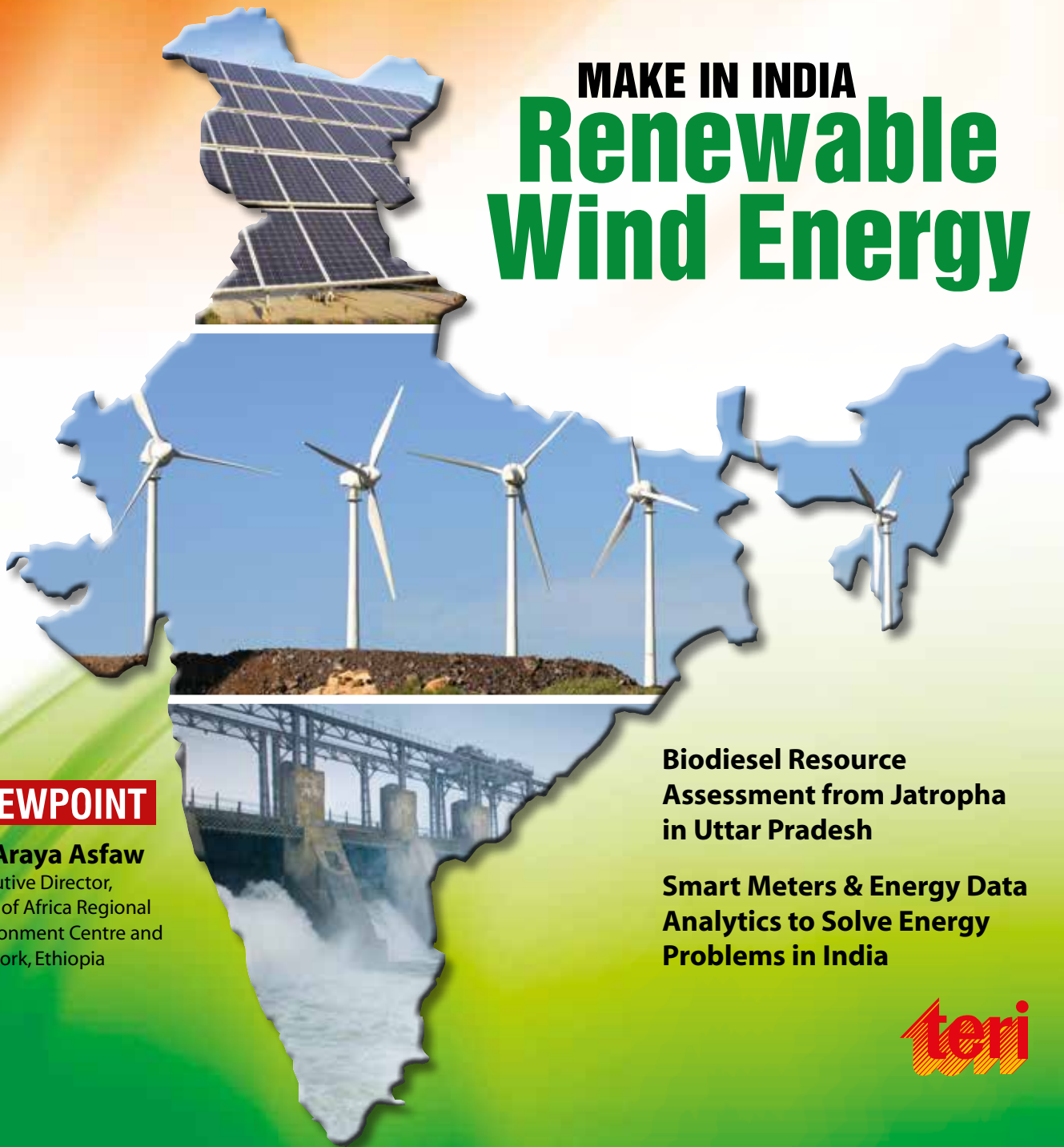
April–June 2015

ENERGY FUTURE

The Complete Energy Magazine

Volume 3 • Issue 3 • Annual ₹800



MAKE IN INDIA
Renewable Wind Energy

VIEWPOINT

Dr Araya Asfaw
Executive Director,
Horn of Africa Regional
Environment Centre and
Network, Ethiopia

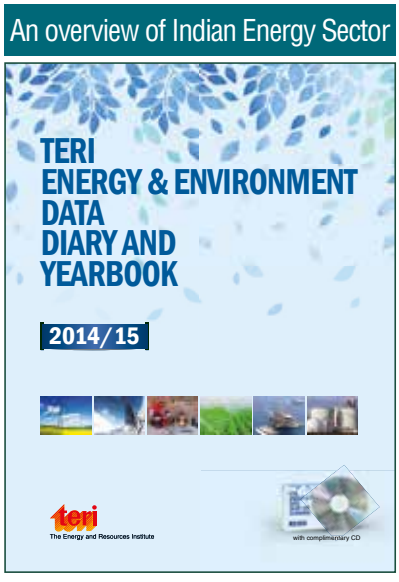
Biodiesel Resource Assessment from Jatropha in Uttar Pradesh

Smart Meters & Energy Data Analytics to Solve Energy Problems in India

teri

A teri Publication

JUST RELEASED



TERI Energy & Environment Data Diary and Yearbook (TEDDY) 2014/15

With Complimentary CD

2015 • ISBN: 9788179935743
Pages: 400 • Binding: Hardback
Size: 220 × 280 mm • Price: ₹1995.00

TERI Energy & Environment Data Diary and Yearbook (TEDDY) is an annual publication brought out by The Energy and Resources Institute (TERI) since 1986. It is the only comprehensive energy and environment yearbook in India which provides updated information on the energy supply sectors (coal and lignite, petroleum and natural gas, power, and renewable energy sources), energy demand sectors (agriculture, industry, transport, residential, and commercial sectors), and environment (local and global). It also provides a review of the government policies that have implications on energy and environment in India.

Key features

- Exhaustive compilation of data from energy supply and demand sectors
- Recent data along with data for the past years covered in the form of structured and easy-to-understand tables
- Recent advances made in the energy sectors are represented in the book
- Self-explanatory figures and graphs showing the latest trends in various sectors are also part of chapters
- The "Green focus" section in every chapter highlights a topical issue
- The book comes with a complimentary CD that contains all the chapters and additional tables

Topics covered:

• **Indian Energy sector:** An overview • Commercial energy balance tables and conversion factors • **Energy supply:** Coal and ignite, petroleum and natural gas, power, and renewable energy sources and technologies • **Energy demand:** Agriculture, industry, transport, and household energy • **Local and global environment:** Environment, Climate change • **Energy and Environment goals**: Sustainable Development Energy and Sustainable Energy

For sample chapters and Sankey diagram, please visit: www.teriin.org/projects/teddy

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

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

To purchase the book, visit our online bookstore at http://bookstore.teriin.org or send us your demand draft or cheque in favour of TERI, payable at New Delhi

Head Office
TERI
Darbari Seth Block, IHC Complex
Lodhi Road, New Delhi – 110 003
Tel. +91 (11) 2468 2100 or 2468 2111
Fax +91 (11) 2468 2144 or 2468 2145
Regional Centres
Southern Regional Centre
TERI, CA Site No. 2
4th Main, 2nd Stage Domlur
Bengaluru – 560 071
Email: terisrc@teri.res.in
North-Eastern Regional Centre
TERI, Chachal Hengrabari
Express Highway, VIP Road
Guwahati – 781 036
Western Regional Centre
TERI, F-9, La Marvel Colony
Dona Paula, Panaji – 403 004 (Goa)
Email: teriwrc@goatelecom.com
Affiliate Institutes
TERI North America
1152 15th Street NW Suite 300
Washington, DC 20005
Email: terina@teri.res.in
TERI Europe
27 Albert Grove, London SW20 8PZ, UK
Email: ritukumar@aol.com
Overseas Representation
TERI Japan
C/o IGES
Nippon Press Centre Building (8th Floor)
2-2-1, Uchisaiwai-cho, Chiyodi-ku
Tokyo, Japan - 100-0011
Email: teris@iges.or.jp
TERI South-East Asia
Unit 503, 5th Floor
Menara Mutiara Majestic
15 Jalan Othman,
Seksyen 3, 4600 Petaling Jaya,
Selagor Darul Ehsan, Malaysia
Email: nimtech@tm.net.my
TERI Gulf Centre
Flat No. 105, Dalal Building, Al Qusais,
Dubai, UAE

From the editor's desk...

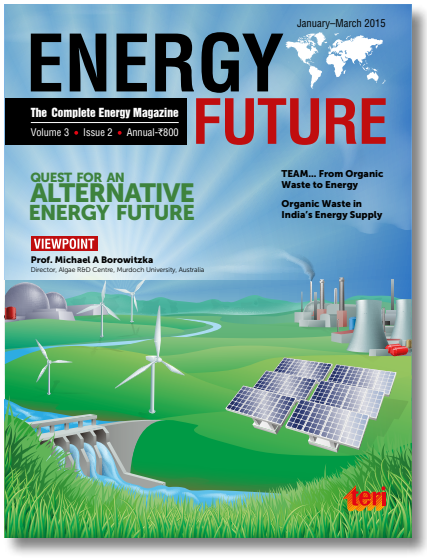
Renewable energy has been identified as one of the significant sectors under the national level 'Make in India' programme. As the primary drivers for this sector, this programme lists the vast potential of renewable energy resources in the country, along with their facilitative measures and import dependency. In fact, the federal governments' ambitious goals are indicative of creation of a large domestic demand that can benefit from indigenous manufacturing, besides providing the manufacturing industry a ready-to-tap market. For renewable manufacturing to be truly competitive, India requires policies that incentivize industry to acquire latest technologies, state-of-the-art manufacturing setup, and economic scales of operation. The key is to focus on the complete value-chain— on components, balance of systems, and products. However, in order to sustain 'Make in India' over a long period of time, it is imperative that simultaneous attention is paid to indigenous R&D and technology development because the maximization of value addition is possible only with self-developed technologies and products.

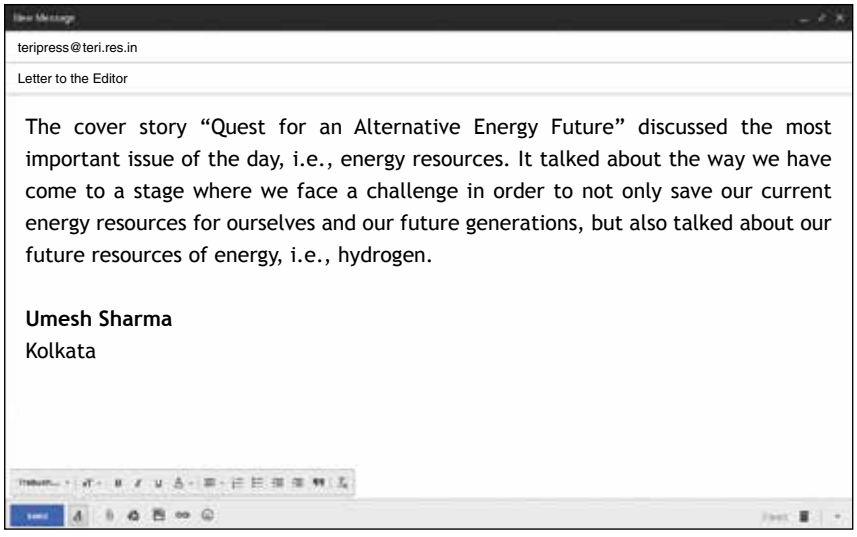
Besides technological innovations, sectorial practices and delivery models are also going to play a pivotal role in the fields of renewable energy and energy efficiency; not to mention developments that are taking place in seemingly unrelated areas—for instance Internet of Things—which would have large bearing on the way we generate and consume energy in time to come. In an energy-deficient country like India, optimized management of demand and supply itself will go a long way in addressing some of the key challenges facing us today. The largely unorganized and energy-intensive Small and Medium-sized Enterprises (SMEs) sector is a case in point where even to deliver specific, state-of-the-art technological solutions, and innovative practices are required for knowledge sharing and empowerment. And therefore, rather than viewing 'Make in India' as a monolith, let us see how myriad pieces of this complex jigsaw puzzle could be put together, smartly.

Amit Kumar

Amit Kumar
Director, TERI

Editor: Amit Kumar Radheyshayam Nigam
Printed and published by Dr R K Pachauri for The Energy and Resources Institute, Darbari Seth Block, IHC Complex, Lodhi Road, New Delhi- 110 003. Tel. +91(11) 24682100, 4150 4900, Fax +91(11) 2468 2144 or Email teripress@teri.res.in, and printed by Batra Art Press, A-41 Naraina Indl. Area PH- II, New Delhi-28.





"Article 'Organic Waste in India's Energy Supply' seems a specialized article as it discusses a very specialized topic, i.e., organic waste. Humans create lots of waste every day and we really don't realize which part of our waste is useful, so much so that we can generate energy from it.

In addition, the article discusses the methods applied in the process of generation of energy from the organic waste. Only people specially trained to extract energy from the organic waste, following such processes, can help us bridge the gap in energy demand and energy supply."

Radhika
Karnal

Thank you very much for your encouragement. The editorial team of Energy Future will ensure that the magazine caters to your information and knowledge needs. We welcome your suggestions and comments to further improve our content and presentation.

Email: teripress@teri.res.in

Editor
Energy Future

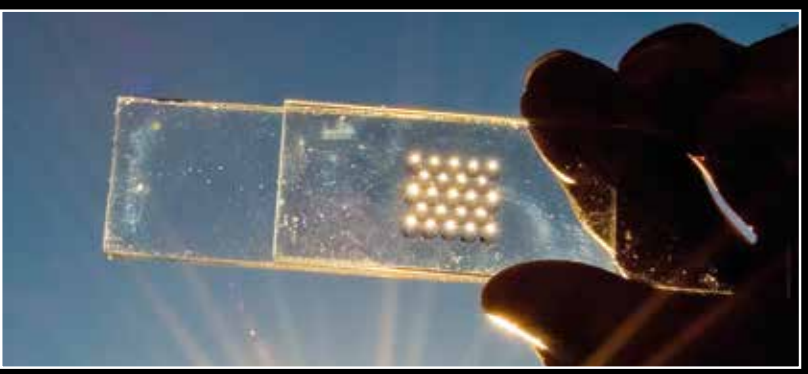
"The article discussing India's solar power potential contains the details of global as well as Indian solar energy. The basic idea of the article is to let the world know that India is all set to become solar superpower. With so many Indian firms manufacturing the SPV and so much investment coming into this field, the efforts made by the Government of India are applaudable. I think the article carries an entire set of possibilities in the field of solar energy."

Shweta Aggarwal
Roorkee

"Cremation is the last ceremony of a person, and one of the articles in this issue of the magazine discusses a new process of cremation of a dead body. It talks about bio-cremation, a process in which some chemicals are used to cremate the dead body. I think it's too early in our country to adopt such a scientific way, although logically it's a pollution-free way. I think people will not accept it in India, as of date. But, they should understand that the current cremation practices lead to pollution.

Ekta Kapoor
Mumbai

CONTENTS



CASH SUBSIDY ON LPG—WORLD'S LARGEST DIRECT BENEFIT TRANSFER SCHEME

The ambitious scheme of giving cash subsidy on cooking gas directly to consumers has become the world's largest direct benefit transfer with 2.5 crore households getting about ₹550 crores since November 15, 2014.

The direct benefits transfer for LPG (DBTL), which has now been renamed as PAHAL or *Pratyaksh Hanstantarit Labh*, under which cash subsidy is paid to consumers so that they can buy cooking gas at market price, was rolled out in 54 districts of different states in the country.

According to Oil Minister Shri Dharmendra Pradhan, in 54 districts, 75 per cent of the population is now covered by DBTL, which, as of now, has become the world's largest direct benefit transfer scheme. The scheme has surpassed number of beneficiaries in direct benefit transfer programmes in China and Brazil.

The Oil Ministry officials as well as top executives of oil marketing companies have adopted one district each in the country to oversee roll out of the scheme under which consumers have to get their bank accounts seeded with their LPG connection. The moment they join the scheme, oil companies transfer advance cash subsidy in their bank accounts to enable them to buy LPG refills at market rate. Once a consumer takes delivery of the cylinder, another advance cash subsidy is transferred to the bank account. At present, a subsidized LPG cylinder costs ₹417 per 14.2-kg bottle while its market price is ₹752, the difference being the subsidy component. EF

Source: www.articles.economictimes.indiatimes.com

CENTRE PLANS TO SET UP PETRO PARK IN MANGALURU

Union Minister for Chemicals and Fertilizers Shri Ananth Kumar has announced that the Centre plans to set up a Petroleum, Chemicals, and Petrochemicals Investment Region (PCPIR) in Mangaluru.

Shri Ananth Kumar said that the PCPIR would also come up at Paradeep, Visakhapatnam, Nagapattinam, and Dahej at an estimated cost of ₹10.5 lakh crore. He added that this project would provide employment to 37 lakh people.

MP Nalin Kumar Kateel said, "We will support setting up of petro park. It should come up on the Special Economic Zone land. Farmers' land should be protected." Dharmasthala Dharmadhikari D Veerendra Heggade, Union Minister of State for Heavy Industries and Public Enterprises, G M Siddeshwara, Campco President, Konkody Padmanabha, and others were also present on this occasion. The minister said that the country should become self-reliant in the production of fertilizers in next five years. He added that the Centre is planning to set up a fertilizer factory in Madhya Pradesh. EF

Source: www.deccanherald.com

CLP INDIA AWARDS 100-MW WIND POWER PROJECT IN MP TO GAMESA

CLP India, the Indian subsidiary of Hong Kong-based power company CLP, has awarded a 100 MW wind power project in Madhya Pradesh to wind energy firm Gamesa. The project is a turnkey project to construct 100 MW wind farm in Madhya Pradesh. The Chandgarh project is due for commissioning in December 2015. The new wind project will increase CLP India's wind power portfolio close to 1,100 MW across six states, i.e., Rajasthan, Gujarat, Maharashtra, Tamil Nadu, Karnataka, and Madhya Pradesh. Gamesa will handle the entire infrastructure and operate the wind farm. The contract also includes a long-term operation and maintenance service. EF

Source: www.articles.economictimes.indiatimes.com

CENTRE'S ₹5,800 CRORE INVESTMENT PLAN, A BIG BOOST TO SOLAR POWER

Even as the solar power industry is expecting more favourable policy and funding support in the forthcoming Union Budget, Central Government's proposed spend to the tune of ₹5,800 crore in the solar sector is expected to give a much-needed fillip to the industry.

It has been proposed to establish 1,000 MW of grid-connected solar photovoltaic (PV) power projects by Central Public Sector Units (CPSUs) and other government organizations. These projects are to be established with Viability Gap Fund (VGF) support of ₹1,000 crore over a period of three years (2015–18). Organizations such as NTPC, NHPC, CIL, IREDA, and Indian Railways, among others, have agreed to set up solar plants.

In addition to CPSUs, defence organizations will also be joining the solar bandwagon. With ₹750 crore support through VGF under the National Solar Mission, defence establishments under the Ministry of Defence and Paramilitary Force under the Ministry of Home Affairs will set up over 300 MW of grid-connected and off-grid solar PV power projects during 2014–19. These two schemes will have to use only locally made PV cells and modules, a move aimed at helping the domestic manufacturers. EF

Source: www.thehindu.com

GET MINI LPG CYLINDERS AT PETROL PUMPS AND GROCERY STORES, SOON

In a bid to make cooking gas, i.e., Liquefied Petroleum Gas (LPG), easily available to consumers, 5 kg mini LPG cylinders will now be available at select petrol pumps and neighbourhood grocery stores besides regular gas agencies in almost all major cities.

Till now, LPG was available for domestic use in 14.2 kg cylinders only from gas agencies. Consumers were entitled to 12 such cylinders in a year at a subsidized rate of ₹417 in Delhi. Now, subsidized cooking gas will also be available in 5 kg packs. Those entitled to subsidized gas can buy 34 bottles of 5 kg each at ₹155 per cylinder in Delhi.

While the subsidized 5 kg mini LPG cylinder will be available only with LPG distributors, market-priced mini LPG cylinders costing ₹351 can be bought across-the-counter, without prior booking and minimal paper work at petrol pumps, gas agencies, and select grocery stores. EF

Source: www.businesstoday.intoday.in

HARYANA MAKES SOLAR POWER MUST FOR ALL BUILDINGS

The Haryana Government has decided to usher in the New Year with one of the biggest pushes for solar power in the country. The state has made it mandatory for all buildings on a plot size of 500 square yards or more to install rooftop solar power systems by September 2015.

The order will be applicable to private bungalows, group housing societies, builder apartments, malls, offices, commercial complexes, schools, hospitals—any building, new or old, that meets the plot size criteria.

The government will offer a 30 per cent subsidy on installation costs on "a first-come-first-serve" basis, which means it would depend on availability of funds. EF

Source: www.eai.in

RE-INVEST 2015: COMPANIES COMMIT $200 BILLION TO CLEAN ENERGY

The Indian Government's largest clean energy initiative, the first global renewable energy conference, i.e., RE-INVEST 2015, was held from February 15–17, 2015 amid $200 billion commitments by companies. Power and engineering companies, sugar mills, and even healthcare firms have promised to set up big renewable power capacities in the next five years.

RE-INVEST drew interest from the US solar power major SunEdison Energy, which has committed 15,200 MW–10,000 MW solar power and the rest wind power. Following closely in commitments is the Sumant Sinha-promoted ReNew Power, which will set up 7,000 MW of solar power and 4,500 MW of wind power capacity. Azure Power will set up 11,000 MW solar power capacity.

Welspun Renewables has committed to 8,660 MW of solar power and 2,341 MW of wind power. Reliance Power and Adani Power have signed green commitments for 6,000 MW of solar power each. Hero Future Energies, a part of the Hero group, will set up 5,150 MW of renewable energy capacity. US company First Solar, which is present in the Indian photovoltaic cell market, has committed to 5,000 MW of solar power. EF

Source: www.business-standard.com

PUNJAB BAGS BEST PERFORMING STATE AWARD IN RENEWABLE ENERGY SECTOR

Prime Minister Shri Narendra Modi awarded the 'Best Performing State Award' in renewable energy capacity building to Punjab for its innovative and result-oriented solar mission.The award was received by Punjab New and Renewable Energy Minister Shri Bikram Singh Majithia.

During an interaction with investors, Shri Bikram Singh Majithia said that Punjab had achieved much in the renewable energy sector in a short period due to "political will and innovative ideas". He exhorted the entrepreneurs to invest in Punjab as the state was committed to extending every possible support to them to set up their projects.

Pointing to the fact that Punjab had formulated a policy to allot projects within 60 days by using single window project clearance system, he said that as the minister in charge, he himself monitored day-to-day developments, besides involving the district administration to address local issues on the spot. Urging investors to set up biomass power projects, Shri Bikram Singh Majithia said that the state had huge potential of 21 million tonnes of agriculture residue availability. EF

Source: www.maninblue1947.wordpress.com

BURLINGTON, VERMONT NOW RUNS ON 100 PER CENT RENEWABLE ENERGY

Burlington, Vermont, has become first city in the USA to be powered 100 per cent by renewables. Some may say Greenburg, Kansas was the first, but here the comparison is between 800 people in Kansas and 42,000 in Burlington. Reliant on coal a generation ago, Vermont's largest city has slowly revamped its energy portfolio, culminating in the purchase of a hydropower plant.

About 20 per cent of the city's electricity comes from wind power, most of it from a nearby 40 MW project that has operated for four years. The largest share of electricity comes from hydropower—much of it is purchased from plants running in Maine, in addition to the city's latest purchase, a plant on the Winooski River. Other programmes, such as a smart grid project, have helped the city use energy more efficiently. In fact, Burlington uses less energy now than it did in 1989. EF

Source: www.triplepundit.com

DENMARK SETS WORLD RECORD IN WIND ENERGY

In 2014, wind-generated energy made up 39.1 per cent of Denmark's overall electricity consumption, according to the country's Climate and Energy Ministry. The figure makes the country the world's leading nation in wind-based power usage.

Wind energy only contributed to 18.8 per cent of the overall electricity production in Denmark in 2004. But 10 years later, this figure has more than doubled. In January 2014 alone, power from wind made up 61.4 per cent of the Danes' electricity consumption.

"These are incredible figures," said Denmark's Climate and Energy Minister Rasmus Helveg Petersen. "We still plan to put up more wind turbines. We are moving forward and have more targets," he added.

The Energy Minister also said that the country was firmly on track to meet its emissions and renewable energy targets for 2020, where 50 per cent of overall energy consumption has to come from renewable energy sources. Petersen stated that Denmark has "found the key to stop global warming". EF

Source: www.euractiv.com

EAST AFRICAN COUNTRIES MOVE TO ADOPT RENEWABLE ENERGY TECHNOLOGIES

The East African region is leading the continent's charge to embrace renewable energy, including solar, geothermal, and wind power. Kenya, Ethiopia, and Rwanda are investing heavily in these forms of clean energy and moving away from traditional hydropower sources as demand for power continues to surge and economies grow.

Countries lying in the Great Rift Valley, known for their huge geothermal power potential, are investing heavily in resource prospecting, with Kenya leading in both exploration and development. East Africa's geographical location in the tropics also equates to huge solar potential.

The tiny country of Rwanda is leading in solar energy, with an 8.5 MW solar farm that was commissioned in 2014. The $24 million farm in Agahozo has 2,800 solar panels. Though this may seem small compared to American or European standards, it accounts for 7 per cent of the country's installed power capacity.

Ethiopia leads in wind power with its 120 MW Ashegoda wind farm located in the north of the country, which was built in 2013. Ethiopia is already producing another 51 MW through wind generated from two different sites in the south of the capital, Addis Ababa.

In Kenya, private investor Greenmillenia Energy Limited is developing a 40-MW solar plant in the north of the country that is expected to start feeding electricity to the national grid by mid-2015. Greenmillenia has applied for a generation license from Kenya's energy regulator, the Energy Regulatory Commission (ERC). EF

Source: www.renewableenergyworld.com

EGYPT AND RUSSIA AGREE TO BUILD NUCLEAR REACTORS

Egypt and Russia have agreed to build a nuclear power plant together and officials from both countries have signed a memorandum of understanding on the proposed project. Egyptian President Abdel-Fattah el-Sissi announced the plan during a joint press conference in Cairo with Russian President Vladimir Putin.

Within the framework of the visit, Russian state nuclear corporation Rosatom and the Egyptian Ministry of Electricity and Renewable Energy "agreed to launch detailed discussions on the prospective project," Rosatom said in a statement.

Rosatom Overseas and Egyptian Nuclear Power Plants Authority have signed a project development agreement for a nuclear power plant with a desalination facility. The Rosatom Director General Sergey Kirienko said that the agreement provided for the construction of two nuclear power units, with the prospect of a further two. EF

Source: www.world-nuclear-news.org

UNIVERSITY OF CYPRUS LAUNCHES STATE-OF-THE-ART SOLAR PARK

The 'Phaethon' photovoltaic park was recently launched at the University of Cyprus. According to its Rector, Mr Constantinos Christofides, the University of Cyprus aimed to become completely energy self-sufficient through two solar panel parks.

The park, made up by 1,645 solar panels, has the capacity to produce 632,000 kWh of electric energy annually. All the energy produced would go towards reducing the institution's electricity needs.

The University plans to launch the second solar panel park, to be named 'Apollon', which will have a 10 MW capability very soon.

The 'Phaethon' was officially opened by Energy Minister Giorgos Lakkotrypis. The government has also, in cooperation with the International Renewable Energy Agency (IRENA), launched a roadmap for the development of renewable energy sources on the island, in which various scenarios were considered for the 'energy mix' that would work in Cyprus. EF

Source: www.cyprus-mail.com

IRENA REPORT STRESSES OFF-GRID RENEWABLE ENERGY FOR UNIVERSAL ELECTRICITY ACCESS

According to a report by the International Renewable Energy Agency (IRENA), a market-based approach to the deployment of off-grid renewable energy is essential for achieving the goal of universal electricity access. The publication presents the conclusions of the Second International Off-grid Renewable Energy Conference (IOREC 2014) and the results of a survey conducted among more than 400 stakeholders from South and Southeast Asia.

The report, titled *Accelerating Off-grid Renewable Energy*, draws key findings and makes recommendations based on the seven sessions organized during the conference, which centred on market development, socio-economic impacts, financing, and technology.

On policy and regulatory requirements for the development of markets, for standalone renewable energy systems, the report outlines possible measures, including, realistic plans; abiding by the plan with stable and predictable policies, targeted support, subsidy reform, and support to innovation. EF

Source: www.energy-l.iisd.org

500 MW RENEWABLE ENERGY PROJECTS IN AMMAN TO BEGIN OPERATIONS IN 2015

In Amman, several renewable energy projects with a total capacity of 500 MW will be operational in 2015. According to Hamzeh Tarawneh, an official representing the Energy Ministry, the solar and wind projects will generate between 1,500 to 2,000 GW hours. The projects will create 2,000–3,000 jobs.

Jordan is committed to facilitating the implementation of renewable energy projects, has already laid down the legislative basis for such ventures, and has signed several agreements in this regard. Such projects are crucial to face the country's rising energy bill and reduce the National Electric Power Company's (NEPCO) losses. NEPCO's cumulative deficit, as a result of disruptions in Egyptian gas supplies, stood at around 4.5 billion Jordanian Dollars by the end of 2014, according to the Finance Ministry figures. The Jordanian Kingdom is on track to realize its strategy to increase renewables' contribution to the overall energy mix to 10 per cent by the year 2020.

The small-scale installation of renewable energy systems for houses, mosques, and hospitals is also on the rise, and the total capacity of such projects stands at 30 MW at present. EF

Source: www.jordantimes.com

WOLLONGONG COUNCIL BUILDING ACHIEVES AUSTRALIA'S FIRST GREEN STAR PERFORMANCE RATING

A range of building upgrades combined with good management practices has led the Wollongong City Council's Administration Building to become the first building in Australia to achieve a 5 Star Green Star–Performance rating, signifying "Australian Excellence". The rating is also the highest Green Star–Performance rating achieved in Australia till now.

First occupied in June 1987, the 13-storey Administration Building houses 660 Council staff. The Council has, over the past 10 years, introduced a series of measures including upgrades and practices to improve the building's sustainability performance, while replacing ageing equipment to meet modern building compliance standards.

The Council began a project in 2014 to improve the building's operational performance from a sustainability perspective, using the Green Building Council of Australia's Green Star–Performance rating tool.

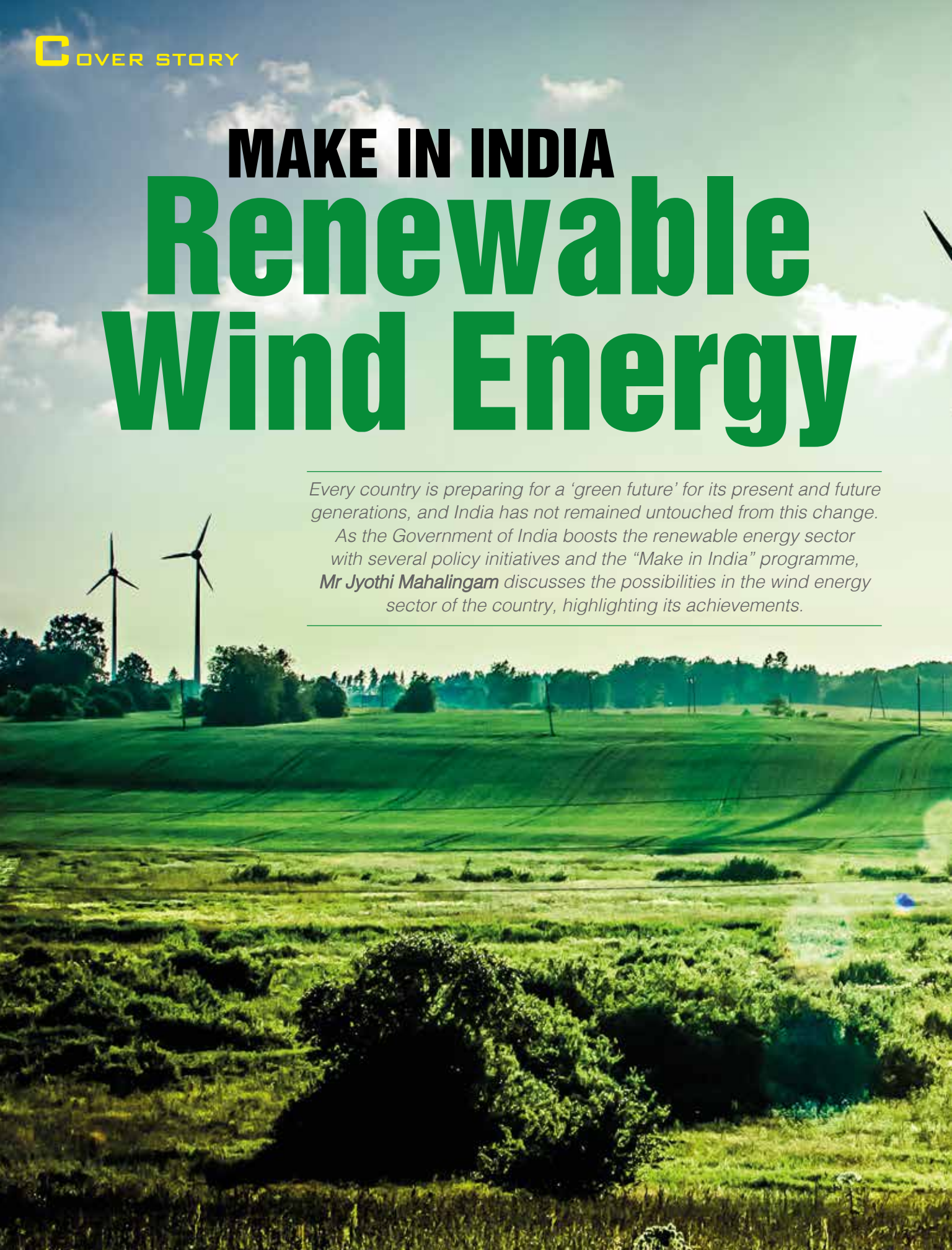
All these efforts have resulted in energy efficiency gains of 55 per cent and water efficiency gains of 85 per cent, based on the Green Star–Performance rating tool's calculations. According to Council estimates, the energy efficiency gains alone in the building are saving $200,000 in electricity costs each year when compared to 2007–08 consumption.

The Council is now developing a Sustainable Building Strategy, which will guide how it improves the operational sustainability of existing buildings, in addition to how new buildings will be designed, constructed, and operated. EF

Source: www.architectureanddesign.com.au

MAKE IN INDIA
Renewable Wind Energy

Every country is preparing for a 'green future' for its present and future generations, and India has not remained untouched from this change. As the Government of India boosts the renewable energy sector with several policy initiatives and the "Make in India" programme, ***Mr Jyothi Mahalingam*** *discusses the possibilities in the wind energy sector of the country, highlighting its achievements.*



Paul Krugman, the Nobel Prize winning economist, in his recent address at the 'Airtel Economic Times Global Business Summit 2015', named India as 'definitely a country of the future'. He recalled the resilience shown by India during the global economic depression in 2008 and praised the country for springing back to growth, despite inflation and the inability to press reforms at a faster pace. He stressed on the fact that the country with a big shortfall in its infrastructure is poised for a promising growth because there is so much to build and so much to fuel its growth.

The growing population and upward rising economy make India starve for electrical energy. According to a report released by the Ministry of New and Renewable Energy (MNRE), as on December 31, 2014, the country had an installed capability to generate a total of 255,681 MW power. India generated nearly 178,342 MW (69.8 per cent) through conventional thermal energy using coal, gas, and oil. By using renewable energy sources such as hydro, solar, wind, biomass, and others, it produced around 72 559 MW (28.4 per cent) and the other 4,700 MW (1.9 per cent) using nuclear energy. *The International Energy Outlook 2013* report, released by Energy Information Administration (EIA), projects that energy demand in India will grow by 2.8 per cent every year. It adds that the country will undergo serious implications if its domestic energy generation is not matched with its energy consuming economic growth.

India, in the process of achieving a higher growth trajectory in the economy, is currently on the cross roads in meeting its growing energy needs. The country, with around 250 GW of installed and grid-connected power generation capability, struggles to cope up with its growing energy requirements. Deficient fuel supply, power production, and inadequate transmission capabilities lead to regular power shortages and blackouts in the country.

The latest BP Energy Outlook 2035 report projects that the energy demand of India will surpass the energy need of China by 2035. It indicates that the energy demand will grow as much as 132 per cent and almost double the aggregate demand by all the non-OECD (Organisation for Economic Co-operation and Development) countries, while its power production will grow slowly at the rate of 112 per cent. The report figures that shortfall in energy generation will make India place an energy import bill of around $300 billion by the year 2030. The country, projected to achieve 6.4 per cent growth in 2015 by the International Monetary Fund (IMF), is currently on the right path to achieve its energy targets.

The 'Make in India' programme aims to make renewable energy power generation affordable in order to supply electric power to villages in remote places, so as to bring a change in the lives of the people, and consequently, in the economic equation of the country.

RENEWABLE ENERGY IN INDIA

The looming climate change poses a formidable challenge to any country trying to achieve economic growth. The task of cutting down the carbon dioxide (CO_2) emissions, while achieving the economic progress, has become a tough responsibility for the governments globally. The Indian Government also faces a similar situation and is taking adequate efforts to address the complex problem with utmost caution.

India, in an effort to expand its power generation portfolio and reduce its CO_2 discharges, continues to promote the aggressive use of renewable energy. The country, i.e., India, which is leading the renewable power generation

and was at fourth position globally in 2012, slipped to ninth position in 2013. The reasons attributed for the slip include, removal of generation-based incentives for wind power, barriers in developing proper infrastructure, poorly managed clean energy certificate trading procedures, and inordinate delays in conducting the second phase auctions of the national solar mission. Even the reintroduction of incentives in August last year could not prevent the slide. At the end of 2014, against the projected target of adding

The 'Make in India' programme aims to make renewable energy power generation affordable in order to supply electric power to villages in remote places, so as to bring a change in the lives of the people, and consequently, in the economic equation of the country.

3,770 MW clean energy, the country could achieve only 2,104.09 MW.

According to a news release from the MNRE, as on December 31, 2014, India had generated a total of 33,791.74 MW of grid-connected renewable energy. Wind power leads the table with 22,465.03 MW, followed by small hydropower with 3,990.83 MW, and solar power with 3,062.68 MW. The other renewable sources such as biomass power and gasification, bagasse co-generation, and waste-to-power accounted for 4,273.20 MW power.

CLEAN ENERGY INVESTMENT IN INDIA

- The clean energy market in India is mostly treated as an asset-based investment. Nearly 94 per cent of the investments received by the sector follow the same pattern.
- Most of the renewable project investments received finance from registered companies, banks, and others.
- The Indian Renewable Energy Development Agency (IREDA) and development banks are considered as an important source for medium-term investment on project finance.
- Most such institutional investors are either from state governments or the joint venture of a state and investing institutions.
- India is projected to receive around $100 billion investment in the forthcoming years before 2020.

The central government has unveiled its ambitious plans to make huge investments in the renewable energy sector to achieve several giga watts

According to a report released by the CRISIL Research, the Indian wind energy sector is mainly dominated by Original Equipment Manufacturing (OEM) companies such as Gamesa, Suzlon, Vestas, Inox, and Regen Powertech.

(GW) of power generation capability in future. The plan entails making renewable power generation affordable to meet the power needs of the people, residing even in remote villages to achieve planned economic growth and above all, to cut down its contribution to global CO_2 emission levels. The latest announcement to upgrade the existing power grids and the reintroduction of the tax incentives to wind power generation are examples of its intentions that are expected to thrust a new boost to the renewable power generation in the years to come.

WIND ENERGY IN INDIA

India made its first attempt to generate electrical energy from wind in 1983–84, during its 6th Five Year Plan. The effort, aimed at commercializing wind energy generation, assisted research in the development of wind energy farms, and offered help to set up the projects. Unlike the USA, Denmark, and other European countries, India entered the wind energy segment very late. However, support from the government and the enactment of favourable policies helped it to become the fifth largest nation with 19,565 MW wind power installed capabilities as on June 2013.

Wind energy, as a large clean energy source, leads nearly 67 per cent of the total renewable energy installed capacity in India. The wind energy sector, which peaked with 3,200 MW new power additions in 2011–12, suffered a setback and added only 1,700 MW new installed capacity in 2012–13. The lull in its growth is attributed to withdrawal of two significant incentives by the government. It is estimated that the wind energy sector had lost almost ₹7,300 crore worth new investments due to withdrawal of the incentives.

As on March 2014, over 21,000 MW wind power generation capacity has been established in India, of which almost 18,000 MW has been installed in the period from 2004 to 2014. India enjoys a Capacity Utilization Factor (CUF) of 18.33 per cent, a better average than Spain with 17 per cent and Germany with 18 per cent. Though the MNRE initially announced its target to achieve 27,300 MW wind power capability by 2017, it doubled the capacity to 40,000 MW and has now unveiled its plans to achieve the revised target.

Favourable Government Policies for Wind Energy Sector

The Government of India introduced Renewable Purchase Obligations (RPOs) in its National Action Plan for Climate Change (NAPCC) in June 2008, to join the attempts to cut down CO_2 emission levels. This necessitated the companies to meet the specific

RPOs either by generating their own renewable power, or buying it from the renewable power generating plants, by entering into a Power Purchase Agreement (PPA). The state governments such as Gujarat, Rajasthan, Tamil Nadu, Andhra Pradesh, Karnataka, Madhya Pradesh, Kerala, and Maharashtra have made it mandatory for the companies to meet 7–9 per cent RPO by the year 2015. The State Electricity Regulatory Companies (SERC) were authorized to issue their own RPOs. They thus introduced 'Open Access' method which enables the energy consumers to buy power from any clean energy producer after paying the State Load Dispatch Charges (SLDC) and Regional Load Dispatch Charges (RLDC) known as wheeling, transmission, and point-of-connection charges.

The MNRE assists the wind power producers with incentives such as long-term loans and tax holidays for 10 years through IREDA. Apart from the energy generators, various companies engaged in the manufacture of wind turbines also avail the exemption from paying excise duties and duty concessions to import electric generators for wind turbines.

The Accelerated Depreciation (AD), allowing 80 per cent depreciation in the wind farm installation investment in the first year, assisted the investors to cut down their taxable income. The scheme, discontinued in April 2012, was again reintroduced in July 2014 to help the proliferation of wind power generation. Similarly, the Generation Based Incentive (GBI) scheme, discontinued from March 2012, was reintroduced in August 2013.

The reintroduction of the AD and the GBI incentives is expected to give wind energy generation a new growth drive. It is estimated that AD was instrumental for almost 65–70 per cent of the total installed capacity of 21,693 MW as on March 2014. The states such as Tamil Nadu, Maharashtra, West Bengal, Andhra Pradesh, and Karnataka, which charge ₹7–7.50 a unit from the industrial establishments, had given a boost to wind power generation with lower power generation costs. The restoration of AD further assisted in achieving the profit margin. Also the 10 year tax holiday under Section 80IA extended to the wind power generating companies, availability of low interest finance from IREDA, and the concessions in custom duty and immunity from excise duty in the import of wind turbine, and other components benefit the wind generation companies. The reintroduced schemes and the extended concessions aim to achieve 15,000 MW wind power generation target before 2017.

With an idea to take the wind power generation to the next level, India constituted the National Offshore Wind Energy Authority (NOWA) supported by the MNRE. The authority came into existence after a detailed study submitted by the Centre for Wind Energy Technology (C-WET) on the potential of ocean wind power generation over 54 locations in India. The NOWA is expected to assist the offshore wind project developers, as a single nodal point and deal with other national agencies for getting quick clearances for a project. The proposed draft plan similar to onshore wind projects proposes to allow similar tax holidays, excise duty exemption, and custom duty concessions for the imports related to offshore wind projects. The proposed draft also contains features to offer feasibility survey and offshore installation vessels required for developing offshore wind projects. The government proposes to lease the seabed location for a fixed number of years, pending transfer of ownership to the government, after the expiry of the leased period.

CHANGED SCENARIO IN INDIAN WIND POWER GENERATION

According a report released by the CRISIL Research, the Indian wind energy sector is mainly dominated by Original Equipment Manufacturing (OEM) companies such as Gamesa, Suzlon, Vestas, Inox, and Regen Powertech. The Small and Medium-sized Enterprises (SMEs) segment, which is engaged

in the wind power sector, lacked the required experience and preferred the OEM model that offered end-to-end solutions such as wind site inspection, buying of land for the project, erecting of wind turbines, maintenance, and operating of wind turbines for power generation. The SMEs in turn made the necessary investments and availed the benefits offered to wind power generation. In the past two years, many Independent Power Producers (IPPs) have entered wind power generation, eroding the total dominance of the sector by the OEMs.

The research anticipates that the present constraints experienced in conventional power generation segment will drive more IPPs towards the renewable energy sector. It expects the participation of the leading players such as the National Thermal Power Corporation (NTPC), China Light & Power, and TATA Power in the wind power generation. The research finds that both the OEM and IPP model will prevail in the wind energy sector in the forthcoming years.

The Renewable Energy Country Attractiveness Index (RECAI) of Ernst & Young, released in September 2014, indicates a turnaround and upward positioning for India. The country, demoted to ninth position in the index in 2013, has at present moved to sixth position. The projected $8 billion grid upgradation programme and reintroduction of incentives in wind energy sector fuelled this push. The planned wind and solar projects, intended to generate 300 GW by the year 2022, are expected to bring in investments worth $33 billion.

'MAKE IN INDIA' PROGRAMME AND WIND ENERGY GENERATION

The 'Make in India' programme, unveiled last year, has plans to augment the wind energy generation. Presently, India with 21.1 GW installed wind energy capability meets nearly 70 per cent of renewable energy generation. The country, as the fifth largest wind energy generator, is set to add 15 GW from onshore wind power by the end of the year 2017.

The programme proposes to set up offshore wind power generation facilities up to 12 nautical miles from the coast from select locations. The specially promoted exclusive economic zones for offshore wind generation will include quicker promotional features to encourage indigenous offshore wind technology.

To assist the growth of wind power generation, the basic custom duty on forged steel rings used in the manufacture of bearings deployed in wind turbines has been reduced from 10 per cent to 5 per cent. Over and above, a 4 per cent exemption is extended on Special Additional Duty (SAD) on parts used in the manufacture of wind power generators. Further, the programme proposes to use the services of foreign investors such as Suzlon, Enercon, Vestas, RRB, and NEG MICON for more Foreign Direct Investment (FDI) in wind energy generation.

NATIONAL WIND MISSION AND OFFSHORE POLICY

The recently unveiled draft policies on inland and offshore wind power generation define the government's intention to give a new thrust to wind power generation. The policies include a well-defined framework for the development of hybrid, small wind, onshore wind, and offshore wind technologies.

- Increased use of locally manufactured wind turbines
- Allocating the required resources without delay for quicker installation
- Finance to improve the wind farm power generation capability by changing and replacing the old turbines
- Cut-down in administrative procedures to enable single window clearance
- Proper long lease agreements for installing offshore wind farms
- Green energy corridor for all renewable energy generation with right type of grid connectivity

Wind Energy is Attractive for FDI

- The Geographic Information System (GIS) technique, used in assessing the wind power potential in India, estimated it close to 3,000 GW in 2011. This observation, validated by Lawrence Berkeley National Laboratory (LBNL) in 2011, surpassed

With an idea to take the wind power generation to the next level, India constituted the National Offshore Wind Energy Authority (NOWA) supported by the MNRE. The authority came into existence after a detailed study submitted by the Centre for Wind Energy Technology (C-WET) on the potential of ocean wind power generation over 54 locations in India.

the most conservative 45 GW estimation made in the 1990s.

- To overcome the present constraints in transferring the produced wind power to the grid, exclusive green transmission corridors are on the way. The integrated National Grid completed in 2014 is expected to play a crucial role in this regard. As a first step, the green transmission corridors are being built in South India, with abundant wind power. Such integration, while assuring the efficient transfer of generated power, will also pave the way for installation of more wind energy farms. Such increase in demand for wind turbines improve the opportunities in the turbine manufacturing sector.
- Presently, the domestic turbine manufacturing has reached a level of 10,000 MW per year. The present demand for 2,000–3,000 MW worth of new turbines is expected to go up due to the release of favourable wind power policies. Also, the recently unveiled national offshore wind generation policy is expected to generate demand for high-end wind turbines in the near future with improved technologies.
- The country is planning to augment its power generation from the present 1,000 TW-h (2014) per annum to 3,400 TW-h per annum in 2032. This proposal includes a minimum of 20 per cent power generation using renewable energy. The wind energy is expected to contribute around 100 GW or more power generation.
- Above all, the Indian wind project cost proved to be very low, compared to other international destinations. According to a recent analysis of project cost prepared by Bloomberg New Energy Finance Council for the World Energy Council, it costs around ₹6.64–₹7.69 crore

for the establishment of a 1-MW wind power generation set up in India. Whereas, it costs ₹8.37 to ₹8.43 crore in China, ₹11.26 crore in the USA, ₹8.37 to ₹8.98 crore in Germany, ₹8.79 to ₹9.35 crore in the UK, ₹8.55 to ₹10.03 crore in Spain, and ₹10.27 crore in Brazil.

Salient Features of FDI India

- It is easy to make 100 per cent directly using automatic route without the need of prior approval either from the government or Reserve Bank of India. This is regulated by the consolidated FDI policy of the Government of India issued from time to time.
- The Indian company that receives the FDI needs to report its receipt within 30 days of getting the FDI.
- In case of issuance of shares for such investments, the Foreign Currency Gross Provisional Return (FC-GPR) is filed within 30 days of the issuance of shares.
- The shares are distributed within 180 days of the receipt of FDI.
- The government supports in transferring and deploying foreign technology in such an investment.
- Special tariff and secured payment mechanisms are kept as financial and fiscal advantages.

Joint Venture (JV)

- Routine and easy approval for JV participation up to 74 per cent of foreign equity.
- Liberalized government approvals for FDI.
- The Foreign Investment Promotion Board (FIPB) approves 100 per cent foreign investment as equity.
- Assistance from the chamber of commerce and industry associations in finding a right partner for JV and make investments.

To assist the growth of wind power generation, the basic custom duty on forged steel rings used in the manufacture of bearings deployed in wind turbines has been reduced from 10 per cent to 5 per cent. Over and above, a 4 per cent exemption is extended on Special Additional Duty (SAD) on parts used in the manufacture of wind power generators.

- Permission to set up a liaison office in India.
- Encouragement to install renewable energy projects on build-own-operate basis.

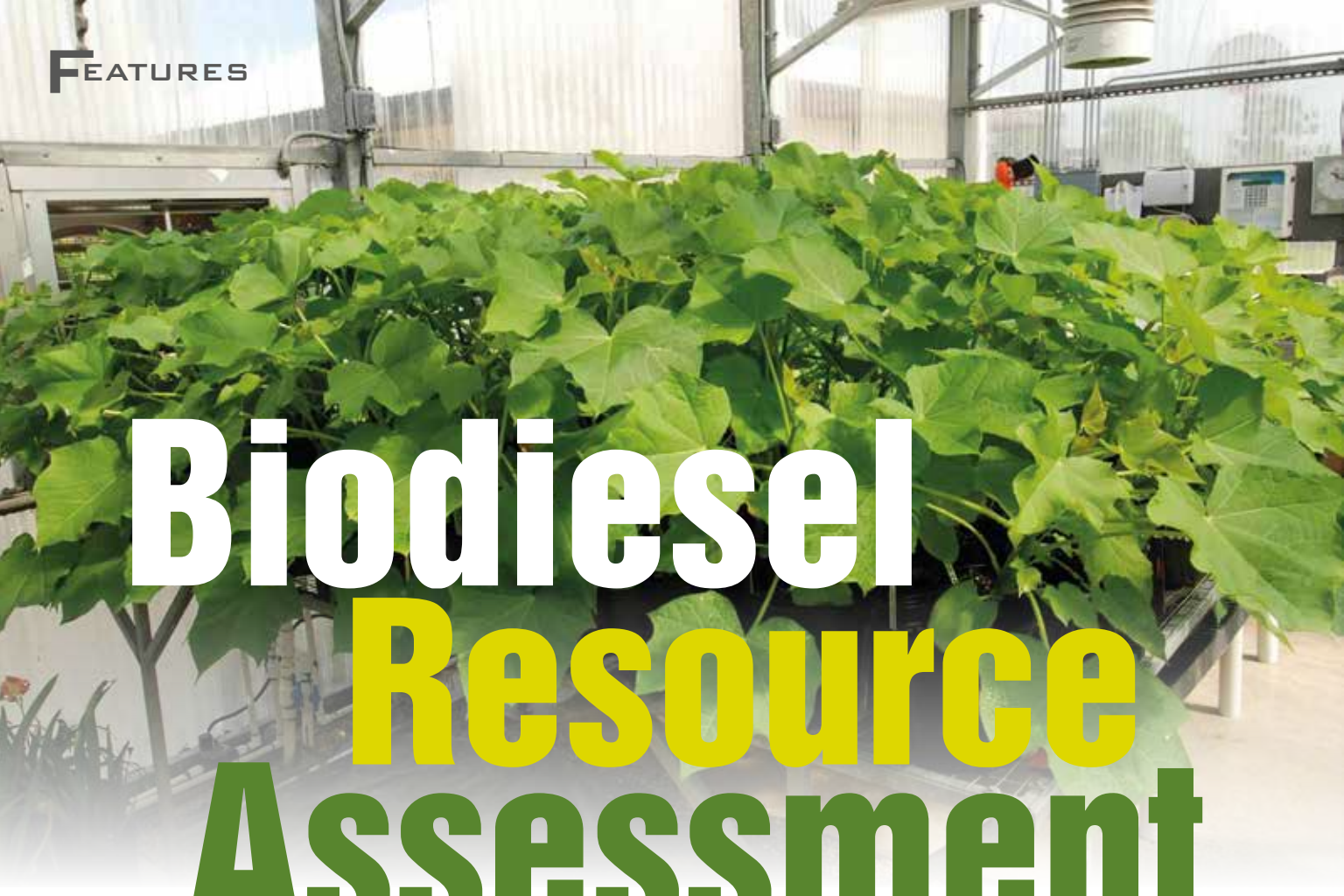
Other Features and Concessions Available

- Exemption from paying income tax for a period of 10 years for the income earned out of selling power under Section 801A.
- Maximum reduction on Value Added Tax from 12.5 per cent to 5.5 per cent.
- Allotment of forest lands on lease for the development of wind energy projects.
- Setting up of C-WAT for R&D, product assessment and testing, certification for a range of wind energy products, and institutional training as required.

CONCLUSION

There is a visible change on the future of clean energy in India. Rapid urbanization, growing population, increased levels of CO_2 emissions, and above all, rapid depletion of other energy resources has prompted the country to turn towards green energy. While achieving its rapid economic growth in all segments, the country is also looking forward to promote sustainable development by investing in the renewable energy sector. Wind energy, as the major contributor to renewable power generation in India, offers tremendous potential for FDI. High levels of investment in manufacture and infrastructure development of wind energy is expected to offer top-level returns for long-term investors. To tap its vast wind energy resources, the government has formulated a number of favourable policies to attract FDI in the wind sector. It is a heartening fact in recent times that a growing number of investors have shown interest to invest in wind energy power generation in India. Though, we have a long way to go in achieving and attracting FDI, like China, the initiated efforts to remove the bottlenecks and offer a most conducive atmosphere for the investors are expected to yield positive results in the forthcoming years. EF

Jyothi Mahalingam *is a professional freelancer living in Chennai, India. He is a contributing writer for TERI publications. He holds a Master's Degree in Journalism and Mass Communication from Madurai Kamraj University and a Post-Graduate Diploma in Marketing Management from Annamalai University. He works as a consultant freelance writer and contributes to leading publications and web portals.*
Email: ajm.content@gmail.com.



Biodiesel Resource Assessment

from Jatropha in Uttar Pradesh

*India is a tropical country and has high forest land with a large range of trees which yield significant quantity of oil seeds. Jatropha is one such variety. **Dr Niraj Kumar** explores the possibility of commercial production of jatropha, especially in Uttar Pradesh, for biodiesel production, which will help achieve the dream of clean and green energy in the country.*

Energy is one of the basic requirements for economic and social growth of a country. Every sector of Indian economy—agriculture, industry, transport, commercial activities, etc.—needs energy. As a result of rapid economic growth of the country, consumption of energy in all forms has been steadily rising during the last decade. Despite a slowing global economy, India stood as fourth largest energy consumer in the world, after the US, China, and Russia, in the year 2011. In 2014, India's growth rate was 5.8 per cent. The International Monetary Fund has reported that India is expected to grow at 6.3 per cent this year and 6.5 per cent in 2016 by when it is likely to cross China's projected growth rate. Currently, the greater portion of India's energy thrust is quenched from fossil resources such as petroleum, coal, and natural gas. The rising oil consumption along with relatively flat domestic production has left the country largely dependent on imports to meet its domestic petroleum demand. Currently, India is among the top 10 oil consuming countries in the world. The country's existing annual crude oil production is at about 32 million tonnes as against the demand of about 110 million tonnes. Over 60 per cent of freight and 80 per cent of passenger traffic is nearly carried by road. Moreover, diesel

and petrol contribute to 98 per cent of energy consumed in the transport sector. Transport sector accounts for about 70 per cent consumption of diesel. In the past, India's oil import bill in terms of value had increased from ₹409,077 crore in 2009–10 to ₹726,386 crore in 2011–12. The overbearing dependence on petroleum products and related economic and environmental problems have created a disquieting situation. These resources (oil, gas, etc.) are under extreme pressure and depleting at a faster rate and making energy and fuels insecure in terms of availability. The known petroleum reserves are not only limited, but also concentrated in certain regions of the world.

Alarming situation of energy security in world calls for an immediate search of new sources of fuel, which must be renewable, locally available, and environmentally benign. Out of the many fuels put forth as being alternatives to diesel, biodiesel is considered as one of the best alternatives. Biodiesel can be defined as mono-alkyl esters of long-chain fatty acids derived from vegetable oils or animal fats which conform to the American Society for Testing and Materials specification for use in diesel engine. Biodiesel offers potential advantages over diesel, i.e., reduction in most of the tail-pipe gases, better lubricity, renewability, free from sulphur and aromatics, and above all, derived from locally available feedstock. Throughout the world, biodiesel is produced from renewable biological resources such as vegetable oils and animal fats, depending on the availability. The feedstock of biodiesel can be characterized as follows:

- **First generation feedstock**: Edible oils
- **Second generation feedstock**: Non-edible
- **Third generation feedstock**: Microalgae

BIOFUELS VERSUS FOOD SECURITY

Biofuels versus food is the dilemma faced by the world as it involves the risk of diverting farmland for biofuels production to the extent of food scarcity. Previous assessments on the basis of low Energy Return on Investment (EROI) of biofuels in comparison to fossil fuels have revealed that demand on land, water, and labour per net gigajoule (GJ) delivered will extensively increase. Further, diverting of land utilization for biodiesel production will have a significant impact on food crops and entail trade-offs across multiple dimensions. Many have argued that the stiffer rise in prices of basic food staples in 2008 was created as more farmers throughout the world opted for biofuels crops than food crops. However, some studies argue in favour of cultivation of biofuels, especially on wasteland to make harmony with food crops production. Others suggested for small-scale production of non-edible oil through contract farming, as it will create employment and income opportunities for local populations.

In India, switching to edible oil for production of biodiesel is out of choice because the demand of edible oil is much higher than its domestic production. So, the obvious choice is non-edible oil. India is a tropical country and has high forest land with a large range of trees which yield significant quantity of oil seeds such as *neem* (*Azadirachta indica*), *mahua* (*Madhuca indica*), *karanja* (*P. pinnata*), *sal* (*Shorea robusta*), *kusum* (*Schleichera oleosa*), and *ratanjyot* (*Jatropha curcas*) and their production is about 100,000, 180,000, 55,000, 180,000, 25,000, and 15,000 tonnes per annum, respectively. Many previous studies have reported the possibility of commercial production of jatropha, *karanja*, and *mahua* for biodiesel.

OVERVIEW OF UTTAR PRADESH LAND RESOURCES

Uttar Pradesh is located between 23°52′ to 31°28′ N latitudes and 77°06′ to 84°37′ E longitudes with an area of 23.8 M ha (238,566 km^2). The climate of the state is, in general, subtropical, continental, with mild and dry winters and hot summers. It is the fourth largest state in India. The economic growth of Uttar Pradesh virtually relies on agriculture sector. A majority of the population, especially below the poverty line, depends largely on cultivation for their livelihood. Uttar Pradesh has a significant share in domestic agriculture products of the country, which amounted to 13 per cent in 1999–2000. The state has immense significance in the production of sugarcane (40 per cent of country's production), food grain (20 per cent), and wheat (33 per cent). On the basis of soil and rainfall pattern, the state is divided into eight agro-eco regions namely: Western, Mid-western, Southwestern semi-arid, Central plain, Northeastern plain, Eastern plain, Vindhya, and Bundelkhand. Among all regions, minimum rainfall of 780 mm is generally recorded in Bundelkhand region. About 70 per cent of the available land (16.8 M ha) is dedicated to the agriculture purpose. Figure 1 shows the details of the land use pattern.

Biodiesel offers potential advantages over diesel, i.e., reduction in most of the tail-pipe gases, better lubricity, renewability, free from sulphur and aromatics, and above all, derived from locally available feedstock. Throughout the world, biodiesel is produced from renewable biological resources such as vegetable oils and animal fats, depending on the availability.

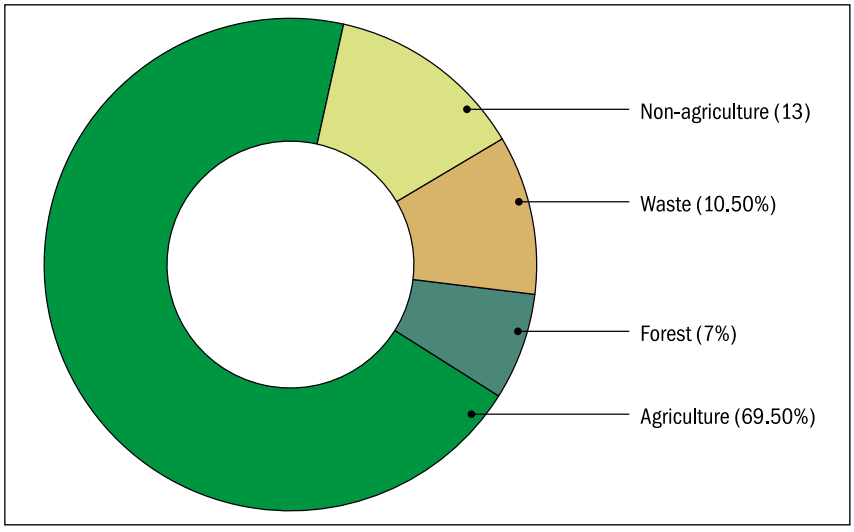


Figure 1: Land use pattern in Uttar Pradesh

During the course of time, the soils are degraded by water erosion, covering 12,884 thousand ha (54 per cent of Total Geographical Area [TGA] of the state). Most of the districts in the state are affected by soil erosion. The highly affected districts are: Lakhimpur Kheri (468 thousand ha), Sondhara (437 thousand ha), Jhansi (426 thousand ha), Lalitpur (416 thousand ha), Baharaich (406 thousand ha), and Allahabad (381 thousand ha). Banda, Agra, Bijnor, Hamirpur, Mirzapur, Sultanpur, and Saharanpur are also prone to erosion and each of them has share of more than 300 thousand ha area as shown in Table 1. However, the most unaffected districts are Gautam Buddha Nagar and Bareilly.

About 22 thousand ha is affected by saline soils including Ballia (six thousand ha), Unnao (five thousand ha), and Lucknow (five thousand ha). While, about 1,320 thousand ha (about 6 per cent of TGA) is covered by sodic soils. Sodicity is also a prominent problem in the state; it is mostly encountered in Jaunpur (125 thousand ha), Mainpuri (120 thousand ha), Azamgarh (100 thousand ha), Pratapgarh (94 thousand ha), and Sultanpur (85 thousand ha). Other affected districts are Etah, Ghazipur, Auraiya, and Kannauj. Further, eastern Uttar Pradesh has the highest percentage of agricultural landholdings below one hectare, which classifies a farmer as marginal.

Ironically, the huge wasteland area of about 2.53 million ha cannot contribute to the economic development of the state. In fact, this area is 15 per cent more than the cultivated land in Punjab and has huge potential for the development of poor people of the state. It is worth noting that there was no change in the land use pattern during last two decades, except mere 1 per cent change in unutilized area. Hence, it is imperative to look into the possibilities of exploring new avenues to transpire the unutilized land into productive land.

SOLUTION

As the above discussion attests, currently India is facing crisis of environmental degradation from the use of fossil fuel, drainage of large amounts of foreign exchange in terms of petroleum import, and utilization of wasteland for the growth of the poor community. In the face of stated problems, one of the options for efficient use of wasteland is to cultivate jatropha in infertile land such as arid, semi-arid, and saline land. This will also be helpful in meeting the demand of renewable fuel in the form of biodiesel and reduce the environmental degradation caused by fossil fuel. This crop not only can meet the oil demand for biodiesel production, but can also green the wastelands in drought prone or waste areas without sacrificing the food and fodder security and improve the livelihoods of the rural poor. Further, it can meet the rural agricultural sector demand of diesel for watering purpose due to interrupted electricity supply and lack of canal network. The significance of jatropha as technically and commercially viable alternative to fossil-diesel has led to intense research in the field.

JATROPHA CURCAS: PROMISING FEEDSTOCK FOR BIODIESEL

Jatropha curcas is claimed to be a non-edible, draught resistant shrub or tree, mainly cultivated in Central and South America, Southeast Asia, India, and Africa. Within India, it is mainly cultivated in central and western parts. Jatropha, which belongs to the *Euphorbiaceae* family, consists of around 800 species. It can thrive in a number of climatic zones and in different soil conditions. Jatropha plants start yielding from the second year of planting, but in limited quantity. However, yield depends on a number of factors including water, soil conditions, altitude, sunlight, and temperature. With proper cultivation, production of 4–5 kg per tree can be achieved from the fifth year onwards. In addition, the productive life of the jatropha is estimated up to 40–50 years from the day of plantation. If properly managed, production of 5 metric tonne (mt) seed can be harvested from 1 ha of land. The fruits are 2.5 cm long, ovoid, black, and 2–3 halved. It has nearly 422 fruits per kg available after decortications of jatropha seed for oil extraction. The oil content of jatropha seed ranges from 30 per cent to 40 per cent by weight and the kernel itself ranges from 45 per cent to 60 per cent. Jatropha

Table 1: Degraded and wasteland statistics of Uttar Pradesh (Area in '000 ha)

Districts (70)	Degraded and wastelands classes*											Others**	Total
	1	2	7	8	13	14	16	17	18	19	Total no. of classes		
Agra	333	0	0	0	2	1	0	0	0	0	336	63	399
Aligarh	206	0	0	0	4	12	0	0	0	4	226	145	371
Allahabad	381	0	0	0	19	16	0	0	0	8	424	115	539
Ambedkar Nagar	194	0	0	0	0	24	0	0	0	3	221	14	235
Auraiya	17	0	0	0	37	18	0	0	0	0	72	132	204
Azamgarh	244	0	0	1	32	68	0	0	0	11	356	64	420
Baghpat	23	0	0	0	0	0	0	0	0	0	23	113	136
Baharaich	406	0	0	0	0	0	0	0	0	10	416	153	569
Ballia	236	0	0	6	5	6	0	0	0	3	256	40	296
Balrampur	109	1	0	0	0	0	0	0	0	1	111	178	289
Banda	346	3	0	0	0	0	0	0	0	0	349	89	438
Bara Banki	111	0	0	0	6	2	0	0	0	5	124	253	377
Bareilly	2	0	0	0	0	0	0	0	0	2	4	401	405
Basti	291	0	0	0	0	1	0	0	0	3	295	7	302
Bijnor	308	13	0	0	0	0	0	0	0	0	321	130	451
Budaun	134	0	0	0	2	0	0	0	0	1	137	373	510
Bulandshahr	73	0	0	0	0	0	0	0	0	0	73	293	366
Chandauli	130	66	0	0	7	13	0	0	0	2	218	36	254
Chitrakut	173	68	0	0	0	0	0	0	0	1	242	75	317
Deoria	208	0	0	1	0	1	0	0	0	1	211	42	253
Etah	146	0	0	0	55	24	0	0	0	8	233	208	441
Etawah	73	0	0	0	30	18	0	0	0	0	121	105	226
Faizabad	190	0	0	0	2	5	0	0	0	3	200	74	274
Farrukhabad	153	0	0	0	0	14	0	0	0	0	167	58	225
Fatehpur	282	0	0	0	0	1	0	0	0	3	286	125	411
Firozabad	99	0	0	0	36	7	0	0	0	0	142	92	234
Gautam Buddha Nagar	2	0	0	0	0	0	0	0	0	1	3	122	125
Ghaziabad	30	0	0	0	0	0	0	0	0	3	33	160	193
Ghazipur	201	0	0	0	21	44	0	0	0	6	272	64	336
Gonda	276	0	0	0	0	0	0	0	0	3	279	159	438
Gorakhpur	210	6	0	0	2	10	0	0	0	1	229	100	329
Hamirpur	326	0	0	0	1	0	0	0	0	0	327	101	428
Hardoi	94	0	0	0	0	0	0	0	0	10	104	485	589
Hathras	126	0	0	0	6	13	0	0	0	1	146	29	175
Jalaun	272	0	0	0	0	0	0	0	0	0	272	180	452
Jaunpur	160	0	0	0	56	69	0	0	0	9	294	108	402
Jhansi	426	0	0	0	0	0	0	0	0	0	426	72	498
Jyotiba Phule Nagar	92	0	0	0	1	1	0	0	0	0	94	135	229
Kabirnagar	131	0	0	0	0	2	0	0	0	2	135	8	143
Kannauj	74	0	0	0	36	17	0	0	0	0	127	71	198
Kanpur Dehat	94	0	0	0	31	2	0	0	0	0	127	184	311
Kanpur Nagar	74	0	0	0	10	1	0	0	0	0	85	214	299
Kaushambi	150	0	0	0	0	0	0	0	0	0	150	32	182
Kushinagar	264	1	0	0	0	0	0	0	0	1	266	23	289
Lakhimpur Kheri	36	0	0	0	0	0	0	0	23	491	269	760	432
Lalitpur	367	49	0	0	0	0	0	0	1	0	417	84	501
Lucknow	66	14	5	0	17	20	2	0	0	1	125	126	251
Maharajganj	229	0	0	0	0	0	0	0	0	1	230	63	293
Mainpuri	105	0	0	0	57	63	0	0	0	0	225	49	274

Classes*: 1 Exclusively water erosion (>10 tonnes/ha/year); 2 Water erosion under open forest; 7 Exclusively saline soils; 8 Eroded saline soils; 13 Exclusively sodic soils; 14 Eroded sodic soils; 16 Sodic soils under open forest; 17 Eroded sodic soils under open forest; 18 Mining/Industrial waste; 19 Waterlogged area (Permanent)

Others**: Normal agricultural lands, water bodies, rivers, lakes, habitats, etc. (based on the limited reconnaissance survey)

prevents erosion, and responds better to organic manure than chemical fertilizers. In addition, presence of some toxic components renders this oil unsuitable for use in cooking, which makes it a obvious choice for fuel production. It is possible to utilize *Jatropha curcas* not only for extraction of biodiesel, but also for complete utilization of its by-products such as oil cake, glycerine, and seed husk.

Diesel engine test with Jatropha

Jatropha oil can be used in diesel either directly as straight vegetable oil or as biodiesel. Vegetable oils have high molecular weight in the range of 600–900 Dalton, almost three times higher than diesel and contain about 10 per cent inbuilt oxygen, which makes some of the properties such as viscosity, calorific value, and density inferior as compared to those of diesel. In view of the stated hurdles, direct use of vegetable oils encountered problems such as pumping, atomization, gumming, injector fouling, piston ring sticking, and contamination of lubricating oil in the long-run operation. Hence, it is essential to reduce the viscosity for better combustion of the vegetable oils by using methods such as blending with diesel, preheating, micro-emulsification, thermal cracking, and transesterification. Transesterification is primarily used to convert vegetable oil to a form that can be used in diesel engines and is called biodiesel.

In recent times, many experiments were carried out in order to evaluate the performance of jatropha not only as Straight Vegetable Oil (SVO), but also as biodiesel. It was shown that preheating of jatropha to 100°C brought down the viscosity in close range to diesel. Based on experimental data related to Brake Specific Fuel Consumption (BSFC) and Brake Thermal Efficiency (BTE), smoke opacity and optimum fuel injection pressure (200 bar) were found same for both fuels. Jatropha blended with diesel resulted in increase in BTE, Brake Power (BP), and reduction of Specific Fuel Consumption (SFC). While experimenting with neat jatropha biodiesel and different blends, the results show that BTE of jatropha methyl ester and its blends with diesel was lower than diesel, while BSFC and brake specific energy consumption were found to be higher. Moreover, all tail-pipe emissions except NO_x were substantially reduced. It was also shown that biodiesel can actually reduce wear of critical component of diesel engine due to its inherent lubricity. Further, it was demonstrated that for successfully utilizing neat jatropha oil in diesel engines, different parameters such as swirl, injector opening pressure, injection rate, and injection timing have to be optimized.

Jatropha oil can be used in diesel either directly as straight vegetable oil or as biodiesel. Vegetable oils have high molecular weight in the range of 600–900 Dalton, almost three times higher than diesel and contain about 10 per cent inbuilt oxygen, which makes some of the properties such as viscosity, calorific value, and density inferior as compared to those of diesel.

BIODIESEL POLICIES

The aim of the policy is to bring accelerated development and promotion of the cultivation, production, and use of biofuels to increasingly substitute petrol and diesel for transport and can be used in stationary and other applications, while contributing to energy security,

climate change mitigation, and also contributing towards sustainable development. The proposed programme of the Government of India has been divided into two phases. The first phase consists of demonstration phase, which includes plantation in 0.4 million ha land covering 26 states. The second phase aims for self-sustaining production of biodiesel, which will help in achieving the 20 per cent blending of biodiesel with diesel by the year 2017. Public sector oil companies in India have offered an assured buy back price for biodiesel at ₹25 per litre. The Ministry of Rural Development (MoRD) has prepared a Detailed Project Report (DPR) on the National Mission on biodiesel. The MoRD has also identified various end uses for non-edible SVO such as, transport application and power generation on a decentralized basis apart from conversion of SVO to biodiesel. National Bank of Agriculture and Rural Development (NABARD), Indian Renewable Energy Development Agency (IREDA), Small Industries Development Bank of India (SIDBI), and other financing agencies as well as commercial banks would be actively involved in providing finance in farming and utilization of biofuels.

Because of the very high saponification value, jatropha oil is being extensively used for making soaps in India and other countries. It is also being used to make varnish in China, as illuminating fuel in villages. It is used for spinning in England. Jatropha oil also finds application in treatment for skin disease and rheumatism.

OTHER USES OF *JATROPHA CURCAS*

Jatropha curcas is a multipurpose plant; its use is not limited to oil production. Some of the species found in India are grown in gardens for their ornamental foliage and flowers. Jatropha can be well adopted as hedge around agricultural fields by virtue of easy propagation, rapid growth, and is not browsed by goats or cattle. In near future, it may be possible to convert jatropha into edible oil as some innovative projects are currently under developed. Because of the very high saponification value, jatropha oil is being extensively used for making soaps in India and other countries. It is also being used to make varnish in China, as illuminating fuel in villages. It is used for spinning in England. Jatropha oil also finds application in treatment for skin disease and rheumatism. It is reported to be abortificient and also efficacious in dropsy, sciatica, and paralysis. The presence of alkaloid known as "jatrophina" in jatropha renders it anti-cancerous properties. The leaf's juice is helpful for treating piles. The roots are believed to act as antidote for snakebite. The oil is also used for hair growth. The bark of jatropha yields a dark blue dye which is used in a number of applications such as colouring cloth, finishing nets and lines in Philippines. Jatropha oil cake contains a rich amount of nitrogen, phosphorous, and potassium; hence, it can be used as organic manure for enrichment of soil. The oil cake is rich in protein but its toxicity prevents its use as feed to cattle. However, with suitable research it could be possible to transform non-edible cake into a feed for cattle and poultry in mass scale. Jatropha also finds its application as insecticide/pesticide. Moreover, simple and cost-effective technology of growing jatropha in variety of land, with or without irrigation, makes it a very attractive agro-forestry crop.

CONCLUSIONS

Jatropha oil has enormous potential as biodiesel but it also finds a huge application in the soap and detergent industry. To meet the demand of different sectors, India has to import jatropha oil. As per the Solvent Extractors' Association, India imported 1,095,466 tonnes vegetable oils during January 2015 as compared to 905,814 tonnes in January 2014, consisting of 1,082,670 tonnes of edible oils and 12,796 tonnes of non-edible oils. Plantation of jatropha in degraded land and on hedges of the field not only will bring prosperity amongst farmers, but also improve environmental conditions. While using as biodiesel, jatropha oil will reduce the burden on foreign exchange by reducing the import of crude petroleum. Also, it will help in reducing the adverse effects of exhaust of petroleum diesel, as it is less polluting. Hence, more emphasis must be given on plantation of jatropha on wasteland and also training must be provided to farmers so that they can learn and enjoy the benefit of jatropha cultivation and biodiesel production. EF

***Dr Niraj Kumar**, Assistant Professor (Sr. scale), Moradabad Institute of Technology, Moradabad, UP, India, Email: kniraj@yahoo.com*

PPP Models for Energy Management in SMEs

*While discussing the current state of Indian manufacturing units, especially Small and Medium Enterprises (SMEs), and exploring the current business policies in the country, **Mr Sapan Thapar** suggests that the government should promote public–private partnership model for the success of 'Make in India' campaign.*

Nowadays, 'Made in India' has been replaced by 'Made in China' mark on a number of items we use/consume on a daily basis. This has become as ubiquitous as the 'Sun' in the day or the 'Moon' in the night. We hardly have an Indian manufacturer to compete with companies on a global scale. There are several reasons for our manufacturing units to reach this sad state of affairs.

The Small and Medium Enterprises (SMEs) sector, over 26 million in number, provides employment to 60 million people in India, with a contribution of 9 per cent in Gross Domestic Product (GDP) and 40 per cent share in our exports. These units are besieged with high cost of production and poor quality standards due to use of inefficient systems/processes and obsolete technologies. Within the overall production costs, the share of energy (including electricity) for these units in many cases is as high as 30 per cent.

With increase in the cost of energy, the business viability of these units has decreased tremendously, leading to closure of several units. This has resulted in a marked orientation of the economy from manufacturing to service sector (GDP profile) over the last decade, with the share of manufacturing tipping to 15 per cent.

Looking into the human resource intensity of our country, this shift is not appropriate as it shall exacerbate existing high levels of unemployment among the masses.

PROBLEMS FACED BY SMEs

With over 96 per cent un-registered units, these SME units are typically run by family entrepreneurs, having limited knowledge in terms of quality, standards, and technologies. There is also a dearth of technology providers at the cluster level in the form of Energy Service Companies (ESCOs), suppliers, and system integrators. ESCOs are generic in nature and lack the analytical skills to undertake energy audit for a particular set of industry/technology. Moreover, the SME units lack the financial acumen to undertake modernization of their activities. Further, there are competing business needs of limited resources, making energy saving projects a low priority for the management.

BANKABILITY OF ENERGY PROJECTS

Both the SME units and ESCOs do not enjoy a strong credit profile, resulting in difficulty in borrowing funds from banks and Financial Institutions (FIs). Being small in size, the transaction and processing charges are high (on a project basis), making them unattractive. Further, due to technology oriented nuances of the Energy, Efficiency, and Conservation (EEC) projects, the personnel from banks and FIs have limitations in terms of credit appraisal of 'Energy Saving Projects'. Moreover, it is difficult to estimate energy savings due to lack of standardized and accepted Monitoring & Verification (M&V) protocols. The EEC projects also require customized financial products to meet their specific needs.

EXISTING POLICIES

Through its various agencies, the government has been working hard to make the sector competitive. However, the impact has been much below the desired outcome. This is due to the fact that the schemes developed on the concept of 'one size fits all' cannot meet the diverse requirements of SME units. Besides, the roll-out is limited to a few units in the form of pilot projects (kind of preliminary energy audits) which cannot be easily scaled-up. Further, the financial instruments developed to source funds at competitive terms are difficult to leverage as over 96 per cent of SMEs are not registered, therefore, making them out of the ambit of our financial system. Moreover, due to small size of EEC projects and technological nuances involved, banks and FIs are not active to support the sector.

As such, a need is felt to make the EEC projects attractive to different stakeholders, be it unit owners, bankers, ESCO's, employees, and others. As in many other areas, the government and private sector can work hand-in-hand and complement each other towards the betterment of the sector, making the Indian SMEs competitive with their global peers. It may be further noted that India has about 200 energy intensive clusters, providing a good potential of energy savings of the order of 15–20 per cent, which shall help in reducing the energy intensity of our economy in line with global commitments.

The government has recently launched the 'Make in India' mission with an objective to improve the competency of Indian manufacturing sector, making it competitive with global companies. The small and medium enterprises can benefit out of this initiative and improve their market profile/share.

PPP BUSINESS MODEL

In this regard, Public–Private Partnership (PPP) model can provide a good recipe for success, wherein, the government frames conducive policies and regulations with an objective to leverage technology and financing from the much-capable private-sector. The overall rationale for using PPP business model(s) is towards development of policy and regulatory instruments to overcome the initial barriers so as to leverage commercial financing for scaling-up investments.

It may be worth to mention here that sectors like renewable energy have witnessed phenomenal growth on the shoulders of PPP by way of investor friendly policies and active participation by private entrepreneurs.

In this regard, some pragmatic PPP models have been framed and are presented below. These can be deployed based on the local needs of the unit/cluster/zone/state.

MODEL 1: PLUG & PLAY INDUSTRIAL PARKS

The government can earmark contiguous land parcels for a cluster of SME units manufacturing similar, or, related projects (including ancillary units). This can be a kind of plug and play mode, wherein, entrepreneurs can come and set up industrial units with the ecosystem (infrastructure support in the form of energy/power, water, land, banking, pollution control systems, etc.) facilitated by the government. This shall be akin to Special Economic Zones (SEZ), which were planned a decade back, but could not prosper due to issues pertaining to land acquisition. This issue can be taken care of by procuring non-arable land/wasteland and with some defined upper area limits.

Benefits in the form of income-tax holiday and accelerated depreciation on assets may be provided to make

The Small and Medium Enterprises (SMEs) sector, over 26 million in number, provides employment to 60 million people in India, with a contribution of 9 per cent in Gross Domestic Product (GDP) and 40 per cent share in our exports.

the business financially viable. Further, forward linkages may be established to facilitate deeper penetration in markets. Cues can also be taken from the 'Solar Energy Parks scheme' recently announced by the government.

With uniformity in scale and production and utilization of similar systems/machinery, energy efficiency activities measures can be easily identified and rolled out across the cluster by sector specific ESCOs. As the units would be new, baseline values (Specific Energy Consumption–SEC) can be easily determined for ease of energy accounting. M&V protocols can be defined and standardized across a cluster. The systematic arrangement of units in an industrial park shall facilitate ease of M&V towards sharing of savings/benefits accrued on account of EEC measures. The physical proximity of the units shall further enable sharing of best practices and ideas.

With a standardized M&V systems, it shall be easy for the industries to portray their green quotient and the same can be highlighted by issuance of Green Tags (similar to ISO, AGMARK, and Bureau of Energy Efficiency—BEE star labelling). This shall further improve the acceptance of their products/services both domestically and abroad.

With the units being energy efficient in nature, they shall be construed to be part of Green Supply Chain of bigger industries as SME caters (as suppliers/ancillaries) to large industrial units. For the same, material and experiential support may be provided by the large industries under their CSR budgets.

The funding of EEC activities can be arranged from existing Carbon Funds (Programmatic CDM mode). BEE can also utilize this opportunity to establish SEC standards across a cluster (particular domain of industry) and issue energy saving certificates (ECerts) for trading in the market.

MODEL 2: CENTRE OF EXCELLENCE (CoE)

As enunciated above, the availability of technology and its integrators has been one of the deterring factors in promoting energy conservation across SME units. This is further hampered by the limited outreach of the units with respect to technology providers, field practitioners/experts and ESCO companies.

In this respect, it is proposed to create regional Centres of Excellence (CoE) focusing on a particular cluster/ industrial sector. Government can provide funds for the establishment of such centres, wherein, an ecosystem for development of energy efficiency technologies shall be inculcated. There is a precedent in the city of Munich (in Germany) where, a similar centre has been established to cater to the needs of the industries and other energy consumers.

These CoE shall provide a 'one-stop-shop' for all business needs of an entrepreneur. The centre shall work towards understanding the issues afflicting the sector and design and develop appropriate/suitable energy efficient technologies for a particular cluster. The centre shall disseminate technology among the firms located within a cluster in hub and spoke format/model.

As there are issues with respect to Intellectual Property Rights (IPR), the centre shall enable sharing, or, transfer of technology from other hubs (both within and outside the country) on defined business models and cost structures. The CoE can empanel experts from industries as well as academia to propel its research activities.

The funding for development of such centres can be arranged from the 'National Clean Energy Fund' (NCEF),

The government can earmark contiguous land parcels for a cluster of SME units manufacturing similar, or, related projects (including ancillary units). This can be a kind of plug and play mode, wherein, entrepreneurs can come and set up industrial units with the ecosystem (infrastructure support in the form of energy/ power, water, land, banking, pollution control systems, etc.) facilitated by the government.

which has a mandate to support such research and development activities. Any profits made out of the operations of a centre can be ploughed back for further research. Provision of similar kind of centres also exists under the National Mission on Strategic Knowledge.

MODEL 3: INCUBATION LABS

If we analyse the development of renewable energy sector in India, a substantial share has been made by private players, many of them first generation entrepreneurs. These young engineering graduates levered on funding support by Private Equity (PE) to set up projects under Special Purpose Vehicle (SPV) mode. A similar business model can be developed for the EEC sector also.

In this case, BEE certified energy managers and auditors can act as 'Clean Energy Entrepreneurs'. They can take up the challenge to undertake EEC measures in SME units under SPV business models.

The equity in the form of seed capital can be sourced from the respective State Developmental Agencies (SDAs), which in turn can tap the State Energy Conservation Fund (accumulated by levying of Green Cess). This money can be given at a nominal Return on Investment (RoI). The equity from the government agency will facilitate raising debt from banks/FIs for meeting the remaining funding needs of the SPV company.

With a firm background in energy, these 'Clean Energy Entrepreneurs' shall be able to prove the business viability of EEC measures to the unit owner, making a smooth take-off of their ventures. The company, as when it gets developed, can unlock its potential by attracting PE & VC (Venture Capital) funds. Government equity in the form

of initial seed money can be recycled/ rotated back to similar ventures.

Recently, Bombay Stock Exchange (BSE) has launched SME bourse with easier listing procedures for SME units. These SPVs, being SMEs in themselves, can take advantage and list at the SME bourse to tap market/public funds and attract higher valuation from large investor groups.

It may be noted that the Centre for Innovation, Incubation and Entrepreneurship (CIIE) at IIM Ahmedabad provides an ecosystem for supporting clean energy ventures.

MODEL 4: ENERGY SERVICES BY EPCO

Of all the expenditure items, the share of energy is particularly high for SME units and has a profound impact on the overall competitiveness. This is compounded by the fact that the energy (including electricity) for SME (comes under industrial category) is priced much higher than other class of consumers. Further, the availability of energy is itself an issue due to high levels of energy deficit.

These CoE shall provide a 'one-stop-shop' for all business needs of an entrepreneur. The centre shall work towards understanding the issues afflicting the sector and design and develop appropriate/suitable energy efficient technologies for a particular cluster.

As such, there can be energy providing companies (EPCOs) who can meet the entire energy needs of a SME unit (kind of outsourcing of services). With the government thrust on harnessing renewable energy sources, EPCOs can tap on the available renewable energy resources to provide energy to the SME units located in a cluster.

In this model, government can provide land on subsidized rentals to EPCOs, besides offering the RE equipment at discounted rates to improve the project viability. With the cost of generation from renewable sources (like solar) significantly lower than the alternate fuels (like diesel generator sets), and in many cases competitive with industrial power tariffs, the off-take of renewable energy by SME units would be smooth. Many of the RE systems provide the twin output of heat and electricity (Combined Heat & Power-CHP), which shall help to meet the entire energy needs of the unit.

Under the Electricity Act, there is a concept of 'Distribution Franchisee', wherein, power can be sold in a circle to a particular class of consumers. Gujarat rooftop solar scheme can be analysed

for understanding best practices in terms of business model, contractual agreements, and policy support from the government. It may be worth mentioning that many of the cellular phone companies have outsourced energy services for maintaining their cell phone towers.

The EPCOs should be allowed to receive Renewable Energy Certificates (REC) for the amount of clean power generation, besides getting ECerts on account of lowering of energy intensity of a particular industry.

THE WAY FORWARD

The proposed PPP models can be developed and adopted in different permutations and configurations, leading to accelerated deployment of EEC activities across the SME sector.

SEZ/Industrial parks can come up in the cities being planned along the upcoming dedicated railway fright corridors. To complement the sustainability mantra, these parks can also be made an intrinsic feature of the proposed smart cities.

Technology centric CoEs can be set up in energy intensive clusters (regions) as identified by BEE. Out of the 200-odd clusters, this activity can initially be targeted in 25 clusters (where diagnostic audits/studies have been conducted by BEE) and rolled out further on the basis of the experience and lessons learnt.

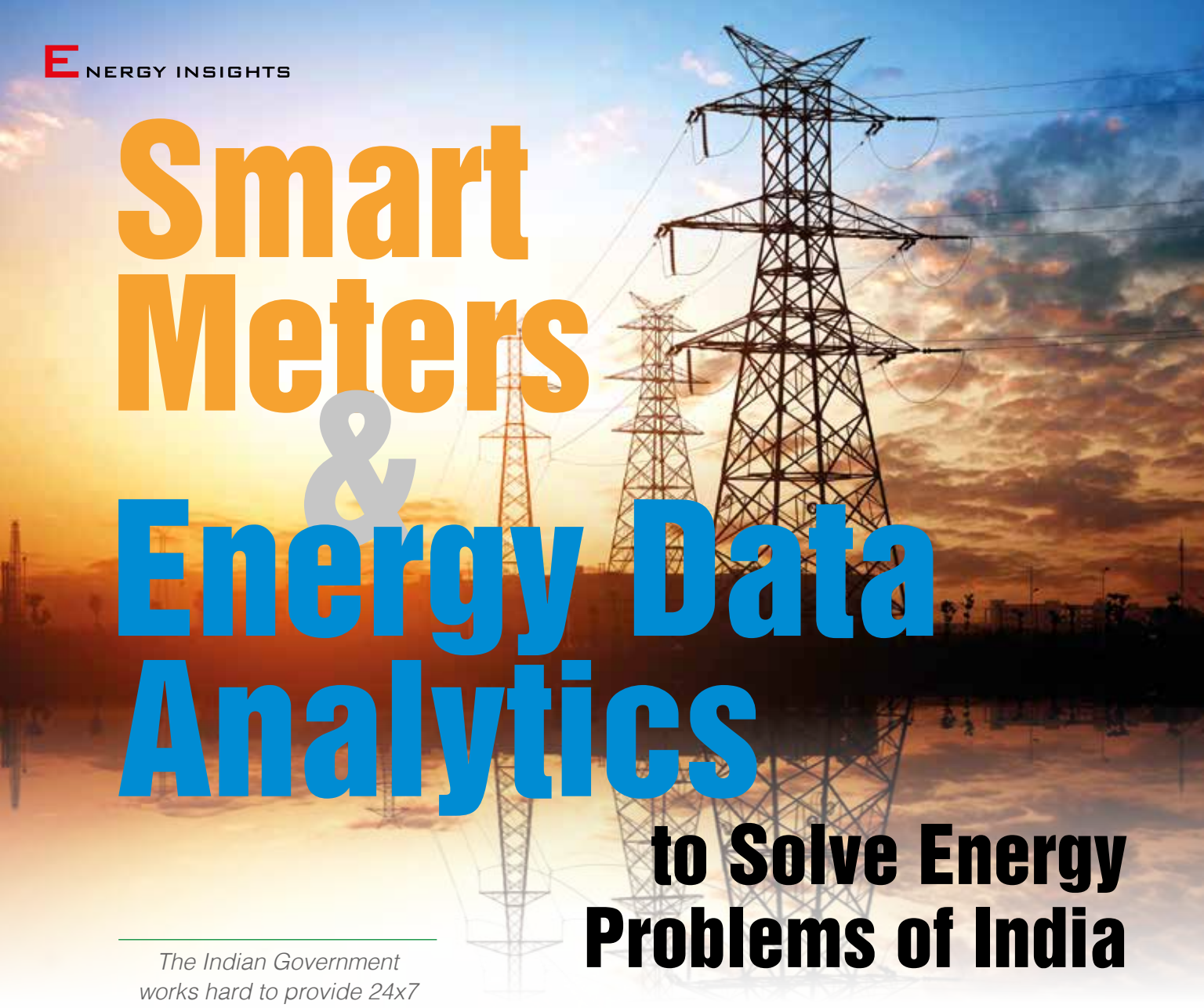
Business incubation labs can come up in the states having large number of energy intensive SMEs as well as proactive SDAs. States like Gujarat, Maharashtra, and Tamil Nadu qualify in this category. The proposed EPCOs can focus SMEs located in the areas lacking access to energy and which have also the providence of renewable resources (like solar insolation, biomass, etc.). These clusters can include Faridabad, Morbi, Coimbatore, Rajkot, Tirupur, among others.

SEZ/Industrial parks can come up in the cities being planned along the upcoming dedicated railway fright corridors. To complement the sustainability mantra, these parks can also be made an intrinsic feature of the proposed smart cities.

These PPP models shall facilitate leveraging low-cost private capital and clean technologies enabling our SME units compete with their global counterparts and boost the skill and employment levels of our country.

We can hope of an era, wherein, we shall be proud to read the phrase 'Made in India' inscribed on the products, systems, and services in both domestic and international markets. EF

***Mr Sapan Thapar**, Fellow, TERI & Adjunct Faculty, TERI University.*
Email: sapan.thapar@teri.res.in



Smart Meters & Energy Data Analytics

to Solve Energy Problems of India

*The Indian Government works hard to provide 24x7 electricity to every house in the country and **Dr Amarjeet Singh** thinks it's possible. However, we need to tap the energy resource available in the form of energy wastages to have enough for all our needs. This optimization of energy consumption is possible today with the help of smart meters and Energy Data Analytics (EDA). In this article, he discusses the utility of EDA in bringing in energy efficiency and eliminating the wastages.*

There has been a dramatic rise in the average cost of electricity over the last few years, primarily due to an overall increasing demand along with higher costs of setting up new power plants that can supplement the existing (limited) supply. Increasing costs also result from increasing losses due to inefficiencies in managing the energy consumption. A one per cent loss (due to inefficient operations) nowadays could imply lakhs of rupees per month for a big hospital or educational institution. With such high energy prices, it is therefore important to know where the energy is being consumed and what part aspect of energy needs to be focused upon first for deriving maximum savings.

Out of the total energy used in a country, buildings amount for a significant percentage, especially in developing countries like India. As an example, buildings account for 41 per cent, 47 per cent, and 45 per cent of total energy consumption in the USA, India, and the UK, respectively. New constructions, adding more building space every day, further contribute to the building energy use. Therefore, modest improvements in building energy use can result in significant aggregate impact at the national level.

Often, people consider their electricity bill to be a fixed cost akin to their rent which they cannot control. A quick look around will burst this myth. A simple example is the air conditioners that come with different star ratings, as their power consumption differs. A 1°C change in set point of air conditioner often implies more than ₹500 difference in the monthly electricity bill. We also often forget to turn off an appliance, which then continues to consume valuable energy. Even devices switched off using remotes are not completely turned off and in standby mode, they continue to consume electricity. Standby power consumption is typically 5–10 per cent of total residential energy consumption in many developed countries. Studies show that 5–15 per cent energy savings can be achieved just by getting the detailed feedback of your consumption and acting on it without making any changes in appliances.

Everyone knows that regular servicing of their cars and motorbikes can help improve their mileage. How many times do people go for regular servicing of their electronic appliances, which after all are also machines, often with motors and moving parts? More importantly, even when someone wants to get their electrical equipment serviced, how would they know when to service which equipment—that's where Energy Data Analytics (EDA) comes to the rescue.

Smart electricity meters which have been in existence for several years now, are different from traditional meters as they have the capability to communicate the meter readings over standard interfaces such as Modbus. Typically, these meters are networked to a controller that can collect data from multiple meters and relay it over the Internet using Ethernet/Wi-Fi/GSM. Further, since internet connectivity can be unreliable at times, the controllers should be able to buffer data locally for several months, which can then relay the buffered data once the network connection is re-established. Buffering data in controllers is very essential in a developing country like India wherein the network connections are typically very unreliable. Figure 1 illustrates an installation of smart meters installed at the main level and multiple distribution points to get detailed and real time energy consumption information for a facility.

Traditionally, for homes, we get an electricity bill once a month (or less frequent) which gives details about the number of units consumed and the overall price we need to pay. Now just compare this with our monthly mobile bill, which contains details of each call, short message service (SMS), and data packet and hence allows us to pick the plan that is best for us. Imagine a scenario wherein the electricity bill gives details such as number of units consumed by air conditioner (AC), refrigerator, etc., together with customized tips for reducing this appliance level consumption. For example, how much savings can be realized by increasing the AC set temperature by 1°C or how much savings can be realized by replacing the current inefficient refrigerator with an energy efficient one? Such an itemized electricity bill, together with personalized tips to reduce energy is a possibility today with a smart meter that can collect electricity consumption data on per second basis. State-of-the-art machine learning algorithms that

Out of the total energy used in a country, buildings amount for a significant percentage, especially in developing countries like India. As an example, buildings account for 41 per cent, 47 per cent, and 45 per cent of total energy consumption in the USA, India, and the UK, respectively.

Figure 1: Installation of energy meters at different feeder locations easily executed at the panel level

Studies show that 5–15 per cent energy savings can be achieved just by getting the detailed feedback of your consumption and acting on it without making any changes in appliances.

mine the collected energy data to look for patterns that can then help identify appliance level consumption from main meter level data (also called as load disaggregation) only to eventually provide detailed consumption information and personalized feedback are now moving from research to commercial space in western world. There is a need to develop this load disaggregation for the Indian context as our appliances and their usages are different from those in the western world (e.g., we use geysers for hot water while central water heating for the whole apartment complex is common in the USA and Europe).

According to various studies, commercial buildings waste up to 30 per cent of their energy usage. The primary reason is that the users do not pay for the electricity directly (e.g., we do not directly pay for electricity in office, shopping malls, or hospitals) and hence are less conscious about energy wastage. Often, the commercial buildings include centralized air conditioning, which typically accounts for around 60 per cent of the total energy consumption. While air conditioning is something that we increasingly take for granted, it comes up with huge inefficiencies. Costs for inefficient operations and therefore the opportunities for savings from AC system are much more in commercial buildings than at home. One such example is changing the set point for AC system automatically based on building occupancy and outside weather conditions.

Further, several building occupants, especially Information Technology (IT) and Business Process Outsourcing (BPO) companies, employ Uninterruptible Power Supply (UPS) for their critical loads. All UPS come with inherent inefficiencies leading to electricity losses of 7–30 per cent. The losses can be minimized by optimal scheduling of the UPS or by optimizing the loads running on UPS. Different sub-systems in a building, for example, Air Handling Units (AHUs), Chillers, HVAC Pumps, lighting, UPS, fans, plug points, lifts, and water pumps, can each be separately monitored with smart meters that can provide high resolution data. This data from smart meters can then be used to monitor, understand, and improve the overall building energy consumption.

Several states in India employ Time of Day (ToD) based pricing wherein peak hours (typically in the evening) are charged at a premium (usually 10–15 per cent extra) and off-peak hours (typically in the night) are charged at a discounted rate (usually 5–10 per cent less). ToD-based breakup of different loads can lead to an insight of scheduling non-critical load (for example, water pumps used to store water in overhead tanks) to run only during off-peak hours and exploit savings due to discounted pricing. This will further help utilities flatten their peak load demand and work easily towards providing reliable 24x7 power supply to its consumers.

Thus, whether it's a residential or commercial building, data collected using smart energy meters can help in detailed understanding of energy consumption, identify what needs to be serviced or replaced, provide the exact Return on Investment (RoI) for replacements and identify optimal building operations based on external factors such as occupancy and weather conditions.

Many people prefer investment in mutual funds or taking tips from financial experts when investing in stock market. Similarly, energy should be managed by those who understand its patterns and can develop insights based on high resolution data analytics. Prices are changing on frequent basis, new technologies are emerging and therefore, expert guidance is required to monitor these trends and make recommendations accordingly in order to reduce energy consumption. EDA is different from traditional Energy Audits or services offered by Energy Saving Companies (ESCOs). These companies typically do one time monitoring and suggest interventions based on it. However, the buildings are living systems interacting with outside weather, its occupants, and its different sub-systems on per second basis. Thus, the job of savings should ideally go to those who understand energy and algorithms to find out inefficiencies in the collected data. While big data is becoming the big buzz in today's world, the next big opportunity using big data is in EDA. Smart meters are often capable of collecting data at higher rates, once every minute which can amount to 240 TB of data collected from 5 million homes a month. Contrasting this with big data in other domains, 500 TB of data is generated daily from Facebook and less than 100 TB of data generated from particle physics (Large Hadron Collider) daily and astronomy (Sloan Digital Sky) yearly. To give a concrete example, 10 smart meters in a facility, each collecting 10 electrical parameters on per second basis, will generate more than 8.5 million data points in a day. Besides understanding of energy data, detailed knowledge of efficient data storage and big data analytics is critical to derive insights from such high volume data.

India needs innovation on this front of EDA, especially since the operating conditions are very different from those that are common in Europe or in the USA. For example, homes in India usually have room level air conditioning while centralized cooling/heating is more common in developed countries. Similarly, moderate weather conditions and unreliability in the grid, and hence dependence on diesel generators, are conditions typical of Indian context. The government needs to promote both research and small enterprises

Imagine a scenario wherein the electricity bill gives details such as number of units consumed by air conditioner (AC), refrigerator, etc., together with customized tips for reducing this appliance level consumption.

Different sub-systems in a building, for example, Air Handling Units (AHUs), Chillers, HVAC Pumps, lighting, UPS, fans, plug points, lifts, and water pumps, can each be separately monitored with smart meters that can provide high resolution data. This data from smart meters can then be used to monitor, understand, and improve the overall building energy consumption.

in this space for this home grown innovation to prosper and address the energy challenges for the country.

Zenatix is an example of 'Make in India' for the EDA. Zenatix, co-founded by alumni from IIT Delhi, IIM Ahmedabad, and University of California, Los Angeles, provides an energy monitoring and analytics solution that helps consumers save energy by understanding their energy consumption pattern and taking steps to optimize the usage. Zenatix mission is to empower energy consumers with data, insights, and recommendations that will drive significant energy savings. Understanding that it is extremely difficult to drive energy savings without understanding the consumption pattern of various systems/appliances and occupant-building interactions, Zenatix solutions enables the energy consumers monitor their energy consumption patterns at various system/appliances levels, and take actions based on the recommendations given by our energy analytics. In the first six months of their initial product offerings, Zenatix boasts of savings from 5–20 per cent for all their customers. Figure 2 shows the operational cycle for Zenatix solution, starting from aggregating energy related data sources using their proprietary controller to providing web dashboard and insights based on sophisticated modeling and analytics.

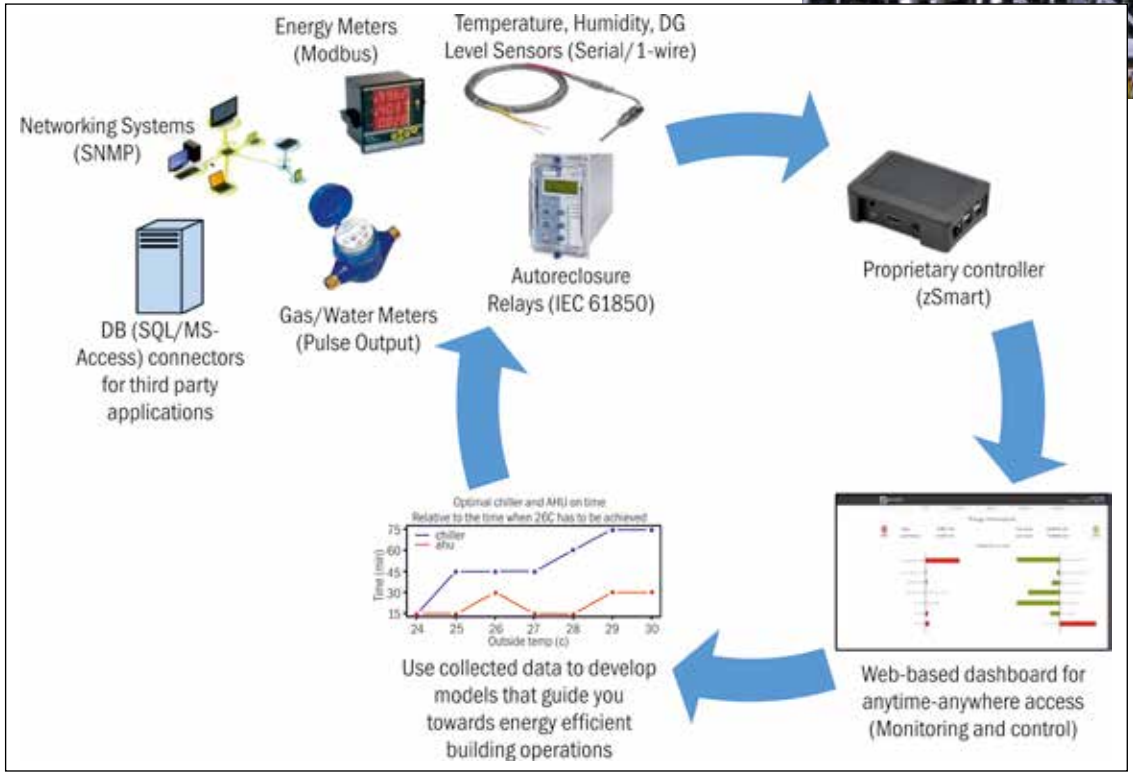


Figure 2: Illustration of EDA operations, as executed by Zenatix

Coming from a two year research, Zenatix has the right platform (operating in the cloud) that can handle millions of data points every day from thousands of customers, together with the ability to be responsive to sudden changes and reconfiguration if so desired. Zenatix engineers understand the Indian context when it comes to developing suitable algorithms for EDA. The following are a few examples of this understanding:

- In-house developed controller has local storage of 6 GB, which can store data for any premises for more than a year, something that is critical for remote areas where network connectivity is otherwise not possible.
- Zenatix controller can interface with any energy meter, including several Indian manufacturers such as Trinity, ElMeasure, and Neptune, and hence is vendor agnostic.
- The company has developed several India-based utility cases (which are otherwise missing in this data driven energy efficiency space). These include AC optimization for a college campus, production, and energy correlation for a big manufacturing unit, diesel generator monitoring, and optimization for an IT company and load disaggregation for a restaurant chain.

With a huge potential to save billions of energy units from existing in efficient operations, Zenatix provides a low investment methodology towards reaching the audacious goal of "access of electricity for all" by the Indian Government. EF

To give a concrete example, 10 smart meters in a facility, each collecting 10 electrical parameters on per second basis, will generate more than 8.5 million data points in a day. Besides understanding of energy data, detailed knowledge of efficient data storage and big data analytics is critical to derive insights from such high volume data.

***Dr Amarjeet Singh**, Faculty at IIIT Delhi and cofounder of Zenatix Solutions Pvt. Ltd (www.zenatix.com). Email: amarjeet@iiitd.ac.in*

Renewable Energy Systems for Community Scale Usage at Brahma Kumaris, Mount Abu

Brahma Kumaris Shantivan Campus in Mount Abu, Rajasthan is equipped "India One", i.e., a 1 MW solar thermal power plant. In this article, ***BK Jayasimha*** *showcases how Brahma Kumaris have successfully employed amply available solar energy for applications in institutional use, such as solar steam cooking systems, solar sterilization, and laundry system.*

India is a country blessed with ample sunlight. It is also a homeland of many great saints and spiritual organizations. Sun connects people with spirituality as they worship '*Surya Devataynamaha*'.

Brahma Kumaris, a socio-spiritual organization with international footprints in over 135 countries all over the world, teaches Raj Yoga meditation and helps people in inculcating moral and spiritual values in day-to-day life.

Brahma Kumaris, together with its daughter organization—World Renewal Spiritual Trust (WRST)—have been actively involved in the research and demonstration of various renewable energy concepts for more than 18 years. It is one of the pioneer institutes which successfully developed number of applications in the field of solar energy for institutional use, such as solar steam cooking systems, solar sterilization, and laundry system, as early as in the beginning of 1990s. They were further widely replicated by other organizations in India. So far, across India, WRST has installed six large steam cooking systems, more than 1.2 MW peak standalone solar photovoltaic (PV) power systems, and approximately 50,000 L/day solar hot water systems at the headquarters.

The headquarters of the institute is situated in the lush green laps of Aravalli hills, i.e., Mount Abu, Rajasthan.

In Abu Road, Rajasthan, just before the climb up to Mount Abu, lays, a magnificent complex, one of the three Brahma Kumaris campuses, Shantivan. This sprawling collection of buildings was built in response to University's ever-growing world-transforming activities in the area of spiritual education and training. It provides an excellent venue for holding large conferences, spiritual congregations, and retreats. It features modern means of communication, transport, extensive kitchen, and dining facilities, well-laid-out roads, electricity, and solar energy. Residential buildings can lodge 25,000 guests. Shantivan is a place where hundreds of thousands of people from various paths of life from all over the world gather to deepen their meditation practice, benefit from participating in various value-based retreats and conferences. Clear and subtle atmosphere of spirituality inspires profound experiences.

Keeping a vision of creating a sustainable community model, the institution installed and is using solar energy solutions on a large scale to cater to energy needs in the form of hot water, steam for cooking, and electricity. The cluster of this solar energy equipment makes Brahma Kumaris one of the largest institutional users of renewable energy in India.

Solar steam cooking system for preparing 15,000 meals twice a day was installed in Brahma Kumaris Shantivan in 1999 and is in use since then. It has been serving as a replication model for many religious and educational institutions across India.

Brahma Kumaris Shantivan Campus is also equipped with 250 kW solar PV system with a battery bank to provide the electricity for emergency lighting, computers, and the telephone exchange. Over the years, the institution has been propagating solar energy for individual use. Over 10,000 solar lanterns, 1,000 home lighting systems, and 3,000 solar box cookers have been distributed with the help of the Ministry of New and Renewable Energy (MNRE) subsidies through Solar Aditya shop.

This Research & Development (R&D) project featuring various innovative solutions is supported by the MNRE and the German Federal Ministry for the Environment, Nature Conservation, Building and Nuclear Safety (BMUB) with GIZ (Deutsche Gesellschaft für International Zusammenarbeit GmbH).

The main aim of the institute is to develop, demonstrate, and help to replicate an easy–to–install, cost-effective, and long-lasting renewable energy technologies.

In this view, presently, with the help of wide first-hand experience and applied research in the field of concentrating solar heat technologies, WRST is executing "India One" Solar Thermal Power Plant. This Research & Development (R&D) project featuring various innovative solutions is supported by the MNRE and the German Federal Ministry for the Environment, Nature Conservation, Building and Nuclear Safety (BMUB) with GIZ (Deutsche Gesellschaft für International Zusammenarbeit GmbH).

"India One" is a 1 MW el. Solar Thermal Power Plant with 16 hours energy storage for the night operation (Pictures 1–8). This captive power plant supplies electricity and hot water to Brahma Kumaris headquarters in Abu Road, Rajasthan with total capacity of 25,000 people.

KEY FEATURES OF "INDIA ONE" SOLAR THERMAL POWER PLANT

1. 60 sq. m paraboloid reflector

a. Static focus

The in-house developed paraboloid reflector is a lateral section of bigger parabola and designed in such a way that it rotates along with polar axis and maintains the focus in a static position. This key feature of the reflector enables to integrate a decentralized storage at focus and avoids high pressure moving joints.

b. Space frame design for optimum steel usage/sq. m

The 60 sq. m paraboloid reflector is structurally designed based on light weight space frame analysis. The structural optimization is achieved through this design that requires steel material of approximately 50 kg/m^2 of the reflector. The reflector is designed taking into consideration the local availability of the material and the ease of fabrication for large-scale manufacturing. Currently, 770 numbers of such reflectors are being manufactured at the "India One" Solar Thermal Power Plant at Abu Road, Rajasthan with the optimum productivity and highest quality.

c. Fully automatic dual-axis tracking mechanism

In order to synchronize the reflector rotation with the sun (daily tracking) and to achieve various shapes in the same structure in an accurate manner (seasonal tracking and shape change tracking), automatic dual-axis tracking is achieved with the help of optical camera for sensing the bright pixels at focus, sensors, microprocessor, and electromechanical actuators. The tracking is developed in such a way that it considers real focus position as a result of reflection rather than calculated or measured sun position.

The tracking mechanism is network enabled, can be remotely monitored, and has communication

capabilities. The details are as follows:

- **Daily tracking**
  The reflector automatically tracks the sun from morning 8:00 am to evening 5:00 pm from East to West direction with accuracy of 0.1° maintaining sharp static focus at the focal point. This is achieved with the help of camera installed at the centre of reflector parallel to the axis of rotation of the reflector. The camera generates the image of the focus which then sends to the processor for image processing for the position of the focus. Mechanically, it is run with rack & pinion arrangement powered by DC motor.
- **Seasonal and shape change tracking**
  In order to achieve flexible parabolas for each day of the year, the reflector has to perform inclinations with respect to the sun position in the north–south plane, it is called it seasonal tracking. Also, the reflector has to undergo deformation in shape like deeper parabola for winter and flatter parabola for summer in order to maintain the static focus, it is called shape change tracking. This is achieved with the help of electromechanical actuators powered by DC motors.

d. Reflective surface area

The 60 sq. m reflective surface is the result of in-house developed curved mirrors. Special solar grade mirrors with 93 per cent reflectivity are used for the reflection. The curving of the mirrors is achieved through sandwich process by using special low viscous, fast curing two-component silicon glue that is also UV resistant, and is suitable for external weather conditions. Each 60 sq. m reflector accommodates around 750 numbers of curved

mirror pieces and have 16 numbers of different curvatures that makes perfect parabola shape of the reflector.

e. Reflector thermal output

Each 60 sq. m paraboloid reflector with automatic dual-axis tracking mechanism delivers peak thermal output about 3.25 kWh/m^2/day at its focal point. Thus, the reflector efficiency under ideal conditions reaches up to 60 per cent at its focal point. The static focus concentration area ratio with respect to the reflector area is 1:350 and the temperature at the focal point reaches up to 1,200°C.

2. Decentralized thermal storage for round the clock operation

Thermal energy storage plays a vital role in harnessing the solar energy effectively. As the Direct Normal Irradiance (DNI) peaks up at noon hours, thermal energy storage acts as a buffer between production and consumption. Moving forward from this basic requirement, WRST developed a unique thermal storage that can cater the user round the clock by using cast-iron cavity receiver that has high energy density and high specific heat and long life cycle.

a. Design

The indigenous static cast-iron cavity receiver is placed at the focal point of the paraboloid reflector in line with the axis of rotation of the reflector.

The reflector and the receiver storage can be used in various industries and institutes for wide range of applications, round the clock, to provide steam at high temperature, hot air, high-pressured hot water, etc.

The conical cavity is designed for perfect black body absorption. Thermal energy delivered by the reflector is absorbed by the solid cast-iron metal around the cavity, thus provides excellent thermal storage. The heat exchanger coil is tightly wound around the solid cast-iron body that improves heat transfer through surface contact. This mechanism allows direct steam generation when water is pumped into the coil. The result is superheated steam of range up to 350°C round the clock.

b. Insulation

The cavity opening of the receiver is sealed with clear quartz glass to avoid convective losses through the cavity during the day. Automatic front door is designed in such a way that it closes the cavity opening in the evening and night to avoid overnight thermal losses. The rest of the receiver body is insulated with high density ceramic fibre and glass wool layers to further reduce the thermal losses.

c. Receiver output

The static cast-iron cavity receiver delivers peak output of @150 kWh/day of thermal energy. The peak temperature of steam generated is 350°C at 42 bar pressure under ideal sunny day, thus, delivering superheated steam as well as saturated steam. The receiver is designed for 25 years lifespan and has high residual value even after the lifecycle.

PROCESS HEAT APPLICATIONS

The reflector and the receiver storage can be used in various industries and institutes for wide range of applications, round the clock, to provide steam at high temperature, hot air, high-pressured hot water, etc.

The dish can deliver steam temperature from 100°C to 350°C, super-heated and saturated.

To promote solar energy specifically for process heat applications, WRST provides its experience and knowledge to interested entities and individuals, in the form of information sharing, demonstration and training, etc. Recognizing this contribution, WRST was awarded with an assignment of an Awareness Cum Training Centre on Concentrating Solar Thermal Technologies (CSTs) under UNDP–GEF Concentrated Heat Technologies Project, with the MNRE, Government of India. The CST Centre is located at "India One" Solar Thermal Power Plant in Abu Road, Rajasthan.

Among the main objectives of the CST Centre is to create awareness among various groups of stakeholders from industries, institutions, and commercial establishments through seminars/workshops/demonstration of various available CST systems out of which proposals for installations of CST-based systems at their establishments would be facilitated. EF

***BK Jayasimha Rathod**, CEO "India One" Solar Thermal Power Plant. Website: www.india-one.net and www.facebook.com/indiaonesolar. Email: bkjsimha@yahoo.co.uk*

teri

Books on Renewable Energy
Special Package Offer

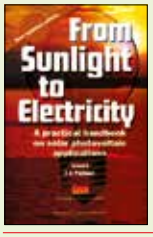
~~List Price: 4085~~
Offer Price: 3600
You Save: 485
with free postage

Biogas Technology: towards sustainable development

R S Khoiyangbam, Navindu Gupta, and Sushil Kumar

The global demand for energy is met mainly by fossil fuels. Their excessive and indiscriminate use, coupled with increasing demand for energy, will soon deplete their existing reserves. Therefore, it is extremely important to find alternative, environment-friendly, and ecologically sound sources of energy for meeting the present and future energy requirements. Biogas Technology: towards sustainable development makes an attempt to explore the potential of utilizing biodegradable biomass as fuel and manure.

Reprint 2013 | 218 pages | Hardback | 160mm x 240mm | 9788179934043 | ₹350.00

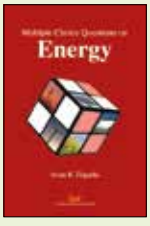


From Sunlight to Electricity: a practical handbook on solar photovoltaic applications, 2nd Edn.

Suneel Deambi

This book is a compilation of information that gives the readers an overall understanding of the PV (photovoltaic) sector in India, designs and applications of specific devices and related benefits, finance, and policies. The document also discusses the PV technology programme in India, the issues therein, and its future directions. The information has been presented in a format that is easy to understand and apply.

Reprint 2013 | 132 pages | Paperback | 140mm x 215mm | 9788179931561 | ₹200.00



Multiple Choice Questions on Energy

Arun K Tripathi

Multiple Choice Questions on Energy contains about 1300 multiple choice questions covering various sectors of energy, including mechanical energy, electrical energy, chemical energy, nuclear energy, thermal energy, magnetic energy, sound energy, energy from coal, petroleum oil and natural gas, renewable energy, and energy conservation. An introduction to energy has been presented in a comprehensive yet simplified form. This book is useful for academicians, students pursuing engineering or agriculture-related courses, aspirants of various competitive exams, professionals, and stakeholders in the energy sector. It can also be a tool for various quiz programmes organized in schools, universities, and engineering institutions.

2011 | 354 pages | Paperback | 160mm x 240mm | 9788179933053 | ₹395.00

Production and Technology of Bio-diesel: seeding a change

Alok Adholeya and Pradeep Kumar Dadhich

Production and Technology of Bio-diesel: seeding a change is based on the work that TERI has been doing in the field of bio-diesel production from jatropha. This unique publication covers the entire value chain involved in the production of bio-diesel, right from the nursery stage involving the saplings to the production of transesterified oil (bio-diesel) for use in diesel-powered engines. The user will get in one volume valuable information pertaining to the production of bio-diesel, a process that requires inputs from various disciplines, like environment, biotechnology, chemical engineering, finance, economics, and automotive engineering.

2008 | 256 pages | Hardback | 140mm x 215mm | 9788179931578 | ₹495.00

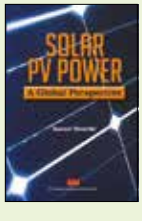
Renewable Energy Engineering and Technology: principles and practice

Revised International Edition

V V N Kishore (ed.)

Renewable Energy Engineering and Technology: principles and practice is a comprehensive guide to renewable technologies and engineering, intended to cater to the rapidly growing number of present and future engineers who are keen to lead the renewable energy revolution. All the main sectors are covered—photovoltaic, solar thermal, wind, bioenergy hydro, wave/ tidal, geothermal—progressing from the fundamental physical principles, through resource assessment and site evaluation, to in-depth examination of the characteristics and deployment of the various technologies.

Reprint 2013 | 914 pages | Hardback | 185mm x 240mm | 9788179932216 | ₹2250.00



Solar PV Power: a global perspective

Suneel Deambi

Solar photovoltaic (PV) technology has been successfully implemented in the remote regions of India for more than two decades now. It has various end-use applications like lighting, pumping water, and charging battery for multiple uses. However, recently, there has been a growing bias towards the use of PV grid connected power plants. The larger issue here is that of tracing a connection between solar energy and grid connectivity. This book provides an insight into the basic understanding of PV grid power plants from various end-use considerations.

Reprint 2012 | 288 pages | Hardback | 160mm x 240mm | 9788179933893 | ₹395.00

For more offers, visit us at: http://bookstore.teriin.org

Solar-Powered Energy

Generation in India

Su-Kam is an India-based power solutions provider which has been recognized as one of the top players in the Solar rooftop segment, especially, in the residential market as confirmed by Solar consulting firm Bridge to India. 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 W to 1 MW. This extensive range is suitable for smallest residential home systems as well as for multi-megawatt power plants.

The Ministry of New and Renewable Energy (MNRE) had appointed Su-Kam as its channel partner under its scheme "Off-grid and Decentralized Solar Applications" of the Jawaharlal Nehru National Solar Mission (JNNSM) for undertaking off-grid projects.

Su-Kam has conducted large-scale off-grid and grid-tie solar installation projects across numerous sites both in India and abroad. In India, the company has installed solar systems in remote areas, i.e., with the security forces in the Assam Rifles regiment in Nagaland, Manipur, Mizoram, and Tripura; in deep forest areas of Madhya Pradesh Forest Department; in government buildings like the Raj Bhawan in Itanagar, Assam State Electricity Board; in educational institutes like Punjab Engineering College in Chandigarh, Shivalik Public School in Punjab, Loyola College in Chennai, Gates Institute in Andhra Pradesh, J J Polytechnic in Trichi; at a number of petrol pumps; in hospitals and nursing homes in Bihar, Andhra Pradesh, and Maharashtra; street lighting projects in Tamil Nadu; and in industries like Ashok Leyland, to name a few. In all the aforementioned projects, the company has reduced the site's requirement of energy from conventional sources of energy to almost zero per cent.

Su-Kam has undertaken a large number of solar projects overseas, like installing solar solutions to power telecom towers in Afghanistan to aid the US Army's needs, installing solar solution at schools, colleges, institutions, hospitals, industries, forests, street lights in African countries of Nigeria, Rwanda, Gabon, Malawi, etc., to name a few.

TURNING SUNLIGHT INTO ELECTRICITY FOR 40,000 RURAL HOUSEHOLDS IN UTTAR PRADESH (UP)

People in the various villages of Uttar Pradesh had never had electricity in their houses; *Bijli* was a luxury that they thought they would never be able to afford. In the absence of electricity grid, they had to rely on polluting kerosene lamps and household stoves to meet electricity needs. But in 2014, Su-Kam won a large-scale rural electrification project to install solar power systems in 40,000 rural households in Uttar Pradesh. Su-Kam bagged this project after winning a tender from the Uttar Pradesh New and Renewable Energy Development Agency (UPNEDA), which had been assigned this project under the Lohia Awas Project by the UP Government.

As part of this project, Su-Kam has installed three LED lights, one ceiling fan, and a solar charge controller with a mobile charging point in each of the rural houses spread across 19 districts and 1,800 villages with a backup of eight hours a day and autonomy of 72 hours.

The residents who are benefiting from solar installations in their houses expressed their relief and happiness. One of the customers, Vidhya Devi from Sahijna village, Lucknow said, "I am very happy that we have electricity in our village. My children can now study peacefully in the house at night. Electricity is a boon for us."

POWERING 19 SITES OF ASSAM RIFLES RANGING FROM 50–100 KW

One of the landmark projects undertaken by the company is the Assam Rifles project, which required Su-Kam to supply, install, commission, and maintain off-grid solar power plant installed for the Assam Rifles base in various locations in North East India. This solar-powered plant supplies electricity to the base station during the daytime and provides 4–5 hours of backup in the night time.

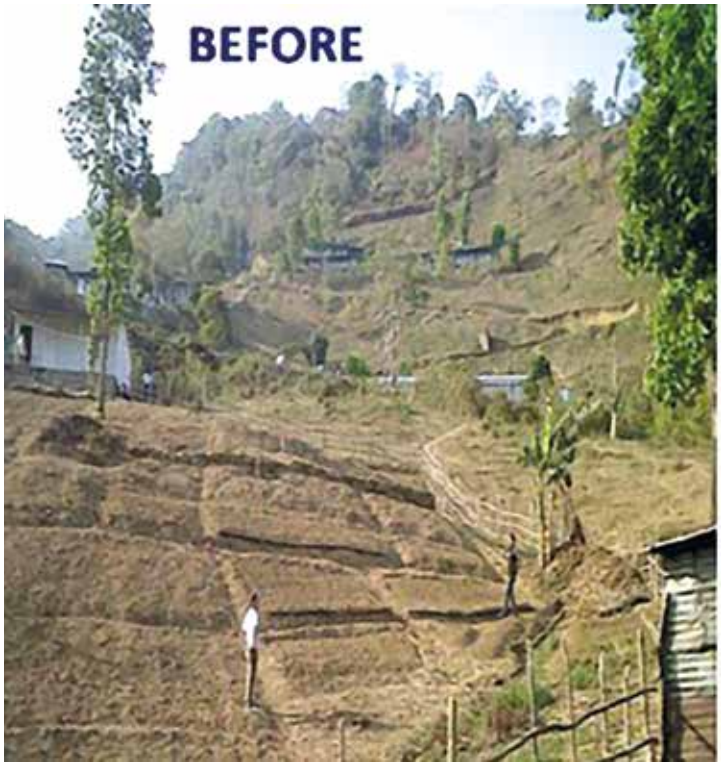
The switch to solar energy at the Assam Rifles base locations in Manipur, Nagaland, Tripura, Mizoram, and Assam has helped the paramilitary force in bringing down the use of costly and polluting diesel. As per the latest estimates, the diesel consumption of the sites is down by 40 per cent. All the plants have been installed under the MNRE subsidy scheme as per the JNNSM directives.

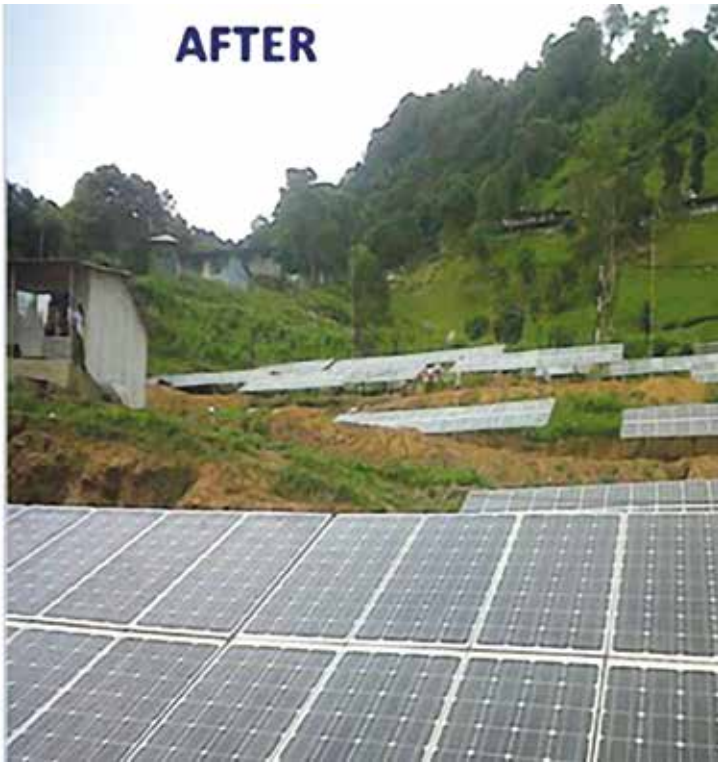
Besides other benefits, the solar plants have also resulted in employment for local residents. They have been trained in installation, commissioning, and maintenance of the solar power plants.

Su-Kam's team worked diligently in inhospitable terrain, bad weather conditions, scarce transportation, and insurgency problems.

100 kWp Ground-mounted Solar Power Plant, Assam Rifles, Keithalmanbi, Manipur

100 kWp Ground-mounted Solar Power Plant, Assam Rifles, Aina, Manipur





100 kWp Solar Power Plant Installed at Assam Rifles, Lunglei, Mizoram

SOLARIZING HOUSES UNDER THE CHIEF MINISTER'S GREEN HOUSE PROGRAMME, TAMIL NADU

Su-Kam has successfully installed solar power systems in over 39,000 houses in 15 districts of Tamil Nadu under the Chief Minister's Green House Programme launched by the Tamil Nadu Energy Development Agency (TEDA).

Under the Chief Minister's Green House Programme, the Government of Tamil Nadu has launched solar-powered Green House Scheme. Under this scheme, three lakh houses are to be constructed with solar-powered lighting system over a period of five years from 2011–12 to 2015–16 for the benefit of poor in rural areas.

Speaking on the occasion, Ashish Sethi, VP-Solar projects, Su-Kam said, "We are pleased to work for the TEDA and provide them a customized solution to harness solar energy to meet basic power requirements in rural homes."

"With the ever-increasing cost of non-renewable energy, solar power has become the most cost-effective mode for generating electricity in the present times. Therefore, as part of our solar plan in this fiscal, we are bullish in making solar power available to both the urban and rural segments for residential as well as commercial applications in Tamil Nadu. We are working to spread awareness about the feasibility of solar installations and make our solar presence felt in homes, offices, institutions like schools, colleges, government buildings, hospitals, commercial establishments, etc., in the state," he added.

90 KWP GRID TIE SOLAR POWER PLANT FOR ENGINEERS INDIA LIMITED (EIL), GURGAON

This plant is installed on the rooftop of R&D building of EIL, Gurgaon. As the area available for installation of 90 kWp plant on the rooftop of the newly constructed EIL building was not sufficient, Su-Kam did a detailed engineering analysis and drew out a meticulous customized plan to accommodate the plant. This solution was delivered while meeting stringent quality, reliability, and functional requirements.

The state-of-the-art Grid Interactive Solar System generates over 1.25 lakh units of electricity per year, thereby, helping EIL save over 10 lakh in electricity consumption. This plant powers three floors of the building.

Moreover, Su-Kam has devised supervisory control and data acquisition (SCADA), which is a data logging system provided for remotely monitoring plant performance on a regular basis. This remote monitoring system enables easy maintenance from a far-off location.

70 KWP GRID TIE SOLAR POWER PLANT FOR NATIONAL HYDROELECTRIC POWER CORPORATION (NHPC), FARIDABAD

Grid tie solar photovoltaic (PV) system on the rooftop of the NHPC building generates over 84,000 units of electricity/year thereby helping NHPC corporate office save 7 lakh of electricity consumption annually.

The solar PV plant installed is unique as it is based on dead load foundation with interacted grid matrix that gives a huge stability to the structure along with avoiding any damages on the waterproofing of the roof.

1 MW SOLAR POWER PLANT FOR PUNJAB ENGINEERING COLLEGE

Su-Kam has installed the largest solar power plant in an educational institution across India. This 1 MW plant is installed across 14 buildings in the same campus taking care of the College's power requirement during the day. The initiative is in line with the Chandigarh Renewable Energy Science and Technology Promotion Society's master plan to make Chandigarh a solar city through their solar city programme. Su-Kam is responsible for assessing the sight, drawing out a detailed engineering plan, and customized structure for setting up the solar system at the location.

CONCLUSION

Su-Kam is committed to provide Indian villages the solar-powered devices in order to promote clean and green energy usage in the country. EF

Source: www.Su-Kam.com

Reasons for Failure of Solar PV Companies Globally

Lessons for Investors

*In this article, **Dr Sudhir Kumar** explores reasons of the failure and bankruptcy of several SPV manufacturing companies globally during the last couple of years and suggests the dos and don'ts of how to invest in this most promising sector of the renewable energy.*

Stupendous growth of solar photovoltaic (SPV) sector all over the world discussed in several recent reports makes it hard to believe that many such companies became bankrupt or were acquired by other companies. Personally, I thought of analysing the reasons for such large-scale failures of SPV companies. To start with the analysis, Eric Wesoff's article (*Source:* http://theenergycollective.com/eric-wesoff/2165821/rest-peace-fallen-solar-companies-2014) gives an exhaustive list of failed companies all over the world, which he claims to be little incomplete.

Many reasons are given for the failures of SPV companies: (a) GTM Research forecasts 21 GW of PV module manufacturing capacity coming offline by 2015 as the global market reconciles a dire supply–demand imbalance (*Source:* http://www.greentechmedia.com/research/report/pv-supply-2012); (b) Craig Lawrence (*Source:* http://www.quora.com/What-are-some-autopsies-of-failed-solar-companies) has given many reasons for failure such as: undue favour from the government; overenthusiasm of venture capitalists; difficulty in scaling up; impatience of investors; and inability to lead

the laboratory technology to commercialization. Although all these may not be tagged as frivolous, the real reason seems to be something else, which needs to be delved into for the benefit of future investors. Most of the analyses were carried out by market researchers and investment experts; thus, the technological intricacies involved in functioning and manufacturing of SPV have been missed out.

CHRONOLOGICAL STATUS

If we take a closer look at the complete list of these failed companies (from 2009 to 2014), the analysis reveals many startling facts. Let us first have an insight into the profile pattern of these companies who have become bankrupt and were either closed, acquired, exposed to fire sale, or were forced to restructure.

- Out of the total 109 failed solar companies, year-wise break up is: 10 companies in 2009–10, 11 companies in 2011, 45 companies in 2012, 31 companies in 2013, and 12 companies in 2014.
- Of the 10 companies in 2009–10, total eight used thin-film technology and majority of them were based on Amorphous Silicon (a-Si). One of them had used nanotechnology and another Gallium Arsenide (GaAs). Remaining two companies used to carry out other solar activities.
- The year 2011 saw failure of 11 SPV companies. Out of these, seven companies used thin-film technology using a-Si, CdTe (Cadmium telluride), and Copper indium gallium selenide (CIGS). Only one of them used crystalline silicon technology. The other one had Concentrated PV (CPV) technology.
- A relatively larger number, i.e., 45 companies failed in 2012. Out of these, 18 used thin film technology a-Si, CdTe, CIGS, and Organic Solar Cell (OSC). Nine of them used crystalline silicon technology. Three companies used CPV technology. Remaining were either Balance of System (BoS) suppliers or solar developers/module manufacturers.
- The year 2013 was also fatal for many SPV manufacturing companies. Out of 31 companies, 12 used thin film technology, CdTe, and CIGS. Five of them used crystalline silicon technology. Three companies used CPV technology. A new technology of Solar Combined Heat and Power (SCHP) was used by one of the companies. Remaining were BoS suppliers, solar developers, and module manufacturers.
- Fortunately, lesser failures were observed in 2014. Out of 12 companies, five used thin-film technology, CdTe, and a-Si. Two of them used crystalline silicon technology. Two companies used CPV technology. Remaining were BoS manufacturers and developers.

The given data indicate that overall 48 per cent of the failed companies used thin film technologies and majority of them were of a-Si. CIGS is the next one followed by CdTe. Only 15 per cent companies using crystalline technology were the failures.

ANALYSIS OF THE PROBLEM

The given data indicate that overall 48 per cent of the failed companies used thin-film technologies and majority of them were of a-Si. CIGS is the next one followed by CdTe. Only 15 per cent companies using crystalline technology were the failures. Interestingly, 2 per cent companies dared venturing into unproven new technologies such as OSC, nanotechnology, GaAs, and SCHP. Around 8 per cent were using CPV. The rest of them, i.e., 28 per cent companies were developers and equipment suppliers. The report also warns that many of the CPV companies are on the watch list in 2014.

One can understand the failures of developers and equipment suppliers due to their faulty marketing strategy and volatility of market. If we keep aside this category, majority of failures pertain to technological issues that can be analysed as follows:

- Thin-film technology attracted the attention of solar industries from 2005 onwards due to its cost effectiveness as: (a) it requires low process temperature, enabling module production on flexible and low-cost substrates; (b) the technological capability for large-area deposition; (c) very thin film has low material requirements; (d) there is low energy consumption during manufacture; and (e) there is a possibility of automation of the manufacturing process.
- Venture capitalists, with an objective of making a big kill by challenging the existing crystalline technology, supported many companies without proper technical due diligence. They were oblivious to the technical facts that any thin-film solar cell in general has the following risk factors:
  - Thin-film solar cells are always 40–50 per cent less efficient than crystalline ones, requiring comparatively 30 per cent more land for the same installed capacity and obviously, more BoS, e.g., structure, wiring, etc.
  - Thin films generally have problem of material instability on the substrate on which they are deposited.
  - Even with stable films, the efficiency degradation rate per year is faster as compared to crystalline solar cell; hence, it

So, what is the lesson we learn from these failures? We should not only depend upon the reports prepared by the market analysts or investment experts. A thorough technological due diligence with incisive analysis is a must.

has lesser life and lesser power output during its entire lifespan. Moreover, the most used a-Si has initial light soaking degradation (in first 1,000 hours) in addition to the annual inherent degradation.

- In the case of thin-film solar cells, the thin layer of absorber material is fixed between two glass layers of around 3-mm thickness each. In the event of rise in ambient temperature, the two rigid layers of glass face severe stress due to temperature difference between top and bottom layers and due to high inherent cell temperature under illumination. This causes micro-cracks in the top glass layer, especially during water cleaning. Therefore, the thin-film power plants have to compulsorily replace 1 per cent of modules per year that leads to an additional cost.
- At the project level, thin film technology has higher environmental externalities due to the presence of heavy metals as compared to crystalline PV technologies. This is important from the societal perspective.

- In the past few years, CdTe has been claimed to have comparable efficiency and stable on substrate although uncertainty about annual degradation rate is still to be authentically verified by a third party. There has been a concern about highly poisonous Cd being used and its possible health hazard. The claim by some companies for its safe use is yet to be substantiated by an independent government agency.
- Great claims have been made about CIGS in laboratory. But on practical ground at project level, it is still to see the light of the day as good commercial venture mainly due to material instability on substrate.
- GaAs, although technically at very advanced stage, suffers from unusual high cost and its business will never survive the market with the current rock-bottom cost scenario of technologically advanced crystalline silicon technology.
- OSC and nanotechnology, although fascinating for researchers, are well known for their poor efficiency and practical efficacy. It is a big risk to go for manufacturing with these technologies at their nascent stages of development.
- Using SCHP has its own operational problems; it is yet to prove cost economics. Hence, it is not advisable to go for manufacturing before sufficient due diligence of some pilot projects.
- Mono-crystalline and poly-crystalline silicon technologies have shown far better performance in the field since many decades due to their better material stability, higher efficiency, lesser annual degradation, long-term commercial viability, etc. Thus, only 16 per cent companies based on crystalline technology have failed due to tough competition fuelled by drastic reduction in cost in recent years. Most of them have been acquired or restructured. Only very small percentage of companies using crystalline technology have been left haywire.
- The CPV technology has an interesting case. I had visited, courtesy World institute of Sustainable Energy (WISE), Pune, a reputed institute working

extensively on CPV, namely ISFOC, Puertollano, Spain (http://www.isfoc.net) and found that CPV suffers from—(a) inherent problem of inaccurate focus of hundreds of lenses or concave mirrors on solar cells placed on a single large panel; (b) overheating of the cell support material; (c) moisture collection on inner surface of lenses; (d) practical difficulty in hermetical sealing, etc. Performance of CPV at commercially successful scale leaves much to be desired although some megawatt-scale plants have been installed. It is but natural that nine companies have been reported to fail. Naturally, Wesoff's report has kept all the CPV companies on watch list.

LESSON FOR FUTURE INVESTORS

So, what is the lesson we learn from these failures? We should not only depend upon the reports prepared

by the market analysts or investment experts. A thorough technological due diligence with incisive analysis is a must. In short, before jumping to any investment decision, you must have in your hand techno-economic due diligence report prepared by an expert with wide experience.

Getting good due diligence report is itself an art. The first task is to find the right consultant to prepare it. Find out the consultant who has at least 5–10 years' experience in solar sector. He must have prepared at least five detailed project reports (DPRs) for solar power projects of minimum 2-MW capacity. The most important criterion is that he must have in-depth knowledge of solar cell semiconductor physics. He should be able to differentiate one solar cell from other based on their material properties such as: band gap, efficiency, stability on substrate, fill factor, temperature coefficient, radiation performance, inherent annual degradation, potential induced degradation, Ohmic contact efficacy, weather endurance, material availability, cost of raw material, cost of production, environmental/health hazard, etc. As an investor in solar cell manufacturing company, one has to be careful in getting the due diligence report prepared, which must incorporate the following, but not restricted to the points:

Technology evaluation

This section should elaborate details of material science of the solar cell with a good literature survey of laboratory research and its latest developments. As far as possible, it should give the reference of pilot stage test results to inculcate confidence in expansion of technology for field application. An accelerated test result with respect to its material stability and outdoor sustainability with rigorous environmental/weather examination is necessary. It should predict the theoretical limits of efficiency. Possibility of efficiency enhancement needs to be analysed. Practical problems in scaling up the technology have to be examined.

Manufacturing procedure

The large-scale production needs closer look into quality control measures to be adopted for consistent performance of the solar cells. For better profit, the details of manual and automated components and their optimum ratio need to be analysed. The production rate must be compared vis-à-vis rejection rate. It is necessary to ensure good quality encapsulation-procedure and packaging system. An uninterrupted availability of raw material at reasonable cost has to be ensured. Proper study has to be

done for inventory management, manpower management, delivery mechanism, etc.

Financial analysis

To ascertain it as a good business proposition, the market forecast and proposed marketing strategy has to be analysed in detail. Initial investment, projected profit-loss account, and balance sheet need to be realistically assessed with respect to detailed risk analysis. The risk analysis has to assess the impact of technical issues, market status, socio-economic condition of the country, bureaucratic environment, local political will to promote the technology, environmental aspects, any possible health hazard of the raw material, ease of availability of raw material, local industrial policy/laws/rules, etc. One of the most important criteria is the easy and low cost availability of finance.

Approvals and clearances

Approvals and clearances as per the local laws and policies before the beginning of manufacturing are the key factors, which investors generally have the tendency to overlook. It is necessary to have detailed information in advance of complete procedures, statuary fees to be paid, requirement of documentary proofs to be submitted, exact applicable forms, approving authorities, offices where forms are to be submitted, stages of approvals, etc. It has been observed that many projects fail to kick start due to undue delay in approvals and face the threat of surmounting escalation in total cost. It is, therefore, imperative that time taken in getting statuary clearances should be realistically assessed. An intelligent investor always makes it sure that the procedure of financial closure and getting statuary clearances go hand-in-hand.

CONCLUSION

All the above suggestions are indicative. These may vary depending on the project type, place, and situation. Those investors are winners who take up project not as emotional decision, but arrive at realistic conclusion based on proper techno-economic due diligence. Thus, dos and don'ts should be taken care of. The dos are—keep being solar an enthusiast; take up solar business for profit making; have a long-term vision, and go for well-established technology. The don'ts are—must see technology working before believing in it; never get trapped into unrealistic financial jargons; never venture without proper market survey; and do not go for manufacturing of new product which is not yet tested at pilot scale even after being highly successful in laboratory. EF

Dr Sudhir Kumar, *Chief Executive, Green Energy Solutions, Pune, India. Email: drsk22@gmail.com*

ENERGY FUTURE

The Complete Energy Magazine

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

CONTENTS

• Energy News • Cover Story • Features • The Solar Quarterly • Viewpoint • Energy Insights • Product Update • Book Review • Book Alert • Technical Corner • Current R & D • Industry Registry • Learning Packages • RE Statistics • Events

OUR SUBSCRIBERS

• Individuals interested in energy • Energy Industry Professionals • Investors in stocks and commodities markets • Policy Institutes and Think-Tanks • Academic and Research Institutes • Government Sector / PSUs • Corporations / Corporate Professionals

Energy Future Tariff

Magazines	Tick one	1 year	2 years	3 years
Energy Future (Print+Online)		₹ 800	₹ 1440	₹ 2040
		US$ 80	US$ 144	US$ 204

You can be a part of TerraGreen and Energy Future

• Send us interesting photographs, essays, or any other inputs related to environment, energy, and sustainable development.
• Suggest ideas or topics in the field of environment, renewable energy, and sustainability, you would like to see more coverage on.

Customer Code.....(in case of renewal) .....

Name of the Customer (IN BLOCK LETTERS).....

Designation..... Company / Organization.....

.....

City..... State..... PIN.....Country.....

Email.....Tel.....

PAYMENT PROCEDURE

Enclosed a Cheque/Demand Draft number.....drawn in favour of 'TERI' payable at New Delhi for ₹.....for 1/2/3/ year subscription of *Energy Future*.

Buy online at http://bookstore.teriin.org

FOR SUBSCRIPTION QUERIES CONTACT

Kakali Ghosh, Asst Executive (Marketing), Email: kakalig@teri.res.in

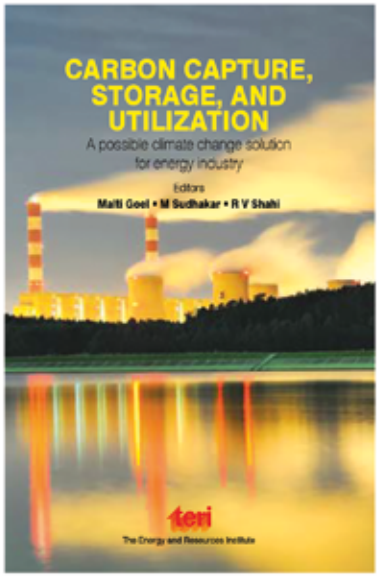
The Energy and Resources Institute

THE ENERGY AND RESOURCES INSTITUTE
Darbari Seth Block, IHC Complex
Lodhi Road, New Delhi – 110 003
Tel. 2468 2100 or 4150 4900, Fax 2468 2144 or 2468 2145
India +91 • Delhi (0) 11

http://bookstore.teriin.org

A teri Publication

JUST RELEASED



CARBON CAPTURE, STORAGE, AND UTILIZATION

A possible climate change solution for energy industry

Editors

Malti Goel, M Sudhakar, and R V Shahi

2015 • ISBN: 9788179935682
Pages: 290 • Binding: Hardback
Size: 180 × 240 mm • Price: ₹950.00

Carbon Capture and Storage (CCS) is among the advanced energy technologies suggested to make the conventional fossil fuel sources environmentally sustainable. It is of particular importance to coal-based economies.

Carbon Capture, Storage, and Utilization deals at length with the various aspects of carbon dioxide capture, its utilization and takes a closer look at the earth processes in carbon dioxide storage. It discusses potential of carbon capture, storage, and utilization as innovative energy technology towards a sustainable energy future. Various techniques of carbon dioxide recovery from power plants by physical, chemical, and biological means as well as challenges and prospects in biomimetic carbon sequestration are described. Carbon fixation potential in coal mines and in saline aquifers is also discussed.

Key Features

- Analyses how current research on carbon capture, storage, and utilization is being pursued throughout the world.
- Presents details of earth process in carbon sequestration such as saline aquifers, minerals, rocks, and coal mines.
- Describes the new cost-effective processes being developed in carbon dioxide utilization for value-added products.

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

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

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

CAPACITY BUILDING HUB FOR SUSTAINABLE ENERGY

Launch of SE4ALL Capacity Building Hub by Prof. Achim Steiner

The Sustainable Energy for All (SE4All) initiative brings together top-level leadership from all sectors of society to achieve a broad-based transformation of the world's energy systems towards a prosperous, healthier, cleaner, and safer world.

In this regard, The Energy and Resources Institute (TERI) and the TERI University launched the SE4ALL Capacity Building Hub in June 2014. The Hub aims at addressing the capacity needs of the stakeholders, including policymakers, energy entrepreneurs, system designers and integrators, financial institutions, and development practitioners. The Hub leverages mutual strengths of SE4ALL Hubs and other national, regional, and global institutions to trigger attainment of SE4ALL goals. The delivery modes include a combination of workshops/conferences, video lectures, live webinars, virtual laboratories, and hands-on training.

Since inception, the Hub has steered a range of training and capacity building activities in South-Asia and Africa. This includes development of e-learning modules on energy access, focusing upon solar lighting, and improved biomass cooking, with support from Department for International Development, UK.

For more information, visit www.se4allcapacityhub.org.

Explore the Courses

Course on Solar Lighting Technologies: Concept to Commissioning and Beyond

Mr Debajit Palit, Course Coordinator

Training on Improved Biomass Cookstoves

Mr S Arun, Course Coordinator

15th DELHI SUSTAINABLE DEVELOPMENT SUMMIT (DSDS)

The Energy and Resources Institute (TERI), since 2001, annually organizes the Delhi Sustainable Development Summit (DSDS), an international platform to facilitate the exchange of knowledge on all aspects of sustainable development. Over the past 14 years, it has emerged as one of the foremost fora on issues related to global sustainability. The DSDS 2015 was held in New Delhi from 5–7 February 2015. DSDS 2015 witnessed the participation of 16 current and former Heads of State and government, three Nobel Laureates, 15 current and former ministers from 12 countries, and many other eminent speakers. Deliberations at DSDS 2015 were hosted under the broad rubric of 'Sustainable Development Goals and Dealing with Climate Change'.

The High Level Corporate Dialogue (HLCD) held on February 4, 2015, the curtain raiser to DSDS 2015, witnessed around 300 participants from across the industry, over 100 top companies, more than 45 chief executive officers, and over 120 senior colleagues from the business fraternity. Themed as 'Delhi to Paris: Corporate Vision on Climate Change', the Dialogue aimed at bringing together corporate India on one platform to deliberate on various issues and challenges in tackling climate change. The year 2015 marks an important milestone when the UN General Assembly is expected to come up with and set Sustainable Development Goals (SDGs) to be accepted by all the countries of the world. The period following the DSDS 2015 would be one of major and hectic discussions for the UN General Assembly as it arrives at acceptance of these SDGs.

The HLCD addressed the challenges of tackling climate change across various issues and themes—Adapting to the Impacts of Climate Change; Efficient Waste Management; Ensuring and Expanding Access to Energy; Ensuring Water Availability in a Changing Climate; Expanding the Use of Renewable Energy; Financing the Energy Transition and Sustainable Development; Improving the Efficiency of Energy Use; Low Carbon Technologies in SMEs; Sustainable Buildings; and Towards Sustainable Mobility. Leaders from major corporates in India brainstormed to identify major action points to tackle the issues of climate change.

In a special interactive luncheon session with Shri Suresh Prabhu, Minister of Railways, India, various issues such as providing insights into planning, development, and the safety aspects of Indian Railways were touched upon. On this occasion, TERI-BCSD and YES Bank released two knowledge papers: *Enabling Finance for Scaling up Energy Efficiency in MSMEs* and *Ganga: An Inclusive Multi-Stakeholder Approach*. TERI also pre-launched the Global Sustainability Development Report 2015—*Climate Change and Sustainable Development: Assessing Progress of Regions and Countries*. The concluding session discussed various aspects related to climate change and concluded with a discussion on what can be expected from COP21 to be held in Paris.

The three days of the DSDS event were full of action and various thematic sessions touched upon many relevant and significant themes. Many eminent personalities, speakers, professors, policymakes, leaders, etc., deliberated upon the themes. The inaugural session of DSDS 2015 stressed on the significance of the year 2015, when the SDGs would be finalized and climate negotiations would take place in Paris. The session began with lighting of the lamp by the dignitaries, followed by a video presentation on DSDS 2015 that highlighted the theme, 'Be there for the future we want.' Nobel Laureate Mr Kailash Satyarthi elaborated on the impacts of environmental degradation and climate change on livelihood, health, and education in rural areas. In the sessions that followed, the participants discussed—Solutions for Inclusive, Green, and Resilient Cities; Sustainable Production and Consumption: Policy and Practice; Engaging All Stakeholders for the Future We Want; SDGs in a World of Wealth and Income Disparities; and Sustainability, Climate Change, and Corporate Sector Initiatives. The special session concluded with the thought that sustainable production and consumption have to be significantly different from 'business as usual'. This involved a change in the political will to think of issues from a

global perspective and a partnership between NGOs, developing countries, private sectors, and the academia could serve as a driving force. This was followed by a special address by Mr Ban Ki-moon, Secretary-General of United Nations (via video).

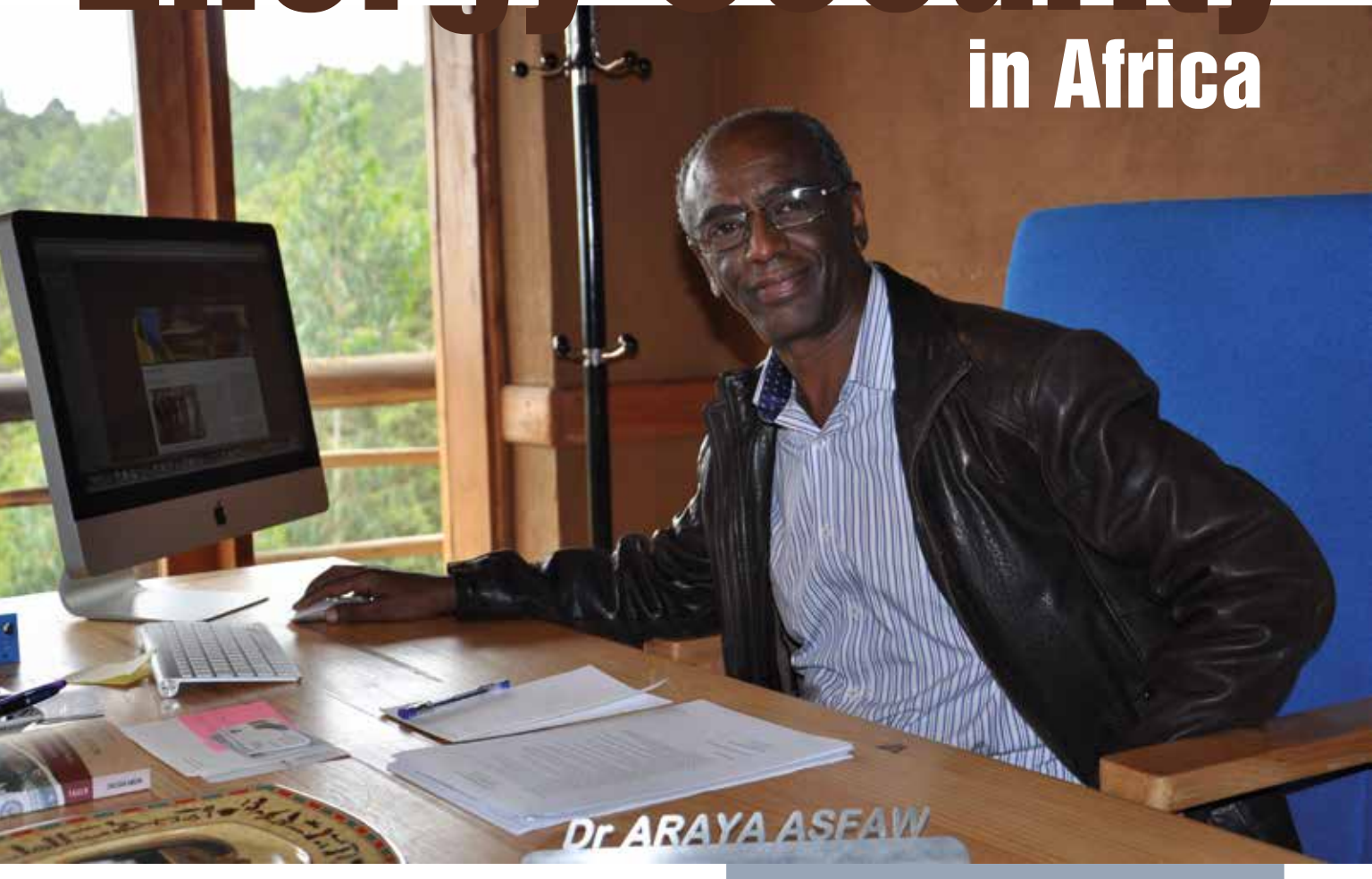
The second day of DSDS 2015 began with the ministerial session that discussed the agreement that the world requires at COP21. The speakers focused on the urgency of taking action in adapting to the impacts of climate change. The 3rd Nicholas Georgescu-Roegen Award in the category of 'Lifetime Achievement' was presented to Prof. Herman Daly, Professor Emeritus, University of Maryland. Professor Jacques Grinevald won the Georgescu-Roegen Award in the Unconventional Thinking Category. This was followed by several thematic parallel discussions and the conclusions were as follows: demand side management and energy efficiency were identified as important means to achieve low-carbon sustainable development; governance is to be aligned with scientific solutions and groundwater science should be demystified to reach out to the local people; financial, social, and economic aspects need to work in coordination to pave the way for sustainable environment; there is a need to approach frameworks that would address the national and sub-national challenges, amongst the different stakeholders. Shri Piyush Goyal, Minister of New and Renewable Energy, Government of India, stated that the idea of renewable energy germinated some 32 years ago. Today, new forms of energy are being explored that have reverence for the environment.

The third day of DSDS 2015 began with an emphasis by Prof. Jeffrey D Sachs to focus on the importance of the year 2015 in achieving SDGs in relation to climate change. He spoke about aiming at finalizing an agreement on climate change and developing a meaningful financial agreement, which underpins sustainable development. The climate change session focused on the issues of social and economic justice while tackling climate change. The conclusions for various thematic tracks were as follows: one of the major barriers in implementation of sustainable transport policy is the highly fragmented institutional arrangement for transport in India; strong policy incentives can work but the policy setting is often carried out in an ad-hoc and piecemeal manner; there is a need to develop participatory approaches for engaging with different stakeholders, including industry, governments, research organizations and community and civil society; the basic structure of the Intergovernmental Panel on Climate Change (IPCC) should be kept intact, leaving enough space for innovations and adjustments for specific and timely updates, integrated comprehensive findings, greater representation of developing countries, and better communication. In the ministerial session that followed, Mr Rajiv Pratap Rudy, Minister of State (I/C) for Skill Development and Entrepreneurship, emphasized on skill development strategies for India, as only two per cent of the country's total population is skilled at present. He added that a skilled workforce is essential to implement programmes like the National Solar Mission. The 11th Sustainable Development Leadership Award was presented to the Former President of the European Commission & Former Prime Minister of Portugal, Dr José Manuel Durão Barroso in recognition of his pioneering efforts to de-carbonize the European economy and to promote renewable energy and energy efficiency.

The valedictory session had the theme of 'Vasudhaiva Kutumbakam'. A gathering of religious leaders discussed the urgent need to make religious followers across the world aware about climate change and the corresponding importance of sustainable development. They emphasized that the true movement towards sustainable development requires not only a top-down approach but also a bottom-up approach. DSDS 2015 successfully brought together some of the best minds from around the world to discuss the upcoming SDGs and find out how all stakeholders can be engaged in tackling climate change. EF

DSDS Secretariat. Email: dsds@teri.res.in

Energy Security in Africa



Africa has an abundance of natural resources. African renewable energy resources complement each other as there are numerous rivers, large stretch of ocean and coastline, large span of land, lots of biomass-based energy, and 365 days of sunshine. ***Dr Araya Asfaw****, Executive Director, Horn of Africa Regional Environment Centre and Network, Ethiopia, discusses energy efficiency, energy security, global investment, and the future of renewable energy in Africa, especially in Ethiopia, in an interview with* ***Pawan Garg****, for* ***Energy Future****.*

Dr Araya Asfaw earned his PhD in Physics, Master of Engineering and BSc in Mechanical Engineering from Howard University, Washington, DC. He worked as a research scientist at various national laboratories in the US (including the National Institute of Standard and Technology, Centre for Advanced Microstructure and Devices, Lawrence Livermore National Laboratory and the Advanced Light Source of Lawrence Berkeley National Laboratory) before joining the Physics Department of Addis Ababa University in 1996. Dr Araya Asfaw conducted research in the area of computational fluid dynamics and heat transfer, laser spectroscopy, application of physics to material, food, environment, and sustainable energy. He has published more than 40 papers in journals of various disciplines.

As an expert of advance physics, do you feel that this field of knowledge and its implementation through various projects, can help us solve the problem of energy security?

Well, of course I have worked in physics and energy related issues in the past. However, when one looks at the problem of energy security today, it requires a lot more effort and consideration to the business and social aspects.

Currently, in Africa and Ethiopia in particular, energy security is crucial because our source of energy is dependent on biomass and imported oil. As you know, oil accounts for only 7 per cent of Ethiopia's primary energy needs, but it literally consumes all of the country's import capacity, especially when oil price is high. This way, what you earn from exports goes into importing oil. So in this sense, moving away from oil, i.e., exploring new and different sources of energy, will reduce emissions and produce significant benefits in terms of energy security.

Recently, the Government of Ethiopia has planned to build an electric railway extending from Port of Djibouti to Addis Ababa. What this means is that: a) emissions will be reduced; b) a significant amount of money will be saved by using hydropower, which is a form of renewable energy, to run the electric train. This will help the country save energy and money which otherwise would have been utilized for importing expensive oil. So basically we will need to move away from fossil fuels as much as possible, and at the same time generate electricity through local resources such as hydropower, wind, and solar which Ethiopia is extremely blessed with.

How do you see the Horn of Africa poised as far as the successful exploitation of renewable energy is concerned? Also, how can India help African countries in optimum usage of solar energy?

Well, the Horn of Africa has significant potential for both hydro and solar energy. We have almost 365 days of sunshine and many rivers like the Nile. Ethiopia alone has about 40 GW capacity for hydropower. We are blessed with geothermal, wind, and tidal energy. But unfortunately, we haven't been able to exploit all these sources of renewable energy except for hydro because the necessary technology for exploring other sources has not been developed. However, the technology that will allow the use of wind and solar energy on large scale is gradually coming to Africa.

On the same note, the huge project that India has undertaken to produce 100 GW of solar energy by 2020 is not only opening up doors for India, but also for Africa. India has the know-how, expertise, and resources to mobilize big businesses and this will give the country leverage for catching up with well developed nations in Europe and North America. Africa can also benefit a great deal by using solar and wind energy to meet its energy demands. Solar energy can be somewhat costly when it comes to storage, but this can be avoided by using solar energy during peak hours and hydro as its backup during the night. So, by combining solar, wind, and hydro energies, we can have a tremendous amount of power. This in turn can help Africa meet its growth and transformation ambitions and insure green growth. Although Africa has lots of oil, we will need to really focus on renewable energy sources.

How are we preparing for getting maximum benefits from the renewable energy sources? Is there any government plan, or a public–private partnership that is taking place? What are various businesses doing for it?

Governments are prepared and there are policies in place. For example, Ethiopia will soon be a major power supplier to the Horn of Africa region. Countries like Somalia, South Sudan, and Kenya can actually benefit from the electricity generated in Ethiopia

What is currently missing, however, is the involvement of the private sector and some policy issues which call for attention. Nonetheless, many negotiations have already been done to solicit the private sector's involvement.

Although a significant amount of electricity is being produced in Ethiopia, this is currently done

through small and medium plants and in a decentralized way. The private sector can be encouraged to make investments to fill existing gaps. When you have the private sector engaged in electricity production, it will significantly contribute to the country's development. If the Ethiopian economy continues to grow at its current rate, the demand for power is going to be very high in the future. Therefore, I don't think we can meet the demands of the future without the involvement of the private sector. In addition to the involvement of the private sector, I also believe we will need to attract international financing.

When the private sector doesn't seem to be interested in investing in power generation, how will the international financial institutions get attracted to invest in the renewable energy sector in Africa?

It is true that international investment is linked to local investment. So, I think it can be done in the form of co-generation plants. For example, if you have a sugar or agri-business plant, you can in fact generate electricity that can be fed into the grid. So these are some of the areas which can be considered. At the same time, there are many industries who are interested in investing in power generation provided that the generated power can be exported for a profit. Thus, if the tariff issue is resolved, many investors will be attracted and international financing can be secured

In India, there are several companies which manufacture solar PV panels and storage batteries. What message would you like to give to the Indian manufacturers and investors who would like to invest in Africa?

India is definitely going to be one of the leaders in the field of solar energy. I think the Indian manufacturers should look for opportunities to partner with African and Ethiopian investors and entrepreneurs. There are some encouraging policies coming up in Ethiopia for the private sector in terms of generating power. I would say that Indian companies should really think about investing in the solar energy industry in Africa, especially in Ethiopia.

How do you think the events such as DSDS 2015 help us bridge the gap?

These events help by contributing to knowledge and in raising awareness. There are several gaps that events such as Delhi Sustainable Development Summit (DSDS) and think tanks like The Energy and Resources Institute (TERI) can fill. Our Centre has been working closely with TERI for some time now and I believe TERI has lots of experience and history from which its partners can draw from.

Under the current leadership, i.e., of Shri Narendra Modi in India, do you foresee India poised for achieving the renewable energy targets in the next five years?

The current Indian leadership's performance is truly encouraging. No doubt India has lots of experience and knowledge, but this is now really being transformed into action. Just by looking at an ambitious plan of renewable energy targets, it's evident that the new Government is undertaking a lot of action. But at the same time, India should continue to encourage the use of efficient technologies in all arenas. If India continues in its current direction, I think it will have a huge market in Africa. EF

CURRENT R&D SOLAR

A Review of Combined Wave and Offshore Wind Energy

Renewable and Sustainable Energy Reviews, Volume 42, 2015, Pages 141–153

C Pérez-Collazo, D Greaves, and G Lglesias

The sustainable development of offshore wind and wave energy sectors requires optimizing the exploitation of the resources, and it is in relation to this and the shared challenge for both industries to reduce their costs that the option of integrating offshore wind and wave energy arose during the past decade. The relevant aspects of this integration are addressed in this work—the synergies between offshore wind and wave energy, the different options for combining wave and offshore wind energy, and the technological aspects. Because of the novelty of combined wave and offshore wind systems, a comprehensive classification was lacking. This is presented in this work based on the degree of integration between the technologies, and the type of substructure. This classification forms the basis for the review of the different concepts. This review is complemented with specific sections on the state of the art of two particularly challenging aspects, namely the substructures and the wave energy conversion.

A Study on Global Solar PV Energy Developments and Policies with Special Focus on the Top Ten Solar PV Power Producing Countries

Renewable and Sustainable Energy Reviews, Volume 43, 2015, Pages 621–634

Bikash Kumar Sahu

The mitigations of global energy demands, climate change, and energy related greenhouse gas effects are the most important factors in the modern days. However, renewable energy is one of the alternative sources which has the capacity to mitigate all the above. Among all the renewable energy sources, solar energy is one of the most abundant and the cleanest energy source. Different laboratories of the world have achieved different solar cell efficiencies, which have been discussed in this paper. The paper presents the global solar PV developments, per capita values, government supportive invectives, and policies of the top 10 solar power producing countries. This paper also presents the investments of the global solar energy among the countries. Finally, through study, it was found that these top 10 leading countries were following fulfillment of their projections, supportive tariff rates, net metering, green certificates and government incentive policies as their instruments.

Repowering: An Actual Possibility for Wind Energy in Spain in a New Scenario without Feed-in-Tariffs

Renewable and Sustainable Energy Reviews, Volume 41, 2015, Pages 319–337

Antonio Colmenar-Santos, Severo Campíñez-Romero, Clara Pérez-Molina, and Francisco Mur-Pérez

At the end of January 2012, the Spanish Government suspended the economic incentives for electricity generation facilities using renewable energy sources, including wind energy plants.

Spain maintains a high level of energy dependence that can only be reduced by applying measures to increase energy efficiency and using massive amounts of renewable sources. In addition, the target assumed by Spain, i.e., to have at least 20 per cent of the primary energy to be supplied by renewable sources by 2020, has not yet been reached.

In Spain, wind farms, a number of which have been in commercial operation for over 15 years, offer a broad market appropriate for repowering. The use of more efficient wind turbines by means of repowering provides benefits to the electricity sector as a whole by optimizing the use of natural resources and facilitating the grid integration of the energy generated.

This paper analyses existing wind farms to quantify and characterize the market suitable for repowering. We discuss whether repowering is a valid alternative from the point of view of feasibility to enable the continuation of the integration of wind energy in the Spanish energy mix and whether this feasibility is sufficient when the energy generated is charged at the electricity market price in terms of grid parity. The results support that repowering is a profitable alternative and is often even better than the construction of new wind farms under certain conditions.

Mercury Emissions by Beijing's Fossil Energy Consumption: Based on Environmentally Extended Input–Output Analysis

Renewable and Sustainable Energy Reviews, Volume 41, 2015, Pages 1167–1175
J S Li, G Q Chen, T Hayatb, and A Alsaedi

Fossil energy burning is one of the most important sources of atmospheric mercury emissions, which poses great threats to both environment and human health. Urban regions are dominant energy consumers; however, the information on the resultant mercury emissions in urban regions has been lacking. Therefore, in light of environmentally extended input–output analysis, this study used Beijing as a case to investigate embodied (direct + indirect) mercury emissions induced by fossil energy consumption in urban regions. The results show that embodied mercury emissions caused by Beijing's fossil energy consumption amounted to 5.86 tonnes, which is over 1.5 times the direct emissions, indicating that the conventional direct emission accounting method will lead to significant emission leakage. Coal combustion takes the major responsibility for energy-related mercury emissions. As a net importer of embodied mercury emissions, Beijing avoided a considerable amount of mercury emissions. Sectors like construction which play key role in embodied mercury emissions are also identified in this study. To comprehensively reduce mercury emissions from energy consumption, the Beijing Government should devote efforts to develop clean coal technology and high efficiency mercury removal devices, shift investment from infrastructure construction to tertiary industries, and optimize green consumption among the residents, especially the urban residents. The method and findings may be useful for compilation of overall urban mercury emissions inventory as well as have important policy implications for global cities to control mercury emissions.

Assessing Land-Use Impacts by Clean Vehicle Systems

Resources, Conservation and Recycling, Volume 95, 2015, Pages 112–119
Patricia Pontaua, Yi Houa, Hua Caia, Yi Zhena, Xiaoping Jiae, Anthony SF Chiuf, and Ming Xua

Transition of the current gasoline-based transportation system into a renewable fuel-based clean vehicle system has the potential to reduce greenhouse gas emissions and improve national energy security. However, the realized net environmental benefit or energy security improvement is tightly linked to the electricity fuel mix (for electric cars and plug-in hybrids) and fuelling strategy (for cars using alternative liquid fuels). In addition, different types of transportation fuels have significantly different demands on land resources, both on land type and quantity. For example, biofuel production requires large quantities of agricultural land, while wind farms require land with sufficient wind density. Furthermore, there is substantial regional variation in the quality of necessary resources. Regions with higher wind speeds require less land to produce the same amount of electricity than those with lower wind speed, assuming the same turbine design. Similarly, regions with optimal soil conditions and climate for crop cultivation require less land to produce the same amount of biofuel. To enable comparison of land demand among different fuel choices for clean vehicles, this research provides a county-scale assessment of land demand based on a "per-vehicle-mile-travelled" basis. Potential clean vehicle fuels assessed in this study include ethanol produced from different feed stocks (corn and switch grass), biodiesel from algae cultivated in open ponds and closed systems, and electricity produced from renewable sources (wind and solar). Our results show that, in general, engineered systems (wind electricity, solar electricity, and biodiesel from closed-system algae) are more land efficient than natural systems (corn ethanol from corn starch and stover, switch-grass ethanol, and biodiesel from open-pond algae). Solar electricity is the dominant regional optimal fuel choice from the land-use perspective for engineered systems while lowland switch grass ethanol and biodiesel from open-pond algae are the major optimal choices for the natural systems. These results shed light on developing both federal and state level policies to minimize land-use impact for the development of a clean vehicle system.

Assessment of the Energetic and Mechanical Properties of Pellets

Produced from Agricultural Biomass

Renewable Energy, Volume 76, 2015, Pages 312–317
Ignacy Niedziołka, Mieczysław Szpryngiel, Magdalena Kachel-Jakubowska, Artur Kraszkiewicz, Kazimierz Zawislak, Paweł Sobczak, and Rafał Nadulski

This paper presents an assessment of the energetic and mechanical properties of pellets produced from agricultural biomass. For the production of pellets, the following raw materials were used: wheat straw, rape straw, and maize straw. Additionally, the mixtures of wheat-rape straw, wheat-maize straw, and rape-maize straw (each accounting for 50 per cent of the mass) were applied. The studied resources

were ground with the use of a universal shredder driven by a 7.5 kW electric engine. A pelleting machine fitted with a fixed flat matrix with two driven thickening rolls was used to produce the pellets. Analyses of the moisture and calorific value of resources as well as the bulk density and mechanical strength of pellets were performed according to biding standards. The moisture of resources ranged from 16.5 per cent to 18.5 per cent for rape and maize straw, respectively. The average calorific value fluctuated between 15.3 MJ/kg for a mixture of wheat and rape straw to 16.2 MJ/kg for maize straw. The bulk density and mechanical strength of pellets depended on the type of resources used. The lowest bulk density was recorded for wheat straw pellets (386–420 kgm^3), and the highest (561–572 kgm^3) for maize straw pellets. The lowest mechanical strength of pellets was noted for rape (95.4–96.8 per cent), whereas the highest was for pellets made from a wheat and maize straw mixture (96.8–98.9 per cent).

Capacity Allocation of a Hybrid Energy Storage System for Power

System Peak Shaving at High Wind Power Penetration Level

Renewable Energy, Volume 75, 2015, Pages 541–549

Pan Zhao, Jiangfeng Wang, and Yiping Dai

High wind power penetration in power system leads to a significant challenge in balancing power production and consumption due to the intermittence of wind. Introducing energy storage system in wind energy system can help offset the negative effects, and make the wind power controllable. However, the power spectrum density of wind power outputs shows that the fluctuations of wind energy include various components with different frequencies and amplitudes. This implies that the hybrid energy storage system is more suitable for smoothing out the wind power fluctuations effectively rather than the independent energy storage system. In this paper, we proposed a preliminary scheme for capacity allocation of hybrid energy storage system for power system peak shaving by using spectral analysis method. The unbalance power generated from load dispatch plan and wind power outputs is decomposed into four components, which are outer-day, intra-day, short-term, and very short-term components, by using Discrete Fourier Transform (DFT) and spectral decomposition method. The capacity allocation can be quantified according to the information in these components. The simulation results show that the power rating and energy rating of hybrid energy storage system in partial smoothing mode decrease significantly in comparison with those in fully smoothing mode.

Combining Wind Farms with Concentrating Solar Plants to Provide Stable Renewable Power

Renewable Energy, Volume 76, 2015, Pages 539–550

F J Santos-Alamillos, D Pozo-V_azquez, J A Ruiz-Arias, L Von Bremen, and J Tovar-Pescador

This paper evaluates the extent to which a combination of wind power and Concentrating Solar Power (CSP) may lead to stable and even base load power by taking advantage of: 1) spatiotemporal balancing of solar and wind energy resources and 2) storage capabilities of CSP plants. A case study is conducted for the region of Andalusia in Spain. To this end, spatiotemporal variability of modelled CSP and wind capacity factors in a 3-km spatial resolution grid were analysed based on Principal Component Analysis (PCA) and Canonical Correlation analysis (CCA). Results reveal that renewable base load power can be obtained in the study region by locating wind farms and CSP plants using balancing patterns derived from CCA and PCA. In addition, the power fluctuation reduction attained from these patterns was substantially higher than those obtained by interconnecting randomly-located wind farms and CSP plants across the study region.

Results were particularly meaningful for the winter season. Upon considering storage capability of the CSP plants, results proved better. The main difference was a higher firm capacity value associated with spring and summer seasons. For the other seasons, the contribution of thermal storage capabilities of the CSP plants to stable power proved less relevant.

Ecological Impacts of Wind Farms on Birds: Questions, Hypotheses, and Research Needs

Renewable and Sustainable Energy Reviews, Volume 44, 2015, Pages 599–607

Shifeng Wang, Sicong Wang, and Pete Smith

Wind power is increasingly being used worldwide as an important contribution to renewable energy, due to its low greenhouse gas emissions compared to fossil fuels. However, it has been suggested that the development of wind power has caused an adverse impacts on birds. The paper summarises current evidence of bird fatalities resulting from wind power, outlines the reasons why and how birds are killed by wind power developments. It is important to identify research needs and inform researchers, decision makers, developers and other stakeholders, to help mitigate any adverse impacts of wind power developments on birds. EF

Solar Refriger & Freezers

Solar refrigerators and solar freezers are particularly useful on RVs, boating trips, recreational storage, and as well as for isolated locations such as camping trips and cabins. These are very good for aid work or emergency relief.

ators

Solar refrigerators and solar freezers have surged in popularity because these solar appliances are particularly useful for Recreational Vehicles (RVs), boating trips as well as for isolated locations such as cabins and camping trips. In addition, they are particularly useful for aid work or emergency relief. There are several solar refrigerators and solar freezers of varying sizes that suit the needs of different customers.

A solar refrigerator or solar freezer is a refrigerator which runs directly on energy provided by the sun, and may include photovoltaic or solar thermal energy. Such solar refrigerators or freezers are able to keep perishable goods, such as meat and dairy products, cool in hot climates as well as retain vaccines at their appropriate temperature to avoid spoilage. Solar refrigerators may be most commonly used in the developing world to help mitigate poverty and climate change.

RATIONALE

The conventional refrigeration technologies which include contribution to ozone layer depletion and global warming have several environmental concerns. Refrigerators which have substances that result in ozone depletion and global warming such as chlorofluorocarbons (CFCs), in their insulation foam or their refrigerant cycle, are extremely harmful. In 1980s when the CFCs were banned, substances such as hydrochlorofluorocarbons (HCFCs) replaced them. These are ozone-depleting substances and emit hydrofluorocarbons (HFCs). Both of these are environmentally destructive and have the potential of emitting global warming chemicals. In addition, it is understood that an inefficient refrigerator will lead to more global warming as compared to an efficient one. Thankfully, the use of solar energy to power refrigeration aids in minimizing the negative impacts of refrigerators on the environment.

UTILITY

Due to remote locations and inaccessible energy supply, researchers and aid workers face a challenge while safely storing food supplies, agricultural produce, medical supplies, and frozen products. Solar refrigerators and freezers come in different capacities that meet specific storage requirement at the varied remote locations. In addition, solar refrigerators and solar freezers can also be configured for residential or commercial field applications.

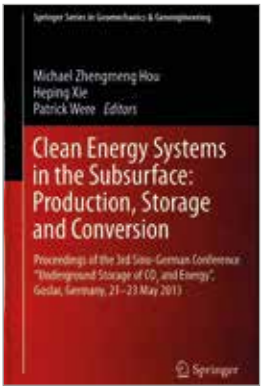
BENEFITS

Solar refrigerators and solar freezers have many benefits, the major ones being:

- Solar refrigerators run on electricity provided by solar energy and can keep perishable goods such as meat, dairy products, and vaccines at their appropriate temperature to avoid spoilage
- Solar refrigerators may be the best fit for climate change. This is the perfect solution for the power crises; these devices just need water and some sunlight for their functioning
- Solar refrigerators and freezers come with the most energy efficient ways to keep things cool
- Solar refrigerators and freezers are the best solution for power storage
- Solar refrigerators and freezers have several qualities including—low energy consumption, efficient units, low maintenance, and are economical in use EF

Source: www.solartown.com

CLEAN ENERGY SYSTEMS IN THE SUBSURFACE: PRODUCTION, STORAGE AND CONVERSION



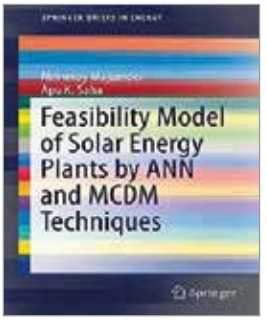
Editors: Michael Zhengmeng Hou, Heping Xie, and Patrick Were
Publisher: Springer

This volume is the conference proceedings of the 3rd Sino-German Conference "Underground Storage of CO_2 and Energy", held in Goslar, Germany from 21–23 May 2013.

The volume is a collection of diverse quality scientific works from different perspectives elucidating on the current developments in CO_2 geologic sequestration research to reduce greenhouse emissions including measures to monitor surface leakage, groundwater quality, and the integrity of caprock, while ensuring a sufficient supply of clean energy. The contributions herein have been structured in to six major thematic research themes– Integrated Energy and Environmental Utilization of Geo-reservoirs: Law, Risk Management & Monitoring; CO_2 for Enhanced Gas and Oil Recovery, Coal Bedded Methane and Geothermal Systems; Trapping Mechanisms and Multi-Barrier Sealing Systems for Long-Term CO_2 Storage; Coupled THMC-Processes and Numerical Modelling; Rock Mechanical Behaviour Considering Cyclic Loading, Dilatancy, Damage, Self-sealing and Healing; and Underground Storage and Supply of Energy.

Clean Energy Systems in the Subsurface is invaluable to researchers, scientists, and experts in both academia and industry, trying to find a long-lasting solution to the problems of global climate change, energy security, and sustainability. EF

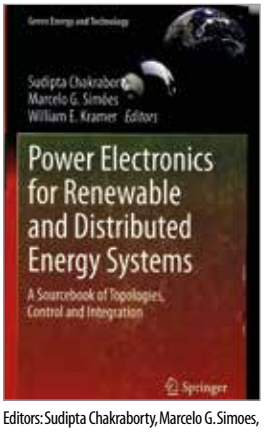
FEASIBILITY MODEL OF SOLAR ENERGY PLANTS BY ANN AND MCDM TECHNIQUES (SPRINGER BRIEFS IN ENERGY)



Authors: Mrinmoy Majumder and Apu K. Saha
Publisher: Springer

Feasibility Model of Solar Energy Plants by ANN and MCDM Techniques highlights a novel model to find out the feasibility of any location to produce solar energy. The model utilizes the latest multi-criteria decision-making techniques and artificial neural networks to predict the suitability of a location to maximize allocation of available energy for producing optimal amount of electricity, which will help satisfy the demands from the market. According to the results of the case studies, further applications are encouraged. EF

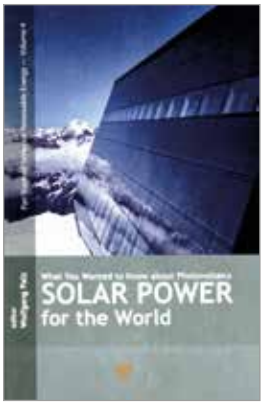
POWER ELECTRONICS FOR RENEWABLE AND DISTRIBUTED ENERGY SYSTEMS



Editors: Sudipta Chakraborty, Marcelo G. Simoes, and William E. Krammer
Publisher: Springer

Power Electronics for Renewable and Distributed Energy Systems takes an integrative approach discussing power electronic converters topologies, controls, and integration that are specific to the renewable and distributed energy system applications. An overview of power electronic technologies is followed by the introduction of various renewable and distributed energy resources that include photovoltaics, wind, small hydroelectric, fuel cells, microturbines, and variable speed generation. Energy storage systems such as battery and fast response storage systems are discussed along with application-specific examples. After setting forth the fundamentals, the chapters focus on more complex topics such as modular power electronics, microgrids, and smart grids for integrating renewable and distributed energy. Emerging topics such as advanced electric vehicles and distributed control paradigm for power system control have been discussed in the last two chapters. With contributions from subject matter experts, the diagrams and detailed examples provided in each chapter make *Power Electronics for Renewable and Distributed Energy Systems* a sourcebook for electrical engineers and consultants working to deploy various renewable and distributed energy systems and can serve as a comprehensive guide for the upper-level undergraduates and graduate students across the globe. EF

SOLAR POWER FOR THE WORLD

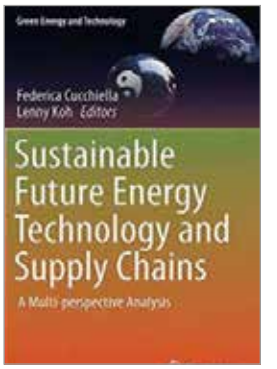


Editor: Wolfgang Palz
Publisher: Pan Stanford Publishing Pte. Ltd

Solar Power for the World describes the industrial revolution associated with the implementation of electric power generation by photovoltaics (PV), the conversion of the sun's radiation. It also describes the dramatic events in the industry that happened between 2009 and 2013—hundreds of PV companies in difficulty and the trade war between the European Union and China mobilizing state leaders on both sides to avoid a serious conflict. The contributing authors are protagonists all over the world who brought PV from its industrial birth in 1954 all the way up to the stormy developments during the first decade of the new century.

According to this book, virtually non-existent at the beginning of this century, solar installations worldwide have reached over 100 GW in late 2012. Eventually, in 2012, PV became cheap enough to provide decentralized power to all. In one single year, more solar power capacity was installed globally than nuclear and other types of conventional power. Investments reached hundreds of billions of US dollars, i.e., a multiple of the cost of "Apollo", which was used to send men on the moon. Over half a million new PV jobs were created despite the financial crisis in the Western economies. EF

SUSTAINABLE FUTURE ENERGY TECHNOLOGY AND SUPPLY CHAINS: A MULTI-PERSPECTIVE ANALYSIS

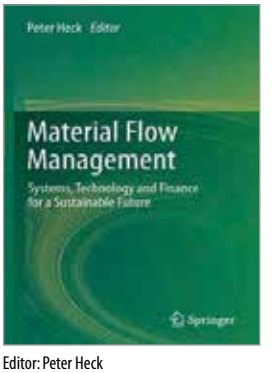


Editors: Federica Cucchiella and Lenny Koh
Publisher: Springer

Sustainable Future Energy Technology and Supply Chains: A Multi-Perspective Analysis is organized around real examples and case studies that can be applied to real-world problems. This book provides a valuable resource for anyone who wishes to understand how sustainable use of energy can lead to increased efficiency of industrial supply chains and improved financial profitability. Furthermore, insight is provided by an international panel of contributors, and the book provides comprehensive coverage of current practice and future developments in the evolution of sustainable supply chains and energy consumption.

The text underlines how organizations are now looking seriously at supply chain assets in order to help their suppliers retool and focus on renewable energy. Renewable energy technology is a fast growing market with promising financial returns and substantial environmental gains; this book shows how the right management of renewable investments can have significant advantages by providing critical opportunities in driving costs down and making renewable energy sources more competitive with conventional energy; making infrastructure expansion easier; increasing employment in manufacturing and services supply chains in order to support renewable energy generation; and mitigating the impacts of climate change. This book is intended for business professionals, researchers, and students working in supply chain management or energy management. EF

MATERIAL FLOW MANAGEMENT: SYSTEMS, TECHNOLOGY AND FINANCE FOR A SUSTAINABLE FUTURE



Editor: Peter Heck
Publisher: Springer

The guidebook—*Material Flow Management: Systems, Technology and Finance for a Sustainable Future*—gives a comprehensive introduction into the optimization of energy and material systems, i.e., companies, cities, and counties. It combines the fields of ecology, management, technology, and microeconomics. Thus, the book offers the theoretical background of material flow. It explains how to apply material flow management and encourages the reader to develop new material flow management projects. An interactive web-based e-Learning tool will complete the book. EF

RENEWABLE ENERGY TECHNOLOGY DEVELOPMENT

ONE STEP CLOSER TO ARTIFICIAL PHOTOSYNTHESIS AND 'SOLAR FUELS'

Caltech scientists, inspired by a chemical process found in leaves, have developed an electrically conductive film that could help pave the way for devices capable of harnessing sunlight to split water into hydrogen fuel. When applied to semiconducting materials such as silicon, the nickel oxide film prevents rust build-up and facilitates an important chemical process in the solar-driven production of fuels such as methane or hydrogen. The development could help lead to safe, efficient artificial photosynthetic systems—also called solar-fuel generators or "artificial leaves"—that replicate the natural process of photosynthesis that plants use to convert sunlight, water, and carbon dioxide into oxygen and fuel in the form of carbohydrates, or sugars. The artificial leaf consists of three main components: two electrodes—a photoanode and a photocathode—and a membrane. The photoanode uses sunlight to oxidize water molecules to generate oxygen gas, protons, and electrons, while the photocathode recombines the protons and electrons to form hydrogen gas. The membrane, which is typically made of plastic, keeps the two gases separate in order to eliminate any possibility of an explosion, and lets the gas be collected under pressure to safely push it into a pipeline. The team has shown that its nickel oxide film is compatible with many different kinds of semiconductor materials, including silicon, indium phosphide, and cadmium telluride. When applied to photoanodes, the nickel oxide film far exceeded the performance of other similar films. That film was more complicated—it consisted of two layers versus one and used as its main ingredient titanium dioxide (TiO_2, also known as titania), a naturally occurring compound that is also used to make sunscreens, toothpastes, and white paint.

http://www.sciencedaily.com/releases/2015/03/150309155525.htm

CHINA SOLAR FIRM LAUNCHES PV MODULE TESTING LAB

The facility aims to speed up R&D and reduce lead times in solar technology Firm JinkoSolar has opened of a PV module testing laboratory in China. The Chinese solar manufacturer's "state-of-the-art" facility, which is in Jiangxi, can conduct over 16 different kinds of tests, ranging from basic pressure and impact tests to challenging hot spot, pre-decay and UV aging tests.

Kangping Chen, CEO of JinkoSolar, said, "The opening of JinkoSolar's new world class PV module testing laboratory complements our mission to produce the highest quality and most reliable solar panels in the industry. The professional personnel and testing facilities will help the company accelerate its R&D process and reduce lead time of testing and qualification so that we can bring the latest solar technology to our customers as fast as possible. We believe that only non-compromising quality standards of PV modules can guarantee customer trust and loyalty."

The China facility has been awarded the Underwriters Laboratories (UL) Witness Testing Data Program (WTDP) Certificate. JinkoSolar worked with UL, a global leader for product safety, to conduct the testing required to obtain the certification. Through its WTDP, customer and third party

facilities may conduct tests under the supervision of UL personnel, which both ensures high quality products and expedite the time to market. The factory is furnished with cutting edge equipment to conduct tests in accordance with UL test standards and procedures. All tests conform to UL and International Electrotechnical Commission regulations.

In establishing the facility, JinkoSolar received both technical guidance and oversight from professional technical expert witnesses from UL. In two to three years, JinkoSolar aims to reach a higher level of strategic partnership with UL under its Client Test Data Program (CTDP). Under the CTDP, JinkoSolar will be authorized by UL to conduct test programmes independently.

http://www.jinkosolar.com/press_detail_224.html

CHINESE SOLAR POWER FIRM LAUNCHES PV FOR INDIA

ReneSola to manufacture PV modules outside of China for first time and develop 250MW for Indian market. China's ReneSola expects to provide 250MW of PV modules to India over a two-year period. A leading Chinese photovoltaic manufacturer is to develop its PV modules in India. ReneSola, a global manufacturer of solar photovoltaic modules and wafers in China, has introduced its latest multi-crystalline PV modules to the Indian market.

The Virtus II modules were launched at the 6th Renewable Energy India 2012 Expo event in New Delhi. In addition, ReneSola has started providing locally produced PV modules to the Indian market and expects to provide 250MW of India-made PV modules over a two-year period. This is the first time the company has provided locally produced PV modules outside of China, emphasizing the importance of the India PV market. The India launch follows the successful introduction of the solar modules to the US and Australian markets. ReneSola said it will realize the 250MW target through collaborating with local strategic partners in India.

The news from ReneSolar marks another example of Chinese renewable energy firms moving into India to expand their business. In July, Chinese wind firm Ming Yang formed a strategic partnership to build 2,500MW of wind and solar projects in the BRIC country.

http://www.onlinetes.com/renesola-solar-modules-india-11812.aspx

BENEFITS OF ADDING A SECOND, SMALLER ROTOR TO WIND TURBINES

Aerospace engineers are developing dual-rotor technology to improve the energy harvest of wind turbines. The idea to look for better performance by adding a second rotor to wind turbines came from a previous study. The study used wind tunnel tests to see how hills, valleys and the placement of turbines affected the productivity of onshore wind farms. Hui Hu picked up a 3-D printed model of a typical wind turbine and began explaining two problems with the big, tall, three-bladed machines. The study explains that they're big, round structural pieces. They're not shaped like an airfoil. And so they don't harvest any wind, reducing a turbine's energy harvest by about 5 per cent. Second, the big blades disturb the wind, creating a wake behind them and reducing the energy harvest of any downwind turbines. Hu said that a turbine sitting in the slipstream of another can lose 8–40 per cent of its energy production, depending on conditions. To try to solve these problems, the researchers put a small rotor on the turbine, and found that with two rotors on the same tower, one gets more energy.

Using lab tests and computer simulations, the researchers have found those extra blades can increase a wind farm's energy harvest by 18 per cent.

http://www.sciencedaily.com/releases/2015/03/150309174513.htm

CO_2 INCREASE CAN INTENSIFY FUTURE DROUGHTS IN TROPICS, STUDY SUGGESTS

A new article discusses the importance of research that suggests increases in atmospheric CO_2 could intensify extreme droughts in tropical and subtropical regions. For the first time through computer climate modeling, the study shows that the Hadley Circulation will intensify as the world warms. This is the first study that suggests a possible intensification of droughts in the tropic-subtropical margins in warmer climate. The finding is critical to understanding what the world will be like as the climate continues to change. The Hadley Circulation, associated with the prevailing trade winds in the tropics, is an atmospheric air current centered around the equator that affects areas between the latitudes of about 30° north and 30° south.

The Hadley Circulation influences the distribution of rainfall, clouds, and relative humidity over half of Earth's surface. It can expand or contract in a warmer or colder global climate, leading to substantial changes of regional rainfall. During the past decade or two, the Hadley Circulation has become stronger and expanded toward the poles at a rate faster than predicted by global climate models, contributing to increased droughts over many subtropical regions and increased rainfall in equatorial regions. Past studies have attributed the intensifying of the Hadley Circulation to natural decadal climate variability, because climate models have predicted that the Hadley Circulation will weaken in the future as climate changes. But the study found that the Hadley Circulation intensified in warmer climate, which is expected to continue. EF

http://www.sciencedaily.com/releases/2015/03/150309155535.htm

INDUSTRY REGISTRY

KUKA Systems GmbH
Turnkey solutions for photovoltaic and solar thermal module production. Engineering, robot technology and service from one source.
Bluecherstr. 144 86165 Augsburg, Germany
Tel: +49/821/797-1076
Email: solar@kuka.de
Website: www.kuka-systems.de

Mastervolt
Manufacturer of grid-connected and stand-alone inverters in range from 100 W–25 kW. Also for system design and advice. High-quality products and services.
PO Box 22947, NL-1100 DK, Amsterdam
Tel: +31-20-3422100
Fax: 6971006
Email: info@mastervolt.com
Website: www.mastervolt.com

ABB
ABB is a leader in power and automation technologies that enable utility and industry customers to improve their performance while lowering environmental impact. The ABB Group of companies operates in around 100 countries and employs about 130,000 people.
Hiomotie 13, FI-00380, Helsinki, Finland
Tel: +358/102211
Email:feedbackmaster.solar@fi.abb.com
Website: www.abb.com/solar

Voltronic Power Technology
Leading OEM/DOM manufacturer of grid-tied inverters, hybrid inverters off-grid inverters and MPPT charger with user-friendly LCD.
5F, No. 151, Xinhu 1st road, Neihu dist. Taipei, Taiwan
Tel: +886-2-27918296
Email: sales@voltronic.com.tw
Website: www.voltronicpower.com

ECOPROGETTI Srl
With 25 years of experience in the photovoltaic industry, we design and construct complete turnkey lines and personalized equipment for the production of photovoltaic modules.
Via dell'industria e dell'artigianato 27/C Carmignano di Brenta, Italy
Tel: +390-49-5991959
Fax: 9459210
Email: info@ecoprogetti.it
Website: www.ecoprogetti.it

SCHMID Group
Process and automation equipment as well as turnkey solutions for wafer production, cell production and module assembly.
Robert-Bosch-Str. 32-36 D-72250 Freudenstadt, Germany
Tel: +49/7441/538-0
Email: info@schmid-group.com
Website: www.schmid-group.com

Grenzebach Maschinenbau
Production technology for thin-film modules: Glass sheet loading, transport cleaning, storage, cutting, snapping, edge deletion, robot handling, inspection lamination, simulation systems
Albanusstraße 1 86663 Asbach-Bäumenheim, Germany
Tel: 0049906982-2000
Fax: 0049906982-2108
Email: info@grenzebach.com
Website: www.grenzebach.com

LPKF SolarQuipment GmbH
LPKF Allegro TM - Laser systems for fast and precise scribing of thin-film solar panels CdTe, CIS, a-Si/µSi) on glass and flexible substrates.
Mittelbergstr. 17, D-98527 Suhl, Germany
Tel: +49(0)3681/8924-0
Email: solar@lpkf.de
Website: www.lpkf-solarquipment.com

Meco Equipment Engineers
Plating equipment for semi conductor and solar industry. Turn-key plating lines for thin-film solar cell manufacturing, metallization on silicon solar cells and on flex foil.
Marconilaan 2 NL-5151 DR Drunen, Netherlands
Tel: +31/416/384384
Fax: 384300
Email: meco.sales@besi.com
Website: www.meco.nl

M-Solv
Innovative and independent laser-processing tool manufacturer with standard and bespoke products for crystalline and thin-film photovoltaic production.
Oxonian Park Kidlington Oxford OX5 IFP, UK
Tel: +44/1865/844070
Fax: 844071
Email: m-solv@m-solv.com
Website: www.m-solv.com

General Solar Power (Yantai) Co., Ltd
Manufacturer of a full range of a-Si modules for residential, commercial, utility, and BIPV applications; total solutions provider combining up & down stream capabilities; Certifications: IEC 61646, EN 61730
TUV I ntercert, CGC, TUV Rheinland, CE, UL No.22, Yingteer Av., Fushan Dist., Yantai 265500
Tel: +86 535 6980888
Fax: +86 535 6985888
Email: sales@solargsp.com
Website: www.solargsp.com

Vikram Solar
Manufacturer of high efficiency PV modules for on-grid and off-grid applications from 5W-270W with TUV and UL certification and backed by 25 years limited power warranty.
Tobacco House 4th Floor, 1 Old Court House Corner, Kolkata-700001, India
Tel: +913322307299 (3 lines)
Fax: +913322484881
Email: sales@vikramsolar.com

NATIONAL AND INTERNATIONAL EVENTS

INTERNATIONAL

Greentech Media's 8th Annual Solar Summit

April 14–16, 2015

Phoenix, USA
Website: https://www.energymeetings.com/

ACEEE 2015 National Symposium on Market Transformation

April 20–22, 2015

Washington, DC, USA
Website: https://www.energymeetings.com/

Power Up Energy Expo

April 20–23, 2015

Miramar Beach, USA
Website: https://www.energymeetings.com/

CxEnergy 2015

April 27–30, 2015

Las Vegas, USA
Website: https://www.energymeetings.com/

ACI National Home Performance Conference & Trade Show 2015

May 4–7, 2015

New Orleans, USA
Website: https://www.energymeetings.com/

Energy Efficiency Global Forum - Alliance to Save Energy

May 12–13, 2015

Washington, DC, USA
Website: https://www.energymeetings.com/

Utility Energy Forum

May 13–15, 2015

Tahoe City, USA
Website: https://www.energymeetings.com/

AESP Spring Conference 2015

May 19–21, 2015

Portland, USA
Website: https://www.energymeetings.com/

NSERC SNEBRN 4th Annual General Meeting & Workshops

May 19–22, 2015

Saskatoon, USA
Website: https://www.energymeetings.com/

National Town Meeting on Demand Response + Smart Grid

May 26–28, 2015

Washington, DC, USA
Website: https://www.energymeetings.com/

ACEEE 2015 Energy Efficiency Finance Forum

May 31-June 2, 2015

San Francisco, USA
Website: https://www.energymeetings.com/

Solar 2015

July 28–30, 2015

University Park, PA, USA
Website: https://www.energymeetings.com/

NATIONAL

TECHTRADE

April 16–20, 2015

Ahmedabad, India
Website: http://10times.com/techtrade

Isrmax Biomass Expo

May 3–5, 2015

New Delhi, India
Website: http://10times.com/isrmax-biomass-expo

HydroVision Mumbai

May 5–7, 2015

Mumbai, India
Website: http://10times.com/hydrovision-mumbai

Renewable Energy World Asia

May 5–7, 2015

Mumbai, India
Website: http://10times.com/renewable-energy-world-asia

Renewable Energy World India

May 14–16, 2015

New Delhi, India
Website: http://10times.com/renewable-energyworld-india

Annual Crisis and Risk Management Summit 2015

May 31–June 3, 2015

Bangalore, India
Website: http://10times.com/annual-crisis-and-risk-management-summit

---

India Manufacturing Summit 2015

June 18, 2015

Mumbai, India
Website: http://10times.com/manufacturing-summit-mumbai

World Renewable Energy Technology Congress & Expo

August 21–23, 2015

New Delhi, India
Website: http://10times.com/wretc

Renewable Energy at a Glance

Programme/Scheme wise Physical Progress in 2014–15 (During the month of December)			
Sector	**FY 2014–15**		**Cumulative Achievements**
	Target	**Achievement**	**(as on 31.12.2014)**
I. GRID-INTERACTIVE POWER (CAPACITIES IN MW)			
Wind Power	2,000.00	1,333.20	2,465.03
Small Hydro Power	250.00	187.22	3,990.83
Biomass Power & Gasification	100.00	0.00	1,365.20
Bagasse Cogeneration	300.00	152.00	2,800.35
Waste to Power	20.00	1.00	107.58
Solar Power	1,100.00	430.67	3,062.68
Total	**3,770.00**	**2,104.09**	**33,791.74**
II. OFF-GRID/ CAPTIVE POWER (CAPACITIES IN MW_{EQ})			
Waste to Energy	10.00	8.54	141.27
Biomass(non-bagasse) Cogeneration	80.00	34.32	561.64
Biomass Gasifiers -Rural	0.80	0.75	18.23
-Industrial	8.00	6.20	153.40
Aero-Genrators/Hybrid systems	0.50	0.13	2.38
SPV Systems	60.00	52.77	227.12
Water mills/Micro hydel	4.00	2.00	15.21
Biogas based Energy System	0.00	0.30	4.07
Total	**163.30**	**105.01**	**1,123.32**
III. OTHER RENEWABLE ENERGY SYSTEMS			
Family Biogas Plants (numbers in lakh)	1.10	0.42	47.95
Solar Water Heating – Coll. Areas (million m^2)	0.50	0.53	8.63

Source: www.mnre.gov.in

ADVERTISE IN...

TERRAGREEN

Circulation information

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

General information

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

Technical specifications

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

Advertisement tariffs (₹)

Ad location	Back cover	Inside back cover	Inside front cover	Inside full page	Inside half page
Single issue	60,000	50,000	50,000	30,000	18,000
Three issues	171,000	142,500	142,500	85,500	51,300
Six issues	342,000	28,5000	285,000	171,000	102,600
Twelve issues	684,000	570,000	570,000	342,000	205,200

Subscription

One year ₹540 / $102 • Two years ₹1020 / $192 • Three years ₹1440 / $252 *(Free online access for those subscribing for three years)*

ENERGY FUTURE

Circulation information

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

General information

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

Technical specifications

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

Advertisement tariffs (₹)*

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

Subscription

Print+ Online subscription

One year ₹800 / $80 • Two years ₹1440 / $144 • Three years ₹2040 / $204

Contact details

Gitesh Sinha
Email: gitesh.sinha@teri.res.in
<Extn 2718>
Kakali Ghosh
Email: kakalig@teri.res.in
<Extn 2736>
Sangeeta Paul
Email: sangeeta.paul@teri.res.in
<Extn 2734>

Payment mode

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

The Energy and Resources Institute
Darbari Seth Block, IHC Complex
Lodhi Road, New Delhi – 110 003
Tel: 011 2468 2100 / 4150 4900
Fax: 011 2468 2144 / 2468 2145
Website:http://bookstore.teriin.org

DELENG/2012/49326 ISSN 2278 – 7186