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- On-Grid
  - National Hydroelectric Power Corporation (NHPC)
  - National Institute of Teacher's & Training Research
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Dr Suneel Deambi discusses the current scenario of the Renewable Energy (RE) sector in India. The article highlights how the Government of India is planning to make a major global investment in the RE sector through a national event named RE-Invest for making the country energy secure.

As India is naturally blessed with solar energy, the scheme initiated by the Ministry of New and Renewable Energy (MNRE) is aimed at the development of solar parks across the country. A N Srivastava shares details of the MNRE scheme with perspective investors.

P Raman carries out a detailed analysis of investment opportunities related to biomass-based power generation and analyses the status of the technology in context of total available renewable energy potential and power generation potential realized.
We thank you very much for sending the Akshay Urja, December 2014 issue. I must say that the newsletter has proven to be very useful and highly informative in the sector of renewable energy. We eagerly await every forthcoming issue of the newsletter.

G. Palaniappan
Chennai

I received and read an issue of Akshay Urja on National Institutions of Renewable Energy. I was very happy to read it. This magazine is indeed useful in improving my knowledge base in the new and renewable energy sector. It is beautiful magazine and provides a lot of general as well as specific information regarding solar and other resources in alternate energy.

Roop Kumar Singh
Panchwati, Loni Border

I read ‘Akshay Urja’ regularly. This magazine is very informative and good educator, particularly for people like me who live in villages and can use solar energy technology effectively. I am thankful to you for sending me such an informative and useful newsletter which contains latest information on inventions, government programmes and emerging paradigms in the renewable energy sector. It is indeed a need of the hour.

Seema Gautam
Paschim Puri, New Delhi

I enjoyed reading through Akshay Urja magazine on various renewable energy technologies like Biomass, Wind, Bio-gas, Geothermal, Hydro and Solar Photovoltaic technologies/ systems which are the major sources of renewable energy in the power sector. This magazine provides us the latest information about the various renewable energy technologies. This magazine is very informative and useful for the students and new researchers.

Rudraksh Energy, Jaipur, Rajasthan

The layout and contents of the magazine are very appropriate and useful. I must compliment you and your team for bringing out the useful information and updating about the use of these sources. The growth in the use of new and renewable energy sources has been very impressive and all at Ministry deserve special compliments. . . Keep it up.

Dr. A.N. Mathur
Former Dean and Professor,
CTAE, MPUAT, Udaipur, Rajasthan

I congratulate you for the wonderful and very impressive journal Akshay Urja which contains the most useful information which is the need of the hour. I would like to subscribe for this journal which deserves to be in our and all other libraries.

Smt. Deepa Devi
Devli, Khampur, New Delhi

The article “Solar Air Heating in Ladakh” in the Oct 2014 issue of Akshay Urja, is very heartening. In Ladakh, the area of extreme low temperatures and remote access, the idea appears to be very good. This would definitely save conventional fuel and reduce CO\textsubscript{2} emissions. Secondly, the article “Utility of Solar Pumps for Salt Farmers” is also very interesting as the cost of running is much less as compared to the conventional Diesel Pumps.

D S Agarwal
Rudraksh Energy, Jaipur, Rajasthan

Dear Reader, Thank you very much for your suggestions and encouragement. The editorial team of Akshay Urja will make every effort to make this magazine highly informative and useful to all our readers. We welcome your suggestions and valuable comments to make further improvements in the content and presentation.

Editor, Akshay Urja
Dear Readers,

India has an estimated renewable energy potential of about 895 GW from renewable exploitable sources viz., wind: 100 GW (at 80 m mast height); small hydro: 20 GW; bio-energy: 25 GW; and solar power: 750 GW (including 60 GW from grid solar PV rooftops) assuming 3 per cent wasteland is made available. Significant potential from decentralized applications for meeting hot water requirements, space heating/cooling through solar energy for residential, commercial and industrial sector, and meeting cooking energy needs in the rural areas through biogas.

So far, only about 33 GW grid interactive renewable power has been installed and keeping in view the vast potential, limited government’s financial resources, most of the investment has to come from the private sector. In order to attract the private sector investment, the enabling environment along with conducive policies and ease of procedure needs to be put in place by the government. Few of the facilities could be single window facilities to clear all statutory requirements for setting up manufacturing unit or the power projects, fast-track approvals of PPAs, site-wise identification of lands by the states with clear transfer/lease mechanism, evacuation facilities on priority at the project sites, timely payment of the power supplied to the grid to the power producers, encouraging FDIs, providing loans to the investors by Indian Banks, long-term and stable policies of the Central and State Governments, etc.

RE-Invest a mega event being organized by the Ministry of New and Renewable Energy is an effort in the direction of attracting private sectors commitment and investments in renewable energy sector. RE-Invest will be the first major platform for investment promotion in this sector at the Government of India level to signal India’s commitment to the development and scaling up of renewable energy to meet its energy requirement in a sustainable manner. This will enable the global investment community to connect with renewable energy stakeholders in India. The event is expected be attended by over 200 investors and over 1,000 delegates, both domestic and International.

The solar sector has emerged as an important investment destination for investors in the country. The 100 GW solar power gives an investment opportunity of about $100 billion in the next five years. The present issue of Akshay Urja focuses on investment opportunities on renewable energy sector in the country. I hope that the material would benefit the readers who are looking for some investment opportunities.

ARUN K TRIPATHI
aktripathi@nic.in
The Union Cabinet approved setting up of 25 solar parks of 500 MW capacity each, as Ultra Mega Solar Power Projects across the country, which will require financial support of ₹4,050 crore from the Central government. Besides, the Cabinet Committee on Economic Affairs also approved a scheme for setting up 1,000 MW grid-connected solar power projects by Public Sector Units (PSUs) and Central government organizations, with a Viability Gap Funding support of ₹1,000 crore. Solar parks will be set up across the country within a span of five years, from fiscal 2014–15 to 2018–19, while 1,000 MW grid-connected solar PV power projects would be set up under various central and state schemes from fiscal 2015–16 to 2017–18. Solar parks will be developed in collaboration with state governments and their agencies. The choice of implementing agency for developing and maintaining the park would also be decided by the state governments. The scheme will have a mandatory condition that all photovoltaic cells and modules used in solar plants set up under this scheme will be made in India.

Source: www.articles.economictimes.indiatimes.com

The Grundfos Foundation, Grundfos India, and Sunlit Future are entering the first phase of an ambitious project to bring clean water to 100 villages in rural India. The first phase will deliver water to 12,400 people in 28 villages in Odisha, Maharashtra, Madhya Pradesh, and Uttar Pradesh. Given that in India, over 700,000 villages do not have access to water, an off-grid, self-sustaining solar pumping solution is the quickest way to provide water to millions. The Grundfos Foundation has agreed to co-sponsor the construction of the first 28 of 100 solar-powered pumping systems in 100 villages. “We understand the plight of many women and girls in rural India who have to carry up to 20 litres of water 2–3 times a day. We are happy to bring some respite to these women and the 100 villages through this project. We think it is going to make a tremendous difference in a lot of people’s lives,” said Christian Hartvig, Executive Director of the Grundfos Foundation.

Source: www.timesofindia.indiatimes.com
India, Israel to Cooperate in Renewable Energy Sector

India and Israel are set to conclude a broader agreement on cooperation in the renewable energy sector between the two countries. This follows earlier agreements between the two countries to work on the renewable energy sector. Daniel Carmon, Israeli ambassador to India, informed that the Free Trade Agreement (FTA) talks could not be held due to other engagements. But they are poised to be taken up again as both governments are committed to reaching a consensus on the agreement. He also said that the India–Israel trade which had humble beginnings at $2,00,000, a little over 20 years ago, had now topped the $6-billion mark and the same was poised to get a lot bigger as both countries get into more areas of mutual interest. The $6 billion bilateral trade is without the defence business, which is another big area. Israel has developed strong and sound relationships in the defence sector and work is underway to identify a few other clusters of common interest.

Source: www.thehindubusinessline.com

UPNEDA Distributes Solar Home Lights to Registered Construction Workers

In Uttar Pradesh, Solar Home Lights are being set-up in the houses of registered construction workers through the New and Renewable Energy Development Agency under the Building and Other Construction Workers Welfare Board, Department of Labour, Uttar Pradesh government’s ‘Solar Energy Assistance Programme’. Under this scheme, Model-4 Solar Home Light (certified by MNRE, Government of India) is being provided to registered construction workers. More than 30,000 thousand registered construction workers have been targeted to be distributed Solar Home Lights under this programme. So far, approximately 5000 registered construction workers have been benefitted from the scheme.

Source: http://neda.up.nic.in/
A team of researchers is on the cusp of producing cheaper and alternative energy. The group led by Bharat Ratna Prof. C N R Rao has successfully researched on a cost-effective way of producing synthetic gas, i.e., a combination of hydrogen and carbon monoxide, to generate electricity. The team comprises scientist A Govindaraj, associated with Jawaharlal Nehru Centre for Advanced Scientific Research (JNCASR) and Indian Institute of Science, Bangalore, and Sunita Dey and B S Naidu from the JNCASR. The group of researchers has found an efficient way to generate hydrogen and carbon monoxide using lanthanum calcium manganate. This material not only produces larger amounts of hydrogen and carbon monoxide, but achieves it at a relatively lower temperature range. The method requires a temperature of about 1,000 ºC, but the team will try to achieve it using solar energy.

Source: www.avenuemail.in

Rajasthan Electronics and Instruments Ltd (REIL), Jaipur, signed a Memorandum of Understanding (MoU) with Energy Efficiency Services Limited (EESL), New Delhi, for jointly working for the identification, development, and implementation of energy efficiency projects for demand side measures such as municipal functions, agriculture, public building, lighting, industrial, etc. The MoU envisages creating awareness about the energy efficiency and upgrading the existing conventional lighting systems/equipment with energy efficient LED lights and high efficiency star-rated equipment. The MoU was signed in New Delhi in the gracious presence of Mr A K Jain, Managing Director, REIL and, Mr Saurabh Kumar, Managing Director, EESL. Mr Jain and Mr Kumar said that the areas of energy efficiency and conservation needed greater attention and the association of companies having expertise and wide experience in the field of energy and energy efficiency would promote use of energy efficient lights and systems that would also improve upon the environmental impacts in the form of reduced carbon emissions, energy security, and conservation of natural resources.

Source: www.reiljp.com
National

Energy Conservation to Save ₹ 50,000 Crore

Indian Power Minister Shri Piyush Goyal, while addressing the National Energy Conservation Day function, said that pursuing energy efficient ways would help reduce electricity consumption and save as much as ₹ 50,000 crore.

Emphasizing the need for conserving energy, he said that within the next two years the government buildings throughout the country would be equipped with energy saving Light-Emitting Diode (LED) bulbs. He said that India produced about one lakh crore units of electricity and saving 10 per cent of that energy would mean saving 10,000 crore units.

“This is equivalent to as much as ‘₹ 50,000 crore’ savings which can be utilized for lighting up homes of five crore people who live without electricity,” said Shri Goyal. Noting that energy conservation would help in the country’s economic progress, the Power minister said we should aim at saving 10,000 crore units of electricity by the end of 2015.

Source: www.newsnation.in

Sunedison, Adani Group to Build $4 Billion Gujarat Solar Facility

Adani Enterprises Ltd, the flagship company of the $9.4 billion Adani Group, signed an agreement with US-based SunEdison Inc. to set up a joint venture that will build a solar photovoltaic manufacturing facility in Gujarat with an investment of around $4 billion. The new facility will be set up in Mundra, Gujarat, in next three-four years and will vertically integrate all aspects of solar panel production on site. The facility will produce enough solar panels to fuel substantial growth of SPV in India, furthering India’s goals for clean, renewable energy independence.

The memorandum of understanding between SunEdison and Adani Enterprises Ltd was signed in the backdrop of the seventh Vibrant Gujarat summit, inaugurated by Prime Minister Narendra Modi in Gandhinagar.

Vibrant Gujarat was started in 2003 by Shri Modi when he was the Chief Minister of Gujarat to project the state as the preferred destination for investments and business.

Source: www.livemint.com
The Netherlands has unveiled the world’s first solar bike path, a revolutionary project to harvest the sun’s energy that could also be used on roads. The so-called ‘SolaRoad’ bike path is made of concrete modules each measuring 2.5 × 3.5 m (8 × 11 feet), embedded with solar panels covered in tempered glass. To help prevent accidents, the glass has been given a special non-slip surface.

The solar cells currently supply the electricity they generate onto the national grid, but future plans include using this energy to power street lights. Sten de Wit, a physicist who helped develop the project, says, “Electric bikes and cars will one day be able to refuel using contactless charging directly from the road or bike path. The idea is that in the Netherlands, we have approximately 140,000 km of road which is much bigger than all the rooftops put together. We have 25,000 km of bike paths in the Netherlands. If we can integrate it in our roads then we’ll have huge extra potential for generating solar electricity.”

“During the trial of 16 days, the path generated 140 kWh of electricity. It is equivalent to around 140 washing machine cycles,” said SolaRoad spokeswoman Jannemieke van Dieren. The cost of the project has been $3.7 million till now.

The SolaRoad will be tested over the next two years on a path that carries around 2,000 cyclists a day. The aim is to have the solar road commercially available on Dutch roads within the next five years as the number of electrically-powered cars and bicycles grows.

Source: www.asianage.com

Located in Quezon City, Manila, Philippines, the SM City North EDSA is now the world’s largest solar-powered mall. The mall’s rooftop solar power project has been commissioned recently. President Benigno Aquino and SM Prime President Hans Sy led the switch-on (commissioning) ceremony at the rooftop of SM North’s multi-level car park, where the 5,760 solar panels are installed.

“This is significant in light of the challenges that will confront our energy sector,” Aquino said. Solar Philippines, led by 21-year-old Leandro Leviste, partnered with SM Malls to build the solar panels that could generate up to 1.5 MW power. This is SM’s second solar power project after it installed a 1.1 MW project at its SM City Xiamen Mall in China. SM Supermalls President Annie Garcia said that the 1.5 MW of electricity generated by the solar panels could power 16,000 light fixtures, 59 escalators, and 20 elevators of SM North at the same time. This represents five percent of the mall’s total electricity requirements.

Source: www.abs-cbnnews.com
Australian scientists claimed to have made a breakthrough in increasing the efficiency of solar panels, which they hope could eventually lead to cheaper sources of renewable energy. In what the University of New South Wales (UNSW) described as a world first, the researchers were able to convert more than 40 per cent of sunlight hitting the panels into electricity. “This is the highest efficiency ever reported for sunlight conversion into electricity,” UNSW Prof. Martin Green said in a statement.

He explained how they have used commercial solar cells, but in a new way, and how these efficiency improvements are readily accessible to the solar industry. While traditional methods use one solar cell, which limits the conversion of sunlight to electricity to about 33 per cent, the newer technology splits the sunlight into four different cells, which boosts the conversion levels.

Prof. Green is hopeful the technology can also be used for solar panels mounted on people’s roofs, which he said currently had a 15–18 per cent efficiency rate.

Source: www.asianage.com

California’s Topaz project is the largest solar power plant in the world with a capacity of 550 MW, and it is now in full operation. It is located in San Luis Obispo County and has nine million solar panels. Its construction began just two years ago. The electricity produced by the plant will be purchased by Pacific Gas and Electric. The solar panels were manufactured by First Solar and the project was developed by First Solar. Solar Energy Industries Association (SEIA) says that about 200 homes in California are powered for each MW of solar power capacity. So, for a 550 MW solar plant, about 110,000 homes could be powered when the sun is shining. First Solar has said that this figure could be 160,000 homes in the case of Topaz.

The San Luis Obispo County’s population is about 276,000. A majority of this population could be powered by a single solar power plant. Energy storage is a growing field, so the excess electricity generated by solar power could be stored for night time use and for overcast days, extending the impact of Topaz even further.

Source: www.cleantechnica.com
INVESTMENT OPPORTUNITIES IN RENEWABLE ENERGY SECTOR IN INDIA

As we enter into a year full of opportunities, energy security and its adequate supply to every home has become a significant commitment of the Government of India. In this regard, the Government is organizing a mega event, named, RE-INVEST, which explores the investment in India’s renewable energy sector. 

Dr Arun K Tripathi discusses the present scenario and future of the renewable energy sector of the country and shares a roadmap of investing in this much talked about sector.

With accelerated growth of urbanization, industrialization and business activities, India is bound to match the energy supply with the growing energy demand without compromising with environmental degradation. Along with the government’s agenda of “sustainable and inclusive growth”, Renewable Energy (RE) in India has emerged an integral part of the solution to meet the nation’s energy needs and an essential player for energy access. RE has to play a much deeper role in achieving energy security in the years ahead.

Renewable Energy Potential
India has an estimated RE potential of about 895 GW from renewable exploitable sources viz., wind: 100 GW (at 80 m mast height);
Investment Opportunities in Renewable Energy Sector in India

OPPORTUNITIES IN RENEWABLE ENERGY SECTOR IN INDIA

small hydro: 20 GW; bio-energy: 25 GW; and solar power: 750 GW (including 60 GW from grid solar photo voltaic [PV] rooftops) assuming 3 per cent wasteland is made available. Significant potential from decentralized applications for meeting hot water requirements, space heating/cooling through solar energy for residential, commercial, and industrial sector and meeting cooking energy needs in the rural areas through biogas.

Present Scenario
There has been a visible impact of RE in the Indian energy scenario during the last decade. Apart from contributing about 13 per cent in the national grid electricity generation installed capacity, RE-based decentralized and distributed applications have benefited millions of people in Indian villages by meeting their cooking, lighting, and other energy needs in an environment-friendly manner. The social and economic benefits include reduction in drudgery among rural women and girls engaged in the collection of fuelwood from long distances and cooking in smoky kitchens, minimization of the risks of contracting lung and eye ailments, employment generation at village level, and ultimately the improvement in the standard of living and creation of opportunity for economic activities at village level.

RE has been witnessing over 20 per cent growth from the last five years. From the total renewable power installed capacity of 14,400 MW at the beginning of 2009, it has reached a capacity of 33,792 MW as on December 31, 2014. Wind energy continues to dominate India’s RE industry, accounting for over 67 per cent of installed capacity (22,465 MW), followed by biomass power (4,165 MW), small hydro power (3,990 MW), solar power (3,063 MW) and urban & industrial waste 108 MW (Pictures 1–3).

Immediate Goals
India plans an ambitious RE programme, having the target of 15 per cent RE generation by 2020. This trend is only expected to gain momentum. The Government of India is aiming to add about 100 GW solar power and 60 GW wind power capacity in the next five years. The
100 GW solar power also includes 40 GW from grid-connected rooftop. In addition, during the Twelfth Plan, the Ministry of New and Renewable Energy (MNRE) is targeting 2,100 MW from small hydro power, 500 MW from biomass power, and 1400 MW from bagasse cogeneration. India aims at about 9 per cent in the electricity generation mix by the end of the Twelfth Plan.

**Estimated Financial Potential**

The 100 GW solar power in the next five years gives an investment opportunity of about $100 billion, 60 GW wind power gives an investment opportunity of about $60 billion, besides, the $40 billion investment opportunity exists from other sources which include decentralized applications.

There is also ample opportunity towards manufacturing sector. The 100 GW solar and 60 GW wind has a great potential for the manufacturing of solar PV cells, solar thermal dishes, solar inverters, ground mounting units, trackers, wind machines, supporting structures, and many related parts. The Information Technology (IT)-based solutions for monitoring are also required which will attract investment from the IT sector.

**Fiscal and Financial Incentives**

The Government of India provides a mix of fiscal and financial incentives through capital subsidy, interest subvention, concessional excise and custom duties, accelerated depreciation, etc. These fiscal and financial incentives make the RE a viable option in the country. Few States also provide subsidies on the RE systems and projects.

**Resource Availability**

**Solar radiation**

The country is endowed with excellent solar radiation over a majority of its land area. The map in Figure 1 shows the solar resource, i.e., Direct Normal Irradiance (DNI) distribution nationwide as well as in all states and Union Territories of India. It is evident from the map that the states located on the Western, Central, and South-Western parts of the country hold enormous potential for solar power, where many areas show 5–6 kWh/m²/day of DNI. A clear sunny weather is experienced for 250 to 300 days in a year in most parts of the country, and the annual global radiation varies from 1,600 to 2,200 kWh/m².

**Wind**

The wind resource assessment, being carried out in 28 States and three Union Territories (UT) which involve the 789 wind monitoring stations, has found to have wind power density 200 W/m² at 50 m height. As per Indian Wind Atlas, the wind power potential of 50 GW has been estimated at 50 m height and 100 GW at 80 m height. State-wise wind power estimated potential is given in Table.
Table: Wind power potential in India

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Investment options

Although, the subsidy accounts for about 20–30 per cent, the India’s RE sector is primarily driven by private sector investment. In the grid renewable power from solar and wind, there is no direct subsidy and the entire installations are from the private sectors. Following are the opportunities available for investors:

**Foreign investors**

- To enter into joint venture with Indian partners for financial and technical collaborations and also for setting up of renewable power projects;
- Liberalized foreign investment approval regime to facilitate foreign investment and transfer of technology through joint venture;
- 100 per cent foreign investment as equity qualify for automatic approval;
- Customs duty concessions provisions for RE parts/equipment including machinery, instruments, equipment, and appliances required for initial set up of PV and solar thermal power generating units which are also exempt from central excise duty;
- Liberalization of pricing and payment of technology transfer fees and trademark, brand name, and royalty payments;
- Various chambers of commerce and industry associations in India can be approached for providing...
guidance to the investors in finding appropriate partners;
- Foreign investors to set up RE-based power generation projects on build-operate basis (Picture 4);
- Exemption of industrial clearance for setting up of RE industry.

**Indian Investors**

- Banks, financial institutions including the Indian Renewable Energy Development Agency (IREDA) to finance for renewable power projects and equipment manufacturing;
- Facilities for promotion of export-oriented units for RE industry;
- To avail benefits of accelerated depreciation, concessional excise, and custom duties;
- To develop joint ventures with foreign investors;
- Ample opportunity in manufacturing for solar PV cells, module, solar water heaters, solar thermal dishes for steam generation, solar cooking systems, biomass gasifiers, agro residue based briquetting machines, biogas generation related equipment, etc.;
- Sales, marketing, and service sectors;
- Capacity building and awareness;
- Consultancy services.

**Essential Steps for Attracting Investment in RE Sector**

- Single window facilities to clear all statutory requirements for setting up manufacturing unit or the power projects;
- Fast track approvals of Power Purchase Agreements (PPA);
- Site-wise identification of lands by the States with clear transfer/lease mechanism;
- Evacuation facilities on priority at the project sites;
- Timely payment of the power supplied to the grid to the power producers;
- Encouraging Foreign Direct Investments (FDI);
- Providing loans to the investors by Indian banks;
- Long-term and stable policies.

**Conclusions**

India needs renewable power not only to meet climate change related targets, but also to meet the power requirements of its growing economy. The potential is huge and the immediate targets have been set for 100 GW solar power and 60 GW wind power capacity in the next five years. The fast changing trend of the technology is also a challenge and gives a positive impetus as the technology is becoming cheaper day by day. The conducive atmosphere from States is essential to gain the confidence of the investors. The stage has been set which provides ample opportunities to the investors.

Dr Arun K Tripathi, Sr Director, Ministry of New and Renewable Energy. E-mail: aktripathi@nic.in
The new government has zeroed in on the ‘Make in India’ campaign. After all, zero owes its origin to India by virtue of India’s rock solid mathematical and scientific base. The very recent mission to Mars proves this fact in no uncertain terms. It is not a veiled secret though that Indians have been traditionally obsessed with anything and everything of a foreign origin; this was truer until the winds of liberalization swept the country some years back. Till then goods of selective few countries made their way to the Indian shores. However, in the post-liberalization era, Chinese goods for a simple instance have made their presence felt across the country ranging from all and sundry items. The scenario is not a talking point just for the goods. I as a young boy living in the politically sensitive region of Kashmir used to observe every other person talk about the daily news feeds from the British Broadcasting Corporation (BBC) radio network several decades back. It left me wondering for sure as to how a radio service located in the distant lands could deliver the news in hot haste and with wide local acceptability too.

Today, our own news channels churn the content every other minute with a reasonable degree of accuracy. Taking these two scenarios together simply means being able to compete favourably in a fast changing world order. Mobile telephony has ushered in an unexpected revolution lending voice, practically, to every other soul in India. This was largely made possible by the astronomical volumes in tandem with the creation of local manufacturing-cum-assembly hubs. The moot question is if, it would be the very first time when the foreign companies will start

Dr Suneel Deambi discusses the current scenario of the Renewable Energy (RE) sector in India. The article highlights how the Government of India is planning to make a major global investment in the RE sector through a national event named RE-Invest for making the country energy secure.
producing their selected goods in India? I vividly remember a college senior receiving adulation for his very first job in the Maruti Suzuki factory in Gurgaon at the time of its entry in India. The wheels of time have moved quite fast since then bringing more and more ventures within the boundaries of India. The key driver of change whether for goods manufactured in India or abroad is the energy in all its known manifestations. Renewable Energy (RE) technologies, more so solar and wind energy, have come to be known as the large engines of energy growth in the recent times. So, what is it that the ‘Make in India’ means for this nature’s bounty in closer terms is a subject under discussion in the following few sections. This article swells on a fair sprinkling of views, suggestions, and road plans from many such voices as matter in the existing scheme of things under a generous acknowledgement of thankfulness.

Looking at Today’s India
Our Honourable Prime Minister Shri Narendra Modi wants India to be amongst the top 50 in the World Bank’s ‘ease of doing business’ index. It currently ranks at 134. India will soon become the most populated country in the world with a total populace of 1.6 billion. Unlike China and other Southeast Asian countries that have rapidly aging population, India has a huge demographic dividend. India is an old civilization; however, it is equipped with a very young population. Thus, the ‘Make in India’ campaign has to live up to the expectations of such youthful numbers in undeniable terms. Experts believe that around 100 million jobs need to be created over the next decade or so. Therefore, today’s India has to look beyond the conventional glass shield to a clear enough view of actual realization. Is manufacturing in India a magical wand and if so, will it be able transform our day-to-day lives is a billion dollar question?

The ‘Make in India’ vow
A major national programme designed to facilitate investment, foster innovation, enhance skill development, protect intellectual property, and build best-in-class manufacturing infrastructure, there has never been a better time to ‘Make in India’.

Dire Need for Investments in the Indian Power Sector
As per the available estimates, India needs investments of more than $250 billion for development of power sector during the 12th Five-Year Plan period, i.e., 2012–17. This opens up a significant window of opportunity for investors, developers, and power equipment manufacturers in developing power projects and accompanying transmission infrastructure. During this period, India plans to add around 88,537 MW of capacity, out of which 69,280 MW will come from coal. The government has planned an additional RE-based capacity addition of around 30,000 MW, i.e., 10,000 MW of Solar, 5,000 MW of wind, and 2,100 MW of small hydro power. Presently, the cumulative installed power capacity from all sources of energy is around 250,000 MW. On a sad note, India is likely to face a coal shortage of about 200 million tonnes by the end of 12th Plan period. Owing to a higher share of coal-based power generation, there is a high enough environmental impact from increasing levels of greenhouse gas emissions. For this reason too, India is placing a heightened impetus on clean energy development such as solar, wind, etc.

The underlying initiatives
- The Asian Development Bank (ADB) plans to invest $100 million to help Electricite de France (EDF) SA–backed Acme Solar Energy Pvt. Ltd to build 200 MW of solar projects in India. Acme Solar is a venture between EDF’s renewable unit, India’s Acme group, and Eren SA which expects this capacity to come through by 2016.
- As per Bloomberg, an increase in solar energy projects from states and centre is a part of the government’s initiative to enhance the solar energy capacity 40-fold in the next 10 years for which an estimated investment of nearly ₹ 6 trillion is needed.
- New project announcements rose to ₹ 2.14 trillion in the September quarter up from ₹ 90,840 crore of the three months quarter which ended in June, according to the Centre for Monitoring Indian Economy (CMIE).
- Nearly 50 per cent or ₹ 1.05 trillion of these fresh investment intentions are from the electricity generation
sector. That is more than a five-fold jump from ₹ 19,300 crore worth of projects announced in the April–June quarter. Majority of these proposals though are from central or state government bodies which have announced ₹ 81,000 crore worth of projects.

- Of this, ₹ 68,200 crore or nearly three-quarters of total are RE projects. Solar energy projects alone accounted for ₹ 62,800 crore—with a single ultra-mega power unit announced by the Tamil Nadu Government worth ₹ 26,000 crore.
- General Electronics (GE) invested $24 million in India’s largest solar power project in April 2014, a 151 MW plant by Welspun Group is under development. It has also invested in three wind farms in July 2014, based on the premise that new class of turbines can generate more electricity at lower wind speeds.

In totality, clean energy power plants will be a more attractive investment in India than coal or natural gas projects. Wind and solar energy will continue to offer significant value over other fuels for several decades. Importantly, conventional power projects are facing fuel-supply constraints and rising costs.

Enlightened Views of Indian Industry Captains on ‘Make in India’

The industry has pledged its full support to the Prime Minister’s ambitious plan to grow the manufacturing sector’s share in the Gross Domestic Product (GDP) from the current 15 per cent to 25 per cent. However, they have pointed at the challenges on the way to achieve it such as — labour issues, skills, gaps in infrastructure, deficient tax structure, slow decision making. According to them, India’s longterm GDP growth potential is around 8–10 per cent and the country was set to be the fastest growing economy in the world. In the words of Reliance Group’s Chairman Mr Mukesh Ambani, “Make in India coinage is typical of PM’s vision, as it is about present and future as against, ‘Made in India’ which is steeped in the past.” Likewise, Mr Cyrus Mistry from Tata Group fully welcomed the ‘Make in India’ initiative and said that generating around 12 million jobs from the manufacturing, was a challenge and that employability had to be improved through skilling. The need is for sound infrastructure, balanced tax structure, and efficient logistics. Take for example the case of Tata enterprise which has 95 manufacturing facilities ranging from steel to aerospace. On the other hand, Mr Ayukawa from Maruti Suzuki too supported the ‘Make in India’ initiative. However, he said that cost of production in India goes up mainly due to various government policies, procedures, regulations, and the ways some of the laws are implemented. As per Birla Group’s Chairman Mr Aditya Birla, “With the ‘Make in India’ initiative, India should emerge as a preferred centre of choice for manufacturing. There is a definite need to have one million jobs a month from the manufacturing sector alone, failing which, our demographic advantage will fall flat.” The ICICI Group’s Chairperson Ms Chanda Kochhar highlighted the need to focus on four key areas so as to realize the ‘Make in India’ project’s objectives. These include — ease of doing business, access to infrastructure, balanced policies, and the right training to young people.

The Renewable Energy (RE) industry manufacturing showcases a good example of putting the ‘Make in India’ initiative to work. Take for example the glaring case of solar photovoltaics, within which, the need is to produce, on a cost-competitive basis, both low, and high, end balance of system components. The idea is to be able to reap the maximum possible dividends available from the steep decrease in the cost of solar modules more so during the last couple of years. Likewise, the need is to produce wind turbines that can produce an optimum level of power output even under the low wind regimes. Bringing in energy storage technologies to the manufacturing forefront in India is also important as it can give a good enough cost advantage to the traditional lead-acid battery storage. There is a definite need to clean the air in our big cities and towns and the electric vehicle-based solutions may bring in a good hope at the manufacturing level by being competitively priced. Fuel cells have since long been seen as a promising technology but its adoption rate in the country is abysmally low due to the almost non-existent manufacturing base. In all, RE technologies like the one’s mentioned are very promising for the manufacturing level and the ‘Make in India’ campaign can for sure infuse the desired momentum in these technology choices for wholesome development of the country.
‘Make in India’ for Renewable Energy from MSME Window

India has a very large number of micro, small, and medium level enterprises which are collectively known as the MSMEs. The RE industry, as part of its supply chain management, is dependent on these MSMEs, especially at the sub-component level. The MSMEs need to adopt energy-efficient practices and high enough reliability at the performing level. Expectedly, the ‘Make in India’ initiative will lead to growth in energy consumption. Thus, there is a need for the MSME ministry to promote the use of renewable energy via creation of, ‘Green Cell’, etc. The ministry should consider allocating a specified portion of its annual financial resources starting with at least five per cent of the total ministry budget for promoting renewable energy in its different schemes and programmes. The study on operations of MSMEs in foreign shores from several key considerations including the quality assurance plans, etc., should be focused upon. Seemingly, the new national initiative of ‘Make in India’ would lead to a significant growth in the MSME sector and the energy consumption. The MSMEs can, thus, significantly contribute in upscaling the RE manufacturing in the country.

Case Study
Solar in the backdrop of ‘Make in India’ initiative

National
Experts believe that solar electricity will become central to India’s rapidly growing cities as rooftops are harnessed to help combat blackouts. The Ministry of New and Renewable Energy (MNRE) is keen to accelerate solar energy deployment in the country by fitting everything from the farm irrigation pumps and village huts to mall rooftops with solar panels. Till now, nearly all of India’s 2,800 MW of solar power capacity is in large, desert facilities financed by investors such as Blackrock Inc. backed Sun Edison Inc. and Hellion Venture Partners LLC-supported Azure Power India Ltd. The idea is to encourage industries to use rooftop solar—a model which has helped countries like Germany and Japan, amongst the world’s largest solar markets. Take for instance information technology parks which can use solar power with convincing ease. Coal India Ltd (CIL), the biggest producer of fuel, is planning to invest ₹7,000 crore in solar projects. The underlying goal is to compensate for carbon pollution. India has ambitious enough plans to enhance the solar power capacity from 2,800 MW now to 10,000 MW by March 31, 2017, with a budgetary requirement of around ₹50,000 crore. The National Thermal Power Corporation (NTPC) has signed an accord with the southern state of Andhra Pradesh for setting up of 1,000 MW worth of solar projects.

International
As per the International Energy Agency (IEA), solar could be the world’s largest source of electricity by 2050. Solar is one such source that can actually make an appropriate impact in a very short time frame. Technology is already there but the need is to have large chunks of land and evacuation infrastructure. Importantly enough, solar projects can be completed in a short-span unlike nuclear projects which take about 10 years or thermal projects which take a few years or even wind for that matter which takes about two or more years. For instance, one can envision 500 MW projects that can be done in less than a year’s time. Thus, planning large capacities in solar is very much feasible. Solar costs have also come down and RE sources have to play a pivotal role in energy generation and in that renewable space, solar energy is likely to come out as a distinct winner. The primary idea should be to lay emphasis on such industries as they can win, export, and be competitive globally. Today, 90 per cent of the solar supply chain is based on crystalline silicon which is being taken up by thousands of companies worldwide. It seems quite hard for the thin film companies to compete with crystalline silicon today as there are just a handful of companies in that segment. Thus, the ‘Make in India’ manufacturing initiative should be chosen with a lot of care going beyond the customary manufacturing of solar cells and modules alone. Take for instance polysilicon; it is regarded as the crude oil refining equivalent by the industry and needs to be taken up on a priority basis. As per the industry estimates, around 250,000 metric tonnes of polysilicon material is being produced globally. The need is to rope in polysilicon manufacturers considering the investment of billions of dollars that goes with it. Material development from quartzite to final wafer preparation has traditionally been an energy intensive affair.

Seeking of International Cooperation
The government is actively considering the possibility of seeking international cooperation for importing technology
Make in India: A Natural Energy Choice

to boost global investments in the RE sector. To bring to the fore India’s RE potential globally, the MNRE is going to organize a three-day event scheduled between February 15–17, 2015 aptly named as the Renewable Energy Investment promotion meet (RE-Invest) in New Delhi. This is regarded as a follow-up measure to ‘Make in India’ initiative launched by the worthy Prime Minister recently. This prestigious event is expected to provide a window of opportunity to all the states to showcase their policies to facilitate investment via an investment-friendly approach in the RE sector. According to the Global Status Report 2014 of Renewable Energy Policy Network (REN-21), around $6.1 billion has already been invested in renewable energy in India. This is as against the $56.3 billion invested in China’s RE sector during the year 2013–14 mainly for solar and wind power projects.

Global Investment Trends in RE Sector

A consultancy major Deloitte has recently released a report titled, ‘Alternative Thinking 2013 Renewable Energy under the Microscope’. It states that global investment trends in the RE sector have been showing signs of decline owing to the global economic slowdown. According to the report, lack of implementation of Renewable Purchase Obligations (RPOs) by the distribution utilities and other obligated entities is one of the major causes for slowdown in India coupled with selective few financial and fiscal issues. There are two key routes to make investments in RE area more attractive — to increase mass production with quality so that cost of RE equipment comes down and enhance the efficiency at various levels.

It would be in the fitness of things to name here another report titled, ‘Global Trends in Renewable Energy Investment 2013’ prepared by Frankfurt School and Bloomberg New Energy Finance (BNEF). According to this report, a new investment of $6.85 billion in India in 2012 was about 45 per cent less in comparison to the previous year (Figure). Globally too, 2012 turned out to be a bad year for renewable energy as the total investment of $244 billion was about 12 per cent lower than the record figure of $279 billion in 2011. This key report pitches India close to Italy and Spain which have witnessed the sharpest fall of 51 per cent and 68 per cent, respectively, in RE investment. As per the recently released figures of BNEF, the investments in India in the first quarter of 2013 were around $1,407 million and in the second quarter as $1,375 million. It was lower by 29 per cent and 27 per cent from the first and second quarter of 2012.

Embarking on the ‘Make in India Renewable Path’

Several prominent global companies are presently exploring the business opportunities on a large scale in India’s RE sector. One of such initiatives is from Goldman Sachs whose private equity arm has re-upped its investment in Indian Renewable Energy Company ReNewPower Ventures by committing around $70 million. The fast growing RE sector in India presents lucrative business opportunities for the international companies to enter the Indian market. Few prominent companies which are already looking at the Indian market include companies such as Dupont, 3Tier, Siemens, IBC Solar, Conergy group, GE, Fidelis Energy, Applied Materials, Esolar, Abengoa, etc. The ‘Make in India’ path may open up new vistas in the Indian manufacturing segment so as to transcend the international boundaries in terms of being cheap and reliable in an ultimate analysis.

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The Ministry of New and Renewable Energy (MNRE), Government of India, is organizing the first Renewable Energy Global Investors Meet & Expo (RE-INVEST) on February 15–17, 2015 in New Delhi, as a follow-up to the “Make in India” initiative launched by the Prime Minister of India. The central theme of RE-Invest is to attract large-scale investments for the renewable energy sector in India. The event is being organized by the MNRE in collaboration with Indian Renewable Energy Development Agency (IREDA), Confederation of Indian Industry (CII), and Federation of Indian Chambers of Commerce and Industry (FICCI). The event is scheduled to be inaugurated by Hon’ble Prime Minister of India Shri Narendra Modi.

The Objective
RE-INVEST will be the first major platform for investment promotion in this sector at the Government of India level to signal India's commitment to the development and scaling up of renewable energy to meet its energy requirement in a sustainable manner.

Participation
About 1,000 participants associated with renewable energy sector across the world are expected to participate in the event. The event is expected be attended by over 200 investors and over 1,000 delegates, both domestic and international.

In addition representatives from states governments, public sector enterprises, renewable power developers and manufacturers, state renewable energy, nodal agencies, and other related stakeholders will play important roles.

The Indian Renewable Energy Market
Renewable energy contributes about 6.5 per cent in the electricity mix of the country. It is proposed that this would be taken to about 12 per cent in the next three years. Major initiatives by the Government, including accelerated depreciation, generation-based incentive, feed-in-tariff, and viability gap funding, are expected to add massive investments in renewable energy sector. Foreign Direct Investment (FDI) up to 100 per cent under the automatic route is permitted in renewable energy sector.

The Conference and Exhibition
RE-INVEST will be the culmination of a conference and exhibition of manufacturers, project developers, investors, and other players in the renewable energy space to showcase manufacturing capabilities, latest technologies, financing options, and investment opportunities International companies from this sector will also have the opportunity to exhibit and showcase their services at the expo to a wide-ranging Indian audience.

The event is open to one and all to utilize this unique opportunity and meet and interact with the global investment community, renewable energy businesses across the world, and Central and State Government officials from India.

Pre-Preparations
Road shows
Five road shows have been organized as preparatory events for RE-INVEST 2015. These road shows were organized in Amsterdam, Netherlands (November 5, 2014), Paris, France,
RE-INVEST 2015

(November 4, 2014), Hamburg, Germany (November 3, 2014), London, UK (October 16, 2014), and Hyderabad, India (October 13, 2014). These road shows created massive awareness about the development of renewable energy sector in India and about this mega event.

**Renewable Energy Global Investment Promotion Expo**

RE-INVEST will have a large exhibition of manufacturers, project developers, investors, and other players in the renewable energy space to showcase India’s manufacturing capabilities and latest technologies to provide an idea to foreign investors about the potential areas of investment in the renewable energy sector. International companies in the renewable energy space from different countries will also have the opportunity to exhibit and showcase at the Expo to a wide Indian audience.

**Interactive Meet with Chief Executives of CPSEs and Private Sector Companies**

There is need for collective effort from all the stakeholders of the renewable energy industry to achieve the targets set for the sector in India. This was said by Shri Piyush Goyal, Minister for Power, Coal and New and Renewable Energy, at “Interactive Meet with Chief Executives of CPSEs & Private Sector Companies” in New Delhi (Picture). The Meet was organized to deliberate on various issues pertaining to the renewable energy sector ahead of the first RE-Invest. Addressing the representatives of the central public sector enterprises, private sector companies, and officials of the MNRE, IREDA, CII, FICCI, and financial institutions, Shri Goyal said, “We should not work in silos. We need to be innovative to attain competence and achieve desired goals. I invite ideas on which we can work on practical grounds.**

www.re-invest.in
India is endowed with huge solar energy potential of about 300 days of sunshine per year with annual mean daily global solar radiation in the range of 4–6 kWh/m²/day. Solar power projects can be set up anywhere in the country. A solar park is a concentrated zone of development of solar power generation projects and provides developers an area that is well characterized, with proper infrastructure and access to amenities, and where the risk of the projects can be minimized. Solar park also facilitates developers by reducing the number of required approvals. It has quickly emerged as a powerful mechanism for the rapid development of solar power projects in the country.

The scheme for development of ‘Solar Parks and Ultra Mega Solar Power Projects’ has been rolled out by Ministry of New & Renewable Energy in December 2014. The Scheme has been conceived on the lines of the “Charanka Solar Park” in Gujarat which is a first-of-its-kind large-scale Solar Park in India with contiguous developed land and transmission connectivity. The Ministry of New and Renewable Energy (MNRE), through this scheme, aims to target the development of solar parks across India. This scheme envisages supporting the States in setting up solar parks at various locations in the country with a view to create required infrastructure for setting up of Solar Power Projects. The solar parks will provide suitable developed land with all clearances, transmission system, water access, road connectivity, communication network, etc. This scheme will facilitate and speed up installation of grid connected solar power projects for electricity generation on a large scale. All the States and Union Territories are eligible for benefitting under the scheme.

Objective

The scheme aims to provide a huge impetus to solar energy generation by acting as a flagship demonstration facility to encourage project developers and investors, prompting additional projects of similar nature, triggering economies of scale for cost reductions, technical improvements, and achieving large-scale reductions in Green House Gas (GHG) emissions. It would enable states to bring in significant investment from project developers, meet its solar Renewable Purchase Obligation (RPO) mandate, and provide employment opportunities to the local population. The states would also be able to reduce their carbon footprint by avoiding emissions equivalent to the solar park’s installed capacity and generation. Further, they would also avoid procuring expensive fossil fuels to power conventional power plants.
As India is naturally blessed with solar energy, the scheme initiated by the Ministry of New and Renewable Energy (MNRE) is aimed at the development of solar parks across the country. **A N Srivastava** shares details of the MNRE scheme with perspective investors.

**Target and Duration**

The MNRE through this scheme plans to set up 25 solar parks, each with a capacity of 500 MW and above, thereby, targeting around 20,000 MW of solar power installed capacity. These solar parks will be set up within a span of five years commencing from 2014–15 and the solar projects may then come up as per demand and interest shown by developers.

**Capacity**

The park to be taken up for development should be of 500 MW capacity and above. Smaller parks in Himalayan and other hilly states, where contiguous land may be difficult to acquire, in view of the difficult terrain, will also be considered. Smaller parks may also be considered in states where there is acute shortage of non-agricultural lands.

**Implementing agency**

The solar parks will be developed in collaboration with the state governments and their agencies. The MNRE nodal agency would be Solar Energy Corporation of India (SECI), on behalf of Government of India. The SECI will handle funds to be made available under the scheme, on behalf of the government. It will also administer the scheme under direction from the MNRE. The states applying under the scheme will have to designate an agency for the development of solar parks. Solar parks are envisaged to be developed in the following four modes:

- **Mode 1**: The designated state nodal agency undertakes the development and management of the solar park. This agency could be a state government Public Sector Undertaking (PSU) or a Special Purpose Vehicle (SPV) of the state government.

- **Mode 2**: A joint venture company is set up between the state designated nodal agency and the SECI for the development and management of solar park with 50 per cent equity from both the parties (the state government may also allow more than one agency, provided the total equity from the state government remains 50 per cent).

- **Mode 3**: The state designates the SECI as the nodal agency and the latter undertakes the development and management of the solar park, on behalf of the state government on mutually agreed terms.

**THE SOLAR PARKS WILL BE DEVELOPED IN COLLABORATION WITH THE STATE GOVERNMENTS AND THEIR AGENCIES. THE MNRE NODAL AGENCY WOULD BE SOLAR ENERGY CORPORATION OF INDIA (SECI), ON BEHALF OF GOVERNMENT OF INDIA. THE SECI WILL HANDLE FUNDS TO BE MADE AVAILABLE UNDER THE SCHEME, ON BEHALF OF THE GOVERNMENT. IT WILL ALSO ADMINISTER THE SCHEME UNDER DIRECTION FROM THE MNRE.**
A JOINT VENTURE COMPANY IS SET UP BETWEEN THE STATE DESIGNATED NODAL AGENCY AND THE SECI FOR THE DEVELOPMENT AND MANAGEMENT OF SOLAR PARK WITH 50 PER CENT EQUITY FROM BOTH THE PARTIES (THE STATE GOVERNMENT MAY ALSO ALLOW MORE THAN ONE AGENCY, PROVIDED THE TOTAL EQUITY FROM THE STATE GOVERNMENT REMAINS 50 PER CENT).

Mode 4: Private entrepreneurs promote solar parks without any equity participation from the SECI but may have equity participation from the state government or its agencies.

The implementing agency or Special Purpose Vehicle (SPV), as identified under the above provisions, shall undertake the following activities to achieve the objective of speedy establishment and implementation of solar power parks in the states:

- Plan, finance, develop, execute, operate, and maintain the solar power park
- Identify potential site and acquire/leasehold/possess land for solar power park
- Carry out site related studies/investigations
- Obtain statutory and non-statutory clearances and make area development plan within solar power park
- Design a plan for sharing development cost between the developers
- Create necessary infrastructure, such as water, transmission lines, roads, drainage, etc., to facilitate the solar power project developer for faster implementation of solar power projects
- Frame out transparent plot allotment policy and specify procedures pursuant to the relevant state policies and their amendments thereof
- Provide directives for technology-specific land requirements
- Engage the services of national agencies/global experts/consultants to promote solar power park and related activities
- Facilitate the state government to establish educational institutions/training facilities within solar power park (Picture 1) for development of manpower skills related to solar power
- Include any other activity related to solar power park such as manufacturing as per the directives from the MNRE and the state government
- Conduct necessary evaluation of environmental and social impacts of utility-scale solar deployment as per law and before allocating the land to prospective developers.

Facilities

The solar park will provide specialized services to incentivize private developers to invest in solar energy in the park. These services while not being unique to the park, are provided in a central, one-stop-shop, single-window format, making it easier for investors to implement their projects within the park in a significantly shorter period of time, as compared to projects outside the park which would have to obtain these services individually. In the Charanka Solar Park, Gujarat, the implementing agency is tasked with acquiring the land for the park, cleaning and levelling it, and also allocating the plots for individual projects. Apart from this, the agency will also be entrusted with providing the following facilities to the solar project developers for the development of the solar park:

- Land approved for installation of solar power plants and necessary permissions including change of land use
- Road connectivity to each plot of land
- Water availability for construction as well as running of power plants and demineralization plant
- Flood mitigation measures, such as flood discharge, internal drainage, etc.
- Construction power
- Telecommunication facilities
- Transmission facility consisting of pooling station (with 400/220, 220/66 kV switchyard and respective transformers) to allow connection of individual projects with pooling station through a network of underground cables or overhead lines
- Housing facility for basic manpower wherever possible
- Parking, warehouse, etc.

**Financial Model**

Significant investments will be made in the operation and maintenance of the solar park, employing staff, and other activities, such as marketing. The entire cost of development including cost involved in acquisition of land will form the total cost for the project for which an estimate will be prepared beforehand by the nodal agency. Based on this estimate, the implementing agency will formulate a recovery model to ensure the sustainability of the park. The implementing agency may raise the funds as given below:

- The implementing agency may offer wide publicity and have a process of registration for prospective developers to register so that the demand for the solar park can be assessed.
- The implementation agency may sell/lease out the plots to the prospective project developers. The lease period shall be of 30 years or so, as per the state land policy. The allotment price per metre square (inclusive of all applicable taxes, duties, cess, etc.) payable by the plot applicant for the applications must be specified in a transparent manner. The allotment price may be reviewed annually and an annual increment may also be specified. The maximum stretch of plot to be allotted will be decided as per the benchmarks finalized by the implementing agency.

A one-time registration fee (per project or per MW) may be collected by inviting applications from the prospective buyers when the scheme is finalized, and land is identified and marked. An advance may be collected from the prospective buyers when 50 per cent of the land is acquired. This advance will be 10 per cent of the sale price or lease amount. Another installment of 25 per cent of the price of land or lease amount may be taken when the full land is acquired. Further installments of 10 per cent each may be collected while plot is being developed. Final 15 per cent of the price of land or lease amount may be collected at the time of allotment of the plot to the buyer. The implementing agency may put in some of its own equity and can raise loans, depending on the availability of funds and requirement. The subsidy of the MNRE under the scheme would bring down the cost of the project to that extent. The SPV will also create a small corpus for working capital to ensure upkeep and maintenance in the future, which may be supplemented with some annual charges. The implementing agency may change the above plan if it is in the interest of the solar park.

**Central financial support**

The state government will first nominate the implementing agency for the solar park and identify the land for the proposed solar park. It will then send a proposal to the MNRE for approval along with (or later) the name of the implementing agency. The implementing agency may be sanctioned a grant of up to ₹ 25 lakh for preparing a Detailed Project Report (DPR) of the solar park, conducting surveys, etc. The DPR must be prepared in 60 days. Thereafter, application may be made by the implementing agency to the SECI for the grant of up to ₹ 20 lakh/MW or 30 per cent of the project cost including grid-connectivity cost, whichever is lower. The approved grant will be released by the SECI as per the milestones given in Table 1 (see next page).
TABLE 1: Milestones set for solar parks in India

<table>
<thead>
<tr>
<th>Sl. No.</th>
<th>Milestone</th>
<th>Percentage of subsidy disbursed</th>
</tr>
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<tbody>
<tr>
<td>1</td>
<td>Date of issue of administrative approval</td>
<td>5</td>
</tr>
<tr>
<td>2</td>
<td>Land acquisition (not less than 50% land acquired)</td>
<td>20</td>
</tr>
<tr>
<td>3</td>
<td>Financial closure</td>
<td>20</td>
</tr>
<tr>
<td>4</td>
<td>Construction of pooling substation, land development and other common facilities as per DPR</td>
<td>25</td>
</tr>
<tr>
<td>5</td>
<td>Construction of transmission line and grid connectivity</td>
<td>20</td>
</tr>
<tr>
<td>6</td>
<td>Final installment on completion</td>
<td>10</td>
</tr>
<tr>
<td></td>
<td><strong>Total</strong></td>
<td><strong>100</strong></td>
</tr>
</tbody>
</table>

The grant will be managed and released by the SECI, on behalf of the MNRE for which the former will be given a fund handling fee of 1 per cent. If the park is developed in phases, grant will also be phased out in proportion to the expenditure in each phase. Based on the above details, the estimated cost has been worked given in the Table 2.

TABLE 2: Estimated cost of the solar parks scheme

<table>
<thead>
<tr>
<th>Sl. No.</th>
<th>State</th>
<th>Capacity (MW) &amp; No. of Solar Parks</th>
<th>Name of the implementing Agency</th>
<th>Area of land identified at</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Andhra Pradesh</td>
<td>Two parks of 1500 MW &amp; 1000 MW</td>
<td>AP Solar Power Corporation Pvt. Ltd. -JV Company floated by SECI, APGENCO and NREDCAP</td>
<td>5628 hectares at Anantpuramu, Kadapa &amp; Kurnool Districts</td>
</tr>
<tr>
<td>2</td>
<td>Telangana</td>
<td>One park of 1000 MW</td>
<td>SECI, Telangana GENCO and Telangana New &amp; Renewable Energy Development Corporation Ltd. (TNREDC)</td>
<td>5408 acres at Gattu, Mehboob Nagar dist.</td>
</tr>
<tr>
<td>3</td>
<td>Madhya Pradesh</td>
<td>Two parks of 750 MW each($500 million for Rewa project- separate proposal to WB)</td>
<td>JV of SECI and MP Govt. PSU.</td>
<td>(i) 1400 hectares at Rewa (ii) 800 &amp; 600 hectares at Neemuch &amp; Agar respectively</td>
</tr>
<tr>
<td>4</td>
<td>Karnataka</td>
<td>Two parks of 800 MW each</td>
<td>JV of SECI and KREDAL to be formed.</td>
<td>(i) 4000 acres at Belagavi dist. (ii)2000 acres each at Bellary and Tumkur dist.</td>
</tr>
<tr>
<td>5</td>
<td>Uttar Pradesh</td>
<td>One park of 600 MW</td>
<td>JV between UPNEDA and SECI formed</td>
<td>1038 hectares at Jalaun, Sonbhadra, Allahabad &amp; Mirzapur districts</td>
</tr>
<tr>
<td>6</td>
<td>Rajasthan</td>
<td>Three parks of 700 MW, 1000 MW &amp; 1000 MW</td>
<td>(i) Rajasthan Solar Park Development Company Ltd. (RSDCL), a subsidiary of RRECL (ii) Formation of JVC between State Govt. and IL &amp; FS Energy Development Company Ltd (is under process)</td>
<td>(i) 1400 hectares at Bhadla Phase II (ii) 2000 hectares at Bhadla Phase II &amp; 2000 hectares at Jaisalmer Phase I</td>
</tr>
<tr>
<td>7</td>
<td>Tamil Nadu</td>
<td>One park of 500 MW</td>
<td>To be finalized</td>
<td>1405 acres at Ramanathapuram dist.</td>
</tr>
<tr>
<td>8</td>
<td>Punjab</td>
<td>Two parks of 500 MW each</td>
<td>PEDA</td>
<td>6167 acres at Patiala, 1786 acres at Fatehgarh Sahib, 2311 acres at Ludhiana and 2790 acres at Gurdaspur</td>
</tr>
</tbody>
</table>
Transmission and Evacuation of Power from Solar Park

Interconnection of each plot with pooling stations through 66 kV or other suitable voltage underground or overhead cable will be the responsibility of the solar project developer. The designated nodal agency will set up the pooling stations (with 400/220, 220/66 kV or as may be suitable switchyard and respective transformers) inside the solar park and will also draw transmission to transmit power to 220 kV/400 kV sub-station. The responsibility of setting up a sub-station near the solar park to take power from one or more pooling stations will lie with the Central Transmission Utility (CTU) or the State Transmission Utility (STU), after following necessary technical and commercial procedures as stipulated in the various regulations notified by the Central or State Commission. If the state government is willing to buy over 50 per cent of the power generated in the solar park (Picture 2), preference will be given to STU, which will ensure setting up of sub-station and development of necessary infrastructure for transmission of power from sub-station to load centres. If the state is not willing to buy, then the CTU may be entrusted with the responsibility of setting up 400 kV or a bigger sub-station right next to the solar park and its connectivity with the CTU.

Power sale arrangement

Acceptance for development of solar park under the Scheme does not guarantee Power Purchase Agreement (PPA) or tariff for the power to be produced. The project developers need to have their own arrangement for a PPA or get selected in any Government of India or State Government Scheme. The developer will be free to set up projects under any scheme or for third-party sale.

Loan

The MNRE will also put in efforts to tie up with multilateral/bilateral funding agencies to finance the entire or a part of the cost of the solar parks. Its grant will be treated as the implementing agencies’ contribution to get this loan. The loan tenure and the moratorium period will be set in accordance with the banks’ terms and conditions while the annual interest will be set in accordance with banks’ London Interbank Offered Rate (LIBOR)-based lending facility.

Fund for power evacuation

The connectivity with grid, i.e., 220/400 kV substation and transmission line to connect with CTU/STU’s existing network is a very important component. For power evacuation network, the MNRE grant may be used. Loan from multilateral/bilateral agencies may also be used to the power evacuation network. If the expenditure is high then a separate proposal may also be considered for funding from National Clean Energy Fund (NCEF), Green Corridor Programme or any other source.

Equity contribution

The implementing agency whether single company or joint venture may not require a high equity infusion as most of the cost will be covered through the MNRE grant and loan. Most of the land is expected to be government land. The total expenses on development of park will be worked out by the implementing agency in a transparent manner. The expenses after taking into account the MNRE subsidy may be recovered through sale or lease charges of land from the developers. The implementing agency can generate a reasonable amount of surplus which can be profit for the agency or its promoters. It may preferably be converted into equity of the joint venture partners or the implementing agency so that the implementing agency gets financial strength for long-term sustenance.

A N Srivastava, Director, MNRE. Email: adityanand.s@nic.in.
Investment Opportunities in Biomass-based Power Generation

P Raman carries out a detailed analysis of investment opportunities related to biomass-based power generation and analyses the status of the technology in context of total available renewable energy potential and power generation potential realized.

In India, compared to other technologies of renewable energy, biomass power plants are in their growing stage. As the country is having a strong agricultural industrial base, there is a large potential for installation of biomass power plants. Due to increase in energy demand, power generation from biomass will have a tremendous potential. Biomass from agricultural residues is a sustainable source of energy. Hence, for a sustainable energy supply, biomass-based power generation technology will play a key role.

It is estimated that during 2025, the technology applications related energy will have an economic impact of $50–95 billion per year. Investment on biomass energy could have more priority among renewable energy sources as it is completely indigenous (technology as well as equipment/product). With upgradation on technology, biomass power plants’ capacity utility factor can be brought to as high as the plant working on conventional fuels. High utility factor leads to higher profit in comparison to other renewable energy-based power plants.

Hydrogen generation from biomass is one of the new evolving areas, which will have a large potential for transport fuel. Another area of business from biomass is biomass to liquid fuel, which will have a large potential for replacement of furnace oil in industries, which need thermal energy for process heating.

Renewable Energy Potential

So far, the realized potential of renewable energy is only 12.95 per cent of the total estimated potential of 249,188 MW. More than 87 per cent of the potential of renewable energy source is remaining untapped. The basic reason for the present status is availability of appropriate technologies which are adoptable and affordable. The technology status and economics differ a lot according to the energy sources. Hence, the potential realized from different sources of renewable energy also have differences. The status of estimated renewable potential for power generation and the installed capacity is presented in Table 1, where it may be noted that the potential of wind and bagasse-based power plants (Picture 1) are explored better in comparison to other renewable energy sources. India has an enormous potential for solar power but the potential realized is negligible. Table 1 shows that to increase the power generation from solar and biomass, there is a need to upgrade technologies to establish a profitable and sustainable market environment.
Investment Opportunities in Biomass-based Power Generation

Table 1: Renewable energy potential and installed capacity

<table>
<thead>
<tr>
<th>Renewable Energy Source</th>
<th>Potential (MW)</th>
<th>Installed Capacity (MW)</th>
<th>Potential Realized (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wind power (50 m height)</td>
<td>49,130</td>
<td>22,465.00</td>
<td>45.7</td>
</tr>
<tr>
<td>Small hydro power</td>
<td>19,750</td>
<td>3,991.00</td>
<td>20</td>
</tr>
<tr>
<td>Biomass power and gasification</td>
<td>17,538</td>
<td>1,365.00</td>
<td>8</td>
</tr>
<tr>
<td>Bagasse cogeneration</td>
<td>5,000</td>
<td>2,800.00</td>
<td>56</td>
</tr>
<tr>
<td>Waste to power</td>
<td>2,711</td>
<td>107.58</td>
<td>4</td>
</tr>
<tr>
<td>Solar power</td>
<td>------</td>
<td>3,062.00</td>
<td>------</td>
</tr>
</tbody>
</table>

Social benefits

The power generation potential realized from biomass power generation is only 8 per cent. Appropriate technology in place can increase the adoption of biomass power plants. Biomass is available at local level to a large scale. However, adoptable and economically viable technology to convert different types of agricultural residues into useful energy, such as electricity, is yet to evolve. Biomass to power can benefit farmers by adding value to the agricultural residues. Realizing large potential of biomass to produce power can lead to energy security, economic development, and social uplift of livelihood.

Biomass Gasifier-based Power Plant

For installation of biomass power plants using steam turbines, the Central Electricity Regulatory Commission (CERC) considers a capital investment as ₹ 57.3 million per MW of installed capacity. It may be noted that the CERC considers variations in capital investment and tariff according to the regions and sources. Similarly, there are variations in capital investment according to the technology. Different technologies use different materials for manufacturing the equipment. The materials used in manufacturing process have a strong influence in life of the system and in Observations and Measurements (O&M) expenses. The economics of operation is
discussed based on practical experiences. The details about capital investment and other details for various sources of renewable energy based power plants (as per the CERC report) are presented in Table 2. The biomass consumption is the key factor that influences the operating cost and sustainability of the system. The biomass consumption to produce one unit of electricity is generally referred as Specific Fuel Consumption (SFC) rate with the unit of kg/kWh. According to the present technology status of biomass gasification for power generation, the SFC is 1.2 kg/kWh at its maximum load. The biomass consumption goes beyond 6.0 kg/kWh when the operating load is below 10 per cent of the design capacity. The economics will work out to be profitable only if the plant operates above 60 per cent of the design capacity. Hence, a detailed analysis of base load scenario has to be carried out for the location where the biomass power plant is to be installed. Operating load of the biomass power plant, operating hours per day, and number of operating days in a year are the key factors for a successful operation of the plant with adequate profit.

<table>
<thead>
<tr>
<th>Energy Source</th>
<th>Tariff (₹/kWh)</th>
<th>Cap Millions of ₹/MW</th>
<th>O&amp;M Lakh/MW</th>
<th>CUF (%)</th>
<th>PLF (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wind</td>
<td>5 (3.93–6.29)*</td>
<td>62.4</td>
<td>9.51</td>
<td>26</td>
<td>---</td>
</tr>
<tr>
<td>Biomass (Steam turbine)</td>
<td>6 (5.49–6.24)*</td>
<td>65.0</td>
<td>23.57</td>
<td>---</td>
<td>80</td>
</tr>
<tr>
<td>Biomass (Gasifier)</td>
<td>6 (5.85–6.65)*</td>
<td>57.0</td>
<td>42.29</td>
<td>---</td>
<td>85</td>
</tr>
<tr>
<td>Solar (Photo voltaic)</td>
<td>8.75</td>
<td>80.0</td>
<td>11.63</td>
<td>19</td>
<td>---</td>
</tr>
<tr>
<td>Solar thermal</td>
<td>11.98</td>
<td>120.0</td>
<td>15.86</td>
<td>23</td>
<td>---</td>
</tr>
</tbody>
</table>

* The numbers in brackets show the range in tariff

Table 2: Details of investment, power tariff Capacity Utilization Factor (CUF), and Plant Load Factor (PLF)

Plant load and capacity utilization factors

For a better understanding of the economic benefit, a biomass gasifier-based power plant (Picture 2) is worked out for a 100 kWe system. An advanced biomass gasifier system with a capacity of 100 kWe will cost about ₹ 80 lakhs. The fuel consumption rate will vary according to the operating load of the plant. A profile showing the power generation cost of a gasifier plant at various operating loads is shown in Figure 1. It may be noted that, according to the operating load of the system, the power generation cost varies from ₹ 6 to 25 per kWh. It is essential to see that the plant operates at higher PLF for optimizing the operating cost of the plant. The CERC suggests a PLF of 85 per cent for biomass gasifier-based power plants.

Potential sites for biomass gasifier-based power plants are the locations where no grid exists or the places where there is acute shortage of power supply, which usually relies on diesel generator sets.
biomass fuel cost, the power generation cost of a biomass gasifier works out closer to be ₹ 6.00 per kWh. The selling cost of ₹ 10.00 per kWh is considered with a dedicated distributing grid system. Cost of electricity as ₹ 10.00 per kWh is reasonably profitable, when considering the power generation cost at local level using Diesel Generator (DG) sets. The payback period works out to be six years, when the system is operated for 24 hours a day and 300 days per year at 80 per cent load. At the same operating conditions, when the plant operates for 10 hours per day, it will end up with a payback period of about 10 years, which is not a desired situation for business. Hence, the CUF and the PLF are the key influencing parameters in determining the profitability and success of biomass power plant. A view of the biomass power plant based on gasification technology is shown in Picture 3.

Future technology options

Presently, the producer gas derived biomass using biomass gasifier system has only 40 per cent combustible gas and 60 per cent non-combustible gases. The fraction of non-combustible gases reduces not only the energy content of producer gas but also the power generation efficiency. Reduction in efficiency increases the fuel expenditure and reduces the profit level and investment opportunities. Technology for hydrogen-rich producer gas generation can increase the scope of investment and large-scale adoption of biomass gasifier-based power plants.

Data Envelopment Analysis

Data Envelopment Analysis (DEA) method is used to compare the performance of the power plants with reference to capital investment. It is always preferred to maximize the profit with a minimum capital investment. The DEA presents a graphical representation of profit level against capital investment. It also represents the competitive situation of various sources in the market. It was applied to the power plants using different sources of renewable energy sources. A diagram presenting the DEA of renewable energy power plants is shown in Figure 2.

The horizontal axis of the diagram represents the capital investment in units. Here, one unit of capital investment is ₹ 55 million, which is the capital investment required for a biomass power plant through Steam Turbine route (Biomass-ST). The vertical axis represents the profit in units and one unit is equivalent to ₹ 10 million. In Figure 2, ABCDE represent the data envelope. Any point lying out of the box will be out of the market. ABCDE can be represented with segment of priority zones. High priority zone will have power generation technologies with less investment and high profit level. Medium priority zone will have power generation technologies, which will have a medium level investment and profit, and thus will be sufficient to sustain in the market. Low priority zone will have technologies, which demand more capital investment and a medium level profit. Generally, it is preferred to have the technology with minimum capital investment to minimize the risk factors. In DEA diagram, the points closer to one another will indicate the level of completion.
ABOUT 12.95 PER CENT OF THE TOTAL ESTIMATED RENEWABLE ENERGY POTENTIAL IS REALIZED FOR POWER GENERATION. THERE IS A LARGE SCOPE FOR INVESTMENT TO TAP A LARGE FRACTION OF THE REMAINING 87 PER CENT OF RENEWABLE ENERGY POTENTIAL FOR POWER GENERATION. SOLAR AND BIOMASS ARE THE TWO RENEWABLE ENERGY SOURCES WHICH NEED TO BE FOCUSED AND ANALYSED, AND MEASURES TO BE TAKEN TO BRING A SIGNIFICANT INCREASE IN THE INSTALLATION CAPACITY PER YEAR.

Biomass Power Plants

Here, the data available from the CERC report was referred for the DEA analysis. The data used for the DEA analysis is referred from Table 2. Biomass power plant using steam turbine route falls in the high priority zone with competitive capital and profit ratio. However, profit from biomass power plant is more influenced by prevailing cost of biomass in the area of the location of the plant. In the diagram, the profit level of biomass power plant (Picture 4) was arrived based on the O&M cost limit and tariff recommended in the CERC report. To compete with the tariff of ₹ 5.00 per kWh is possible only in the scenarios where the biomass cost is less than ₹ 2.00 per kg. However, at many places the fuelwood cost works out to be ₹ 4–5 per kg. Agricultural residues such as rice husk also cost about ₹ 5 per kg. Thus, a purchasing cost of ₹ 5.00 per kWh can place the biomass power plants out of the box of ABCDE Eventually, the biomass power plants will not be able to compete with other technologies. Similarly, the cost of power generation per unit of electricity varies from ₹ 6 to 25 per kWh. It is essential to define a location-based tariff for biomass power plants, considering the biomass and other O&M cost with the local specifications.

Conclusions

About 12.95 per cent of the total estimated renewable energy potential is realized for power generation. There is a large scope for investment to tap a large fraction of the remaining 87 per cent of renewable energy potential for power generation. Solar and biomass are the two renewable energy sources which need to be focused and analysed, and measures to be taken to bring a significant increase in the installation capacity per year. According to the DEA, biomass power plants sector can grow faster, when considering the variable cost of biomass according to the local conditions.

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‘elmex’ is a leading brand of DIN Rail mounted terminal blocks having manufacturing facility in Vadodara, Gujarat and has the distinction of producing electrical connectors as an import substitute component since 1963. To serve larger segment of industry, ‘elmex’ has extended its domain knowledge in wire termination technology to develop Solar products for PV applications through its design and development initiative.

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In 2009-10, two separate MOUs were signed between governments of Gujarat and Rajasthan and the Clinton Climate Initiative (climate arm of US-based William J Clinton Foundation) in partnership with TERI. The primary objective was setting up Solar Parks (SP) in their respective states. Presently, Gujarat 214 MW Solar Park (SP) is already commissioned and the one in Rajasthan (several hundred MW) is under construction. Although it does not include Concentrated Solar Power (CSP) and has much less capacity than 3,000 MW (originally envisioned), but the concept of large-scale deployment of solar at one location, pre-permitting, concessional financing through the Asian Development Bank (ADB) and World Bank (WB) (in the case of India), and shared infrastructure (transmission, master planning) has been largely adopted and implemented.

A solar park is a collection of multiple solar power projects designed to generate and supply power at utility scale. Generally having a combined installed capacity in excess of 500MW, it serves as an ideal mechanism for a country like India to meet its aggressive solar targets. Every solar park comprises of the basic infrastructure in the form of a fully developed estate, road connectivity, water and telecommunication accessibility, housing, parking area, etc. The potential for ultra megawatt solar farms has been realized and in recent years, the Ministry of New and Renewable Energy (MNRE), along with state governments and financial institutions has actively pushed for solar park development in India.

MNRE Support and Draft Policy on Solar Parks

The MNRE has demonstrated its commitment towards the advancement of solar parks in the country by coming up with the ambitious ‘Draft Scheme for Development of Solar Parks and Ultra Mega Solar Power Projects’ in September 2014. The programme aims at generating 20,000 MW of solar power through installation of 25 solar parks with capacities ranging from 500 MW to 1,000 MW (for smaller states and UTs, parks of lesser scale to the tune of 100 MW or so shall be considered). This endeavour, although still in preliminary stages, is certainly progressive in nature and will span over a period of five years bringing in a plethora of employment opportunities, contributing towards meeting the state Renewable Purchase Obligation (RPO) targets and aid in curtailing Greenhouse Gas (GHG) emissions, thus reducing the country’s overall carbon footprint. In addition to that, installation of solar power on such large scales would also facilitate in reducing the cost of solar power. The policy promises to galvanize the indigenous solar power industry and encourage investors and private project developers into implementing such projects.
In order to engage project developers, the MNRE intends to provide financial and fiscal incentives along with other facilitative support such as single window clearance, provision of land and basic infrastructure, etc. SECI will implement this programme in cooperation with the state governments.

**Asian Development Bank and Gujarat and Rajasthan Solar Parks**

India’s association with ultra mega solar projects began in 2009 with ADB conducting feasibility assessment studies of select sites in Gujarat for construction of the world’s largest solar park. In 2009, the introduction of the Gujarat Solar Power Policy with the assistance of Clinton Foundation provided the necessary impetus and led to the development of the Gujarat Solar Park. A total of 87 project developers have been enlisted to establish 986.5 MW of solar power in sites throughout Gujarat.

Spread across 5,384 acres of waste land, the largest site unidentified among them was the desert village of Charanka (Pictures 1 & 2) located in Northern Gujarat. Apart from receiving heavy amounts of direct solar radiation, the Charanka region also provides flat topography favourable for setting up a solar power project. In December 2010, construction began at the Charanka solar park site and till now 224 MW out of the planned 590 MW of solar power has been commissioned. The programme involves 20 individual project developers employing cutting-edge thin film technology resulting in investment costs to the tune of $280 million. It is the world’s second largest solar power generating system and upon completion, would lead to 3,42,400 MT of carbon emission reductions.

![Picture 1: Aerial view of Charanka Solar Park](image)
Proposed Solar Parks with World Bank Assistance

The first solar Ultra Mega Power Project (UMPP) of capacity 750 MW is coming up in Rewa district’s Gudh area of Madhya Pradesh. The region receives healthy sunshine throughout the year and enjoys good connectivity by means of national and state highways. The WB is set to finance 50 per cent of the total project cost which is estimated to be $400 million. The rest will be borne by the joint venture of centre and the state.

Advantages of Solar Park over Standalone Solar Projects

The development and implementation of SPs can effectively bring down the costs of solar power in the country due to usage of domestically manufactured equipment and reductions resulting on account of huge scale. On an average, a solar plant built as a part of a SP would cost about 26 per cent less than a standalone solar plant of same capacity. As an example, Figure 1 shows a comparison of cost of a standalone CSP plant and a CSP plant part in a solar park (with and without thermal storage capacity).

![Picture 2: Panoramic aerial view of Charanka Solar Park](image)

![Figure 1: Standalone CSP plant Costs and Solar Park Costs](image)
As shown in Figure 1, the Capital Expenditure (CAPEX) per kW of power for solar parks is considerably lower for a standalone plant.

It is interesting to note that after the Chinese manufacturing boom and Germany rooftop solar revolution, grid-connected solar prices in India are under $1 m per MW, one of the lowest in the world. It brings large-scale solar to almost grid parity in India. Also, India may soon move to feed-in-tariff for solar power from the current auction-based system. The MNRE is further planning to release rooftop and net metering policy, which may kick ‘solar city’ like phenomenon in India. With 1.2 billion people and several 100 million households, rooftop solar could be the next big thing in India. International Finance Corporation (IFC) has already piloted an innovative rooftop project in Gujarat and WB is in talks with SECI for large-scale rooftop solar programme for government building in India.

Currently, Charanka SP in Gujarat and Bhadla SP in Rajasthan are operational. The WB and SECI are working with several state governments including Madhya Pradesh, Andhra Pradesh, and Rajasthan. Every SP capacity is designed to be a minimum of 500 MW attracting approx. $600 M (₹ 30,000 crores). India is on the cusp of a solar revolution, several GW are being planned and implemented in the coming years. One thing is for sure, grid-connected solar is becoming a commercial business now. And the day is not far off when there may not be any need for large-scale subsidies. In 2009, very few people believed in the concept of Solar Park, now it is a reality! 

Amit Jain, IRENA, ADB, and Clinton Foundation. Email: ajain9383@gmail.com, Amit Kumar, Adjunct Professor, Sustainable Energy at TERI University, and Kranav Sharma, TERI University, and CDM Auditor at KBS Certification Services Pvt. Ltd.
Although used in Indian villages since time immemorial, the traditional *chulhas* have a few drawbacks such as the high smoke emission resulting in irritation to eyes and respiration-related disorders, particularly in women, girls, and infants. It was, therefore, decided to introduce high-efficiency biomass stove (as a replacement of the traditional *chulhas*) in the selected five tribal villages of Dahod and Vadodara districts of Gujarat. Samir Vahora, S N Singh, M Shyam, and S Mohana analyse the design features, modifications, and usefulness of the biomass cookstoves that became a swift success story.

Sardar Patel Renewable Energy Research Institute (SPRERI) has been implementing a Department of Science and Technology project “Renewable Energy Intervention for Rural Development” in selected five tribal villages of Dahod and Vadodara districts of Gujarat since May 2010. All the selected villages are fairly large in size and comprise of a few hamlets. The houses are scattered and are, in general, located on the farmlands. The hamlets are normally connected with a network of motorable roads. However, a few houses could be reached only by foot (distances of up to 250 m) and are also not covered by the state electricity board grid supply.

Based on the participatory rural appraisal carried out in the selected villages, domestic cooking was identified as one of the most important activities for renewable energy intervention. Almost all the houses were using C-type traditional *chulhas* and the locally available fuels such as wood sticks, crop residues, and cattle dung cakes. The C-type *chulha* burnt the fuels with low efficiency (7–12 per cent). The high smoke emission resulted in irritation to eyes and respiration-related disorders, particularly in
women, girls, and infants. The village folk are, in general, resource poor. Most of them did not have easy cash for purchase of the new useful gadgets. Besides, effective training in proper operation and maintenance of the new devices was the other important issue that was required to be addressed.

It was, therefore, decided to introduce high-efficiency biomass stove (as a replacement of the traditional chulhas) in the selected villages. The main considerations in selection of the ‘improved biomass cookstove’ design(s) were as follows:

- The design should meet all the Bureau of Indian Standards (BIS) standards in respect of the efficiency, emissions, etc.
- It should be acceptable to the rural users in respect of ease of operation, suitability for the locally available fuels, and preparation of all local dishes, particularly—*rotla*—a large thick *chapati* prepared primarily using *bajra* flour.

**Initial User Level Trials**

Six different models of natural draft improved biomass cookstoves, which were easy to operate and maintain, were selected and tested under the laboratory conditions. Based on the results, the Inverted Downdraft Biomass Gasification (IDBG) cookstove design developed at the SPRERI was selected for the initial user level trials. The portable natural draft stove, which worked in the batch mode, had a thermal efficiency of more than 30 per cent and met other prevalent BIS emission norms. One unit each of the IDBG cookstove was set up in the selected five households of the Chillakota village of Dahod district during 2010 and thereafter, their performance was monitored. All the five users were satisfied with the performance of the IDBG cookstove. However, the important feedback collected was as follows:

- The height of the cookstove (480 mm) ought to be reduced suitably for ease of operation in sitting posture.
- The thermal insulation (insulite-7) of the stove was unstable and required frequent servicing/replacement.
- The temperature of the body of the stove was too high, which may inflict burn injury.
- The cutting of the wood sticks into 10–15 cm long pieces for use as fuel was inconvenient.
- Continuous mode of operation as against batch mode in this design would be preferred.

**Design Modifications after the Feedback**

In keeping with the feedback, further refinements of the stove design were pursued. Its height was reduced from 480 mm to 330 mm and the insulite-7 was replaced by a ceramic liner of 25 mm thickness (Picture 1). The thermal efficiency of the revised design was found a few points lower than the original IDBG stove. It, however, met all the BIS parameters. A few prototypes of the ceramic-lined stoves were set up in the selected houses of Simal Faliya village and the feedback collected was very encouraging (Picture 2). Therefore, 100 units of the ceramic-lined stoves were fabricated and one unit each was set up in 100 selected houses of all the five villages in participatory mode. The performance of all the stoves was regularly monitored for about a year. The feedback is summarized below.

- The fuelwood consumption, in general, reduced by 20–30 per cent as compared to the traditional chulhas.
- Average time periods spent for collection and preparation of the fuel and various cooking activities reduced from 2.31 h/d to 1.78 h/d and 3.22 h/d to 2.46 h/d, respectively.
- About 70 per cent users reported negligible smoke problem while the remaining 30 per cent users reported some smoke problem in the initial stage of the operation in the improved biomass cookstoves.
- There was no problem in use and cooking various local items including rotla with the improved biomass cookstoves. However, handling of the stove was strenuous due to its high mass, i.e., 14 kg.
- The time saved in collection and preparation of the fuel and cleaning of the utensils and kitchen by women and young girls was, in general, used in income generation or other domestic activities.
- Many users, however, expressed preference for a stove that burns long fuel wood sticks for continuous operation.

The design was further refined and the ceramic liner was replaced by an air jacket. The mass of the air insulation stove (Picture 3) was reduced to 8 kg, i.e., 43 per cent lower than the ceramic-lined stove while it met all the BIS requirements. One hundred units of the air insulation stoves were fabricated and one unit each was set up in 100 selected households in participatory mode in Chillakota and Dageria villages (Picture 4). The results of monitoring over a period of more than six months revealed that all the users were fully satisfied with their stoves. However, many women expressed that they will prefer a stove that burns long fuel wood sticks for continuous operation, which does not require periodic recharging of the fuel.

In keeping with the requirements of the target group, another design of the air insulation side-feeding domestic biomass cookstove was developed. It weighed 8.5 kg and could be operated either in batch or continuous mode and met all the BIS parameters. One hundred units of the side-feeding stove have been set up in selected 50 households of Chillakota, Dageria, and Simal Faliya villages during February–August 2014 (Picture 5). The response is very encouraging.
The need to have a sustainable energy supply necessitates the exploration of available energy sources, and among these, renewable resources are at the forefront. It is now an established fact that RE (renewable energy) can be an integral part of sustainable development because of its inexhaustible nature and environment-friendly features. Today RE is an established sector with a variety of systems and devices available for meeting the energy demand of urban inhabitants, but there is a need to create mass awareness about their adoption. Akshay Urja is an attempt to fulfil this need through the dissemination of 20,000 copies (bilingual) in India and abroad. The magazine publishes news, articles, research papers, case studies, success stories, and write-ups on RE. Readers are invited to send material with original photographs and statistical data. The photographs should be provided in high resolution files on a CD or through email. Akshay Urja will pay an honorarium of ₹2,500 to the authors for each published article of 1,500 words and above. The publication material in two copies, along with a soft copy on CD/DVD/email may be sent to:

**Commercialization of Technology**

The manufacturing and marketing rights of technologies, i.e., ‘SPRERITECH portable air-insulation top-feeding and side-feeding biomass cookstoves’, have been transferred to three firms in Gujarat. The commercial units of both the stove models (No. 170-NDT-L and No. 190-NDS-L), manufactured by one of the three firms (Pictures 6-7) were evaluated by the SPRERI and subsequently tested by the Ministry of New and Renewable Energy (MNRE) approved test centre located at Maharana Pratap University of Agriculture and Technology (MPUAT), Udaipur, Rajasthan. Both the models satisfied BIS norms in respect of the thermal efficiency, power ratings, emissions, etc., and have since been approved by the MNRE for proliferation throughout the country.

Email: director@spreri.org

**Picture 6: Commercial units of air insulation biomass cookstoves (Model No. 170-NDT-L; top-feeding)**

**Picture 7: Commercial units of air insulation biomass cookstoves (Model No. 190-NDS-L; side-feeding)**

**Inviting Articles**

The need to have a sustainable energy supply necessitates the exploration of available energy sources, and among these, renewable resources are at the forefront. It is now an established fact that RE (renewable energy) can be an integral part of sustainable development because of its inexhaustible nature and environment-friendly features. RE can play an important role in resolving the energy crisis in urban areas to a great extent.

The need to have a sustainable energy supply necessitates the exploration of available energy sources, and among these, renewable resources are at the forefront. It is now an established fact that RE (renewable energy) can be an integral part of sustainable development because of its inexhaustible nature and environment-friendly features. RE can play an important role in resolving the energy crisis in urban areas to a great extent.

Today RE is an established sector with a variety of systems and devices available for meeting the energy demand of urban inhabitants, but there is a need to create mass awareness about their adoption. Akshay Urja is an attempt to fulfil this need through the dissemination of 20,000 copies (bilingual) in India and abroad. The magazine publishes news, articles, research papers, case studies, success stories, and write-ups on RE. Readers are invited to send material with original photographs and statistical data. The photographs should be provided in high resolution files on a CD or through email. Akshay Urja will pay an honorarium of ₹2,500 to the authors for each published article of 1,500 words and above. The publication material in two copies, along with a soft copy on CD/DVD/email may be sent to:

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Recently, India’s energy demand has been met to a large extent by conventional resources. It is well known that the country receives abundant sunlight that could support a robust solar-based production industry. Solar photovoltaic (PV)-based power production provides a powerful alternative. Hybridizing diesel with solar power would have benefits in terms of improved reliability, energy services, operational life, and energy efficiency. The hybrid system is meant for backup power in case of power shortage, i.e., during peak demands. The Hybrid Optimization Model for Electric Renewables (HOMER) Micropower Optimization Model is a computer model developed by the US National Renewable Energy Laboratory (NREL) to assist in the design of micropower systems and facilitate the comparison of power generation technologies across a wide range of applications.

Description of Existing System

Proposed hybridization of diesel power plant exists in a professional institution, i.e., Sir C R Reddy College of Engineering, Andhra Pradesh, India (case study area). For everyday utilization, electricity was purchased from Andhra Pradesh Eastern Power Distribution Company Ltd (APEPDCL). During peak loads or periods of overcast or power failure, backup diesel generators are used for local power needs. The maximum demand of the institution is 285 kW peak and energy consumption is 4.4 MWh/day. The price of electricity is $0.150/kWh (INR 6.75). This is the tariff at prevailing rate of utility company for high tension (HT) consumer at present. A buyback price of the grid has been assumed as $0.050/kWh for any excess power from hybrid power system. Note that the existing system in the case study area has been continuously monitoring and maintaining power factor nearer to unity by using three capacitor banks of each rated 25 kVA. So, the power factor has been treated as unity for the rest of simulation. And the current price of diesel is $1/L in the case study area.
Simulation of Hybrid Power System

To carry out a preliminary evaluation of the HOMER software by input, the latest real time data obtained by the different sources and techno-economic analysis has been carried out. In the present study, two different cases are evaluated. Case I is operating hybrid system (Figure 1) as standalone mode to serve the demand; Case II is operating hybrid system as grid connected mode.

Optimization Results

Monthly average electricity production profile of different configurations and numerical results that were evaluated during the HOMER simulation has been presented in Table 1. For all cases, the percentage of renewable energy fraction is constant, i.e., 18 per cent. As long as renewable fraction increases, the hours of operation of the diesel power plant start to decrease, which shows that there are periods of time that the energy demand can be covered by the hybrid power system. One of the most interesting results is the least Cost of Energy (COE). Production was obtained with best hybrid power system configuration. The net present cost (NPC) is not affected by the increase of renewable energy fraction if compared with the present NPC. However, for the same percentage of renewable energy fraction, the NPC varies with the configuration. The first and foremost contribution of hybrid power system is reduction in emission of pollutants into the atmosphere. Hybrid electricity production helps in lowering the fuel costs as well as the CO₂ emissions. All emission results are summarized in Table 2. Economically, on comparing the best system configuration with existing diesel–grid configuration, the results are found to be satisfactory. Numerical results are presented in Table 3.
Table 1: Techno-economic results of various configurations

<table>
<thead>
<tr>
<th>Configuration Type</th>
<th>PV kW</th>
<th>Genset 1 kW</th>
<th>Genset 2 kW</th>
<th>Converter kW</th>
<th>Grid kW</th>
<th>Initial Capital ($)</th>
<th>Operating cost ($)</th>
<th>Total NPC ($)</th>
<th>COE ($/kWh)</th>
<th>Renewable Fraction (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Standalone</td>
<td>250</td>
<td>200</td>
<td>50</td>
<td>250</td>
<td>0</td>
<td>3,938,872</td>
<td>1,010,420</td>
<td>13,110,489</td>
<td>0.904</td>
<td>18</td>
</tr>
<tr>
<td>PV-Grid</td>
<td>250</td>
<td>0</td>
<td>0</td>
<td>250</td>
<td>250</td>
<td>2,477,798</td>
<td>258,369</td>
<td>4,822,993</td>
<td>0.333</td>
<td>18</td>
</tr>
<tr>
<td>Diesel-Grid</td>
<td>0</td>
<td>200</td>
<td>50</td>
<td>0</td>
<td>250</td>
<td>38,888</td>
<td>250,192</td>
<td>2,309,895</td>
<td>0.159</td>
<td>0</td>
</tr>
<tr>
<td>Hybrid-Grid</td>
<td>250</td>
<td>200</td>
<td>50</td>
<td>250</td>
<td>250</td>
<td>383,332</td>
<td>209,267</td>
<td>2,282,861</td>
<td>0.157</td>
<td>18</td>
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<tr>
<td>Best System</td>
<td>250</td>
<td>0</td>
<td>50</td>
<td>250</td>
<td>250</td>
<td>352,777</td>
<td>208,435</td>
<td>2,244,754</td>
<td>0.155</td>
<td>18</td>
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</table>

Table 2: Emission results of various configurations

<table>
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<tr>
<th>Pollutant Type</th>
<th>Standalone</th>
<th>PV-Grid</th>
<th>Diesel-Grid</th>
<th>Hybrid-Grid</th>
<th>Best System</th>
</tr>
</thead>
<tbody>
<tr>
<td>CO₂</td>
<td>1,289,538</td>
<td>115,438</td>
<td>150,054</td>
<td>123,494</td>
<td>120,675</td>
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<tr>
<td>CO</td>
<td>31.83</td>
<td>0</td>
<td>31.5</td>
<td>21.3</td>
<td>13.8</td>
</tr>
<tr>
<td>Unburned hydrocarbon</td>
<td>3.53</td>
<td>0</td>
<td>3.49</td>
<td>2.36</td>
<td>1.53</td>
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<tr>
<td>Particulate matter</td>
<td>2.40</td>
<td>0</td>
<td>2.37</td>
<td>1.6</td>
<td>1.04</td>
</tr>
<tr>
<td>SO₂</td>
<td>2,590</td>
<td>3,658</td>
<td>4,376</td>
<td>3,657</td>
<td>3,657</td>
</tr>
<tr>
<td>NOx</td>
<td>28,403</td>
<td>2,670</td>
<td>3,456</td>
<td>2,847</td>
<td>2,785</td>
</tr>
</tbody>
</table>

Table 3: Economic results of best system configuration

<table>
<thead>
<tr>
<th>Metric</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Present worth</td>
<td>$65,141</td>
</tr>
<tr>
<td>Annual worth</td>
<td>$7,176/year</td>
</tr>
<tr>
<td>Return on investment</td>
<td>13.1%</td>
</tr>
<tr>
<td>Internal rate of return</td>
<td>12.7%</td>
</tr>
<tr>
<td>Simple payback</td>
<td>7.37 years</td>
</tr>
<tr>
<td>Discounted payback</td>
<td>14 years</td>
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</table>

Conclusions

It might be concluded that backup hybrid power system is a feasible solution from a techno-economic point of view, since no capacity shortage was noticed in any of the examined configurations. The main reason for this is already installed diesel power plant, which is able to cover the energy demand of the institute. It is also concluded that if the percentage of renewable energy fraction increases, the COE will definitely decrease as long as the fuel price remains at current level. In addition, we can reduce greenhouse emissions and produce environment-friendly energy with the help of hybrid power system.

Dr Satish Kumar Injeti, Member in IEEE, Associate Professor, Department of Electrical and Electronics Engineering, Sir C R Reddy College of Engineering, and Mr S Karunakar, Sr DGM, COEPMM, BHEL. Email: satish_injeti@yahoo.com
Workshop on Solar Energy for School students

The “Solar Energy for Students” programme was organized as part of Science week to commemorate the successful ‘Mangalyaan Mission’ and other achievements in the field of science and technology by Indian scientists in addition to a hands-on workshop at Manav Rachna Public School, Sector 46, Gurgaon, Haryana.

The programme started with an orientation session for students introducing them to the horrors of climate change and the resultant effects on planet earth and its habitat. Concepts of rainfall pattern change, decrease in crop yield, increased vulnerability to diseases and more severe rains, and sea-side calamities were discussed with students who took keen interest in understanding the science behind these abnormal occurrences. As part of the solution regime, low-carbon lifestyle and use of renewable energy in day-to-day life emerged as the most suitable option.

Bhavesh Swami, the man behind this workshop, showed a Direct Current (DC) motor that was having a fan at one end and as soon as the solar module was connected with it, the motor started making a movement.

Bhavesh Swami. Email: bhavesh.swami@gmail.com

India: Sixth Intersolar Solar Show 2014

The sixth edition of Intersolar India 2014, the three-day (November 18–20, 2014) solar show hosted by Messe Munchen International (MMI) India was held at the Bombay Exhibition Centre (BEC), Mumbai. The show is recognized as an integral part of the power industry in India by the associations and the industries at large.

The first day of Intersolar India 2014 proved that ‘Solar Energy’ is the need of the hour, no matter how the economy is, with over 200 exhibitors from across the globe, such as the UK, Germany, China, Japan, Singapore, the USA, the Netherlands, Greece, Spain, Belgium, and Korea in addition to India who showcased their products and technologies for the solar industry. Intersolar India featured various national pavilions, which gave especially small and medium companies from abroad the opportunity to present their products and services to the Indian solar market. It was also for the first time that the exhibition witnessed a state pavilion of Madhya Pradesh (MP). The MP pavilion showcased the latest developments and policies in the state which is now considered to be the top runner for solar space considering its achievements in the past one year. Welspun, SunEdison, and Urjaas were the three major developers who participated inside the state pavilion. The summit brought together senior solar professionals from Consulate General of India, Frankfurt; Solar Energy Society of India (SES); New Renewable Energy Department; Government of Madhya Pradesh; VDMA Photovoltaic Equipment; Alliance for Energy Efficient Economy (AEEE); Semiconductor Equipment and Materials International (SEMI); India Business Group (IBG); Bundesverband Solarwirtschaft (BSW); Emergent Ventures India Ltd (EVI); EPIA; ARE; and other private companies from the solar sector. Intersolar India 2014 was marked by an award felicitation programme that paid tribute and gave further impetus to the innovative power of the industry. The different categories of the awards were—Off-grid Solutions, Industrial and Commercial Application, and Utility-Scale Project. The companies that received the award in these categories were Tata Power for Utility-Scale Project, Bosch for Industrial and Commercial Applications, and Trojan Battery Company for Off-grid Solutions.

Jinesh Zaveri, Media Contact, Intersolar India. Email: jinesh@mutualpr.com
The photovoltaic sector owes its stunning growth rate to a combination of decreasing prices due to economies of scale and the development of new, less expensive technologies. In countries with high solar irradiation, these technologies now provide electricity to the end-user at a similar price that of grid electricity. However, for a truly significant impact of photovoltaics in our future electricity, we need efficient and low-cost solar cells fabricated from abundant non-toxic materials with simple manufacturing processes.

The History of Dye-Sensitized Solar Cells

Dye-Sensitized Solar Cells (DSSC) constitute a novel class of hybrid organic–inorganic solar cells. At the heart of the device is a mesoporous film of titanium dioxide ($\text{TiO}_2$) nanoparticles, which is coated with a monolayer of dye, sensitive to solar spectrum. The role of the dye is similar to that of chlorophyll in plants; it harvests solar light and transfers the energy via electron transfer to a suitable material (like $\text{TiO}_2$) to produce electricity as opposite to chemical energy in plants.

After Alexandre Edmond Becquerel (French physicist) discovered the photo electrochemical (photovoltaic) effect in 1839, the first and second generation photovoltaic cells are made up of semiconductors including crystalline silicon, III-V compounds, cadmium telluride, and copper indium selenide/sulphide (Figure 1). Prof. Michael Grätzel and co-workers at the Ecole polytechnique fédérale de Lausanne (EPFL, English: Swiss Federal Institute of Technology in Lausanne) produced for the first time what is known as the “Grätzel Cell” or the DSSC to imitate photosynthesis —

Solar cells fabricated from non-toxic materials, in a simplified manner, hold the key to our future needs. Rashmi Singh discusses the working of Dye-Sensitized Solar Cells (DSSC), based on the functioning of nanoparticles.
Nanotechnology Renaissance of Dye-Sensitized Solar Cells

by sensitizing a nanocrystalline TiO₂ film. The DSSC and its inventor, Prof. Grätzel, have received prestigious awards, including the Balzan Prize in 2009 and the 2010 Millennium Technology Prize.

In DSSC, light is absorbed by a dye attached to the surface of the mesoporous film of large band gap semiconductor. After light absorption, the excited dye injects an electron into the conduction band of the semiconductor to produce solar electricity. Electrons move through the semiconductor to a current collector and external circuit. A redox mediator in the pores ensures that the oxidized dye species are continuously regenerated and that the process is cyclic. There are seven main charge separation pathways. Forward processes consist of photo excitation, charge injection, dye regeneration, electrolyte regeneration, dye relaxation, recombination via dye, and recombination via electrolyte. According to the journal Nature, the EPFL scientists have developed a state solid version of the DSSC that is fabricated by a new two-step process raising their efficiency up to a record of 15 per cent without sacrificing stability.

Commercialization of the DSSC

The Dye-Sensitized Solar Cell (DSSC) is made up of easily available and cheap materials using inexpensive processes. DSSCs are likely to be a significant contributor to the future commercial photovoltaic technology portfolio. The interest in DSSC has been increasing and a few companies are now looking forward to make this new technology available soon. EFACEC is one of the major national technological companies involved in the development of DSSCs.

According to the EPFL, several commercial providers are promising availability of DSSCs in the near future. Dysoles, a Swiss company specialized in the production of DSSC materials since 1993, has extended their premises in 2010 to host a manufacturing pilot line of DSSC BIPV. Dysoles has also entered into working relationships with Merck, Umicore, CSIRO, Japanese Ministry of Economy and Trade, Singapore Aerospace Manufacturing, and a joint venture with TIMO Korea (Dyesol-TIMO). Solaronix, a Swiss company

G24Innovations, founded in 2006, is based in Cardiff, South Wales, United Kingdom. In October 7, 2007, the company claimed to have produced the first commercial grade dye-sensitized thin films. Sony Corporation has developed DSSC with an energy conversion efficiency of 10 per cent, a level considered necessary for commercial use.

Conclusion

Nanotechnology research and development of commercial products can help to create innovative ways to generate, store, transmit, and even conserve energy. DSSC can be recommended to those interested in solar electricity and its new developments. It is evident how solar energy can grow from a marginal energy source today into a major global energy player in the future. Nanocrystalline DSSC is classified as a low-cost, environment-friendly cell, capable of being highly efficient mainly due to materials, charge carriers generation, and transport used for the manufacture of the cell.

Rashmi Singh, M. Tech. Student, Energy Management, Devi Ahilya Vishwavidyalaya, Indore. Email: rashmisgn90@gmail.com

Figure 1: Energy diagram of the DSSC showing different kinetic processes occurring in cell

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DSSC
Logitech Wireless Solar Keyboard K760 is the successor to Logitech’s first solar keyboard, the K750. The Logitech Wireless Solar Keyboard K760 has a sleek and stylish design. An integrated solar panel can charge the keyboard from any light source (including a lamp), so there’s no need to replace batteries. The K760 can pair with three devices such as Mac, iPad, and iPhone, and switch among them at the touch of a button. With its built-in solar-powered battery, the sleek Logitech Wireless Solar Keyboard K760 will save money in the long run.

**Design and Key Features**

From a design standpoint, the K760 is more compact than the K750 and comes with the addition of the strip of solar cells at the top of the unit. It’s sleek and stylish. It works with Bluetooth-enabled Windows computers and Android tablets/smartphones, though it does have a Mac-centric layout with a couple of Mac-only keys. In the K760, the key feature upgrade is something that Logitech calls ‘Bluetooth connectivity with easy-switching capability.’ It means that the user can pair multiple devices—such as a Mac, iPad, or iPhone—and quickly switch among them with the push of a button without having to reconnect.

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**Advertisement**

Akshay Urja (bilingual) is widely circulated to all stakeholders of renewable energy. We invite advertisements (in colour) from interested organizations, manufacturers, institutions, etc. The advertisement tariffs are as follows:

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<td>Inside front cover (INR)</td>
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<td>150,000</td>
<td>142,500</td>
<td>300,000</td>
<td>276,000</td>
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<tr>
<td>Inside back cover (INR)</td>
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<td>Inside full page (INR)</td>
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<td>120,000</td>
<td>114,000</td>
<td>240,000</td>
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</tr>
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</table>

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Hi Kids! Here are some Frequently Asked Questions (FAQ) on Renewable energy. The knowledge of these will help you to make a difference in your lives as well as contribute to the country’s development.

**In what all ways can we use solar energy?**

Solar energy or energy from the Sun can be used for two purposes – generating electricity or heat production. Solar cells, also called photovoltaic cells, are used to convert sunlight into electricity. When used to generate heat, sunlight can be used to heat water (for use in homes, buildings, or swimming pools), heat spaces (inside homes, greenhouses, and buildings), heat fluids (to high temperatures to operate a turbine to generate electricity), and for cooking (using solar cookers).

A term associated with solar energy is “greenhouse effect”. Greenhouse Gases (GHGs) such as CO₂, water vapour, nitrous oxide or N₂O, and ozone or O₃ trap the Sun’s heat and do not let it escape. As a result, during the day, the Earth’s surface gets increasingly warmer. But when our planet cools down in the night, the heat is released back into the air. However, some heat still remains trapped in the lower atmosphere, keeping our planet warm and cosy. This natural process produced by GHGs is known as the greenhouse effect.

**What is a photovoltaic cell?**

“Photovoltaic” is a composite of two terms – “photo” (meaning light), and “voltaic”, denoting producing an electric current. So the composite term “photovoltaic” means producing electricity in the presence of light. When sunlight is used, the relevant term is “solar photovoltaic”. A photovoltaic (PV) cell, also called a solar cell, is a device that converts sunlight into electricity. Individual PV cells are used in watches and calculators. PV cells can also be combined to form large solar panels that can power homes and offices.

Answers to the crossword puzzle asked in December 2014 issue

A New Effort to Save Energy: www.energysavers.co.in

The energy scenario in India poses a great challenge to our future policies. Energy supply in India was about 750 million tonnes of oil equivalent (toe) in 2011 and is estimated by to be 1,200–1,700 million toe by 2030. As per NATCOM 2007, India emitted 1,728 million tonnes CO₂ equivalent of greenhouse gases, making it the sixth largest emitter of greenhouse gases in the world. As accelerating urbanization takes urban population to 600 million plus by 2030, demand for electricity will rise. In order to improve energy efficiency in the use of power, the Bureau of Energy Efficiency (BEE) periodically mandates regulatory standards. The major promotional functions of www.energysavers.co.in include—create awareness and disseminate information on energy efficiency and conservation; arrange and organize training of personnel and specialists in the techniques for efficient use of energy and its conservation; strengthen consultancy services in the field of energy conservation; promote research and development; develop testing and certification procedures and promote testing facilities, etc.

Harnessing Energy From The Sun: Empowering Rooftop Owners
Editor: International Finance Cooperation
International Finance Cooperation
130 Pages

Harnessing Energy from the Sun looks at the opportunities provided by the rooftop solar for developing countries such as India and highlights the common barriers that prevent the development of the rooftop solar sectors. The book addresses different design and implementation of models which combine policy and regulatory frameworks with market dynamics to deliver bankable and sustainable projects. It also suggests the need of incorporating private sector participation in the rooftop solar market that can help in rapid development. International experience that indicates administrative and institutional challenges need to be addressed to allow each stakeholder to participate in the transition to a mature self-replication phase. Finally, this book brings together the roles and responsibilities of each stakeholder.

Wind Resource Assessment: A Practical Guide to Developing a Wind Project
Editor: Michael C Brower
Wiley
281 Pages

The book provides authoritative, practical guidance for wind energy planners, managers, developers, tower installers, and others involved in wind monitoring and resource assessment for utility-scale wind projects around the world. The book explains how readers can achieve a high standard of resource assessment, reduce the uncertainty associated with long-term energy performance, and maximize the value of their wind assets. Topics addressed include siting, installation, and operation of a high-quality wind monitoring programme, methods of data quality control and validation, extrapolating measurements from anemometer height to turbine height, adjusting short-term observations for historical climate conditions, and wind flow modeling to account for terrain and surface conditions.

2014 Key World Energy Statistics
Editor: International Energy Agency
International Energy Agency
82 Pages

In 1997 the International Energy Agency (IEA) produced a handy, pocket-sized summary of key energy data. This new edition of 2014 responds to the enormously positive reaction to the books since then. The report contains timely, clearly-presented data on the supply, transformation, and consumption of all major energy sources. Readers will have at their fingertips the annual Australian production of coal, the electricity production in Japan, the price of diesel oil in Spain, and thousands of other useful energy facts. Gathering and analysing statistics is one of the important IEA functions. But the Agency administers a plan to guard member countries against the risk of a major disruption of oil supplies, coordinates national efforts to conserve energy, and develop alternative energy sources.
Forthcoming Events

April 8–9, 2015 | New Delhi, India
GRIDTECH
Website: http://www.ifbf.in/index.php?option=com_content&view=article&id=53&Itemid=60

April 16–20, 2015 | Ahmedabad, India
TECHTRADE
Website: http://10times.com/techtrade

April 21–22, 2015 | Mumbai, India
India Nuclear New Build Congress 2015
Website: http://dsds.teriin.org/2015/index.php

April 23–25, 2015 | Bangalore, India
GREEN Summit 2015
Website: http://www.greensummit.in/greensummit_2015/index.php

May 2–5, 2015 | New Delhi, India
ISRMAX– India International Sugar, Rice, Maize & Agriculture Expo
Website: http://www.ifbf.in/index.php?option=com_content&view=article&id=53&Itemid=60

May 11–16, 2015 | New Delhi, India
Power Gen India & Central Asia co located with Renewable Energy World India & Hydero Vision India 2015
Website: http://www.ifbf.in/index.php?option=com_content&view=article&id=53&Itemid=60

April 13–17, 2015 | Hannover Messe, Germany
Energy
Website: http://www.therenewableenergycentre.co.uk/events.html#International-Events

April 14–16, 2015 | London, UK
Argus European Biomass Trading
Website: http://www.bioenergy-news.com/index.php?/Global-Events

April 20–22, 2015 | Minneapolis, USA
International Biomass Conference & Expo
Website: http://www.bioenergy-news.com/index.php?/Global-Events

April 21–23, 2015 | London, UK
NEMEX 2015
Website: http://www.therenewableenergycentre.co.uk/events.html#UK-Events--Industry-Trade-Only

April 21–23, 2015 | Dubai, UAE
WETEX 2015
Website: http://www.wetex.ae/

May 6–7, 2015 | Glasgow, Scotland
All Energy
Website: http://www.therenewableenergycentre.co.uk/events.html#UK-Events--Industry-Trade-Only
Renewable Energy at a Glance: Global

Projected solar PV system deployment cost (2010-20)

Source: IRENA (2014c)

Total investment in renewable energy and cumulative installed capacity for solar PV and wind (2004-13)

Source: IRENA based on (UNEP, BNEF and FS, 2014) and (REN21, 2014)
Seamless support for end-to-end solar solutions under one roof.

In an era of growing energy needs and rising concerns about the environment, Su-Kam offers a wide portfolio of solar products ranging from 100 watts to 100 MW. This extensive range is suitable for the smallest residential home systems as also multi-megawatt power plants.

Solar Solutions
- Roof Top-On Grid and Off Grid Solutions
- Home Lighting Solution from 5 watt to 100 watt
- DC Home Lighting Solutions

Projects
Off-Grid
- Uttar Pradesh New Energy Development Agency
- Tripura Renewable Energy Development Agency
- Tamil Nadu Energy Development Agency
- GATES Institute of Technology
- Assam State Electricity Board
- Assam Rifles

On-Grid
- National Hydroelectric Power Corporation (NHPC)
- National Institute of Teacher’s & Training Research
- CREST (Punjab Engineering College)
- Engineers India Limited

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WITH 40% MORE DISCHARGE.

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- Proven motor and pump technology for long-term reliability
- Shakti Solar Panels are made of tempered glass
- Can work on both solar energy & electricity
- Soft start increases system’s life
- Easy to operate
- Simple installation and no maintenance required

Shakti Pumps is proud to be a Channel Partner for the Ministry of New & Renewable Energy (MNRE).
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