1988 and with changing business scenario it has undergone a sea change with a tremendous growth. The Company has been receiving 'Excellent' rating from the Government of India consistently since 2004. Besides its several segments of operation, the primary one is the niche real estate segment. With added thrust, its real estate business has acquired a whole new dimension.

NBCC has earned a distinction for itself in construction of green buildings. It has embarked on a mission to be a leader with high brand equity in construction business, offering sustainable, innovative, and cost-effective construction products and services contributing to the national wealth and upholding responsibility for the environment. It carries out re-development of Government properties on a model

Picture 1: The re-developed New Moti Bagh Green Residential Complex in Chanakyapuri, New Delhi

of self-sustenance. The New Moti Bagh Green Complex (113 acres) in Delhi, under General Pool Residential Accommodation (GPRA) Scheme is one of the finest examples of such a re-development work in recent times (Picture 1). The project today is certified as the largest Green Home Complex of its kind in the country. The company had taken the first-of-its-kind initiative in 2010 under this project by utilizing the benefits of renewable energy (RE) technologies for this large multi-storeyed residential VIP complex, in providing alternate, eco-benign, and clean source for electricity and water heating applications (since the sun delivers its energy in two forms, viz., light and heat). The technical consultancy for this turnkey solar energy-based project for the installation of both photovoltaic (PV) and thermal solar energy systems in the entire residential complex in New Moti Bagh was entrusted to the author of this article. The total installation and commissioning work of the solar systems in Types VI, VII, and VIII accommodation and common areas including streets and parking areas, was completed in three years. The state-owned enterprise through its core business is determined to set a great example across the community and motivate masses to adapt RE systems generating green and clean energy to support and save the planet earth from climate change through global warming. The Government of India also supports such projects taken up by both public and private sector institutions and organizations in the country.

OVERVIEW: SOLAR ENERGY SYSTEMS

Solar energy systems (PV and thermal type) can be installed in a shadow-free open space either on ground or on rooftop. Its modular systems can be quickly installed anywhere with no gestation period.

Solar PV technology

A solar PV system (SPVS) is a concept of generating DC electricity from the sunlight falling on a solar array and converting it to a normal AC power with the help of an inverter. Once electricity is available, it can be used for a variety of applications, such as lighting, pumping, battery charging, etc. The SPVS can store electricity during daytime in a battery for later use in the night (Figure 1). It is also possible to integrate large (kWs & MWs) solar plants with the grid so that power generated by the PV arrays could be fed to grid with the help of transmission lines.

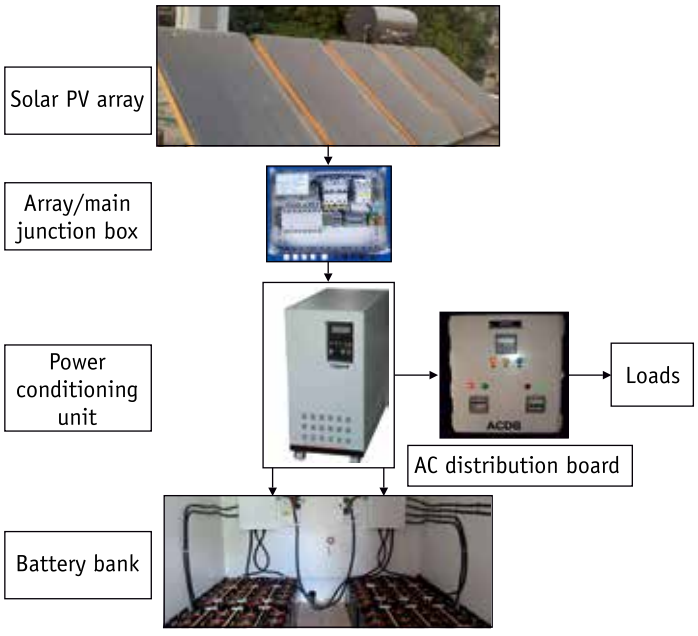


Figure 1: A stand-alone solar PV system

Merits of solar PV system

- Solar energy is environment friendly
- Robust, reliable, and weather proof
- The fuel is limitless, abundantly available, and free of cost
- No moving parts to wear out or break down
- Minimal maintenance required to keep the system running
- Produces no noise, no harmful emissions or polluting gases
- PV modules normally perform over 25 years.

Solar thermal technology

The technology that converts solar energy into heat is known as solar thermal technology and can be used for water heating and cooking requirements in our daily life. Solar water heating is now a mature technology. Widespread utilization of solar water heaters can reduce a significant portion of the conventional energy being used for heating water in homes, factories, and other commercial and institutional establishments. Internationally, the market for solar water heaters has expanded significantly during the last decade.

Solar water heating system

A solar water heating system (SWHS) consists of a collector to collect (absorb) solar energy. The total system with solar collectors, an insulated storage tank to store hot water and pipelines is called solar water heating system as shown in Picture 2. The life of the systems is generally 15–20 years with proper maintenance. The solar collectors are being manufactured in India at par with the ones available abroad.

Picture 2: Solar water heating system (Type VI flat)

Picture 3: Solar PV LED-based lighting in Type VIII towers

The choice of water heating system depends on heat requirement, weather conditions, heat transfer fluid quality, space availability, annual solar radiation, etc. The SHW systems are economical, pollution-free, and easy to operate in tropical countries such as India. There are two types of solar water heaters:

- *Flat Plate Collector Technology*: The solar radiation is absorbed by flat plate collectors (FPC) which consist of an insulated outer metallic box covered on the top with glass sheet. Inside, there are blackened metallic absorber (selectively coated) sheets with built-in channels or riser tubes to carry water. The absorber traps the solar radiation and transfers the heat to the flowing water which is stored in an insulated storage tank. The re-circulation of the same water through absorber panel in the collector raises the temperature to 80°C (maximum) on a good sunny day. (This type of water heating system has been installed in New Moti Bagh residential complex).
- *Evacuated Tubes Collector (ETC) Type:* This system is made of double layer borosilicate glass tubes evacuated for providing insulation. The outer wall of the inner tube is coated with selective absorbing material. This helps absorption of solar radiation and transfers the heat to the water which flows through the inner tube. Life of this system is normally shorter than FPC type.

SOLAR SYSTEMS INSTALLED AT THE RE-DEVELOPED NEW MOTI BAGH RESIDENTIAL COMPLEX

The following solar systems were installed by the NBCC at the re-developed multi-storeyed VIP residential complex with an initiative on RE, initiating its success story.

i) Solar PV Systems

(a) Solar PV stand-alone street light systems on the streets inside the residential complex having 1+ 3 days autonomy for dusk to dawn operation.

Brief technical requirements for the systems:

High efficiency PV multi-crystalline modules of 180 W, SO_x 36 W, low pressure sodium vapour lamp and two 12 V low maintenance lead acid (LMLA) batteries have been installed in each system.

(b) Solar PV LED Based Lighting Systems in Type-VI Towers

(c) Solar PV LED Based Lighting Systems in Type-VII Bungalows

(d) Solar PV LED Based Lighting Systems in Type-VIII Bungalows)

Brief common technical requirements for (b), (c), (d) systems:

High efficiency PV multi-crystalline modules of 370 W, white LED lamps of 15 W each and 12 V LMLA batteries have been installed in each system having 1+ 3 days autonomy, for dusk to dawn operation. (Picture 3 represents a solar PV LED lighting system in Type VIII).

Solar PV power stand-alone systems for common area lighting in each floor of type VI multi-storeyed ten towers. Two types of system's capacity, viz., 15 kWp in two towers and 40 kWp in eight towers have been installed for dusk to dawn operation daily.

Brief common technical requirements for the two systems:

High efficiency PV multi-crystalline modules of 220 W each, 5 kVA PCU, 120 V battery bank and 15 kVA PCU, 240 V battery bank, respectively, have been installed with each system having 1+ 2 days autonomy and for dusk to dawn operation. The system should have rugged design to withstand tough environmental conditions and high wind speeds over 150 km/h. Total number of PV modules installed: 1,538. The life of the modules is over 25 years. Picture 4 shows the solar PV array for lighting system installed in Type VI towers.

Picture 4: Solar PV array for lighting system installed in Type VI towers

ii) Solar Thermal Water Heating Systems

SWH Systems: Flat Plate Collectors (FPC) Type

(a) 500 lpd in Type VIII bungalows

(b) 500 lpd in Type VII bungalows

(c) 75,200 lpd for Type VI multi-storeyed towers with each system consisting of 1,800 lpd (24) and 2,000 lpd (16)

Brief technical requirements for the SWH systems:

Flat plate selectively coated solar collectors (absorber size of size 2.1 m^2) with nine fins and (absorptivity > 0.95)—as BIS standards to be installed on rooftop. The absorber material is copper sheet (0.2 mm) with heat treatment to withstand temperature of 300°C. Risers of copper tube (diameter 12.5 mm) and header of copper tube (diameter 25 mm). *Glazing*: Toughened glass with low iron transmissivity (> 85 per cent) and thickness 4 mm. One number insulated hot water stainless steel storage tank of equivalent capacity as per system size. Solar hot water systems are to be designed in accordance with guidelines laid down by the MNRE, Government of India and as per the relevant BIS standards.

The SWH systems were installed in all bungalows and high-rise towers in this GPRA campus. Picture 5 shows the solar water panel installed at Type VIII accommodation.

CONCLUSION

The initiative of installing RE systems at NBCC's re-developed VIP residential complex is a highly commendable work. It has resulted in various positive outcomes listed below:

- Achieving partial dependence on fossil-fuel based grid electricity.
- Utilization of alternate clean source of electricity with no fuel costs.
- Supporting the environment with zero emission of greenhouse gases.
- Setting a great example across the community and motivating young generation in adapting RE systems through construction projects.
- Support and save the planet earth from global warming.
- Supporting the Government of India's mission of providing "electricity for all" by 2022 in the country.
- Supporting the international agreement at Paris during COP21 and launching of the International Solar Alliance (ISA) in 2015 with India's initiative and leadership.
- Savings achieved in terms of electrical units and financial implications have been provided below:
  a) With Solar PV Systems:
     - Total electricity units saved per day: 2,791
     - Final monetary savings per day: ₹16,946
     - Total monetary savings per annum: ₹508,380
  b) Solar Water Heating Systems:
     - Total electricity units saved per annum: 1,750,248
     - Total monetary savings per annum: ₹16,889,893
- In meeting its own targets for green buildings and catching the imagination of the stakeholders with NBCC being an organization having exclusive expertise in the field.
- Providing a lush green and beautiful residential model complex—an important landmark in central Delhi. EF

Picture 5: Type VIII solar water panel

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The 7th GRIHA Summit 2016

Sharing Knowledge on 'Cities of the Future'

The 7th GRIHA Summit was organized from February 16–20, 2016 at the India Habitat Centre, New Delhi. The theme of the conference was 'Cities of the Future' and it served as a platform for knowledge sharing on sustainability solutions for built environment both at the city and building scale. Some of the key subjects covered in the conference were turning efficient building facades, water distress in growing cities, waste into building blocks, social upliftment and income equality, indoor environment quality, smart metering for buildings, existing buildings, sustainable transport, and post disaster resettlement.

Inaugurating the Summit, Dr Ajay Mathur, Director General, TERI and President GRIHA Council said, "Considering that two-thirds of infrastructure that will exist in 2030 is yet to be built, it presents us with a huge opportunity to ensure that all new buildings are 'green'. Dr A K Tripathi, Advisor/Scientist-G, Ministry of New and Renewable Energy (MNRE), Government of India, congratulated the GRIHA team for creating a 100 per cent indigenous green building rating system. He said that out of the 100,000 MW solar power goal of India, 40,000 MW will be in the form of rooftop solar power, which translates fully into the building stock, which directly relates to green buildings. He also highlighted that the cost of renewable energy at ₹4.50/unit as compared to that of electricity from the grid at ₹5.25/ unit, removes any question of its unviability.

Setting the theme of the GRIHA Summit 2016, Ms Mili Majumdar

said that GRIHA has evolved in the last seven years and has grown from 30 projects to 700, covering almost 28 million m^2 of green footprint. Although there is still a long way to go, substantial impact has been made thus far. This journey would not have been possible without the support of government and private stakeholders. GRIHA is recognized and incentivized by many urban local bodies and was recently acknowledged as a tool to achieve the climate change goals in India's Intended Nationally Determined Contributions (INDCs) submitted to the United Nations Framework Convention on Climate Change (UNFCCC) at the Conference of the Parties 21 (COP21) held at Paris in December 2015.

The four-day GRIHA Summit served as a platform for knowledge sharing in different domains of green building industry. It facilitated multi-stakeholder partnerships and networking among governments, academia, civil society organizations and professionals from different disciplines, such as architecture, engineering, and construction management. In addition to plenary sessions where several eminent speakers addressed the audience, key sessions revolving around feasibility of smart cities in Indian context, architectural design and technology for efficient buildings and hands on activity workshop for students and media were also organized during The GRIHA Summit 2016. Talking about the ideology of cities of the future, Dr Bimal Patel, President & Acting Director, CEPT University said that our capacity to predict the future is very limited, and this uncertainty must be taken seriously and cities must not be subjected to rigid policies. He also pointed out that there is no cost involved in formulating the codes but there are huge costs involved in implementing them, which ultimately leads to difficulty in enforcing them. He emphasized that our focus should be on problems which must be solved immediately and maybe leave some problems to be solved by the next generation.

As a prelude to the main conference, the Summit also hosted a set of side events along with an exhibition of a multitude of green products, all aimed at transforming the discussion of sustainability and green buildings into a comprehensive and prolific experience for the attendees. The summit was concluded on Green Lifestyle where the panellists expressed concerns about the growing disconnect between nature and our lifestyle and how we are not able to protect the environment. Different levels of certification to projects were awarded that have maintained the standard for sustainable habitat according to GRIHA norms. A total of seven projects were felicitated, including three 5-star ratings, two 4-star ratings, and two 3-star ratings. Projects with 5-star ratings were Manipal University, Jaipur; Infosys Pocharam, SDB 4 & 5, Hyderabad; and Institute of Public Enterprise, Shamirpet, Hyderabad. Chandigarh Airport and A J C Bose Road Residential Project, ITC, Kolkata were recognized as 4-star rated projects. Ansal Esencia, Gurgaon and Ganga Cypress, Pune were recognized as being 3-star rated. GRIHA Council also awarded three SVAGRIHA rated projects. IIT Gandhinagar and IIT Ropar were felicitated as GRIHA LD (Large Developments) rated projects.

The Council recognized projects from diverse fields of building and construction for their exemplary work on promotion of sustainable habitats. These nomination categories were health and safety, site management, passive design, energy, materials, and water management. The projects included IIT Hyderabad and High Court, Goa. Dr Ajay Mathur congratulated all the projects that received GRIHA rating and exemplary awards. Mr Ashok Chawla, Chairman, TERI emphasized the linkage between economic growth and environmental responsibility and said that one cannot exist without the other. He highlighted the importance of green buildings in the Indian context and its role in mitigating climate change. He also congratulated the GRIHA Rating system for mainstreaming the green agenda in the country. EF

"Smart People Make Buildings and Cities Smarter"

The Future of Smart Cities

The US Green Building Council (USGBC) is committed to transforming the way our buildings are designed, constructed, and operated through Leadership in Energy and Environmental Design (LEED) verification system for sustainable structures around the world. During the GRIHA Summit in New Delhi, in an interview with ***Abhas Mukherjee*** *for Energy Future,* ***Gautami Palanki****, Director, USGBC, presented her views on various facets of green and sustainable buildings and sustainability issues in India as well as globally.*

Gautami Palanki, Director at US Green Building Council, manages product development and global implementation of the leedon.io —a data driven performance scoring platform. Prior to USGBC, as a sustainability consultant, she managed the design and implementation of energy, water, and resource efficiency initiatives and LEED certification across new and existing buildings. She is an experienced architectural designer, with a focus on international commercial and hospitality projects. Ms Palanki is a licenced architect, with a BArch from Jawaharlal Nehru Technological University and an MS in Sustainable Design from Carnegie Mellon University. She has completed training for the Global Reporting Initiative (GRI) and GRESB, and is a LEED accredited professional based in Washington, DC.

The US Green Building Council (USGBC) believes that "Better buildings are our legacy". What is your take/opinion on that?

Green, high performing and intelligent buildings are our legacy. USGBC represents a talented and mission driven team, which brings together stakeholders from across the world, with a mission of market transformation. With over hundred green building councils and several thousand sustainability professionals worldwide, this is a legacy of a larger community. I am an architect, and it is my professional responsibility to offer new solutions and ideas for better buildings.

What do you do to help make buildings better and more sustainable?

USGBC and GBCI (Green Business Certification Inc.), offer solutions to design and operate an optimal built environment. Our certification frameworks provide guidance to develop the smallest tenant space, for example, through the LEED for commercial interiors rating system, to global standards for Environmental, Social, Governance (ESG) reporting on the largest infrastructure projects, through GRESB Infrastructure. I am on the LEED technical development team, that has developed a data based performance scoring platform; LEEDon (www.leedon.io). We create simple methods for a building, campus, neighbourhood or city to monitor energy, water, waste, indoor air quality, and for people to view and contribute positively to these metrics.

What challenges do you face in implementing your plans and how do you foresee the future of sustainable or green buildings in the world?

It can be challenging to communicate technical content in a simple, actionable manner. Green building professionals are continually finding creative ways to encourage environmentally preferable strategies. For example, carbon emission reduction is a critical issue that needs immediate action from all of us. Together, if we are thoughtful about using less electricity and taking public transport or carpooling instead of driving, we will achieve positive results. Collective action can lower resource consumption, direct and indirect costs. This challenge has tremendous opportunity.

With urbanization, urban areas are expected to house 40 per cent of India's population by 2030, this requires comprehensive development of infrastructure in smart cities. How do you visualize the green building movement in India's smart cities of the future?

Sustainable high performing buildings are critical to smart cities. Smart people designing, operating, and using buildings optimally will make cities smarter. We have a chance to be innovators and leaders! Let us take this unique chance to create infrastructure that can evolve and be flexible to accommodate future technologies and future generations. In India, we are seeing the impact of resource-inefficiency, in water shortages, poor air quality, power cuts, etc. With a large urban influx, the demand on energy, water, and natural resources is going to increase. It is critical that any new environment is responsible and responsive. Building new is not always the only solution, improving existing assets is one too. Let us renew the emphasis on ongoing performance management—continuous verification and improvement of our infrastructure.

Also, strategically USGBC has signed an MoU with India's first smart city, i.e., GIFT City, wherein it aims to accelerate smart and green built environment with this, USGBC shall support various developers, architects, planners, landscape architects, MEP consultants, engineers, etc., of GIFT City as they pursue LEED certification.

Do you think that India's smart cities would be able to face this challenge of green building's implementation strategies?

Yes, it is an opportunity more than a challenge. Green building design concepts are the basis of our vernacular architecture. Bio-climatic design is the root of our design philosophy. We are inherently resource efficient in our lifestyle. In the last decade, we may have taken a detour, and need to course correct. I am originally from Hyderabad, even today, if you go to the Golconda fort during peak summer (+45°C), it is still cool in the fort, with no air conditioning. We need to channel these concepts in contemporary architecture. Today, bio-climatic design, technology, and renewables offer a key combination to intelligent planning and smarter contemporary cities.

What role do you think GRIHA and the GRIHA Council are playing for promoting green building sustainability practices in India?

It is exciting to see organizations worldwide provide regional education and awareness on green buildings. The GRIHA Summit has been a collaborative platform to share experiences and lessons learnt from different parts of the world. The Council has successfully brought together real world solutions and innovative project case studies to demonstrate answers to challenges.

TERI's GRIHA and USGBC's LEED have partnered to promote the best of global and Indian practices to ensure efficiency of design, construction, and operation of high performance buildings. The partnership will focus on two key initiatives:

(i) Existing buildings: The GRIHA Council implementing and supporting the

LEED for Existing Buildings rating system and the LEED Dynamic Plaque for Indian and Southeast Asian markets.

(ii) *New buildings*: Offering seamless pathways for dual ratings for new buildings—GRIHA projects will have the opportunity to earn LEED certification and LEED buildings will have the opportunity to earn GRIHA certification.

There is a unilateral desire to create higher performing assets and professionals can choose from green building rating systems, LEED and GRIHA included, which only results in more green buildings!

Please tell us in brief about the possible strategies related to the design and operations of indoor spaces to achieve the desired air quality. Also tell us that how various green building rating systems, such as LEED and GRIHA are addressing the indoor environment quality issues?

It is appropriate that the GRIHA summit is in Delhi. The World Health Organization (WHO) and the United Nations (UN) statistics indicate over a million people are affected by air quality and the cost of (bad) air quality is about $0.5 trillion a year! Air quality needs to be addressed outside and inside buildings. LEED encourages lower vehicle emissions from locating new buildings in appropriate neighbourhoods, implementation of environmentally responsible materials, including composite material assembly, high performance filtration media, and ongoing monitoring of indoor air quality (IAQ) contaminants in existing buildings. The rating system also requires verification of IAQ periodically in operational buildings, including interior carbon dioxide levels and total volatile organic compounds. LEED credits offer synergies between IAQ and energy efficiency or IAQ and occupant health, resulting in multiple benefits to the end user. The rating system expands the scope to Indoor Environmental Quality (IEQ) which includes acoustics, daylighting, access to external views and air quality to improve the overall experience. These are examples of best practices, supported by scientific research, and structured as a prescriptive framework in the rating system. The step by step approach helps individuals design and operate a property with enhanced air quality and gain occupant health and productivity benefits. EF

ENERGY FUTURE

The Complete Energy Magazine

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

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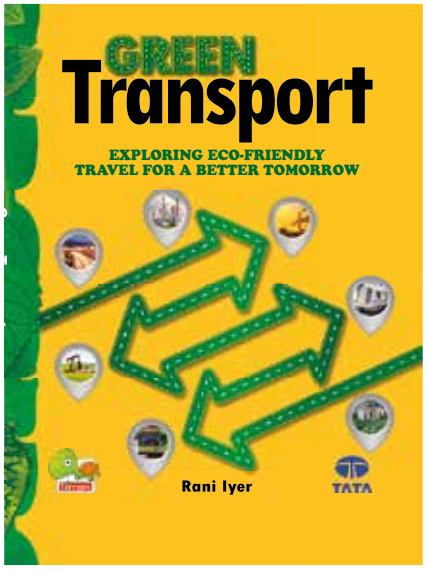

GREEN Transport

EXPLORING ECO-FRIENDLY TRAVEL FOR A BETTER TOMORROW

Rani Iyer

• 2016 • 180 x 240 mm • 120 pages
• Hardback • General Reference
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Ages: 12+ years

Nothing can go faster than the speed of light. But it seems the superfast, snazzy, chic, and hi-tech vehicles will soon outshine this adage. Fast, faster, fastest technological advancements in transportation have made mobility of people and goods easy, connecting the entire world and expanding world trade. It has steered globalization giving a boost to the wealth of nations.

On the flipside, aircraft, ships, trucks, and trains powered by the combustion of fossil fuels, moving across the sky, oceans, and land have accelerated climate change, besides giving way to the problem of global energy crisis due to the huge demand and short supply of fossil fuels.

So the world now aims at combining energy-efficient technologies with clean fuels to enjoy the benefits of vehicles while being sensitive to the environment. Hybrids, electric cars, and biofuels are some of the examples in this regard. However, there is still a long way to go.

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CURRENT R&D SOLAR

Solar Photovoltaic Energy Progress in India: A Review

Renewable and Sustainable Energy Reviews, Volume 59, June 2016, Pages 927–939

Sarat Kumar Sahoo

The mitigation of global energy demands and climate change are the most important factors in the modern world. Development and application of solar energy have been regarded highly by the Government of India and common people, and they thought that solar photovoltaic energy can provide more energy in the future as compared to other renewable energies. In the last decade, solar photovoltaic energy research and development has been supported by the Central government and State governments. This paper discusses the current progress of solar photovoltaic energy in India. It highlights the renewable energy trend in India with major achievements, state-wise analysis of solar parks and industrial applications. Finally, it discusses the Indian government's policies and initiatives to promote solar energy in India. This review on solar photovoltaic energy will help decision makers and various stakeholders to understand the current status, barriers, and challenges for better planning and management in this field.

A Review on Paddy Residue Based Power Generation: Energy, Environment, and Economic Perspective

Renewable and Sustainable Energy Reviews, Volume 59, June 2016, Pages 1089–1100

S M Shafie

Today's world is mostly dependent on fossil fuel for power generation. The dependency on fossil fuels is leading the world into a complex crisis comprising the insecurity of supplies; environmental impact; and also the fluctuation of fuel price. With a view to tackle this crisis, scientists are shifting their interest on new energy sources, such as biomass resources, solar, tidal, and geothermal energies. Among these, biomass resources have been around for domestic use for a long time, but have not yet been utilized for industrial-scale power generation. Whereas other renewable sources have a long way to go on the path to technological advancement, to be utilized in a mass scale and compete with fossil fuel as a cost-effective alternative. The most potential biomass resource is lignocellulosic biomass, which includes paddy residue. Paddy residues are widely abundant agricultural wastes, which have a high potential for utilization in energy industries. The major challenges to the proper utilization of paddy residues in power generation are improper management, lack of economic study, and lack of collection network. Lastly, the economic, environment, and energy policies play an important role for developing paddy residues as a fuel for energy industries.

Basis of Energy Crop Selection for Biofuel Production: Cellulose vs. Lignin

International Journal of Green Energy, Volume 13, Issue 1, 2016, Pages 49–54

T Kikas, M Tutt, M Raud, M Alaru, R Lauk, and J Olt

This paper investigates the suitability of Jerusalem artichoke (*Helianthus tuberosus* L.), fibre hemp (*Cannabis sativa* L.), energy sunflower (*Helianthus annuus* L.), Amur silver-grass (*Miscanthus sacchariflorus*), and energy grass cultivar (cv) Szarvasi-1 for biofuel production in Northern climatic conditions. Above ground biomass, bioethanol production yield, and methane production yield are used as indicators to assess the bio-energy potential of the culture. Results presented show that the energy crops of Southern origin produce 30–70 per cent less biomass than in the origin region. Nonetheless, both perennial and annual energy crops produce high above ground biomass yields (660–1,280 g m^{-2}) for Northern climatic conditions.

Experimental results show that bioethanol yield is dependent on cellulose content of the biomass. The higher the cellulose content, the higher the bioethanol yield. Biogas production on the other hand, depends on lignin content. The lower the lignin content, the higher the biogas yield. Therefore, the selection of the energy crop for bioethanol production should be based on high cellulose content, while for biogas production it should rather be based on the low lignin content.

A Holistic Approach to Energy Efficiency Assessment in Plastic Processing

Journal of Cleaner Production, Volume 118, April 2016, Pages 19–28

B Alexander Schlüter and Michele B Rosano

A significant increase in the industry energy efficiency is crucial for transforming the world's energy systems. Many production sites offer high energy saving capabilities, and if these are accompanied by short periods of economic amortization, companies should be willing to act. This case study provides a novel and extended energy assessment for plastics processing plants including primary energy, greenhouse gas emissions, and energy costs. The research distinguishes between the standard form of separate individual energy assessments and provides a more innovative holistic approach taking all relevant energy flows within the production system into account. Dynamic simulation offers a quick and effective way to predict the results of the possible energy saving measures highlighted in this analysis. The paper presents validated energy consumption simulations based on realistic processing conditions for two injection moulding factories in different climatic zones. The results show that combining a number of separate energy saving measures can reduce the primary energy demand by around 26 per cent for a German plant under temperate climate conditions and 20 per cent for a Western Australian plant under Mediterranean conditions. However, when the separate energy saving measures are holistically combined, the reduction in energy use significantly increases to 41 per cent and 43 per cent, respectively. This holistic energy strategy involves incorporating better cogeneration and waste heat recovery options. For small- and medium-sized companies in particular major energy infrastructure investments may often be considered too expensive without examining the extended benefits from a holistic energy assessment perspective. In contrast, a holistic framework, like the one suggested in this paper could provide a number of new options for increasing energy efficiency that individually might normally not be accepted under conventional economic rate of return analysis.

On the Path to Sustainability: Key Issues on Nigeria's Sustainable Energy Development

Energy Reports, Volume 2, 2016, Pages 28–34

Norbert Edomah

In the face of scarcity of energy resources and rising energy prices due primarily to a world of increasing demand, energy security concerns becomes more crucial both for the private and public sector alike. At the same time, energy policies have been shifting and policy changes have become hard to predict because of radical changes in energy supply. This paper analyses the barriers to sustainable energy development in Nigeria which are: (i) Cost and pricing barriers, (ii) Legal and regulatory barriers, and (iii) Market performance barriers. It concludes by highlighting some key policies that can help address some of the identified barriers in order to ensure a secured sustainable energy future for Nigeria. This paper uses exploratory research tools for data collection from already published statistical reports to analyse the Nigerian energy profile with specific focus on: historical energy production and consumption trends; trends in fossil fuel use for electricity generation; and issues around energy resource vulnerability, with the view of understanding the link to the current barriers towards achieving a sustainable energy future. Data from different sources such as the *US Energy Information Administration, British Petroleum Statistical Review on World Energy*, among other documents were used for the analysis of the Nigerian sustainable energy barriers.

Mountainous Areas and Decentralized Energy Planning: Insights from Greece

Energy Policy, Volume 91, April 2016, Pages 174–188

Nikolas M Katsoulakos and Dimitris C Kaliampakos

Mountainous areas have particular characteristics, whose influence on energy planning is explored in this paper, through a suitably tailored methodology applied to the case of Greece. The core element of the methodology is a linear optimization model with a 'total cost' objective function, which includes financial, as well as external costs and benefits. Altitude proves to have decisive influence on energy optimization results, because it affects energy demand. The improvement of local energy systems provides greater socioeconomic benefits in mountainous settlements, due to the high shares of renewables and energy efficiency interventions in the optimal solutions. Energy poverty can be alleviated by redesigning local energy systems and the structure of the energy market. However, spatial and

aesthetic restrictions, presented often in mountainous settlements, may affect the operational costs of energy systems, which is a crucial parameter for confronting energy poverty. Furthermore, the study indicates that it could be better to electrify remote areas, far from electricity grids, by decentralized systems than by grid expansion. The results of this study and the assumptions made about the way in which energy market should function, could be utilized for reconsidering energy policy measures, aiming at supporting sensitive societies to improve their development perspectives.

Energy Performance Certificates and 3-dimensional City Models as a Means to Reach National Targets—A Case Study of the city of Kiruna

Energy Conversion and Management, Volume 116, May 2016, Pages 42–57

Tim Johansson, Mattias Vesterlund, Thomas Olofsson, and Jan Dahl

Enhanced dissemination of information regarding energy saving and climate change targeted towards property owners is considered to be an important strategy in order to reach the Swedish national target of energy efficiency in the building sector by 2050. Here the municipality energy advisors and the national register for energy performance certificates can facilitate the mitigation of energy use in the building stock. So far, few studies have focussed on the practical roadmap to the national target of energy use on the city/district level and to the communication aspects with stakeholders in the creation of energy city models.

In this paper, a city energy model is developed based on the requests and need for visualization from a group of energy advisors. Six different scenarios are studied in order to analyse the possibility of reaching the energy targets specified by the government in the town of Kiruna. The results show that: (i) It is possible to automatically create city energy models using extract, transform, and load tools based on spatial and non-spatial data from national registers and databases; (ii) City energy models improve the understanding of energy use in buildings and can therefore be a valuable tool for energy advisors, real estate companies, and urban planners. The case study of Kiruna showed that the proposed energy saving measures in the energy performance certificates need to be implemented and new buildings in the urban transformation must be of high energy standard in order to reach the national target in Kiruna.

Dynamic Linkages among Energy Consumption, Environment, Health and Wealth in BRICS Countries: Green Growth Key to Sustainable Development

Renewable and Sustainable Energy Reviews, Volume 56, April 2016, Pages 1263–1271

Khalid Zaman, Alias bin Abdullah, Anwar Khan, Mohammad Rusdi bin Mohd Nasir, Tengku Adeline Adura Tengku Hamzah, and Saddam Hussain

The objective of the study is to examine the four pillars of green growth (or green environment), that is, energy, environment, health, and wealth in BRICS countries namely, Brazil, Russia, India, China, and South Africa, over the period of 1975–2013. The study examines the relationship between energy consumption, environment, health, and its resulting impact on BRICS' economic growth. The study uses three environmental variables (i.e., agricultural technology, carbon dioxide emissions, and population density), three energy sources (i.e., nuclear energy consumption, electricity production from renewable sources, and combustible renewable and waste); two health proxies (i.e., fertility rate, total, i.e., births per woman, and infant mortality rate); and GDP per capita for economic growth. These variables were selected due to the vital importance in the BRICS nations. The overall results indicate that environmental variables have a deleterious effect on the BRICS economic growth, while energy sources significantly increases economic growth in the countries. Health expenditures and infrastructure requires proper care of fertility and mortality related health issues in the BRICS countries. The results emphasized the importance of green growth and sustainable developmental policies that help to expedite growth process and welfare of the countries. EF

Rack-Integrated Energy Storage

For Effective Energy Storage Applications

LD ENERGY STORAGE RACKS

The long duration (LD) Energy Storage Racks (Picture 1) are high performance, fully integrated battery systems for a wide range of long duration energy storage applications. The LD Energy Storage Racks are available in two configurations:

- 700 V (nominal) rack offering 76 kWh of available energy and 38 kW of continuous power (charge or discharge)
- 950 V (nominal) rack offering over 100 kWh of available energy and 52 kW of continuous (charge or discharge).

The LD Energy Storage Racks are fundamental building block of NEC Energy Solutions' GBS™ rack-integrated grid-scale energy storage systems. As standalone DC energy storage components, they are suited for a variety of custom grid and commercial applications. The LD Energy Storage Rack offers industry-leading performance and inherent multi-layer safety for the most demanding energy storage scenarios.

The LD Energy Storage Racks include:

- Battery modules utilizing industry-proven Nanophosphate® technology
- Complete Battery Management System (BMS), orchestrating continuous monitoring of voltage, temperature, and safety conditions, as well as cell balancing and optimization of module state-of-charge
- Integrated ducting for ambient or forced air cooling, depending on application requirements
- Nested safety design providing multiple layers of protection at the cell, module, BMS, and rack level
- Voltage fusing for the entire rack

Picture 1: A Long Duration (LD) Energy Storage Rack

- CAN bus communications between BMS to high level system controls
- Optional Equalizer that automatically balances multi-rack configurations.

Some salient features of LD Energy Storage Racks are as follows:

- *High performance*: The LD Energy Storage Rack delivers an unparalleled combination of cycle life, calendar life, and energy performance. Multi-year testing of the cells and modules, under both realistic and extreme conditions, confirms life expectancy of > 4,500 cycles.
- *Nested safety design*: The LD Energy Storage Rack is engineered for the utmost safety, enabled by the intrinsically safe design, fusing at the cell level, module level and rack level, extensive fault monitoring at the module level and automatic opening of the dual contactors upon power loss or safety cover removal.
- *Battery module features*: LD Energy Storage Racks contain field-replaceable battery modules with on-board intelligence that communicates with the BMS to:
  - Monitor voltage on every cell bank and provide independent module voltage measurements
  - Measure representative cell temperatures
  - Maintain cells in optimum state-of-charge and help prevent overvoltage conditions
  - Monitor overvoltage conditions and signal shutdown, if detected.

HR ENERGY STORAGE RACKS

The High Rate (HR) Energy Storage Racks (Picture 2) are fully integrated battery storage system offering reliable energy storage for a wide range of high rate and high power applications. The HR Energy Storage Racks are available in two configurations:

- 700 V (nominal) rack offering 51 kW continuous power (102 kW maximum, charge or discharge) with 26 kWh of available energy
- 950 V (nominal) rack offering 68 kW continuous power (136 kW maximum, charge or discharge) with 34 kWh of available energy.

The HR Energy Storage Racks are elements of NEC Energy's GBS™ integrated grid-scale energy storage systems. As standalone DC energy storage racks, they are suited for a multitude of customized high power grid and commercial applications. The HR Energy Storage Racks are standardized products that deliver best-in-class performance and inherent multi-layer safety for the most demanding energy storage scenarios.

The HR energy storage racks include:

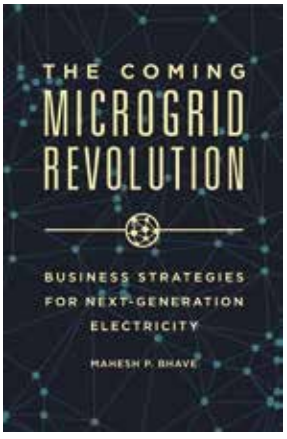
- Battery modules utilizing industry-proven Nanophosphate® technology
- Battery Management System (BMS) that continuously monitors voltage, temperature, and system conditions and performs cell balancing. Nested safety features provide layered protection at the cell, module, BMS, and rack level
- CAN bus communications between BMS and higher system controls. EF

Source: www.neces.com

Picture 2*:* A High Rate (HR) Energy Storage Rack

THE COMING MICROGRID REVOLUTION: BUSINESS STRATEGIES FOR NEXT-GENERATION ELECTRICITY

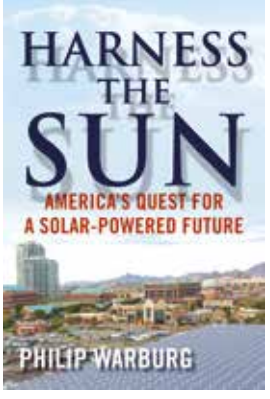
In *The Microgrid Revolution: Business Strategies for Next-Generation Electricity*, the author explains the current state of electricity production, identifies its widespread problems, and proposes a specific approach and particular solution to the puzzle of supplying clean energy for the twenty-first century world. This book explores the tremendous opportunities of the new electricity revolution that looks to threaten the century-old business models of our existing power production infrastructure. This unique book proposes public policy and business strategy-level initiatives that could overcome the structural impediments that prevail in the current electricity industries and predicts the important changes to come in the immediate and distant future. This book synthesizes seemingly disparate concepts from the telecom and electricity industries with business strategy and policy and regulatory issues, allowing readers to see the tremendous opportunity at hand in clean electricity technologies. EF



Author: Mahesh P Bhave
Publisher: Praeger; Year: 2016

HARNESS THE SUN: AMERICA'S QUEST FOR A SOLAR-POWERED FUTURE

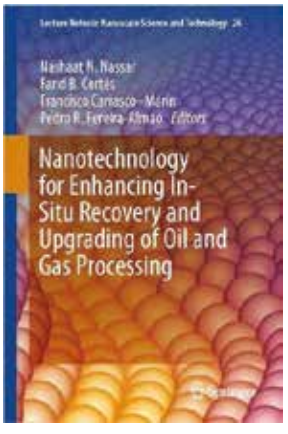
In *Harness the Sun*, Philip Warburg takes the readers on a far-flung journey that explores America's solar revolution. Beginning with his solar-powered home in New England, he introduces readers to the pioneers who are spearheading our move towards a clean energy economy. The readers meet the CEOs who are propelling solar power to prominence and the intrepid construction workers who scale our rooftop by installing panels. The readers encounter the engineers who are building giant utility-scale projects in prime solar states, such as Nevada, Arizona, and California, and the biologists who make sure wildlife is protected at those sites. Warburg shows how solar energy has won surprising support across the political spectrum. Prominent conservatives embrace solar power as an emblem of market freedom, while environmental advocates see it as a way to reduce America's greenhouse gas emissions. Yet solar energy has its downsides and detractors too. *Harness the Sun* offers a grounded, persuasive vision of America's energy future. It is a future fuelled by clean, renewable sources of power, with solar at centre stage. EF



Author: Philip Warburg
Publisher: Beacon Press; Year: 2016

NANOTECHNOLOGY FOR ENHANCING IN-SITU RECOVERY AND UPGRADING OF OIL AND GAS PROCESSING

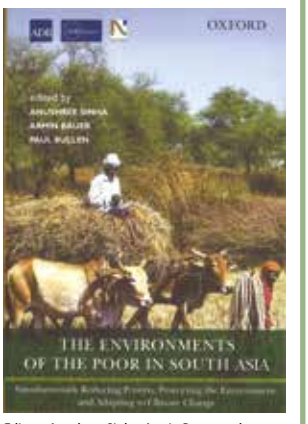
This book assesses the current application of nanotechnology in oil and gas industries and explores new research directions in this frontier field. It outlines the theory and practical challenges of the nanoparticle colloidal behaviour in oil matrixes and aqueous solutions, the interactions between rock and nanofluid, and the surface phenomena relevant to the application of this technology. The book also describes the transport behaviour of nanoparticles in oil/sand media for in-situ upgrading and recovery of heavy oil. Currently, the main objectives of applying nanoscale materials in oil and gas industries are the remediation of formation damage, the improvement of energy efficiency, the abatement of environmental footprint, and the increment of recovery factors of oil reservoirs, to name a few. The book consists of six chapters with contributions by leading experts in the topics of fabrication methods, opportunities, and challenges in the oil and gas industry, modelling, and application of nanofluids in the field and environmental applications of nanoparticles. EF



Editors: Nashaat N Nassar, Farid B Cortés, *et al.*
Publisher: Springer; Year: 2016

THE ENVIRONMENTS OF THE POOR IN SOUTH ASIA: SIMULTANEOUSLY REDUCING POVERTY, PROTECTING THE ENVIRONMENT, AND ADAPTING TO CLIMATE CHANGE

The agendas of those trying to reduce poverty and those trying to protect the environment have been at odds in the past. But they are coming together now due to a recognition of the increasing role of the environment in the lives of the poor in developing countries, especially with the changes to the environment being caused by global warming. This book contains a multitude of studies of the environment–poverty relationship, such as those in the drylands of Rajasthan and Odisha, the Sundarbans Delta, the Nepalese uplands, the Sri Lankan and Bangladeshi coastlands, and the urban slums of India and Bangladesh. Floods, landslides, droughts, degradation of natural resources, and urban pollution exert a greater influence on the people in these areas than on those living in other geographical regions of South Asia. EF

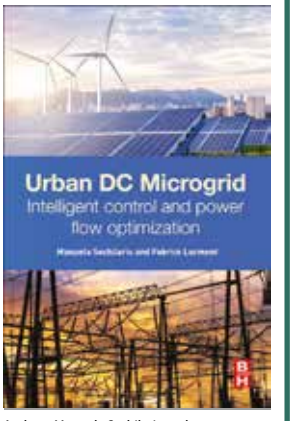


Editors: Anushree Sinha, Armin Bauer, and Paul Bullen
Publisher: Oxford University Press; Year: 2015

URBAN DC MICROGRID: INTELLIGENT CONTROL AND POWER FLOW OPTIMIZATION 1ST EDITION

Urban DC Microgrid: Intelligent Control and Power Flow Optimization focusses on microgrids for urban areas, particularly associated with building-integrated photovoltaic and renewable sources. This book describes the most important problems of DC microgrid application, with grid-connected and off-grid operating modes, aiming to supply DC building distribution networks.

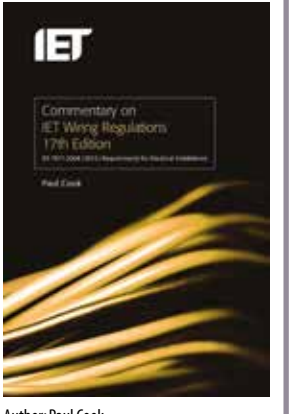
The book considers direct current (DC) microgrid to supply DC building distribution networks for positive energy buildings; dynamic interactions with the utility grid based on communication with the smart grid; supervisory control systems; and energy management. The global power system is exposed and the DC microgrid system is presented and analysed with results and discussion, highlighting both the advantages and limitations of the concept. Coverage at the system level of microgrid control as well as the various technical aspects of the power system components make this a book interesting to academic researchers, industrial energy researchers, electrical power, and power system professionals. EF



Authors: Manuela Sechilariu and Fabrice Locment
Publisher: Butterworth-Heinemann; Year: 2016

COMMENTARY ON IET WIRING REGULATIONS (17TH REVISED EDITION)

This book is a complete guide to the IET wiring regulations and the important changes expected in Amendment 3 to BS 7671:2008. It provides comprehensive guidance on all aspects of electrical installation design, including the Electricity Safety Quality and Continuity Regulations. Derivations of the requirements are included along with the relevant formulas, data installation design calculations, and examples. The Commentary also includes guidance on related subjects, such as the prevention of electromagnetic interference, allowance for harmonic currents, and the use of cable armouring. EF



Author: Paul Cook
Publisher: The Institution of Engineering and Technology; Year: 2016

RENEWABLE ENERGY TECHNOLOGY DEVELOPMENT

THE SPHERICAL SUN POWER GENERATOR

German Architect Andre Broessel believes he has a solution that can "squeeze more juice out of the sun", even during the night hours and in low-light regions. His company Rawlemon has created a spherical sun power generator prototype called the 'beta.ray'. This technology will combine spherical geometry principles with a dual axis tracking system, allowing twice the yield of a conventional solar panel in a much smaller surface area. The futuristic design is fully rotational and is suitable for inclined surfaces, walls of buildings, and anywhere with access to the sky. It can even be used as an electric car charging station. The beta.ray comes with a hybrid collector to convert daily electricity and thermal energy at the same time. While reducing the silicon cell area to 25 per cent with the equivalent power output by using the ultra-transmission Ball Lens point focussing concentrator, it operates at efficiency levels of nearly 57 per cent in hybrid mode. At night-time the Ball Lens can transform into a high-power lamp to illuminate one's location, simply by using a few LEDs. The station is designed for off-grid conditions as well as to supplement buildings' consumption of electricity and thermal circuits like hot water.

http://www.alternative-energy-news.info/spherical-sun-power-generator/

COMMON ALGAE FOR BIOFUEL BUTANOL PRODUCTION

Various methods have been tried for reducing fossil fuel dependency and containing carbon footprint for a healthier and more eco-friendly future. Corn-produced ethanol has been used for mixing with gasoline but there have been side effects, such as corrosion from ethanol. So, for better solution, the focus of the research conducted by University of Arkansas is on converting the common algae into renewable fuel, which can be used in automobiles with combustible type engines. The research is done on algae which survive on nitrogen, phosphorous, sunlight, and carbon dioxide; and from which, organic acids and subsequently biofuel is produced.

http://www.alternative-energy-news.info/common-algae-biofuel-butanol-production/

MAKING THE BEST USE OF POLYMER SOLAR CELLS

In the recent past, a process has been developed by the researchers at the Iowa State University and the Ames Laboratory that can produce thin and constant light absorbing layers on textured substrates. This increases light absorption by polymer solar cells, thereby, increasing their efficiency and enabling its best use.

According to one of the professors, these researchers are making polymer cells that have the capabilities of capturing more light within the ridges. This includes the light they

absorb from outside and the light that gets reflected from one ridge to another. These solar cells are made up of polymers that are lightweight, easy-to-make, and flexible. Their functioning is improved by a textured substrate pattern that lets the removal of a thin light absorbing layer. As the light absorbing layer goes through the small ridges, it maintains good electrical transport properties in the cells.

http://www.alternative-energy-news.info/best-use-of-polymer-solar-cells/

CHEMISTS DEVISE TECHNOLOGY THAT COULD TRANSFORM SOLAR ENERGY STORAGE

The materials in most of today's residential rooftop solar panels can store energy from the sun for only a few microseconds at a time. A new technology developed by chemists at University of California, Los Angeles is capable of storing solar energy for up to several weeks. The new design is inspired by the way the plants generate energy through photosynthesis.

A researcher from the team stated that in photosynthesis, plants that are exposed to sunlight use carefully organized nanoscale structures within their cells to rapidly separate charges pulling electrons away from the positively charged molecule that is left behind, and keeping positive and negative charges separated and that separation is the key to making the process so efficient.

The two components that make the UCLA-developed system work are a polymer donor and a nano-scale fullerene acceptor. The polymer donor absorbs sunlight and passes electrons to the fullerene acceptor; the process generates electrical energy. The new design is also more environmentally friendly than current technology, because the materials can assemble in water instead of more toxic organic solutions that are widely used today.

https://www.sciencedaily.com/releases/2015/06/150619103601.htm

USING WASTE HEAT FROM AUTOMOBILE EXHAUST

A new technology is being developed at Oregon State University (OSU) to capture and use the low-to-medium grade waste heat that is now going out the exhaust pipe of millions of automobiles, diesel generators, or being wasted by factories and electrical utilities. According to the experts, the potential cost savings, improved energy efficiency, and broad application of such technology is enormous. The new systems now being perfected at OSU should be able to use much of that waste heat either in cooling or the production of electricity.

According to a researcher, more than half of the heat generated by industrial activities is now wasted, and even very advanced electrical power plants only convert about 40 per cent of the energy produced into electricity. So, to overcome these issues, the new system developed at OSU may do that as, or more efficiently than past approaches as it is more portable and have one major advantage of the ability to produce electricity.

https://www.sciencedaily.com/releases/2011/06/110610131912.htm

RENEWABLE ENERGY OBTAINED FROM WASTEWATER

Researchers from the Universitat Autònoma de Barcelona (UAB) have devised an efficient way to obtain electrical energy and hydrogen by using a wastewater treatment process. Wastewater contains an elevated amount of chemical energy in the form of organic contaminants. In order to make use of this energy, researchers from around the world study ways to recover it in the form of hydrogen, a process which efficiently eliminates organic matter from wastewater. It not only reduces the amount of energy needed during the process, it also obtains energy from the produced hydrogen. The key to achieve this is what is known as microbial electrolysis cells (MEC). So, researchers from UAB have improved the energetic efficiency of the cells. The experimental results were very positive and demonstrated that these systems would have a market niche at industrial scale. They used real wastewater instead of the biodegradable synthetic water used in most experiments, and achieved a biological production of hydrogen and, to a large extent, the recovery of a good part of the energy contained in the residues. To achieve this, researchers selected a set of bacteria capable of transforming complex substrates, such as methanol, dairy waste, starch, and glycerol, into simpler compounds which could, in turn, be degraded by exoelectrogens.

The results were very positive and high hydrogen production and energy intensity was obtained through the wastewater treatment. EF

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

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NATIONAL AND INTERNATIONAL EVENTS

INTERNATIONAL

Materials Challenges in Alternative & Renewable Energy 2016

April 17–21, 2016

Clearwater, USA
Website: http://ceramics.org/meetings/materials-challenges-in-alternative-renewable-energy-2016

China International Bioenergy & Biomass Utilization Summit

April 21–22, 2016

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

Exhibition and Conference: 17th Solarexpo

May 3–5, 2016

Milan, Italy
Website: www.solarexpo.com

Utility Energy Forum

May 4–6, 2016

Sunnyside Tahoe City, USA
Website: http://www.utilityforum.org

Energy Smart Show

May 14–15, 2016

Mississauga, Canada
Website: https://energysmartshow.com

AWEA WINDPOWER 2016

May 23–26, 2016

LA, USA
Website: http://www.awea.org/

The 10th China (Shanghai) International Wind Energy Exhibition and Conference

May 24–26, 2016

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

Solar Asset Management Asia (Japan) 2016

June 2–3, 2016

Tokyo, Japan
Website: http://www.solarassetmanagement.asia

Intersolar Europe 2016

June 21–24, 2016

Munich, Germany
Website: www.intersolarglobal.com

Scottish Renewables Storage & Systems Conference

June 30, 2016

Glasgow, Scotland
Website: www.scottishrenewables.com

NATIONAL

Solar Expo Gurgaon

April 8–10, 2016

Gurgaon, India
Website: www.eventbrite.com

International Conference on Computation of Power, Energy, Information and Communication (ICCPEIC 2016)

April 20–21, 2016

Chennai, India
Website: http://iccpeic.weebly.com

India's Renewable Energy Congress (InREC)

April 26–27, 2016

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

RENEWTECH INDIA 2016

April 26–28, 2016

Mumbai, India
Website: http://www.india-tech.com

Waptema Water Expo

May 4–6, 2016

New Delhi, India
Website: http://waptema.org

2nd Smart Cities India 2016 Expo

May 11–13, 2016

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

LED Expo Mumbai 2016

May 12–14, 2016

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

Renewable Energy World India

May 18–20, 2016

New Delhi, India
Website: http://www.power-genindia.com

Power-Gen India & Central Asia

May 18–20, 2016

New Delhi, India
Website: http://10times.com/distributech-india-mumbai

Govt Achievements & Schemes Expo

July 22–24, 2016

New Delhi, India
Website: http://10times.com/ govt-achievements-schemes

Renewable Energy at a Glance

Programme/Scheme-wise Physical Progress in 2015–16 (Up to the month of January 2016)			
Sector	**FY 2015–16**		**Cumulative Achievements**
	Target	**Achievement**	**(as on 31.01.2016)**
I. GRID-INTERACTIVE POWER (CAPACITIES IN MW)			
Wind Power	2,400.00	1,744.78	25,188.39
Solar Power	1,400.00	1489.10	5,248.21
Small Hydro Power	250.00	132.30	4,187.65
Bio-Power (Biomass & Gasification and Bagasse Cogeneration)	400.00	342.00	4,760.55
Waste to Power	10.00	12.00	127.08
Total	**4,460.00**	**3,720.18**	**39,511.88**
II. OFF-GRID/ CAPTIVE POWER (CAPACITIES IN MW_{EQ})			
Waste to Energy	10.00	0.50	146.51
Biomass (non-bagasse) Cogeneration	60.00	10.50	602.37
Biomass Gasifiers —Rural	2.00	0.20	18.15
—Industrial	6.00	8.67	160.72
Aero-Generators/Hybrid Systems	0.50	0.15	2.67
SPV Systems	50.00	67.86	302.30
Water Mills/Micro Hydel	2.00	0.00	17.21
Total	**130.50**	**87.88**	**1,249.93**
III. OTHER RENEWABLE ENERGY SYSTEMS			
Family Biogas Plants (numbers in lakh)	1.10	0.22	48.34
Solar Water Heating – Coll. Areas (million m^2)	-	0.00	8.90

Source: www.mnre.gov.in

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ENERGY FUTURE

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- Matte paper
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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.

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