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INSIDE

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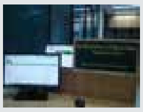

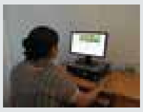
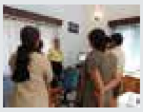

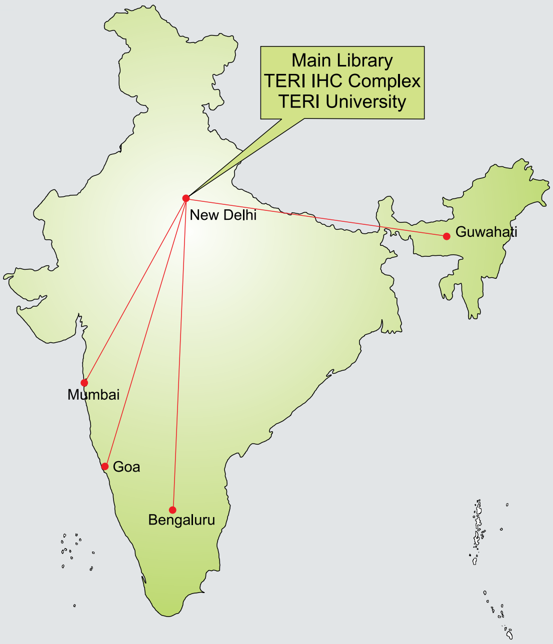

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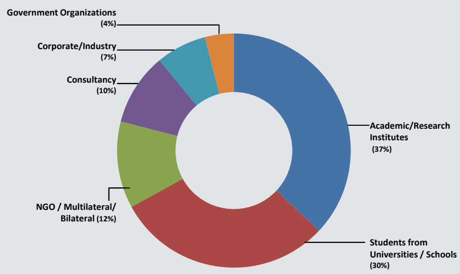

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SOLAR ROOFTOPS IN DELHI RESIDENCES

Compiled by: **Pallavi Shukla,** *Information Analyst, LIC* & **Neha Sharma,** *Project Trainee, LIC, TERI*

Overview

When the Jawaharlal Nehru National Solar Mission (JNNSM) was implemented, the initial focus was on large scale grid-connected power plants. At present, as the prices of solar PV modules have dropped considerably, rooftop PV (RTPV) systems have become popular and are seen as a viable option all over India. According to Census 2011, India has 140 million houses with a proper roof (concrete/asbestos). RTPV has a huge potential as it generates income through the unutilized rooftops and is not faced with unavailability of land as in the case of ground-mounted projects. RTPV is best suited for urban areas where the buildings are highly dense and crowded. RTPV systems are PV systems installed on the rooftops of commercial, residential, or industrial buildings. These can be classified as grid-interactive and off-grid systems that are primarily for self-consumption and are grid-connected. Systems that could either be fed into the utility grid through a regulated feed-in-tariff (FiT) or used for self-consumption through the 'net-metering' mechanism.

RTPV—The Global Scenario

Japan, USA, and Germany were early leaders in adopting RTPV systems and Italy, Australia, and China are emerging with strong growth in recent times. The European Photovoltaic Industry Association estimates that 40 per cent of the EU's demand would be met by RTPV by 2020. In the USA, a 2008 study by the National Renewable Energy Laboratory (NREL) reveals that 22 per cent of the electricity is met by RTPV, where the net metering arrangement is more popular. California has been leading the solar rooftop market in USA and more than 1,000 MW is generated from net-metering consumers (101,284 consumers). Germany and Italy have installed the highest cumulative PV capacity of 24.6 and 12.7 GW, respectively, out of which 60 per cent in both these countries is from RTPV systems in the residential and commercial segments. In Europe, out of 50 GW solar PV capacity, over 50 per cent is generated from RTPV.

RTPV—The Indian Scenario

A recent TERI's survey of 125 GW of RTPV estimates the potential for RTPV in India to be 20–100 GW. The NSM mission documents mention both forms of RTPV arrangements, namely net metering and sale to utility through FiT. The Ministry of New and Renewable Energy (MNRE), Government of India, is in the process of forming the new rooftop policy, based on net metering. Gujarat has already adopted the policy of 'rent a roof', where the roof owner gets paid ₹3 for every unit of energy produced. Three ministries of the Government of India—MNRE, the Ministry of Heavy Industries and Public Enterprises, and the Ministry of Power—have joined hands to launch a 4,000 MW ultra-mega solar power project at Sambhar, Rajasthan, expected to be the largest in the world. The MNRE has identified 60 cities (50 got approved) or towns as 'solar cities', since 2009 to integrate all the renewable energy projects to the saturation level. A solar city aims at 10 per cent reduction in projected demand for conventional energy at the end of five years. It is to be noted that Coimbatore, Tamil Nadu, is one such solar city.

An ever-increasing number of Indian states offer solar policies or directly allocated projects, this includes Karnataka, Rajasthan, Tamil Nadu, Andhra Pradesh, Punjab, Madhya Pradesh, Chhattisgarh, Uttar Pradesh, and Odisha. It can be expected that these policies will facilitate an additional installation of over 6 GW in the next four years. In order to accelerate the growth of solar, supply-side incentives such as the preferential FiTs are complemented by demand-side measures: Solar Renewable Purchase Obligations (RPOs) define a minimum amount of solar power (MWh) that obligate entities—distribution licensees, open access, and captive consumers (1 MW and above)—these have to buy a percentage of their total power sold/consumed. Apart from large, grid-connected plants, the government also supports smaller, rooftop-based installations of less than 1 MW. Such support includes the Ministry of New and Renewable Energy's (MNRE) subsidy scheme (100 MW a year), the "Solar Cities" programme by the MNRE (no capacity limits), Tamil Nadu's solar policy with a FiT for rooftop plants (350 MW), Kerala's rooftop power programme that offers a subsidy (10 MW), and the Gujarat solar policy's rooftop programme that offers a FiT (30 MW). Further, rooftop PV is well-suited to serve commercial consumers and those with a high levelized cost of electricity (LCOE).

The market for such smaller PV projects is expected to exceed 1 GW by 2016 without government support (Bridge to India Report 2013).

Delhi's Geographic Potential for Solar Rooftop Installations

Delhi has the potential to build around 2.6 GW of solar PV on its rooftops. We have only assessed rooftop space for solar PV panels. Other technologies, such as building-integrated PV (BIPV) could additionally make walls of buildings available for solar power generation, but are still too far from commercial viability to be considered here. Delhi borders the Indian states of Haryana on the north, west and south and Uttar Pradesh to the east. The total land area of the National Capital Territory is around 1,484 km^2 with around 700 km^2 of built area. Delhi's built area/ raw rooftop space that is potentially available for solar power generation is around 119 km^2. Raw rooftop space includes only built structures that can accommodate the size and weight of solar installations. Out of this, the estimated, actually available solar-suitable rooftop space is around 31 km^2, which could fit 2,557 MW of solar power. The solar-suitable rooftop space is the unobstructed and shadow-free rooftop area that receives optimal sunlight for solar power generation. Delhi's residential buildings represent 49% of the solar potential. They are followed by industrial buildings with 15% of the potential. Government buildings, commercial buildings and public and semi-public facilities have 13%, 10% and 13% of the total potential, respectively. Transport facilities such as airports and railway stations have a mere 0.1% of the potential—but can make great pilot projects. Green stretches, water bodies, historical buildings and public utilities have been excluded from the analysis.

Can Delhi's Power Demand be Adequately Met by Solar Energy

The National Capital Territory of Delhi has a solar RPO set by the Delhi Electricity Regulatory Commission (DERC). For the financial year 2013–14, this stands at 0.20 per cent and increases to 0.35 per cent by 2016–17. The city has four power distribution utilities (DISCOMS)—Tata Power Delhi Distribution Limited (TPDDL), BSES Yamuna Power Limited (BYPL), BSES Rajdhani Power Limited (BRPL), and the New Delhi Municipal Council (NDMC). Together, these companies provide 100 per cent of the power consumption needs of Delhi. Given their cumulative expected power sales of 25 m MWh in 2013–14, they have a current requirement to purchase 50,000 MWh of solar energy, for which they require 35.5 MW of installed solar capacity. However, the installed capacity of solar PV in Delhi as of March 9, 2013 was only 2.5 MW. This currently leaves the Delhi utilities with the option of either purchasing solar power from outside the state, purchasing RECs or—when enforced—paying a penalty for non-compliance.

Other states in India have set higher solar RPO targets than Delhi. Haryana, Gujarat, and Uttar Pradesh, for example, each aim for 1 per cent solar power in the FY 2013–14. A supposed lack of available space for solar PV in a highly urbanized and congested city like Delhi is often considered to be a key barrier to a more ambitious solar RPO. However, this holds true only if we consider the installation of large, ground mounted power plants. As this report shows, the potential for rooftop-based solar PV systems is significant in Delhi. The total area of Delhi (only the NCT) is 1,483 km^2. If such type of area were unused and exclusively available for solar installations, it could support 123 GW of installed capacity which, at peak power production.

Solar Resource Availability in Delhi

Solar irradiation is the amount of radiant solar energy available per unit area and is usually expressed in terms of kilowatt-hours per square metre per day ($kWh/m^2/day$). As sunlight streams through the atmosphere, only some of it reaches the ground, with the rest being reflected, absorbed, and scattered. The amount that actually reaches the ground depends on a number of factors, such as latitude, season, time of day, air quality, and other atmospheric conditions (e.g., clouds, aerosol particles, etc.). This can be used to generate power by way of technologies, such as solar PV systems.

The average solar irradiation of Delhi according to the RET Screen database is around 5 $kWh/m^2/day$34 as

Table 1: Delhi's Solar RPOs and Required Solar Capacity (per FY)

	2013–14	2014–15	2015–16	2016–17
Power consumption (MWh)	25 m	26 m	28 m	30 m
Solar RPO	0.20%	0.25%	0.30%	0.35%
Required solar capacity (MW)	35	46	60	75

depicted in Table 2. Such a level of solar irradiation is good, but not as high as might be expected due to the high levels of dust in the city.

Table 2: Annual Irradiation Data for Delhi

Source Month	RET Screen Solar Radiation kWh/m²/d	MNRE Solar Radiation kWh/m²/d
January	3.8	3.4
February	4.6	4.7
March	5.8	6.0
April	6.3	6.8
May	6.4	7.0
June	6.0	6.3
July	5.2	5.4
August	4.8	5.3
September	5.0	5.3
October	4.8	4.9
November	4.2	3.9
December	3.5	3.3
Annual	**5**	**5.2**

Source: MNRE India Solar Resource Maps

Exposure to Solar Radiation in Delhi Residential Complexes

The Delhi Master Plan envisages an integrated approach that packages mutually supportive infrastructure components i.e. water-sewerage-drainage for recycling, harvesting and optimal use of water; solid waste-sewerage-power for power generation, etc. Innovative techniques for the use of alternative technologies like solar energy, recycling, etc., are also to be encouraged. Non-conventional energy sources like recovering energy from sewerage, solar energy, etc. should be used for street lighting, lighting at public spaces, open areas, traffic signals, hoardings, etc. It should be encouraged for all establishments with floor area of more than 300 sq.m.

Delhi's residential buildings represent 49 per cent of the solar potential. They are followed by industrial buildings with 15 per cent of the potential and government buildings, commercial buildings, and public and semi-public facilities with 13 per cent, 10 per cent and 13 per cent of the total potential, respectively (Figure 1). Transport facilities such as airports and railway stations have a mere 0.1 per cent of the potential but can make great pilot projects. Green stretches, water bodies, historical buildings, and public utilities have been excluded from the analysis.

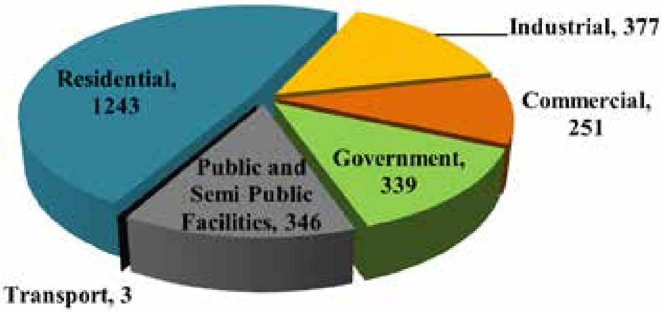

Figure 1: Potential of rooftop solar power generation in Delhi for different land area types (MW)

Source: DDA's Master Plan 2021, Delhi Zonal Plans

Solar Policies and Incentives of Delhi

Delhi had formulated a draft rooftop solar policy in 2011 to promote rooftop, small-scale, and decentralized solar power generation to meet its solar RPO. The policy envisioned that homeowners could either lease their roofs to a developer or install a system themselves. The Delhi government, currently, has no specific policy for supporting rooftop solar power. As part of the first phase of the NSM, the support of the union government has been available in the form of the 30 per cent MNRE subsidy on the PV system cost or a low cost loan at 5 per cent interest, repayable within five years. Such support was applicable up to March 31, 2013. The union government also provides direct tax benefits. One such benefit is accelerated depreciation of 80 per cent, attractive to profit making business entities, paying tax in India that own a PV system. Another is a 10-year income tax exemption for PV power generators and indirect tax benefits such as excise duty and custom duty exemptions or concessions on solar energy devices and equipment.

The Central government support for rooftop solar has been successful but limited: support was initially pledged only for 100 MW. It is available only for off-grid systems. There is no policy framework to allow rooftop systems to connect to the grid, something that can impact viability significantly. A rooftop solar policy by Delhi can set a benchmark by creating a policy that addresses the need for grid-connectivity and achieves significant capacity addition (up to 2 GW) at the limited cost.

Solar net metering

In grid-connected solar PV systems, the DC current from PV panels is converted into AC current through the inverter and fed to the distribution board for internal consumption such as for lights and fans. If excess energy is produced, compared to that utilized for self-consumption, it is automatically exported to the utility

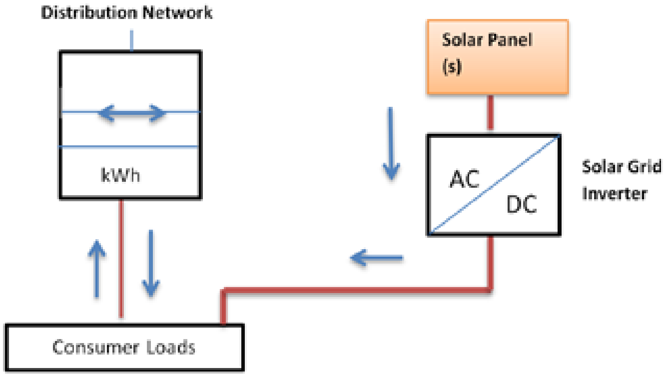

Figure 2: Solar panel-generated electricity

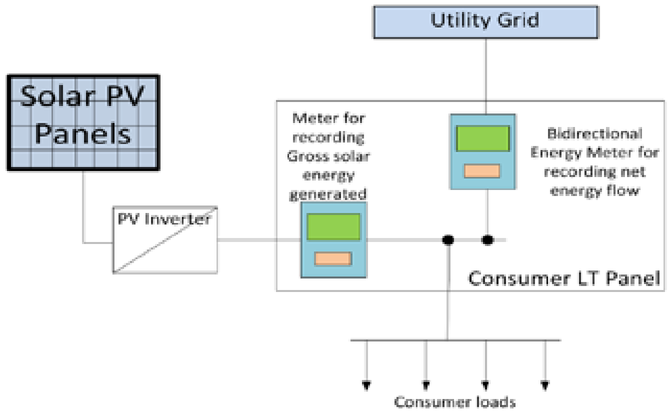

Figure 3: A single line diagram for the solar rooftop plant

grid. For this, a net meter is fixed in the place of normal utility service connection meter that can measure both energy import (from the grid to the consumer) and energy export (from the consumer to the grid). These are known as bidirectional meters with import and export features. Solar RTPV systems have a potential in India, where transmission, distribution losses and AT&C through utility are more than 30 per cent. As the RTPV is used mainly for self-consumption, such losses can be prevented.

Solar Rooftops Minimizes Power Demand of Delhi Residences

The implementation of solar rooftops in residential areas is an innovative concept in India. The following two case studies discuss at length about the experiences of citizens of Delhi in the implementation of solar rooftops.

Case I

Mr Ravi Bansal, a Delhi based businessman from Ishwar Nagar has recently implemented 20kWp on-grid solar rooftop photovoltaic system which is Delhi's first grid-connected solar roof-top model; this system was implemented in April, 2015 at his residence. The installation cost of the plant is ₹14.25 lakhs with 5 years of warranty and an annual maintenance contract (AMC).

Problems Faced Prior to the Implementation of the System

- They were facing the universal problem of high electricity bills; as a matter of fact they were receiving bills in the range of ₹25,000–35,000 and at times, even ₹40,000 per month.
- Load shedding, power cuts, etc., were the other problems they were facing before the application.

So, to deal with these problems, Mr Bansal decided to speak to Mr Surinder Ahuja, Vice President of Medors Renewable Energy Private Limited (Picture 1), and thereafter came up with an idea to implement solar rooftops at their residence. The planning for the plant began in January 2015. To determine the suitable capacity of the system, they examined their electricity bills of the past one year and then pronounced to set up a plant of 20kWp grid connected solar rooftop photovoltaic system to meet their total consumption.

Picture 1: Mr Ravi Bansal (left) and Mr Surinder Ahuja (right) Vice-president- Medors Renewable Energy Pvt. Ltd. Solar Panels are mounted in the form of shades so that the roof space is not occupied.

Key Features

- This plant is Delhi's first grid-connected solar rooftop model at the residential level.
- The additional investment cost for solar rooftops involved is ₹90,000 per kW.
- The solar rooftop are of Medors 250Wp 60 cells Mono-Crystalline model, with total 80 panels, arranged as four strings and 20 panels in series. A mono-crystalline module is 1–1.5 per cent more efficient than poly-crystalline module and therefore generates higher power.
- The inverter installed is Fronius Symo 20 (Picture 2)—rated for 20 kVA with dual MPP tracker and six strings and its maximum efficiency is 98.1 per cent.
- The monitoring of this system is very easy and efficient, it has an in-built data logger and web server; with mobile app for remote monitoring. (This encourages the consumer/s to check the working, production, and consumption of the system on a regular basis). (Pictures 3 & 4)

Picture 2: Inverter at Bansal's residence is Fronius Symo 20

After the implementation of the system, Mr Bansal decided to install the net-metering system so that they can credit the solar electricity to the grid. So, in this regard, they contacted BSES and submitted all the important papers required for checking the compatibility of the system. Thereafter, the BSES members came and approved the compatibility of the plant and installed the net-metering system under DISCOM.

- Now they have a bidirectional energy meter for net metering both for imports and exports of the power.
- They have a gross meter installed for monitoring the total solar generation from the plant.
- Mr Bansal has also applied for the yearly banking facility by DISCOM, in which they will get a demand draft for the power they will export or provide to the grid after one year.

Pictures 3 & 4: Mobile App for remote monitoring

Problem faced during the implementation

- The main problem which they faced was during the certification of net-metering system.
- According to Mr Bansal, the government is not very supportive in the context of solar rooftops.
- The time given by BSES members in the checking the compatibility of the system is too long, they take about 45 days just to approve their system.

List of Solar Installers/ System Integrators/ EPC Companies in India

- Medors Renewable Energy Pvt. Ltd.
- Luminous Power Technologies Pvt. Ltd.
- Lubi Electronics
- Tata Power Delhi Distribution Limited
- Sunkalp Energy
- AKW Electronics
- Sun Clean Renewable Power Private Limited
- Uniline Energy Systems Pvt. Ltd.

Benefits

Today Mr Ravi Bansal and his family are very happy with their solar rooftops and are extremely satisfied with output they are receiving.

- They mentioned that they are deriving 100 per cent benefit from the plant.
- They have not received any bill till date, i.e., the electricity they are getting from their plant is more than enough to meet their consumption and the extra is contributed to the grid.
- The only maintenance involved in this plant is proper washing of the panels and Mr Bansal is planning to install a water canon system.
- The total energy earned from the grid till date is about 4.5 per kw per day with mono modules.

Case 2

Like Mr Bansal, Medors Renewable Energy Pvt. Ltd has also encouraged Mr Ashwani Kapoor (Picture 5), of Kailash Colony to install solar rooftops at their residence. They have installed a 7.2 kWp grid-connected solar panel and 2.4 kWp off-grid connection. The cost involved in setting up the plant is approximately ₹14 lakh for both off-grid and grid connected system.

Problem faced before the implementation of the system

- The Kapoors were also facing the problem of high electricity bills and were getting bills ranging between ₹30,000–40,000 per month.
- The other common issues they faced before the implementation were power cuts, power fluctuation, etc.

Picture 5: Mr Ashwini Kapoor below the installation

Key Features

- This plant is Delhi's first net-metered solar rooftop model by DISCOM under residential category.
- The additional investment cost for solar rooftops involved is ₹90,000 per kW.
- The panel which they have implemented is Medors 300 Wp 72 Cell Mono-crystalline Model with 24 panels.
- PV Inverter implemented is SMA Sunny Tripower 9,000 TL rated for 9 kVA with dual MPP tracker and 4 strings.
- Regarding the monitoring of the system there is an inbuilt data logger and web server with a mobile app.
- They also have a bidirectional energy meter for net-metering (import and export) + Gross meter for solar generation.
- The off-grid inverter is coupled to 30 number of 100 Ah 12 V batteries (Artheon) with five years warranty, which stores the power generated from solar during daytime.
- The off-grid system is used to power up the lighting loads and security systems of the building.

After the implementation of the system, the Kapoors decided to install the net-metering system and contacted the BSES, in this regard, and submitted all the important papers required for checking the compatibility of the system. During the installation of the net-metering of the system, they faced the same problems as mentioned in the above case of Mr Ravi Bansal:

- According to Mr Kapoor, the government is not very supportive in context to solar rooftops as there is no proper subsidy, proper policies as far as residential level is concerned, etc.
- The time given by BSES members in checking the compatibility of the system is too long as they take 45–90 days just to approve their system.

Apart from these rooftops, Mr Kapoor has also implemented the solar water heater and that too of a latest technology. The water heater was also implemented by the Medors group this water heating system is of latest technology as it absorbs the solar energy as well as atmospheric heat, this system is also beneficial as it is installed on the wall of the residence and prevent the roof space and interior heating.

Picture 6: Inverter at Mr Kapoor's residence is SMA Sunny Tripower

Benefits

After the implementation of the system, the Kapoors are very satisfied with their solar rooftop system. Following are the benefits they have experienced after the implementation of rooftops:

- It is estimated that their electricity bill will be reduced to ₹8,000 per month from ₹25,000.
- He also suggests that the solar rooftops will be more successful with the LED lighting.

Mr Bansal and Mr Kapoor have done a great job by implementing the solar rooftops at their residence. They are the green citizens of Delhi who took an initiative to trust non-conventional sources of energy and are in no loss today.

Key Features

- This heater absorbs the atmospheric heat with solar energy to generate energy.
- They are installed on the walls of the residence, which in one way prevents the interior from heating and also saves the area of the roof.

Picture 7: The encircled part is the solar water heating system

Mr Kapoor feels that solar rooftops are so reliable that one can implement these without any government subsidy. Both of them want other people to implement these rooftops in their homes so that the problem of high electricity bills, load shedding, etc., will be reduced and one fine day, in the future, we can say that Delhi has turned into a 'Smart City'.

References

1 Bridge to India 2013 <http://www.greenpeace.org/india/Global/india/report/2013/Rooftop-Revolution.pdf> Accessed on 19 July 2015

2 <http://www.mnre.gov.in/> Accessed on 10 July 2015

RE-NEWS UPDATE

DJB Commissions Biogas Power Plant in East Delhi

The Hindu, June 8, 2015

Biogas from Delhi Jal Board's (DJB) sewage treatment plant in Kondli is now being used to generate power, which will bring the water utility's electricity bill down by ₹20 crore annually.

The DJB said in a statement that the 45 million gallons per day (MGD) sewage treatment plant was providing biogas for the power plant, which is currently producing 10,000 kilowatt hour (kWh) per day. Officials said the electricity generation was expected to increase soon.

The DJB had previously commissioned biogas power plants at Okhla and Rithala sewage treatment plants. While the Okhla plant generates 12,000 kWh per day, the one at Rithala produces 20,000 kWh per day.

Officials say the plan is to set up biogas-based power plants in all DJB sewage treatment plants, wherever feasible, that will be designed to include power generation facilities. Also, electricity generation will soon start at sewage treatment plants at Pappan Kalan, Nilothi, Yamuna Vihar, and Delhi Gate.

The DJB has set a target of 70,000 kWh per day of power generation through its gas-based plants by the end of 2015. Officials say the flaring of biogas at some plants is wasting a potential source of clean energy. The DJB has come up with plans to trap the gas and transport it to the nearest power plant to generate electricity in the next two months.

Solar Energy Parks to be Set up by Year-end

Business Standard, June 9, 2015

The Ministry of New and Renewable Energy (MNRE) is planning to set up around 13,000-Mw of solar park projects by the year-end, after a push from the Prime Minister's Office (PMO).

Spread across 20 states, projects would be executed by the state governments and financed by the Solar Energy Corporation of India (SECI), a wholly-owned subsidiary of the ministry.

After the PMO pushed for expediting solar power development, the ministry started taking weekly updates on these parks. Detailed Project Reports (DPR) for around 10 are ready and funds released for some.

Senior MNRE officials said they were pushing the states to move fast. This will help states achieve their targets to be a part of the 100,000-Mw solar power network by 2022, said an official.

Rajasthan, given its vast expanse of arid land and high solar power potential, would have three solar parks, two of 1,000 MW each and one of 680 MW. It would be executed by the new Surya Urja Company of Rajasthan Limited, a dedicated entity to explore the potential of solar power and attract investments.

Andhra Pradesh would have two of 1,500 MW and 1,000 MW each, to be developed by the state power department.

Madhya Pradesh would develop two parks of 750 MW each. Tenders for one have been issued. Karnataka would develop a 2,000-MW solar park. Punjab would have two parks of 500 MW each.

SECI would provide ₹25 lakh to power developers for preparing DRPs. It would also provide 20 per cent or ₹20 per MW of the investment required for land acquisition, financial closure, construction of pooling sub-station, transmission lines, and grid connectivity. Several power projects would come up at one park and the cumulative output would be pooled and fed to the grid.

Solar Power at 4,000 MW, Rajasthan in the Lead

Business Standard, June 7, 2015

India's solar installed capacity has crossed the 4,000 MW mark. With close to 1.128 MW of projects, Rajasthan has taken the lead ahead of all other states. It has elbowed out Gujarat, which has 957 MW of solar power projects, from the top-slot for the first time. Following closely behind are Madhya Pradesh, Maharashtra, and Tamil Nadu.

Apart from the regular solar power-rich states, Uttar Pradesh, Punjab, and the newly formed Telangana have now joined the solar bandwagon.

By December, an additional 1.7 GW is likely to be added, said a study by Bridge to India, a leading consultancy firm monitoring foreign investment in the Indian renewable energy space. The report said, with

2.7 GW of expected capacity addition in 2015, India might surpass Germany and secure a position in the global top five, for new-yearly capacity addition.

However, some experts feel that 4,000 MW is a minuscule achievement, given that the country needs to add around 15,000 MW every year to meet the targeted 100,000 MW by 2022.

Applied Solar Technologies raises $40 mn

Mint, June 8, 2015

Delhi-based solar power company Applied Solar Technologies (India) Pvt. Ltd (AST) has raised $40 million in a fresh round of funding led by Future Fund, the Australian government's sovereign wealth fund.

AST's existing private equity investors Bessemer Venture Partners (BVP), Capricorn Investment Group, and World Bank investment arm International Finance Corporation (IFC) also participated in the round.

The deal comes in the backdrop of a government initiative to raise India's solar power capacity to 100 gigawatts (GW) by 2022 from around 3 GW now. The government estimates the sector will need about $100 billion in investment to achieve the target.

The investment, which closed late last month, is AST's fourth funding round to date, taking its overall private equity funding to more than $85 million.

In 2009, BVP, the Menlo Park, California-based venture capital firm, invested an undisclosed amount in the company. In 2010, IFC led a $21 million second round of funding; BVP participated in the round. This was followed by a $24.6 million round in 2012 in which BVP, IFC, and Skoll Foundation-backed Capricorn Investment Group participated.

AST, founded in 2008 by Vinod Agarwal, Kathpalia, and Neeraj Saxena, provides off-grid solar power to the telecom and banking sectors. Off-grid power is electricity generated from renewable energy sources without accessing the main grid. The firm offers alternative power sources to telecom operators and banks which often rely on diesel-based power generation for infrastructure such as telecom towers and ATMs.

Adani Plans 1,000-MW Solar Park in Tamil Nadu

Business Standard, May 25, 2015

After announcing solar parks in Gujarat and Rajasthan, Adani Power has firmed up plans to set up a 1,000-megawatt (MW) one in Tamil Nadu. The proposed energy park is likely to attract around ₹7,000-crore investment.

Although an Adani spokesperson declined to comment, a State government official and sources in the company confirmed the development.

The sources said a deal had been signed with the state government and the project is at an "exploratory" level. Sources at the State government said the project would be developed in four phases.

The company is planning to set up the park at Kamuthi in Ramanathapuram district, around 550 km south of Chennai, and is in the process of acquiring approximately 5,000 acres, the sources said.

Going by the current market value, to set up a 1 MW solar-based power plant, the company would need around ₹7 crore.

Sources said construction would commence in the next eight months and the company might look at replicating its Rajasthan model.

The development comes against the backdrop of the Centre's decision to set up 100,000 MW of solar capacity by 2022, and guidelines have been issued for setting up of at least 25 solar parks, each with a capacity of 500 MW and above across the country.

Officials also said Power Purchase Agreements (PPAs) for 200 MW of solar power had already been signed.

These plants are likely to come up at Ramanathapuram, Virudhunagar, and Tuticorin districts of Tamil Nadu, the officials added.

Renewable Energy Trading Set for Big Boost as SC Upholds Green Obligation

Business Standard, May 26, 2015

Compulsory purchase of renewable energy got a major boost last week from a Supreme Court order, even though it is likely to increase the power cost for a host of industries dependent on captive power generation and direct purchase of power for their manufacturing units. With the apex court upholding renewable purchase obligation, power purchasers in all states would have to follow the regulatory norms for renewable purchase obligations (RPOs). This would also boost the market for renewable energy certificates (RECs), which are traded and bought to meet the RPO.

The apex court in the order said regulations framed by electricity regulatory commissions imposing obligation upon captive power plants and open access consumers to purchase electricity from renewable sources cannot, in any manner, be said to be restrictive or violative of the fundamental rights.

In Rajasthan, captive power producers along with open access consumers who buy power directly from the grid, along with distribution companies, are required to buy 8.2 per cent of their power requirement from renewable sources, besides two per cent from solar. Himachal Pradesh has even higher RPO at 11 per cent and Mizoram at 14.75 per cent.

The companies had argued that neither any licence nor any approval from any authority is required to install a captive power plant and therefore, the RERC has no jurisdiction to impose any obligation upon such captive power plant for purchase of renewal energy compulsorily. The renewal energy source and captive generating plants are both alternative sources of energy to be generated, which is the policy that has to be promoted and therefore, one cannot be placed on a higher or lower footing than the other. The RERC by imposing the RE obligation upon CPP to purchase renewal energy compulsorily from renewable source and to pay such charge in case of shortfall to meet out the obligation is contrary to the object and intendment sought to be achieved under the provisions of the Act of 2003 and the same is also opposed to the National Electricity Policy, 2005 and the Tariff Policy, 2006.

With the Supreme Court order, however, stay by various high courts might also become redundant. According to Reconnect Energy Solutions, enforcement of RPO regulations has been lax due to various reasons, including the stay granted by various high courts like in the case of Gujarat (recently vacated), Madhya Pradesh, and Tamil Nadu, among others. The new order would enable stronger enforcement and provide support to the state electricity regulators to impose RPO regulations more forcefully and effectively.

STATUS OF RENEWABLE ENERGY IN ARUNACHAL PRADESH

The seven north-eastern states, also called the seven sisters, viz., Arunachal Pradesh, Assam, Manipur Meghalaya, Mizoram, Nagaland, Tripura, and Sikkim have a special provision constitutionally, and therefore, socio-economically and politically as well. These eight combined states are called the North Eastern Region (NER). This region forms an integrated geographical unit. Figure 1 shows the NER highlighting Arunachal Pradesh. The region offers great diversity—of topography, climatic conditions, language, religion, ethnicity and yet has common developmental challenges. The development concerns of these States are pursued through their respective Five Year and Annual Plans as well as those of the Union Ministries and Central Agencies. In addition, projects of inter-State nature in the Region are funded through by the North-Eastern Council (NEC), which has a separate additional budget for the purpose.

The NER has the potential of about 58,971 MW i.e. almost 40 per cent of the country's total hydro potential.[1] However, the infrastructure to harness has been poor.

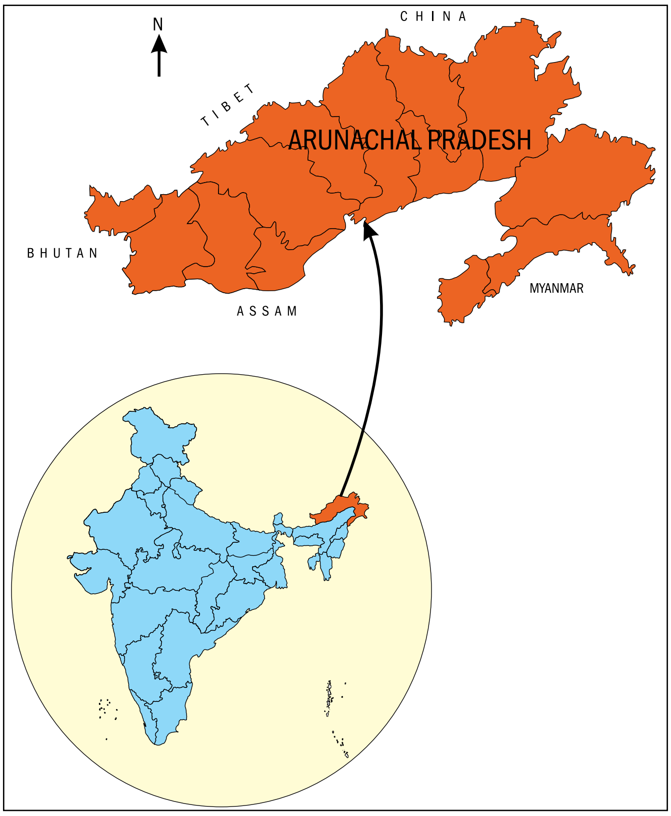

Figure 1: Map highlighting Arunachal Pradesh

Comparatively, the other sectors of renewable energy viz., biogas, solar, and wind have not received as much attention as hydro-power due to inadequate potential.

In order to develop the power sector in the region, the Central Electrical Agency (CEA) in consultation with the concerned states of NER, the Central government has sanctioned schemes of about ₹11,348.50 crores during the Twelfth Five-Year Plan.

The schemes were to be implemented in two phases by 2015–16.[2] In view of the strategic importance, the states Arunachal Pradesh and Sikkim have been allotted a separate scheme for strengthening of transmission system, formulated at an estimated cost of about ₹3,014 crores.[3]

As observed in Table 1, Arunachal Pradesh has the highest potential in energy among the NER states, followed by Sikkim. In tandem, Arunachal Pradesh also receives the maximum amount of funding in recent years, except the last financial year as given in Table 2.

The energy sector in the state is oversight by four department viz.: Department of Power, Arunachal Pradesh, Arunachal Pradesh Energy Development Agency (APEDA), Department of Hydro Power Development, and Arunachal Pradesh State Electricity Regulatory Commission.

According to APEDA, as on March 2013, there are 108 hydro power projects, 13 biomass gasifiers, seven SPV power plants, and two wind-solar hybrid power plants with installed capacity of 3120, 470, 177.2, 16.8 KW, respectively.[6] The details of renewable energy power projects in the state are given in Table 3.

The state's tentative break-up of Renewable Power target to be achieved by the year 2022 as estimated by the Ministry of New and Renewable Energy (MNRE), Government of India, in contribution to country's cumulative target of 1, 75,000 MW by 2022 is 539 MW.[7] The sectoral contribution is reproduced in Table 4.

Biogas

A biogas plant is considered as the best option for households, with feed-material, to become self-reliant for cooking gas and highly organic enriched bio-manure. However, there is little investment in this sector both by the government and private enterprises in the state despite the spectacular achievement, for instance,

Table 1: Installed Capacity of Renewable Energy of the NER and Sikkim (as on 31.01.2015)[4]

States/UTs	Small Hydro Power (in MW)	Wind Power	Bio-Power		Solar Power	Total Capacity (in MW)
			BM Power/ Cogen	Waste to Energy		
Arunachal Pradesh	103.91	-	-	-	0.03	103.93
Assam	34.11	-	-	-	0.00	34.11
Manipur	5.45	-	-	-	0.00	5.45
Meghalaya	31.03	-	-	-	0.00	31.03
Mizoram	36.47	-	-	-	0.00	36.47
Nagaland	29.67	-	-	-	0.00	29.67
Sikkim	52.11	-	-	-	0.00	52.11
Tripura	16.01	-	-	-	0.00	16.01

Table 2: State-wise Funds Released for Development of Renewable Energy Sources in NER and Sikkim (2011–12 to 2014–15 – upto January, 2015)[5] (Rupees in crore)

States/UTs	2011–12	2012–13	2013–14	2014–15 (Upto January 2015)
Arunachal Pradesh	66.62	39.05	27.39	2.32
Assam	18.37	10.58	19.01	8.17
Manipur	3.85	16.61	2.50	0.00
Meghalaya	5.84	1.80	8.93	4.62
Mizoram	1.24	7.03	1.68	1.72
Nagaland	11.53	18.72	7.51	4.24
Sikkim	10.50	6.13	11.13	3.09
Tripura	5.07	0.42	0.00	0.02

Table 3: Status of Renewable Energy of Arunachal Pradesh (as on March 31, 2013)

Hydels				Biomass Gasifiers			SPV Power Plants			Wind Solar Hybrid Power Plant		
No.	Installed Capacity (IC) in kW	No. of Comm. Hydels	IC of com hydels in kW	No.	IC in kW	No. of Comm. Biomass Gasifiers	No.	IC in kW	No. of Com. SPV Power Plants	No.	IC in kW	No. of Comm. Plants
108	3,120	81	1,900	13	470	13	7	177.2	6	2	16.8	2

Table 4: Tentative Contribution of the State towards Country's Renewable Power Target to be Achieved by the Year 2022

Solar Power (MW)	Wind (MW)	SHP (MW)	Biomass Power (MW)
39	—	500	—

during the National Project on Biogas Development (NPBD) of the Ministry of Non-Conventional Energy Sources (MNES) which was started in 1981–82 for promotion of family-type biogas plants the rate of performance and achievement from 1995 to 2000 is 100 per cent or more than 100 per cent except during 1998–99 which was below the country's average.[8] The dwindling investment is observed in the financial assistance released for setting up of biogas plants under National Biogas and Manure Management Programme (NBMMP) in Arunachal Pradesh (2007–08 to 2014–15—up to January 22, 2015)[9] which shows a negative trend, as indicated in Figure 2.

Progammes and schemes related to biogas in the state are implemented by APEDA.

The recent estimated biogas production of Arunachal Pradesh during 2011–12 to 2014–15[10] is reproduced in Figure 3.

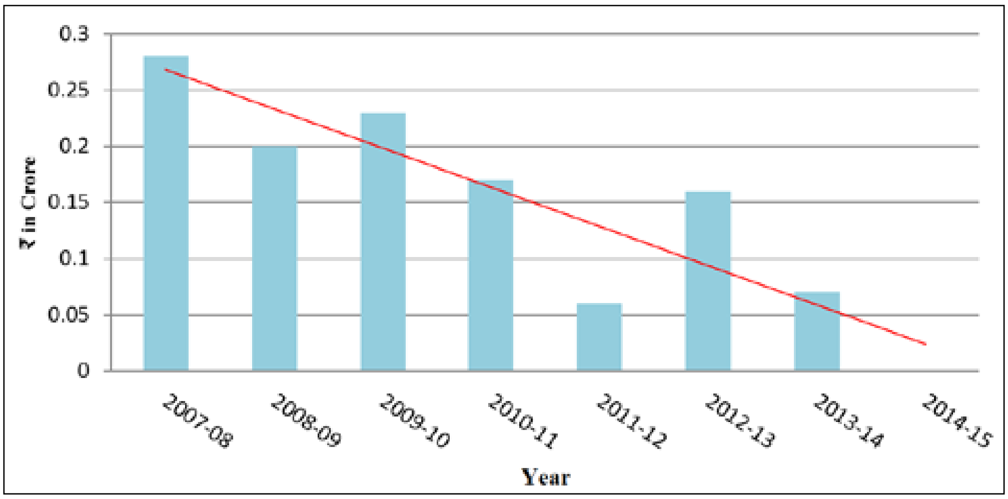

Figure 2: Financial assistance for biogas plants under National Biogas and Manure Management Programme (NBMMP) in Arunachal Pradesh

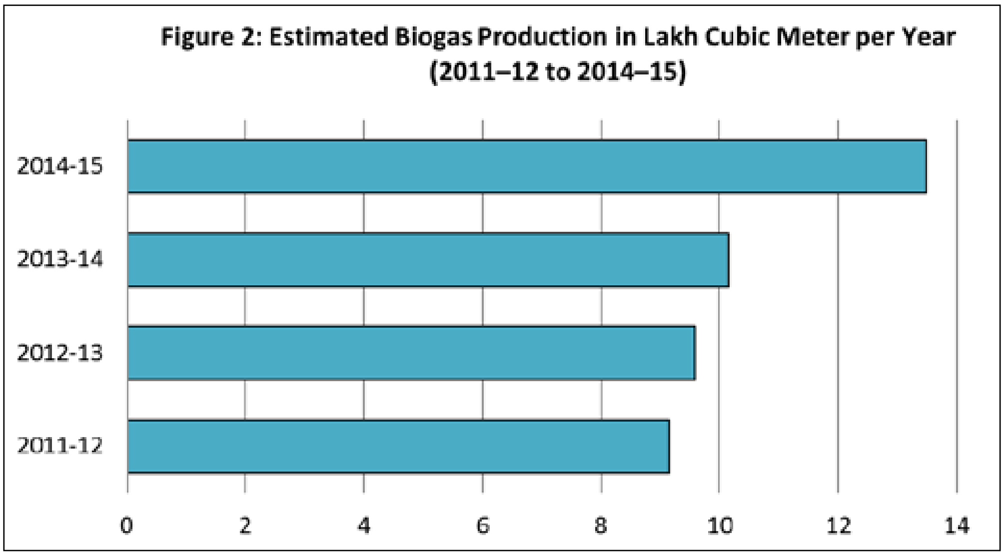

Figure 3: Estimated Biogas Production in Lakh Cubic Meter per Year (2011–12 to 2014–15)

Hydro Power

Among the renewable energy of the state, hydro power has the maximum energy generation, maximum potential, as well as maximum investments.

As per CEA ranking studies, 89 sites have been identified with an estimated installed capacity of 49,162 MW.[11]

Table 5: District-wise Status of Hydro Projects with IC under APEDA (as on March 31, 2013)[12]

District	Numbers	IC (in KW)	No. of commissioned hydels	IC of commissioned hydels in KW
Tawang	15	475	8	260
West Kameng	5	485	1	50
East Kameng	15	295	10	185

Papum Pare	4	110	4	110
Kurung Kumey	13	480	9	315
Lower Subansiri	2	60	2	60
Upper Subansiri	11	190	10	180
West Siang	26	670	23	520
Upper Siang	4	70	4	70
East Siang	0	0	0	0
Lower Dibang Valley	0	0	0	0
Dibang Valley	6	75	6	75
Lohit	0	0	0	0
Anjaw	6	160	4	75
Tirap	1	50	0	0
Changlang	0	0	0	0
	108	**3,120**	**81**	**1,900**

Under the Prime Minister's Package, the state has been allotted ₹550 crore to be spent to achieve the ultimate goal of electrification of all households in the state. The fund has been distributed as described in Table 6:

Table 6: Prime Minister's Package for Developing State Hydro Power

Department	Amount Earmarked (₹in crores)	Amount Released (₹in crores)	Purpose
Department of Hydro Power Development (DHPD)	416.00	169.11	For completion of certain existing incomplete schemes and construction of new small/mini/micro hydel stations
Department of Power (T&D) (DOP)	86.00	33.16	For evacuation of power generated from small/mini/micro hydel stations constructed by DHPD
APEDA	48.00	—	For construction of micro hydel stations and providing solar photo voltaic system in inaccessible areas

As on 2014, April there are 67 mini micro hydro projects (MMHP) under the Prime Minister's Fund implemented by APEDA,[13] of which most have been commissioned.

The Central Government has also identified 42 schemes in the state with an installed capacity of about 27,293 MW for preparation of the preliminary feasibility reports (PFRs). The schemes thus identified in this state alone, is more than 50 per cent of the PM's 50,000 MW hydro initiative.[14]

Besides, there are 8 small hydro projects (SHP) with a total capacity of 220 kW.[15]

Solar

The state has extremely less solar potential because of the climatic and topographic conditions. As a result, very little investment is observed in the state. The estimated solar energy potential of Arunachal Pradesh as in February 2015 is 9 GWp.[16] During 2014–15, the MNRE sanctioned 100 solar pumps each for drinking water throughout the state of Arunachal Pradesh and Meghalaya.[17] Under MNRE, a total of 33,378 household have solar lighting system[18] as on December 31, 2014. In the recent past, a number of households have benefitted from solar lantern, home lights, and pumps. However, very few households benefitted in the solar pump scheme. The cumulative installation of solar water pumps in Arunachal Pradesh as on October 31, 2014 is 18.[19]

The installed grid connected solar power capacity (total commissioned) of the state under Jawaharlal Nehru National Solar Mission (JNNSM) as in February 2015 is 0.025MW.[21] However, the estimated solar power generated in the state during 2012–13 to 2014–15 is zero in all.[22]

Table 7: Number of Households Benefitted from Solar Lanterns, Solar Home Lights, and Solar Pumps in Arunachal Pradesh (2007–12 and 2012–17)[20]

States/UTs	Solar Photovoltaic Systems					
	2007–12			2012–17		
	Lanterns	Home Lights	Pumps	Lanterns	Home Lights	Pumps
Arunachal Pradesh	5,040	5,729	3	0	8,596	0

Wind

Like solar energy potential, there is also very low wind energy potential. In this sector the state has two programmes achieved under the Wind–Solar Hybrid System which aimed to develop technology and promote applications of water pumping windmills and aerogenerators/wind-solar hybrid systems. The names of the programmes are Tenga with capacity of 6.8 kW and Pasuramkund with capacity of 10 kW.

Table 8: Wind Monitoring Stations in Arunachal Pradesh (30.11.2012 and 01.03.2013)

States/UTs	Total No. of Wind Monitoring Stations Established (MNRE)	
	30.11.2012	01.03.2013
Arunachal Pradesh	6	7

Renewable Policies of the State

In consideration of the fragile geological conditions, preservation/protection of rich and rare flora and fauna, respect to the sentiments of the peace loving tribal peoples in the event of displacement and relocation, the state government has taken the policy decision to develop policies in an environment-friendly and judicious manner. The state has two policies on renewable energy in the area of hydro power.

Small Hydro Power 2007

The Small Hydro Power Policy was passed in 2007 and came into force on January 24, 2008. This policy envisaged private participation in development of small hydro projects with certain attractive incentives. This policy also envisages for formulation and notification of an Action Plan for Small Hydro Power Generation. As per this policy, the Government of Arunachal Pradesh would allocate projects to the eligible applicant for development on BOOT (Build, Own and Operate and Transfer) basis for a period of 50 years. The state government would select the most eligible developer for the development of small hydro power projects. The developer/user agency shall strictly comply with the statutory regulations of the Central government/CERC (Central Electricity Regulatory Commission) and the State Government/SERC (State Electricity Regulatory Commission) while implementing the project. Sale of power can be made through IPP (Independent Power Producers) category under a contract with the state government through a PPA signed within six months after signing of Memorandum of Association (MoA). The State Transmission Utility (STU) and the prospective developer shall enter into a proper understanding/Agreement about Power Evacuation System and open excess facility/availability before the developer takes the final investment decision. The existing transmission system or the systems built for the purpose and other allied facilities will be made available to all developers for Open Access and wheeling of power. On all projects governed by this policy, there shall be a moratorium of free power as an incentive for timely completion.

The state government shall facilitate in obtaining subsidies, tax concessions, etc., as may be available from the Central Government for development of SHP; the state government shall allow to the extent of 50 per cent share of Carbon Credit benefit as may be available from Carbon Trading under CDM (Clean Development Mechanism); Indigenous tribal entrepreneurs shall be exempted from supplying free power to the State Government under this policy for projects up to 5 MW capacity.[24]

Hydro Power Policy 2008

The Hydro Power Policy 2008 was issued in superseding the Hydro Power Policy – 2005. This policy has been conceived out of need of new hydropower policy for the development of projects of installed capacity of more than 25 MW. The policy aims to strive a proper balance between the need for hydro power development to meet the acute power demand for developmental purposes and ecological and people's interest on the other hand.

Under this policy the state was privileged to share more than 50 per cent of the Prime Minister's 50, 000 MW hydro power initiatives. The objectives of the policy are as follows:

- To harness hydro-power in consistent with provisions of Electricity Act 2003 and National Electricity Policy.
- To develop hydro-power projects in an eco-friendly.
- To develop hydro-power projects through participation of both public and private players.
- To create job opportunities for local tribals, especially, the project-affected population.

Under the policy, the Department of Hydro Power, Government of Arunachal Pradesh, has been declared as the nodal agency. The policy offers incentives to developers of mega power projects as per the policy of the Central government. Under this offer, the import of capital equipment would be free of custom duties and deemed export benefits in accordance with the Export-Import Policy of the Central government. For private developers, the project shall be developed on Build, Own, and Operate and Transfer (BOOT) basis.

The policy mandates the developers to follow the provisions of the Rehabilitation and Resettlement Policy, 2008, of the Government of Arunachal Pradesh. The developers shall also bear the state government's share of 10 per cent of the project cost of Rajiv Gandhi Grameen Vidyutikaran Yojana (RGGVY) within the radius/surface distance from the site stipulated.[25]

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RESEARCH AND DEVELOPMENT

Solar Energy: Review of Potential Green and Clean Energy for Coastal and Offshore Applications

Vinod Kumar, R L Shrivastava, S P Untawale

Aquatic Procedia, **Volume 4, 2015, Pages 473–480**

World appetite for energy and mineral resources seems insatiable. The study reveals that the natural reserve of fossil fuels represent 150 years (coal), 58 years (natural gas), and almost 46 years (oil) of consumption at current rates. The ocean covers approximately 71 per cent of the Earth's surface and is full of abundant esoteric resources. This blue economy is attracting greater interest for harnessing the ocean wealth. Energy Intensity (EI) for Ocean trades activity, e.g., Extraction of Oil and Gas, Shipping, Fisheries, and Ocean Mining for Excavation of massive Sulphides, Manganese Nodules, Cobalt Crust, and Methane Hydrates is reviewed. Most of the offshore energy requirement is for fuel, cooking, maintaining comfort condition, recreation, preservation of commodity, distillation, etc. Use of high grade energy, viz. electricity through conversion into low grade energy such as water heating, distillation, cooling is not advantageous when abundant low grade energy is capable to do so efficiently. Solar PV/T technology can cater the offshore energy requirement substantially. However, levelized cost of energy (LCOE) of Solar per kWh is more than that of any other renewable energy, but mobility, portability, and feasibility of offshore installations are the key factors which dominate amongst the renewable energy sources. In the present paper, various offshore energy applications are explored and the potential of solar energy to substitute conventional oil and gas fuels for these applications are explained. Marine pollution on account of use of fossil fuel and its devastating consequences on sea creatures has also been reviewed.

Economic Cost Analysis of LED Over HPS Flood Lights for an Efficient Exterior Lighting Design using Solar PV

Nibedita Das, Nitai Pal, Sadhu K Pradip

Building and Environment, **Volume 89, July 2015, Pages 380–392**

The demography and demand for exterior/outdoor lighting surrounding areas have renewed a sense of expectation and exploration regarding the glory of India in exterior lighting design, utilizing solar photovoltaic (PV) systems. The illumination topology has encouraged the civic community to develop an alternative for an attractive and decorative exterior area, for example, shopping precincts, household lighting, parking slots, stadiums, and industrial appliances. In addition to stipulated energy expenditure and economy tariff vision, energy conservation and building an efficiency policy should be considered for PV. There is a strong need to promote renewable energy based on electricity demand and power shortage to meet the exigency source. This paper attempts to illustrate an innovative light design model frame based on building criteria to fulfil consumer and energy demands, to economize cost optimization, to enhance efficiency without interruption, and most importantly, to provide quality flood light for exterior/outdoor lighting design. Moreover, using the Lithonia Visual (LV) software and the HOMER software based computer analyser and photometric tools, an attempt will be made to build a healthy lighting blueprint with assorted appliances.

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

Rashmi Shende, Ramaprabhu Sundara

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

Solar energy is the best source of renewable energy among all other natural resources. Due to the abundant availability of solar energy, it could be effectively used to fulfil the energy requirement of modern industrial society. Application of nanofluids in Direct Absorption Solar Collectors (DASC) can significantly increase its efficiency. Carbon nanotubes (CNTs) and graphene, which exhibit high thermal conductivity, unique optical properties, good mechanical strength, and large surface area, have been of great advantage in the field of nanofluids. In this present work, application of N-(rGO-MWNTs) (nitrogen doped hybrid structure of reduced graphene oxide (rGO) and multiwalled carbon nanotubes [MWNTs]) in DASC has been investigated. The absorption and transmittance studies have been carried out by UV–visible–NIR spectrophotometer. Furthermore, temperature dependant thermal conductivity study with different volume fractions has been carried out. A significant enhancement in thermal conductivity of 17.7 per cent is achieved with 0.02 per cent volume fraction in DI water and 15.1 per cent with 0.03 per cent volume fraction with EG. Furthermore, we have observed that these nanofluids have very good stability without any agglomeration and sedimentation due to percolation network formed through intercalation of MWNTs in between the rGO layers.

Wood Energy in India: Status and Prospects

S C Bhattacharya

Energy, **Volume 85, June 2015, Pages 310–316**

Wood plays a key role in meeting energy demand in India, particularly in rural areas; its share in total energy consumption of the country is estimated to be about 18 per cent. Traditionally, wood is mostly used as fuel in household cooking; small quantities are also used in other applications such as restaurants, brick and tile manufacturing, and agro-processing. The energy crisis of 1973 triggered interest in use of wood in modern applications, initially in gasifiers for pumping water and small-scale electricity generation in rural areas and later in power generation using steam turbines. Although installed capacity of biopower generation has been growing at an annual average rate of about 16 per cent since December 2005, the sector appears to be facing an uncertain future because of rising cost and lack of reliable supplies of wood. This paper presents a review of different aspects of wood energy in India and an assessment of wood energy potential in 2050, based on availability and productivity of different types of land for wood production; the potential of biopower capacity based on surplus wood after meeting demands for timber and fuelwood is estimated to be 180–260 GW.

Household Collection and Use of Biomass Energy Sources in South Asia

Bhagirath Behera, Dil Bahadur Rahut, Aryal Jeetendra, Akhter Ali

Energy, **Volume 85, 1 June 2015, Pages 468–480**

Lack of access to clean, affordable, and adequate energy and large scale use of solid fuels, such as firewood and cow dung cake is one of the reasons for a lower quality of life in developing countries. It is observed that majority of households in the world that use solid fuels are located in South Asian countries. The objective of this paper is to examine the pattern of household energy uses, and identify, and analyse the factors influencing household choices of energy, sources of fuelwood collection, and family members involved in fuelwood collection. The paper uses primary data collected from three Asian countries—India, Bangladesh, and Nepal. A multivariate model is employed to analyse the data. Age, gender, and education levels of a household head influence a household's choice of energy sources. Wealthy households are found to use clean energy sources, such as liquid petroleum gas (LPG) and electricity, whereas poorer households tend to use solid fuels, such as fuelwood and dung cake. Sources of fuelwood collection are largely influenced by a family's labour supply, education, and household wealth status. Females and children are employed by households for fuelwood collection. Nepal and Bangladesh engage mostly female members for fuelwood collection.

Female Labour Force Participation and Household Dependence on Biomass Energy: Evidence from National Longitudinal Data

Paul J Burke, Guy Dundas

World Development, **Volume 67, March 2015, Pages 424–437**

Air pollution from household biomass combustion is an important cause of poor health in developing countries. This study employs national-level longitudinal data for up to 175 countries during 1990–2010 and finds that female labour force participation is associated with reductions in household biomass energy use. Consistent with the "fuel stacking" model, higher incomes are linked to use of other types of energy by households, but not significantly associated with reductions in use of biomass energy. The results highlight the multifaceted nature of household energy transitions and suggest an avenue by which female empowerment can lead to improved health outcomes.

Renewable Energy Scenario in India: Opportunities and Challenges

Souvik Sen, Sourav Ganguly, Ayanangshu Das, Joyjeet Sen, Sourav Dey

Journal of African Earth Sciences, **Available online June 9, 2015**

Majority of the power generation in India is carried out by conventional energy sources, coal and fossil fuels being the primary ones, which contribute heavily to greenhouse gas emission and global warming. The Indian power sector is witnessing a revolution as excitement grips the nation about harnessing electricity from various renewable energy sources. Electricity generation from renewable sources is increasingly recognized to play an important role for the achievement of a variety of primary and secondary energy policy goals, such as improved diversity and security of energy supply, reduction of local pollutant and global greenhouse gas emissions, regional and rural development, and exploitation of opportunities for fostering social cohesion, value addition, and employment generation at the local and regional levels. This focuses the solution of the energy crisis on judicious utilization of abundant renewable energy resources, such as biomass, solar, wind, geothermal, and ocean tidal energy. This paper reviews the renewable energy scenario of India as well as extrapolates the future developments keeping in view the consumption, production, and supply of power.

Research, development, production, and demonstration have been carried out enthusiastically in India to find a feasible solution to the perennial problem of power shortage for the past three decades. India has obtained application of a variety of renewable energy technologies for use in different sectors too. There are ample opportunities with favourable geology and geography with huge customer base and widening gap between demand and supply. Technological advancement, suitable regulatory policies, tax rebates, efficiency improvement in consequence to R&D efforts are the few pathways to energy and environment conservation and it will ensure that these large, clean resource bases are exploited as quickly and cost effectively as possible. This paper gives an overview of the potential renewable energy resources in the Indian context while evaluating the present status, the energy demand of the country, and forecast consumption and production, with the objective to evaluate and assess whether India can sustain its growth and its society with renewable resources.

Development of Hybrid Energy System with Cycle Charging Strategy using Particle Swarm Optimization for a Remote Area in India

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In recent years, renewable energy can be seen as one of the important prospects of today's research, as it is likely to enlighten the lives of millions of people by fulfilling the demand of electricity in their daily life. The present work focuses on the development of optimal hybrid energy system sizing model based on comparative analysis of particle swarm optimization, genetic algorithm, and Homer software for energy index ratio of 1. The model also incorporates renewable fraction, emissions of carbon dioxide from diesel generator, net present cost, and cost of energy. The system is developed to supply the demand of 7 un-electrified villages of Dhauladevi block of Almora district in Uttarakhand, India with the help of the available resources of solar, hydro, biomass, and biogas energy, along with the addition of diesel generator, for meeting the energy deficit. From the optimization results, minimum cost of energy and maximum renewable fraction are obtained as ₹5.77/kWh and 92.6 per cent, respectively.

Overview of Electric Power Potential of Surplus Agricultural Biomass from Economic, Social, Environmental, and Technical Perspective: A Case Study of Punjab

Jaswinder Singh

Renewable and Sustainable Energy Reviews, **Volume 42, February 2015, Pages 286–297**

Biomass is a renewable, economic, and readily available resource of energy that has the potential to substitute fossil fuels in many applications, such as heat, electricity, and biofuels. The increased use of the agricultural biomass can help the agricultural-based societies in achieving energy security and creating employment, without causing environmental degradation. But, the viability and feasibility of electricity generation from agricultural biomass depends upon the availability of biomass supply at a competitive cost. The present study investigates the availability of agricultural biomass for distributed power generation in Punjab. The total production of the crop residues has been estimated by residue-to-product ratio (RPR) method. Further, the restrictions introduced by competitive uses as well as harvesting practices are taken into considerations to evaluate the available biomass potential. The biomass power potential has been obtained on consideration of energy contents of the particular crop residues and selecting appropriate conversion route. A total of 55.396 Mt of the agricultural residues are produced from various major crops. Out of these, 22.315 (40.17 per cent) of the agricultural biomass has been found to be surplus with an average density of 443 t/km². These surplus residues can significantly be used to provide continuous, reliable, and sustainable fuel supply for the power plants. Cereals (rice, wheat, maize, and barley) have major contribution (74.67 per cent) in the surplus biomass, followed by cotton (25.01 per cent) and sugarcane (0.2 per cent). The estimated annual bio-energy potential of unused crop residues is 0.35 EJ (8.43 per cent of India's potential), which is equivalent to 1.43 per cent of India's annual primary energy consumption. It has been revealed that a power potential of 2,000–3,000 MW can be exploited from these resources depending upon thermal efficiency. The study concludes with a discussion on significance and challenges of decentralized electricity generation for rural energy supply, including a brief description about economic, social, environmental, and technical aspects of bioelectricity.

An Assessment on the Sustainability of Lignocellulosic Biomass for Biorefining

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

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

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

The Diverse Applications of Water Hyacinth with Main Focus on Sustainable Energy and Production for a New Era: An Overview

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Renewable and Sustainable Energy Reviews,
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Water hyacinth was introduced as an ornamental crop in many countries more than a century ago, due to its attractive appearance and aesthetic value in the environment. Unfortunately, the flowers developed into invasive species due to their adaptability for a wide range of fresh water ecosystems and their interference with human activities. In the 21st century, they were considered as an alternative to fossil fuels, as many researchers found them capable of converting their content into fuel energy at less cost and recognized as an eco-friendly product. As water hyacinth is among the group of fastest growing plants, its biomass has the potential to become a potential renewable energy source and replace conventional fossil fuels, perhaps during the next decade. This is an essential mission to overcome the depletion of energy sources and also to fulfill the increasing demand of world energy. Instead of fuel energy, the dried biomass can also be fabricated as briquettes, which is suitable as co-firing agent in coal power plant. Thus, in future, compacted biomass residues, produced in the form of briquettes, may decrease the dependence of coal to provide more energy. The other application of water hyacinth into a co-compost material, such as soil amendment to the sandy soil, can improve hydro-physical, chemical parameters of soil and also supply the growing crops with several nutrients. Water hyacinth has also drawn attention due to its bioremediation ability which is capable of removing pollutants from domestic and industrial waste water effluents. Thus, the issue of water hyacinth should be evaluated from energy, engineering as well as environmental perspectives. In this review, the potential uses of water hyacinth are being classified and discussed.

Aquatic Biomass (Algae) as a Future Feed Stock for Bio-refineries: A Review on Cultivation, Processing and Products

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Renewable and Sustainable Energy Reviews, **Volume 47, July 2015, Pages 634–653**

The global outlook of biofuels turns out to be a full-fledged search focusing the viability and sustainability assets. The present day option for immediate and sustainable alternate fuels lies with algal biofuels. Algae are the most sustainable fuel resource in terms of food security and environmental issues. Inefficient and unsustainable biofuel derived from food crops creates twosome food security issues thus, increasing interests towards algal energy. Carbon dioxide mitigation and quick biomass accumulation, accomplishing simultaneous bioremediation have gathered progressive attention. Cultivation of biomass, harvesting, processing, and fuel production by chemical/biochemical reactions are the sequential stages in algal biofuel production. Currently, biofuels produced from algal biomass is not economical since biomass cultivation, processing, and separation of fuel products appears costly although certain advancements in culturing techniques have been recently developed. Further improvements with the biomass processing strategies may step up the third-generation biofuel concept a profitable one in the near future. This article reviews various cultivation methods, processing techniques, and stages in algal biofuel production, thereby extensively investigating their potential application in biofuel refineries.

RE-POLICY PERSPECTIVES

Andhra Pradesh Solar Power Policy, 2015[1]

A state blessed with lots of sunshine, Andhra Pradesh plans to harness this energy potential to meet the deepening energy demand in an environmental friendly approach. The state has passed the "Andhra Pradesh Solar Power Policy, 2015" to promote widespread usage of solar power and to meet the following objectives:

a. To target a minimum total solar power capacity addition of 5,000 MW in the next five years in the State with a view to meet the growing demand for power in an environmentally sustainable manner.
b. To develop solar park(s) with the necessary utility infrastructure facilities to encourage developers to set up solar power projects in the State.
c. To promote distributed generation that can help in avoiding upstream network cost and contribute towards loss reduction.
d. To deploy solar powered agricultural pumpsets and meet power requirements of farmers during day time.
e. To promote local manufacturing facilities that will generate employment in the State.

The policy will remain in effect from the date of issuance and shall remain applicable for a period of five years and/or shall remain in force till such time as a new policy is issued.

During the operative period, Solar Power Projects (SPP) that are commissioned shall be eligible for the incentives declared under this policy, for a period of 10 years from the date of commissioning—unless otherwise the period is specifically mentioned for any incentive.

Under the policy, the New and Renewable Energy Development Corporation of Andhra Pradesh Limited (NREDCAP) shall act as a Nodal Agency, as decided by the government from time to time. The nodal agency shall be responsible for the following responsibilities:

a. Facilitate in obtaining revenue land—wherever required.
b. Facilitate in obtaining power evacuation and/ or Open Access as per the regulation issued by APERC and amended from time to time.
c. Facilitate water allocation from concerned departments.
d. Facilitate and process of proposals for availing subsidy for solar rooftop systems as per Ministry of New and Renewable Energy (MNRE), Government of India, guidelines.
e. Coordinate with MNRE/SECI/APTransco/ Discom(s) and any other Central/State agencies in obtaining necessary clearances, approvals, grants, and subsidies.

To ease the procedure and for quicker implementation of the programmes, a dedicated online system shall be established by the nodal agency for acceptance of applications and providing status updates. On approval or clearing, all applications shall be disposed within 30 days from the date of registration.

A "high level committee," consisting of officials from government and representatives from developers, has been constituted to monitor the progress of implementation of the Solar Power Projects cleared under the policy. The same committee is also authorized to issue clarification as well as interpretation to such provisions in the policy.

Background

In 2002, the erstwhile Government of Andhra Pradesh issued orders formulating Andhra Pradesh Solar Power Policy. Under the policy, 34.85 MW capacity solar power projects were only commissioned before June 30, 2014, though it was envisaged to add 2,000 MW capacity by the Group of Ministers constituted for the purpose of promotion of Renewable Energy. This policy is applicable up to the year 2017 and the incentives were applicable only for the projects commissioned up to June 30, 2014. Further, due to bifurcation of the state, it is felt necessary to come out with a new comprehensive policy for promotion of solar power to meet the demand for power in an environmentally sustainable manner. Thus, the Andhra Pradesh Solar Power Policy, 2015, has been passed.

Andhra Pradesh Wind Power Policy, 2015[2]

With bifurcation of state, Andhra Pradesh has released its new wind power policy which replaces the old policy of the erstwhile Andhra Pradesh. The new policy will be known as Andhra Pradesh Wind Power Policy,

2015. Under the policy, the New and Renewable Energy Development Corporation of Andhra Pradesh Limited (NREDCAP) shall act as a nodal agency. A High Level Committee constituting the representatives of the government and players will monitor the progress of implementation of the Wind Power Policy. The policy aims at the achieving the following:

a. To encourage, develop, and promote wind power generation in the state with a view to meet the growing demand for power in an environmentally and economically sustainable manner.
b. To attract private investment to the state for the establishment of large wind power projects.
c. To promote investments for setting up manufacturing facilities in the state which can generate gainful local employment.

The policy will be operative for the next five years from the date of issuance until amended or till a new policy is passed. The new policy targets of generating 4,000 MW capacity addition through wind power in these active years.

All registered companies, Joint Venture Companies, Central and State power generation/ distribution companies, and public/private sector wind power developers will be eligible for setting up wind power projects. Wind power projects that are commissioned during the operative period shall be eligible for the incentives declared under this policy, for a period of ten years from the date of commissioning—unless the period is specifically mentioned for any incentive.

The details of the policy particulars are reproduced below in the tabular form:

Category of Wind Power Projects	
Category – I	Projects set up in government/ revenue lands or forest areas or assigned lands and also in private lands selling power within the state
Category – II	Projects set up for captive use or group captive use/3rd party sale within or outside the state
Category – III	Sale of power at average power purchase cost and availing Renewable Energy Certificate (REC)

The policy offers the following incentives to the eligible developers:

Particulars	Brief
Power Evacuation	Exemption of supervision charges to APTransco/Discom towards the internal evacuation
Transmission and Distribution Charges for Wheeling of Power	No charges for captive use/third party sale within the state through grid. For sale outside the state shall be as per regulations of APERC
Energy Banking	Banking of 100 per cent of energy shall be permitted during all 12 months of the year
Open Access	Intra-state Open Access clearance for the entire tenure of the project or 25 years whichever is earlier
Electricity Duty	Full exemption, if sale of power to APDiscom
Deemed Public–Private Partnership (PPP) Status	Deemed PPP status shall be provided for projects coming up under Category – I and have entered into a PPA with APDiscom for sale of power
Non-Agriculture Status	Deemed Non-Agricultural (NA) status for the land where wind power projects will be accorded, on payment of applicable statutory fees
Deemed Industry Status	Generation of electricity from wind power projects shall be treated as eligible industry under the schemes administered by the industries Departments and incentives available to industrial units under such schemes shall be available to the wind power producers
Must run status	Injection from wind power projects shall be considered to be deemed scheduled subject to prevailing regulations/grid code of appropriate commission
Pollution Clearance	Wind power projects will be exempted from obtaining any No Objection Certificate (NOC)/Consent for establishment under pollution control laws from Andhra Pradesh Pollution Control Board

Background

In order to promote Wind Power Projects, the erstwhile state of Andhra Pradesh has issued orders formulating Andhra Pradesh Wind Power Policy, 2012. The operative period of policy was 5 years and it expired in April 2013. With bifurcation of state in June 2014, and considering the good wind power potential existing in the state and to achieve 4,000 MW capacity addition through wind power during the next five years period, a new comprehensive wind power policy, Andhra Pradesh Wind Power Policy, 2015 have been brought out.

Conversion of Solar Energy Corporation of India from Section 8 Company to Section 3 Company under the Companies Act, 2013 and Renaming it as Renewable Energy Corporation of India[3]

The Union Cabinet chaired by Prime Minister Shri Narendra Modi, in June 2015, gave its approval to the Solar Energy Corporation of India (SECI) to apply to the Registrar of Companies for: (i) converting it into a Section 3 company under the Companies Act, 2013 (No.18 of 2013); and (ii) renaming it as the Renewable Energy Corporation of India (RECI).

The major impact of the decision will be:

a. SECI will become a self-sustaining and self-generating organization.
b. SECI will engage itself in owning solar power plants generating and selling power and in other segments of solar sector activities, including manufacturing of solar products and materials.
c. SECI will become RECI after change of its name and then will take up development of all segments of renewable energy namely, geo-thermal, off-shore wind, tidal, etc., apart from solar energy.

Section 8 of the Companies Act, 2013 [earlier Section 25 of the Companies, Act 1956] provides for formation of companies with charitable objects, etc. Under this provision, the commercial aspect of a business entity and its growth is completely prohibited. In comparison, for a Section 3 company, the object is not limited, and is mainly for commercial activities which will facilitate growth of the company. It therefore, means that a Section 8 company can only engage in activities of promotion of commerce, art, science, sports, education, research, social welfare, religion, charity, etc., but not commercial activity leading to trade, buying, and selling, etc., resulting in profit and distribution of dividend.

The Government has also decided to enlarge the scope of the activities of SECI to cover all renewable energy sources, with a view to provide a comprehensive and optimized solution for generation of renewable energy integrating various renewable energy sources. The generation profile of solar, wind, and small hydro has complementarity and generating power from these sources is likely to be more uniform. This will also reduce stress on transmission and distribution networks, resulting in better grid management. Considering this aspect, the Government has allowed the change of name from "Solar Energy Corporation of India (SECI)" to "Renewable Energy Corporation of India (RECI)".

Background

After approval of the Government, the SECI was registered as a Section 25 Company under the Companies Act, 1956 (now under Section 8 of the Companies Act, 2013) on September 9, 2011. SECI has initiated various activities for setting up of solar power plants as also for the promotion and commercialization of solar energy technologies, with long-term perspective of assuming the role of a solar power developer.

For the first time, SECI made a profit of about ₹12 crore during the last financial year and has become a networth positive PSU. It is also expected to make a profit of around ₹300 crore this year.

Revision of cumulative targets under National Solar Mission from 20,000 MW by 2021–22 to 100,000 MW

The Union Cabinet chaired by the Prime Minister, Shri Narendra Modi, in the month of June 2015 gave its approval for stepping up of India's solar power capacity target under the Jawaharlal Nehru National Solar Mission (JNNSM) by five times, reaching 100,000 MW by 2022. The target will principally comprise of 40 GW Rooftop and 60 GW through Large and Medium Scale Grid Connected Solar Power Projects. With this ambitious target, India will become one of the largest Green Energy producers in the world, surpassing several developed countries.

The total investment in setting up 100 GW will be around ₹600,000 cr. In the first phase, the Government of India is providing ₹15,050 crore as capital subsidy to promote solar capacity addition in the country. This capital subsidy will be provided for Rooftop Solar projects in various cities and towns, for Viability Gap Funding (VGF) based projects to be developed through the Renewable Energy Corporation of India (RECI), formerly Solar Energy Corporation of India (SECI), and for decentralized generation through small solar projects. The Ministry of New and Renewable Energy (MNRE) intends to achieve the target of 100,000 MW with targets under the three schemes of 19,200 MW.

Apart from this, solar power projects with investment of about ₹90,000 crore would be developed using Bundling mechanism with thermal power. Further investment will come from large Public Sector Undertakings and Independent Power Producers (IPPs). State Governments have also come out with state specific solar policies to promote solar capacity addition.

The new solar target of 100 GW is expected to abate over 170 million tonnes of carbon dioxide (CO_2) over its life cycle. This Solar Scale-up Plan has a target of 40 GW through Decentralized Solar Power Generation in the form of Grid Connected Rooftop Projects. While decentralized generation will stabilize the grid, it will minimize investment on power evacuation.

To facilitate such a massive target, the Prime Minister's Office has been pushing various Ministries to initiate supporting interventions such as:

a. Incorporating changes in land use regulations and tenancy laws.
b. Development of power transmission network/ Green Energy Corridor.
c. Identification of large government complexes/ buildings for rooftop projects.
d. Setting up of exclusive parks for domestic manufacturing of solar PV modules, etc.

Background

JNNSM was launched in 2009 with a target for Grid Connected Solar Projects of 20,000 MW by 2022. In the last two to three years, the sector has witnessed rapid development with installed solar capacity increasing rapidly from 18 MW to about 3800 MW during 2010–15. The price of solar energy has come down significantly from ₹17.90 per unit in 2010 to under ₹7 per unit, thereby reducing the need of Viability Gap Funding/ Generation Based Incentive VGF/GBI per MW of solar power. With technology advancement and market competition, this Green Power is expected to reach grid parity by 2017–18. These developments would enable India to achieve its present target of 20,000 MW. Considering its international commitment towards Green and climate friendly growth trajectory, the Government of India has taken this path-breaking decision.

References

1 "Andhra Pradesh Solar Policy, 2015." Source: http://ireeed.gov.in/. Accessed July 9, 2015.
2 "Andhra Pradesh Wind Power Policy, 2015." Ibid.
3 "Conversion of Solar Energy Corporation of India from Section 8 Company to Section 3 Company under the Companies Act, 2013 and renaming it as Renewable Energy Corporation of India." Source: http://pib.nic.in/newsite/PrintRelease.aspx?relid=122756. Accessed July 9, 2015.

STATISTICS AT A GLANCE

Resource-wise Estimated Medium-term Potential for Renewable Energy in India

(Up to 2032)

Resource	Estimated Potential* (In MW_{eq}.)
Solar Power	>100,000 [1]
Wind Power	49,000 [2]
Small Hydro Power (Upto 25 MW)	20,000 [3]
Bio-Power	
Agro-Residues	16,000 [4]
Cogeneration-Bagasse	5,000 [5]
Waste to Energy	
Municipal Solid Waste to Energy	1,700 [6]
Industrial Waste to Energy	1,000
Total	**192,700** [7]

Abbr.: $MW_{eq.}$: Megawatt equivalent.

Notes:

1. The potential for solar power in most parts of the country is around 30–50 MW per square kilometer of open, shadow free area covered with solar collectors.
2. Potential based on areas having wind power density (wpd) greater than 200 W/m^2 assuming land availability in potential areas @ 1%. Revised estimate by C-WET is ~100,000 MW at 80 m. height (being validated). The lower end of the potential might be suitable for off-grid applications. Preliminary surveys do not at this juncture suggest a sizeable grid-interactive off-shore wind power potential.
3. Technically feasible hydro potential of all sites upto 25 MW station capacity. Technically feasible and economically viable hydro potential is generally accepted at 40 per cent of the total estimated potential.
4. Based on surplus agro-residues. In practice, however, there are several barriers in collection and transportation of such agro-residues to the generation site and biomass power generation units prefer to use fuelwood for techno-economic reasons. A potential of 45,000 MWe from around 20mha of wastelands assumed to be yielding 10MT/ha/annum of woody biomass having 4,000 k-cal/kg with system efficiency of 30 per cent and 75 per cent PLF has not been taken into account.
5. With new sugar mills and modernization of existing ones, technically feasible potential for surplus power is assessed at 5,000 MW_{eq}.
6. With expansion of urban population post census 2001, current technically feasible municipal waste-to-energy potential is assessed at 1,700 MW_{eq}.
7. Potential for solar power is dependent on future developments that might make solar technology cost-competitive for grid-interactive power generation applications.

*: Note all of this potential may be suitable for grid-interactive power for technical and/or economic reasons.

Source: Rajya Sabha Unstarred Question No. 2411, dated on 03.09.2012.

State-wise Funds Released for Development of Renewable Energy Sources in India

(2011–12 to 2014–15–upto January 2015)

(₹ in crore)

States/UTs	2011–12	2012–13	2013–14	2014–15 (Up to January 2015)
Andaman and Nicobar Islands	0.02	0.01	0.00	0.00
Andhra Pradesh	45.61	36.84	3.20	1.10
Arunachal Pradesh	66.62	39.05	27.39	2.32
Assam	18.37	10.58	19.01	8.17
Bihar	7.29	0.63	10.44	0.42
Central Agencies (IREDA, SECI, etc.)	0.00	0.00	497.17	489.58
Chandigarh	11.34	9.07	6.99	8.27
Chhattisgarh	54.48	60.17	16.03	19.91
Dadra and Nagar Haveli	0.00	0.00	0.00	0.00
Daman and Diu	0.00	0.00	0.00	0.00
Delhi	213.38	312.25	74.57	20.73
Goa	1.44	0.04	0.06	0.06
Gujarat	18.14	16.92	38.23	18.83
Haryana	16.22	10.96	7.80	15.90
Himachal Pradesh	16.55	16.74	28.70	16.05
Jammu and Kashmir	102.48	63.46	87.01	51.94
Jharkhand	17.90	2.63	0.00	0.24
Karnataka	55.93	74.09	86.17	44.58
Kerala	13.96	14.91	10.17	28.85
Lakshadweep	8.76	0.00	1.00	0.00
Madhya Pradesh	39.80	20.70	13.94	8.00
Maharashtra	202.21	189.70	156.11	178.10
Manipur	3.85	16.61	2.50	0.00
Meghalaya	5.84	1.80	8.93	4.62
Mizoram	1.24	7.03	1.68	1.72
Nagaland	11.53	18.72	7.51	4.24
Odisha	36.32	7.72	0.59	11.28
Puducherry	2.04	0.23	0.10	0.00
Punjab	46.05	26.66	32.68	20.78
Rajasthan	78.48	61.59	28.64	58.90
Sikkim	10.50	6.13	11.13	3.09
Tamil Nadu	54.24	39.16	67.58	43.97
Telangana	0.00	0.00	25.49	40.24
Tripura	5.07	0.42	0.00	0.02
Uttar Pradesh	71.91	56.89	52.01	52.69
Uttarakhand	22.54	31.42	50.11	5.12
West Bengal	41.24	42.18	15.51	6.66
India	**1,301.35**	**1,195.31**	**1,388.45**	**1,166.38**

Note: Grants-in-aid and Subsidies also include releases made to various agencies in the state.
Source : Lok Sabha Unstarred Question No. 2008, dated on 04.12.2014 & : Lok Sabha Unstarred Question No. 2726, dated on 12.03.2015.

Region/State-wise Electricity Generated (Cumulative) from Renewable Energy Sources in India

(2014–15—up to December 2014)

	States/UTs	Cumulative Achievement (In MU)
Northern Region	Chandigarh	-
	Delhi	90.915
	Haryana	305.723
	Himachal Pradesh	1,276.471
	Jammu and Kashmir	33.774
	Punjab	808.849
	Rajasthan	4,423.135
	Uttar Pradesh	1,407.343
	Uttarakhand	1,016.170
	NTPC—Dadri, Fbd, and Unchahar	16.403
Northern Region Total		**9,378.782**
Western Region	Chhattisgarh	467.393
	Daman and Diu	0.042
	Gujarat	5,637.976
	Madhya Pradesh	1,037.690
	Maharashtra	7,012.460
	NTPC—Rajgarh and Goa	42.723
Western Region Total		**14,198.284**
Southern Region	Andhra Pradesh	2,082.462
	Karnataka	7,512.136
	Kerala	524.200
	Tamil Nadu	10,661.250
	Telangana	529.208
	NTPC—Ramagunda and Puducherry	11.385
Southern Region Total		**21,320.641**
Eastern Region	Andaman and Nicobar Islands	-
	Bihar	119.477
	Jharkhand	3.144
	Odisha	286.700
	Sikkim	16.133
	West Bengal	1,085.749
	DVC	130.087
	NTPC—Talchaand & Andaman	13.290
Eastern Region Total		**1,654.581**
North Eastern Region	Arunachal Pradesh	-
	Assam	57.285
	Manipur	-
	Meghalaya	52.430
	Mizoram	30.720
	Nagaland	76.737
	Tripura	26.573
North Eastern Region Total		**243.745**
Grand Total		**46,796.034**

Source: Lok Sabha Unstarred Question No. 631, dated on 26.02.2015.

Demand for Grants by Ministry of New and Renewable Energy in India

(2014–15 and 2015–16)

(₹ in crore)

Particulars	Major Head	2014–15 (Budget)			2014–15 (Revised)			2015–16 (Budget)		
		Plan	Non-Plan	Total	Plan	Non-Plan	Total	Plan	Non-Plan	Total
Revenue Section										
Secretariat-Economic Services	3,451	23.00	14.14	37.14	23.00	12.87	35.87	10.47	14.06	24.53
North Eastern Areas	2,552	94.00	-	94.00	66.00	-	66.00	29.00	-	29.00
New and Renewable Energy	2,810	2,272.00	1.25	2,273.25	2,100.00	1.02	2,101.02	2,612.20	1.48	2,613.68
Grants-in-aid to State Governments	3,601	35.00	-	35.00	35.00	-	35.00	41.00	-	41.00
Total-Revenue Section		**2,424.00**	**15.39**	**2,439.39**	**2,224.00**	**13.89**	**2,237.89**	**2,692.67**	**15.54**	**2,708.21**
Capital Section										
Capital Outlay on New and Renewable Energy	4,810	95.00	-	95.00	295.00	-	295.00	95.00	-	95.00
Total—Capital Section		**95.00**	**-**	**95.00**	**295.00**	**-**	**295.00**	**95.00**	**-**	**95.00**
Grand Total		**2,519.00**	**15.39**	**2,534.39**	**2,519.00**	**13.89**	**2,532.89**	**2,787.67**	**15.54**	**2,803.21**
Revenue Section										
New and Renewable Energy	2,810	-1,578.00	-	-1,578.00	-1,778.00	-	-1,778.00	-2,500.00	-	-2,500.00
Capital Section										
Capital Outlay on New and Renewable Energy	4,810	-	-	-	-200.00	-	-200.00	-	-	-
Total Recoveries		-1,578.00	-	-1,578.00	-1,978.00	-	-1,978.00	-2,500.00	-	-2,500.00
The Expenditure Provisions, Net of Above Recoveries, Will be as Under										
Revenue		846.00	15.39	861.39	446.00	13.89	459.89	192.67	15.54	208.21
Capital		95.00	-	95.00	95.00	-	95.00	95.00	-	95.00
Total		**941.00**	**15.39**	**956.39**	**541.00**	**13.89**	**554.89**	**287.67**	**15.54**	**303.21**

Note: The above estimates do not include the recoveries shown below which are adjusted in reduction of expenditure.
Source: Budget Documents, Ministry of Finance, Government of India.

RE-PRODUCTS

Anant Urja[1]

The Anant Urja is a 12 V power system that can meet high demands of energy. Launched by SunSwitch, the Anant Urja is an autonomous and mobile energy system that is capable of powering several 12 V loads, such as a TV or a small computer. It uses solar modules with crystalline solar cell technology that can be used for over 20 years. The state of the art Li-battery technology offers unprecedented performance and battery life while being maintenance free. Due to its unique, modular solar home system extension, the system can grow with demand.

Technical data

System Voltage:	12 V
System Capacity:	5, 6 Ah
Module Peak Power:	10 W
Module Current:	0.58 A
Maximum Current:	3 A
Lamp included:	Sun Switch 12 V Lamp (400 lm)
Possible Loads:	Phone charging, Radio, TV, etc.
Daily operation hours of one light:	19 hrs
Daily operation hours of TV:	5 hrs
Charging time:	7 hrs

Contact: SunSwitch India (Private) Limited, Plot No. 51/1/10 Site-IV**,** UPSIDC Industrial Area (Near Vaishali Metro)**,** Sahibabad–201010, District Ghaziabad, Uttar Pradesh
Email: info@sunswitch.in | Twitter: @SunSwitchIndia
Phone: 1800-11-8090 (Toll free) | Fax: +91 11 4703 4450

Power Saver Panel[2]

Voltech Manufacturing Company Limited offers power saver panel suitable for high mast, and outdoor/indoor lightening. Its features are: power saving is above 20 to 25 per cent in lighting; no load current is low below 1 per cent; on/off control by timer, dusk-dawn, PLC and manual; PLC can be used for the sequential on/off for lighting; easy to install with existing control unit and cabling; payback period is 8 to 12 months based on site condition; and low maintenance, no moving parts, easy to service.

Contact: Voltech Manufacturing Company Limited, Voltech Eco Tower, 2/429 Mount Poonamalle Road, Ayyappanthangal, Chennai–600 056
Mobile: 96771 20617
E-mail: haribabu.gp@voltechgroup.com

LED System Lights for 230 VAC[3]

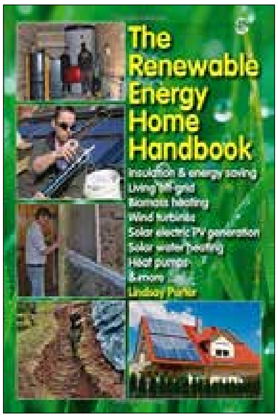
Prolyx LED system luminaires are completely manufactured in Germany in industrial high quality. The lamps have got exchangeable LEDs, which are directly supplied by 230 VAC mains voltage. Transformer power supplies and driver electronics are no more needed. Life expectancy of the lamps increases and there are still less maintenance costs due to the fact that the normally most fault-prone components (power supply, driver) just don't exist! All benefits of the LEDs can be shown to advantage without limitation, such as high life expectancy, low power consumption, low heat generation, vibration resistance, etc. The lamp heads are made from anodized aluminium with high quality and scratch-proof Plano convex glass lens. There is a splash-proof ON/OFF switch on the rear side of the lamp heads. The lamps are equipped with 230 VAC LEDs, emitting a light flux of 600 lumens at a light colour of 5,500 K with a power consumption of 9 watts. By means of a massive flexible metal shall (gooseneck with oil-resistant rubber protection, the light can comfortably be directed towards the tool or the working area. The metal shafts are available with 20 cm and 60 cm lengths. With a modular system with extremely robust connector elements various models are assembled, such as terminal lights, magnetic lights, wall/ceiling lights, desk lights, clamp lights, and floor lights, which can be used accordingly as machine lamps or workplace lights.

Contact: PSE-Priggen Special Electronic Sellen 102a, 48565 Steinfurt, Germany.
Tele +49-2551/5770 | Fax: +49-2551/82422 | E-mail: priggen@priggen.com

References

1 "Anant Urja." http://sunswitch.in/dante/anant-urja Accessed July 30 2015.
2 Source: Industrial Products Source 12.6
3 Ibid.

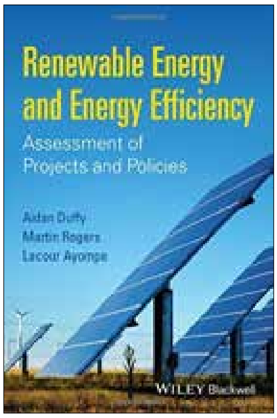
BOOK UPDATE



The Renewable Energy Home Handbook: Insulation & Energy Saving, Living Off-grid, Biomass Heating, Wind Turbines, Solar Electric PV Generation, Solar Water Heating, Heat Pumps, & More

Author: Lindsay Porter
Publisher: Veloce Publishing, 2015
192 pages

The Renewable Energy Home Handbook is biased towards the practical, and covers the installation of all leading types of alternative domestic energy sources—from ground—and air-source heat pumps, PV solar electricity generation and solar water heating, to biomass domestic heating systems and wind turbines. Discussing the pros and cons of each technology, it also provides you with a clear overview of what is genuinely required and the benefits to be gained from each system. The book targets readership interested in renewable energy and people who love to work hands-on with renewable equipments.

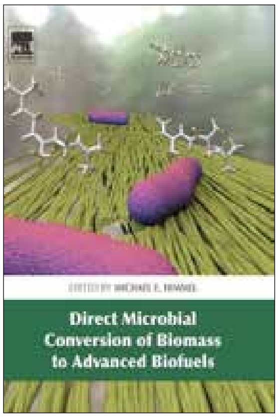


Renewable Energy and Energy Efficiency: Assessment of Projects and Policies

Authors: Aidan Duffy, Martin Rogers, Lacour Ayompe
Publisher: Wiley-Blackwell, 2015
280 pages

The recent rise to prominence of renewable energy and energy efficiency has been driven by their potential to lower the environmental impacts of energy use. As these technologies mature, they must demonstrate not only their environmental benefits, but also their economic competitiveness. The relative costs and benefits of each potential project, whether large or small, must be systematically modelled and assessed before they can be financed and implemented.

The book deals with the appraisal of such projects against financial and non-financial criteria, illustrating the assessment tools necessary to make appropriate, evidence-based decisions as efficiently as possible. The most important technologies are first described, stressing their economic and performance characteristics. Key project appraisal concepts are then introduced, approaches to modelling the cash flows in energy projects are described, and the issues of uncertainty and optimization are fully discussed. These financial concepts, together with methods for estimating greenhouse gas emissions, are extended to address aspects of energy policy. Illustrated with many case studies, this is an ideal introduction to financial and non-financial appraisal techniques as applied to energy efficient and renewable energy technologies.



Direct Microbial Conversion of Biomass to Advanced Biofuels

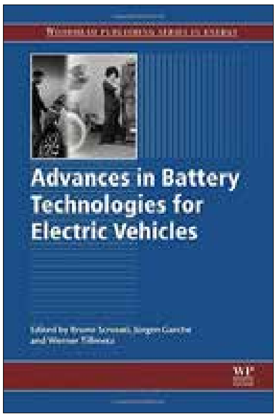
Editor: Michael E Himmel
Publisher: Elsevier, 2015
282 pages

The book is a stylized text that is rich in both the basic and applied sciences. It provides a higher level summary of the most important aspects of the topic, addressing critical problems solved by deep science.

Expert users will find new and critical methods that can be applied to their work, detailed experimental plans, important outcomes given for illustrative problems, and conclusions drawn for specific studies that address broad-based issues.

A broad range of readers will find this to be a comprehensive, informational text on the subject matter, including experimentalists and even CEOs deciding on new business directions. The book:

- Describes an important new field in biotechnology, the consolidated conversion of lignocellulosic feedstocks to advanced fuels
- Up-to-date views of promising technologies used in the production of advanced biofuels
- Presents the newest ideas, well-designed experiments, and outcomes
- Provides outstanding illustrations from NREL and contributing researchers
- Contains contributions from leaders in the field that provide numerous examples and insights into the most important aspects of the topic



Advances in Battery Technologies for Electric Vehicles

Editors: Bruno Scrosati, Jürgen Garche, Werner Tillmetz
Publisher: Woodhead Publishing, 2015
546 pages

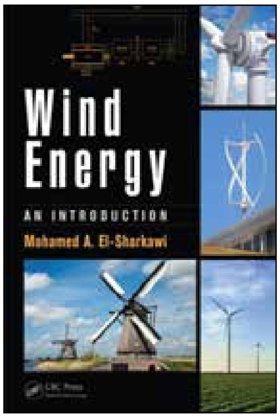
The book provides an in-depth look into the research being conducted on the development of more efficient batteries capable of long distance travel.

The text contains an introductory section on the market for battery and hybrid electric vehicles, and then thoroughly presents the latest on lithium-ion battery technology.

Readers will find the sections on battery pack design and management, a discussion of the infrastructure required for the creation of a battery powered transport network, and coverage of the issues involved with end-of-life management for these types of batteries. Further, the book:

- Provides an in-depth look into new research on the development of more efficient, long distance travel batteries
- Contains an introductory section on the market for battery and hybrid electric vehicles
- Discusses battery pack design and management and the issues involved with end-of-life management for these types of batteries

Managers in the automotive industry and academics and post-graduate students working on battery technology are target audience of this book.



Wind Energy: An Introduction

Author: Mohamed A El-Sharkawi
Publisher: CRC Press, 2015
350 pages

The book covers wind energy system types, operation, modeling, analysis, integration, and control. Beginning with a history of the development of wind energy, this comprehensive book:

- Explains the aerodynamic theories that govern the operation of wind turbines
- Presents wind energy statistics to address the stochastic nature of wind speed
- Employs the statistical modelling of wind speed to evaluate sites for wind energy generation
- Highlights the differences between the most common types of wind turbines
- Analyzes the main power electronic circuits used in wind energy
- Details the induction, synchronous, and permanent magnet generators from the basic principle of induced voltage to the steady-state and dynamic models
- Explores the operation, stability, control, and protection of type 1, 2, 3, and 4 wind turbines
- Discusses the main integration challenges of wind energy systems with electric utility systems
- Features numerous models, illustrations, real-world examples, and exercise problems
- Includes a solutions manual and figure slides with qualifying course adoption

The book requires a basic knowledge of electric circuit theory, making it an ideal text for students at the senior-undergraduate and graduate levels. In addition, the book provides practicing engineers with a handy professional reference.

FORTHCOMING RE-EVENTS

International Conference on Power and Renewable Energy (ICPRE 2015)

15–16 September 2015, Singapore

Contact person: Ms Vera Wang
Tel.: +1-518-478-2659 (USA)
Tel.: +86-28-86528758 (China)
Email: icpre@iacsit.org
Website: http://www.icpre.org/

ICCE 2015: 14th International Conference on Clean Energy

27 September–1 October 2015, Saskatoon, Saskatchewan, Canada

Contact person: Prof. Gap Soo Chang, University of Saskatchewan
Tel.: +61 9468 320; Fax: + 61 9325 4296
Website: http://www.icce2015.net

III European Conference on Renewable Energy Systems (ECRES)

1–3 October 2015, Antalya, Turkey

Contact person: Prof. Dr Erol KURT
Tel. and Fax: +90 312 202 8550
E-mail: ewresinfo@gmail.com
Website: http://www.ewres.info

Global Conference on Renewable Energy (GCRE)

19–21 October 2015, Patna, Bihar, India

Contact person: Organising Secretary
Address: 19, Sunbeam way, Coventry, CV3 1PG, UK
Tel.: + (44) 2477673919
Email: conference@weentech.co.uk.
Website: http://www.weentech.co.uk/gcre2015/

14th World Wind Energy Conference & Exhibition

26–28 October, 2015, Jerusalem, Israel

Contact: Congress Secretariat, Paragon Group
Tel: +41 22 5330 948
E-mail: Secretariat@worldwindconf.net
Registration Queries: Registration@worldwindconf.net

Asia Clean Energy Summit (ACES)

27–28 October 2015, Singapore

Contact person: Ms Elysia Teo
Tel.: +65 6542 2220
E-mail: secretariat@asiacleanenergysummit.com
Website: http://www.asiacleanenergysummit.com/

Solar Projects Egypt

27–28 October 2015, Cairo, Egypt

Contact person: Nadine
Advanced Conferences & Meetings FZ-LLC Building BS17, Ground Floor Office No. G02, PO Box: 478842, Dubai Studio City, Dubai, United Arab Emirates
Tel.: +971 4 361 4001; Fax: +971 4 361 4554
Website: http://www.solarprojectsegypt.com

International Symposium on Concentrating Solar Power Systems

5–7 November 2015, Kusadasi - Aydin, Turkey

Contact person: Dr Koray ULGEN
Fax: +90 232 388 85 62
Address: CSP-TR'2015 Organization Committee
Ege University Engineering Faculty,
Department of Mechanical Engineering,
35040, Bornova-İZMİR-TÜRKİYE
E-mail: cpstr2015@gmail.com
Website: http://csptr.ege.edu.tr

International Conference on Renewable Energy and Environmental Engineering (ICREEE 2015)

20–21 November 2015, Makassar, Indonesia

Contact person: Wafie
ICREEE 2015 Secretariat
International Postgraduate Network (IPN.org)
37B Jalan Pelabur B 23/B Seksyen 23, 40300, Shah Alam, Selangor, Malaysia
Phone: +6011-16697231/+6016-7672061
Tel.: +603-55486116/55455516
Fax: +603-55480616
E-mail: infoipnindon@gmail.com
Website: http://icreee2015.weebly.com/

Second International Conference on Environment Technology & Energy 2015

22–23 November 2015, Colombo, Sri Lanka

Contact person: Mr Prabhath Patabendi (Convener)
Tel.: +1-647-447-2393
Email: prabhath@theicrd.org
Website: http://www.enviornment3000.com

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