Dear Reader,

The growing demand for energy has necessitated the finding of alternative sources for meeting the demand in urban and rural areas. With the change in the rural scenario and agricultural practices, and the advent of gadgets like televisions, mobile phones, and computers, the demand of energy has also increased manifold. Today, people living in rural areas need round-the-clock electricity supply, have LPG for clean cooking, enjoy films and other entertainment events on television, study and work at late hours in the night, and so on. The rural industry also needs energy for optimum production. But, it is not happening in reality, and as a result, we are witnessing a large-scale migration of people from villages to cities. If we can provide adequate energy/electricity to our rural areas, it can check migration and thus, help to reduce the increasing load on the cities.

The Indian government is toiling to provide sufficient electricity, cooking gas, petroleum oil, coal, kerosene, and other such fuels to meet the growing demand of rural areas. However, due to limited resources, difficult geographic conditions, and remoteness of villages, the reach is limited. In this scenario, RE (renewable energy) has proved to be a ray of hope for resolving the energy problem in rural areas. Energy is mainly required for cooking, heating, lighting, motive power, irrigation, small cottage industry, agricultural operations, and drying in rural areas. RE can play a vital role in meeting the energy demands for these end-use applications. The MNRE (Ministry of New and Renewable Energy) is promoting RE applications in rural areas through various fiscal and financial incentives, including concessional interest-based loans.

In addition to the government’s efforts, the corporate houses and private sector companies should also come forward and adopt remote villages as per their capacity for creating the basic infrastructure facilities, including sustainable supply of energy. This will not only connect the remote villages with the entire world, but also provide them equal opportunity for further progress in every field.

I am sure that you will find Akshay Urja informative and useful. We invite your valuable suggestions and contributions for enriching the forthcoming issues of the magazine.

ARUN K TRIPATHI
aktripathi@nic.in
I am a Student of MSc Physics in NIT Jalandhar. I am very much influenced by your Akshay Urja, and I want to subscribe to it (English version).

Avind Kumar
73/2, Sanjay Gandhi Nagar,
Jalandhar City, Punjab

As I am greatly interested in the operational system of solar products and schemes of the Ministry in regards to harnessing solar energy, I would like to request you to send me every copy of Akshay Urja’s future publications.

K Khan Mintahang
Nhatthal Village, B P D Kawnpi,
Churandhur, Manipur – 795128

We, Turbomachinery Engineering Industries Limited, recently chanced upon your newsletter Akshay Urja and found the information therein useful for our focus on renewable energy-related projects. In order to keep abreast with the latest developments taking place globally and in our country, we would like to subscribe to your newsletter Akshay Urja.

PK Mathur
General Manager (Projects)
Turbomachinery Engineering Industries Ltd, 309, IDA Bchipasley, Hyderabad

On a recent visit to the CGO complex in Delhi I read a copy of Akshay Urja. I am a project consultant and I found the information of immense use to me. May I request you to include my name on the mailing list of the newsletter?

Devendra S Kothari
Flat 4A, Lav Kush Apartments
2/1, Beltala Road, Kolkata 700026

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

Editor
Akshay Urja
Proposal to introduce solar inverters

The Delhi government’s power department is mulling over a proposal to introduce solar panels for recharging batteries used to run appliances of everyday use during power cuts and outages. The proposal comes at a time when the department has been stressing the need to use more green energy and reduce dependence on non-renewable energy. An official of the power department said the concept is similar to that of a solar water heater. ‘Solar panels are used to draw the energy of the sun to run appliances just like an inverter does. While an inverter uses energy from the grid to recharge the battery, here the battery gets recharged from solar energy, which is clean and economical,’ he said. The proposal to use solar energy to run the inverter has been put forth by Moserbaer Photo Voltac, a company that manufactures photovoltaic products. The idea is to utilize solar energy at the level of smaller consumers as well. We usually see the use of solar energy in villages and at a large scale. The system will allow consumers to pick the size of the modules as per their requirement and save on their energy bills. ‘The battery here will not require power from the grid to recharge; it will get re-energized even as it is being used from the solar modules attached to it. Apart from the initial investment (the cost of modules) the system does not incur any running costs,’ says Mr Vermani.

Indian Railways to generate 50 MW through solar power

The Indian Railways, which is actively exploring the possibilities of tapping non-conventional energy sources across the country to meet a portion of its ever-growing energy needs and executing a couple of projects in this direction at vantage points, will generate 50 MW of electricity from solar energy by installing the units at Nagpur in near future, Member/Electrical, Ministry of Railways, Sukhbir Singh has said. Mr Singh was here to commission seven windmills, each with the capacity of 1.50 MW, installed at Kasthuriengapuram under Radhapuram taluk in Tirunelveli district. Mr Singh said the Indian Railways had installed four solar power units, each having the capacity of generating 1.90 MW, at Nagpur, one of the hottest places in the country that experiences even 47 degree Celsius during summer. ‘Since we intend to tap the non-conventional energy sources in the maximum possible fashion in the wake of growing energy needs and increased power cuts, we have planned to install more solar power units at Nagpur to ultimately increase the total generation capacity to 50 MW,’ he said. Mr Singh, while hinting that Indian Railways’ windmills would come up on the coasts of Orissa and Tamil Nadu, also informed that more windmills would be installed in Radhapuram region so that the quantum of power generated by Indian Railways from this region would also go up substantially.

Biomass power procurement tariff increased to Rs 4.50

The tariff for biomass power procurement has been increased to Rs 4.50 per unit from Rs 3.15 per unit, the TNERC (Tamil Nadu Electricity Regulatory Commission) said in a press release. This increase makes the state’s tariff the highest in the country for biomass power procurement. With an installed biomass power capacity of 147 MW out of the country’s total of 683 MW, Tamil Nadu has one of the highest biomass power plant capacities in the country. But over the last two years, capacity utilization had declined sharply due to a steep increase in the cost of biomass fuels, the release said. ‘The capacity utilization, which ranged from 5% to 70% during 2007/08, declined to 3% to 48% during 2008/09. Other users of biomass fuel have been procuring biofuels at a much higher price making it unviable for biomass based power plants. This deficiency has been addressed by the Commission by fixing the fuel cost at double the present rate of Rs 1000 per MT,’ the release said.

The new tariff order would also introduce a two-part power tariff based on fixed cost and variable cost, which has been in vogue in other states such as Maharashtra, Andhra Pradesh, and Rajasthan. The variable cost would account for variations in the cost of biomass fuel, the release said. The present tariff order had been arrived at after a consultative process that included discussions with experts, stakeholders, and a public hearing, the release added.

Hampi going fully solar

Hampi will be the first town to be completely powered by solar energy. Principal Secretary of Energy K Jairaj recently announced at Cliktronika 2009 – a renewable energy trade fair – that the plan has been finalized with BHEL (Bharat Heavy Electricals Ltd) and Hampi Development Authority. K Jairaj also unveiled the state government’s plan to invest in solar rooftop set-ups and making KREDL (Karnataka Renewable Energy Development Ltd) a single-window clearance agency for renewable energy projects. Power minister K Eswarappa said that the government is taking various steps to ensure that Hampi will be a solar town. The plan is to construct solar power plants in Hampi so that the town will get completely powered by solar energy. The system will be in operation by 2011.
Centre, the Union government plans development measures lie under across the country. They can be uniformly applied national standard so that will turn them into a unified different cities. The government harvesting and are implemented with exist for energy efficiency and water council when it next convenes. Prime Minister’s climate change will now be presented to the and cleared by the government, urban development ministry a gamut of climate-friendly activities through the urban development ministry under the Eleventh Five-year Plan pilot projects. Demonstration programmes would also be carried out and separately budgeted for as part of the mission. The legal and regulatory measures that cover a broad spectrum of areas will be consolidated under the National Sustainable Habitat Parameters.

The government plans to carry out to leverage the grants it makes under the JNNURM programme to get the states on board. The grants from the centre under the massive urban development programme will have built in conditions to ensure that the national standards are incorporated in the bylaws of cities utilizing the funds. The norms will mandate minimum energy performance standards for residential and commercial buildings. While questions about actual implementation of the norms at present remain questionable considering past experience, the government is looking at less coercive and inspection-based ways of turning the laws into practice. The government has decided to make it mandatory for new buildings to undertake energy efficient measures, rainwater harvesting, and use recycled construction material in parts under the sustainable habitat mission of the national action plan on climate change. The government will also finalize norms for integrating parking, taxation, congestion charges, and other measures to promote public transport across different cities.

The mission report, finalized by the urban development ministry and cleared by the government, will now be presented to the Prime Minister’s climate change council when it next convenes. At present, several different norms exist for energy efficiency and water harvesting and are implemented with a great amount of variance across different cities. The government will turn them into a unified national standard so that they can be uniformly applied across the country. Realizing that urban development measures lie under state governments and not the Centre, the Union government plans to make it a reality. It can be done,’ says Jairaj. ‘Green materials’ to be mandatory for houses from 2010

The construction and housing sector will get a tad greener by the end of the next year. The government has decided to make it mandatory for new buildings to undertake energy efficient measures, rainwater harvesting, and use recycled construction material in parts under the sustainable habitat mission of the national action plan on climate change. The government will also finalize norms for integrating parking, taxation, congestion charges, and other measures to promote public transport across different cities.

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NHPC to invest on wind energy in state

The state-run NHPC (National Hydroelectric Power Corporation) is planning to set up wind energy parks in Karnataka. ‘As Karnataka has huge potential in wind energy, NHPC is keen to explore this,’ said S K Garg, Chairman of the company. With the Ministry of Power granting permission to NHPC to invest in the wind energy sector, the company is foraying into the renewable energy segment by setting up wind energy parks in different parts of the country, including Karnataka. Some places in Gadag, Belgaum, and Chitradurga districts had been identified as the highest wind energy potential areas where NHPC was keen to invest. The chairman mentioned that NHPC would write to the state government in this regard. NHPC’s subsidiary NHDC (Narmada Hydro Development Corporation) is already in an advanced stage of setting up two wind power projects in Madhya Pradesh. The NHPC had earlier proposed to set up a hydro power project in the Cauvery Basin, but it was later shelved due to the dispute between Karnataka and Tamil Nadu on water sharing.

UK–India sign research agreement on solar energy

Research is playing an increasingly significant role in promoting bilateral relations between India and the UK. Initiatives such as the UKIERI have shown how the two countries are taking an active step in promoting not only mutually beneficial and complimentary research but also better cultural understanding. A workshop on India–UK Cooperation in Solar Energy Research was organized at the Indian Institute of Technology-Delhi recently. The main aim of the workshop was to discuss the priorities for a multimillion-dollar joint initiative for collaborative research projects on solar energy—an agreement for which has been signed. The delegates from UK included members of a consortium of universities working together on solar energy research. The Indian delegation comprised their counterparts from IIT-Delhi, Guwahati, Karachi, Kanpur, Mumbai, and Chennai; National Institute of Technology, Tiruchirapalli; and IISI- Bhubaneswar. The cooperation agreement signed during the workshop will act as a statement of intent to cooperate towards the fostering of genuine and mutually beneficial research collaboration in solar energy research through a multimillion-dollar research programme to be initiated in the coming months. The call for research proposals is likely to be made soon.

LDA plans to use solar energy for parks

LDA (Lucknow Development Authority) is going to install solar lights in 100 parks it is developing in the city. Officials believe that the lights will save up to Rs 3 lakh every month, which it had to pay as electricity bill. The LDA had identified these parks in Gomti Nagar, Kanpur Road scheme, Janakpuram, Aliganj, and various other housing schemes. The parks were to be developed and upgraded at the cost of Rs 20 crore. But as the installation of solar lights will cost Rs 15 crore more, the LDA is going to send revised budget, including Rs 15 crore, to the state government seeking its formal approval.

Dr. Farooq Abdullah, Union Minister for New and Renewable Energy, is the new patron of Akshay Urja

Born in 1937 in Soura on the outskirts of Srinagar, Dr Farooq Abdullah did his MBBS from the SMS Medical College, Jaipur. He has had a long and distinguished political career, having served as the Chief Minister of Jammu and Kashmir twice and a Member of Parliament twice. He has been a member of the Committee on Defence, Member of Parliamentary Forum on Population and Public Health, and a Member of Consultative Committee of the Ministry of Civil Aviation. Dr Abdullah has been conferred the ‘Dr B C Roy Award’ as a medical man-cum-statesman and D Litt. (Honoris Causa) from Aligarh Muslim University. An ardent golfer, he is keenly interested in photography, classical music, and ghazals. He is also an avid traveller. Akshay Urja welcomes Dr Farooq Abdullah as its new Patron.
A new report on the SPV (solar photovoltaic) industry from the perspective of semiconductor industry participants has concluded that the rapidly changing balance between supply and demand for high-purity silicon is contributing to a rethinking of priorities in the SPV sector. The report Solar Energy: growth opportunities for the semiconductor industry comes from IC Insights and forecasts that on a megawatt basis, global installations will drop 22% this year. Meanwhile a megawatt basis, global installations are forecast to rise 37% to 6.7 GW, with continued growth achieving a compound annual growth rate of 25% over the 2008-2013 forecast period. The price drop of 2009, while not forecast to repeat in 2010-2013, will make solar systems more attractive in more markets even as government incentives supporting installations start to taper off starting four or five years down the road, IC Insights believes.

With the cost of silicon dropping, R&D investments in solar device design and manufacturing technology will back off the push to minimize silicon consumption and centre on new ways to reduce costs and boost device efficiency, the analysis says.

Solar forecast sees industry bounce back

International news

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Sanyo raises solar cell efficiency to 23%

Sanyo Electric has broken its own record for the highest energy conversion efficiency in a practical size (100 cm² or more) of crystalline silicon solar cells, achieving an efficiency of 23% (until now 22.3%) at a research level for its proprietary HIT (heterojunction with intrinsic thin layer solar cell) technology. The increase in the solar cell conversion efficiency this time is accompanied by significant advances in lowering the production cost of the photovoltaic system and the reduction in the use of raw materials such as silicon. The company has managed to improve the quality of the HIT solar cell junction through developing a technology for depositing a higher quality a-Si layer over the c-Si substrate while protecting the c-Si surface from being damaged.

The company has reduced optical absorption loss in both the a-Si layer and transparent conductive layer. As a result, the fill factor (FF) *1 was improved from 39.2 mA/cm² to 39.5 mA/cm². In a solar cell, generated electric current is collected by and taken out through the surface grid electrode. Sanyo has recently realized lower-resistance electrode material for use in the grid electrode and a higher-aspect ratio through improving printing technology, leading to a success in reduction of resistance loss when an electric current flows through the grid electrode. As a result, the fill factor (FF) *1 was improved from 0.791 to 0.80.

international sporting event will include games like korfball, billiards, dragon boat racing, and women’s tug-of-war. But why are we discussing World Games 2009 in an alternative energy spectrum? Actually, Taiwan can boast of Asia’s first fully solar-powered stadium. The stadium gives a dragon-like impression if you happen to view it from the sky. In their culture, dragon is associated with good fortune. If you happen to spot the dragon scales, look carefully again. These dragon scales are actually 8844 solar panels. These solar panels are enough to meet the stadium’s energy needs. The roof covers an area of 14 155 m². They can produce about 1.14 gigawatt hours of electricity every year. This amount of electricity is enough to power 80% of the stadium’s surrounding neighborhood when it’s not in use. The stadium has 3300 lights and two giant TV screens. The person who is responsible to give this abstract idea a concrete form is a Japanese architect Toyo Ito. This project cost about $150 million to build and can accommodate 55 000 spectators. This stadium is situated in the city of Kaohsiung, Switzerland too has a somewhat similar high-profile Stade de Suisse that is located in Bern. It can accommodate 32 000 spectators and produce 700 000 kWh annually. Beijing National Indoor Stadium too can absorb 19 000 spectators and has 1124 solar panels. However, Taiwan till date can be proud owner of the largest solar-powered stadium in the world. Taiwanese officials claim the stadium’s energy production output will save 660 tonnes of carbon dioxide each year. This is not the whole story. The stadium’s designers have also put lots of effort to curtail the environmental impact of the stadium. They utilized only those raw materials that have been procured from Taiwan and are 100% reusable. The site is surrounded by 19 hectares of open space, with about 7 hectares exclusively kept aside as integrated public green spaces, bike paths, sports parks, and even an ecological pond. To further make the entire project environment friendly, all of the plants occupying the area before construction were transplanted. The stadium will be utilized for rugby and

New solar stadium in Taiwan

It is official now. Taiwan will hold the World Games 2009 in July. This

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For the reduced available business, driving prices down across the solar PV supply chain. However, IC Insights expects demand for solar installations to come charging back in 2010 as new government incentives in the US, Europe, and China gain traction. Installations are forecast to rise 37% to 6.7 GW, with continued growth achieving a compound annual growth rate of 25% over the 2008-2013 forecast period. The price drop of 2009, while not forecast to repeat in 2010-2013, will make solar systems more attractive in more markets even as government incentives supporting installations start to taper off starting four or five years down the road, IC Insights believes.

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*1 Fill factor (FF) is the ratio of actual output of a solar cell to its theoretical maximum output.
Volkswagen, BYD to work on electric cars

Volkswagen will soon give its longstanding partnership with China’s automakers a boost as it cooperates with Chinese automaker BYD on electric cars. In a statement released, Volkswagen says it has signed a memorandum of understanding with BYD – a company charged with Sanyo to make battery packs for future vehicles. The partnership will have to produce a vehicle with about 120 miles of range. It has also partnered with Sanyo to make battery packs for future vehicles. The partnership with BYD will explore possible electric cars, hybrid cars, and battery building, VW added in its release.

PVT solar panels generate heat and electricity at the same time

PTV Solar, manufacturer and seller of integrated SPV (solar photovoltaic) and ST (solar thermal) systems for residential and business purposes, is pioneering an ultra-efficient breed of solar panels. These panels will focus not only on incorporating better PV technology but also use the heat generated by the solar panels to power a ST system. Standard PV systems generate electrical energy from the sun, while ST systems use it to heat something, like water, for consumption within a home. PVT Solar is aiming to marry both systems into one, since PV systems are known to release excess heat that is not used. Apart from taking waste heat and giving it an actual use, this combination would also add the benefit of making the solar panel cooler, which in turn, would make it more efficient, generating more energy. According to the company, these ‘solar cogeneration panels’ are three times more efficient than any other panels in the market!

PTV Solar is funded by Vinod Koshla, the founder of Sun Microsystems. According to a profile in the New York Times, what drew Mr Koshla to the company was the company’s remarkable achievement in efficiency. PVT Solar is the largest company to commercialize solar cogeneration technology, and is the first to really consider deploying a system for residential use.

Interactive map shows US alternative fuel data

The US DOE (Department of Energy) and the NREL (National Renewable Energy Lab) announced the launch of a comprehensive mapping tool to help industry and government planners implement alternative fuels and advanced vehicles. The new TransAtlas tool combines several different types of geographic data to identify areas with potential for developing advanced transportation projects. It is sponsored by DOE’s ‘Clean Cities’ initiative, which aims to reduce petroleum consumption in the transportation sector by promoting advanced vehicle technologies and alternative fuels. This interactive mapping tool is available by visiting www.afdc.energy.gov and clicking on the TransAtlas icon.

What is unique about this interactive website is the bringing together of so many types of alternative vehicle fuels data into one place,’ said National Clean Cities Director Dennis Smith at DOE. ‘Establishing a national network of fuelling stations, fuel production facilities, and transportation infrastructure is vital to the successful implementation of alternative fuel and advanced technology vehicles’, he added.

NREL employed user-friendly Google Maps to display the locations of existing and planned alternative fuelling stations, concentrations of different fuel types, alternative fuel production facilities, roads and political boundaries. The TransAtlas tool allows users to customize the information simply by checking boxes for each element. One or more types of fueling stations can be shown, including stations that dispense biodiesel, compressed or liquefied natural gas, ethanol (E85), electricity, hydrogen, and propane. Checking additional boxes adds existing ethanol production facilities and facilities under construction. To explore the site deeper, the query function can be used to select individual stations or production facilities, or those in an entire region. Querying a station shows its location, contact information, and public access status. Querying a production facility shows its location, production capacity, and feedstock type.

The ability to drill-down and see very detailed information, including a station contact or even the production capability of an individual location, puts a wealth of information directly into the user’s hands,” said Mr Smith. The display can be further customized by using the intuitive pan and zoom functions and setting map elements to various levels of transparency. Once the display has been customized, a print-ready version can be generated.
**Discovery of an unexpected boost for solar water-splitting cells**

A research team from Northeastern University and the NIST (National Institute of Standards and Technology), United States, has discovered, serendipitously, that a residue of a process used to build arrays of titania nanotubes – a residue that was not even noticed before this – plays an important role in improving the performance of the nanotubes in solar cells that produce hydrogen gas from water. Their recently published results indicate that by controlling the deposition of potassium on the surface of the nanotubes, engineers can achieve significant energy savings in a promising new alternate energy system.

Titania (or titanium dioxide) is a versatile chemical compound best known as a white pigment. It is found in everything from paint to toothpastes and sunscreen lotions. Thirty-five years ago, Akira Fujishima started the electrochemical world by demonstrating that it also functioned as a photocatalyst, producing hydrogen gas from water, electricity, and sunlight. In recent years, researchers have been exploring different ways to optimize the process and create a commercially viable technology that essentially transforms sunlight into hydrogen, a pollution-free fuel that can be stored and shipped.

Increasing the available surface area is one way to boost a catalyst’s performance. Thus, a team at the Northeastern University has been studying techniques to build tightly packed arrays of titania nanotubes, which have a very high surface-to-volume ratio. They also were interested in how best to incorporate carbon into the nanotubes because carbon helps titania absorb light in the ultraviolet region, and much of the ultraviolet is filtered by the atmosphere. This brought them to the NIST X-ray spectroscopy beamline at the NSLS (National Synchrotron Light Source)*. The NIST facility uses X-rays that can be precisely tuned to measure chemical bonds of specific elements, and is at least 10 times more sensitive than commonly available laboratory instruments, allowing researchers to detect elements at extremely low concentrations. While making measurements of the carbon atoms, the team noticed spectroscopic data, indicating that the titania nanotubes had small amounts of potassium ions strongly bound to the surface, evidently left by the fabrication process, which used potassium salts. This was the first time potassium has ever been observed on titania nanotubes. Previous ones were not sensitive enough to detect it.

The result was mildly interesting but became much more so when the research team compared the performance of the potassium-bearing nanotubes to similar arrays deliberately prepared without potassium. The former required only about one-third the electrical energy to produce the same amount of hydrogen as an equivalent array of potassium-free nanotubes. ‘The result was so exciting’, recalls Northeastern physicist Latika Menon, ‘that we got sidetracked from the carbon research.’ Since it has such a strong effect at nearly undetectable concentrations, Menon says, potassium probably has played an unrecognized role in many experimental water-splitting cells that use titania nanotubes because potassium hydroxide is commonly used in the cells. By controlling it, she says, hydrogen solar cell designers could use it to optimize performance.

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*The NSLS is part of the Department of Energy’s Brookhaven National Laboratory.*

**Biogas: the how and where**

Biogas represents an alternative source of energy, derived mainly from organic wastes. In India, the use of biogas derived from animal waste, primarily cow dung, has been promoted for over three decades now. According to the 1997 Livestock Census, the cattle population in the country is about 290 million. The estimated potential of household biogas plants based on animal waste in India is 12 million. Till March 2009, under the National Biogas and Manure Management Programme, over 4.1 million biogas plants in the capacity of 1–6 m³ have been installed. Larger units have also been set up in many villages, farms, and cattle houses. The estimated biogas production from these plants is over 4.1 million m³ per day, which is equivalent to a daily supply of about 2.5 million m³ of natural gas. These plants usually provide thermal, electrical, and mechanical power, generating electricity from MW (megawatt) to GW (gigawatt). Standardized models of biogas plants suitable for individual households and institutions/communities are available, meeting specific requirements. Along with the development of plants and related infrastructure, a large pool of skilled manpower has been trained and deployed for plant construction and maintenance. The technology involved is anaerobic digestion, which has been successfully extended to treat industrial and urban wastes on a large scale. This holds potential as a solution to numerous environmental problems, including waste and manure handling, water pollution, and carbon dioxide emission.
**Types of biogas plants**

**Fixed-dome type**

The fixed-dome biogas plant consists of one lower segment (digester) and a hemisphere over it (gas holder). The mixing tank is connected to the digester by a 15-cm asbestos cement pipe. Through the outlet hole provided in the digester, the slurry is pushed and withdrawal of gas.

**Floating-drum type**

The floating-drum type biogas plant consists of a deep well-shaped underground digester connected by inlet and outlet pipes. A mild steel gas storage drum, inverted over the slurry, rises and falls around a guide pipe corresponding to the accumulation and withdrawal of gas.

**Bag-type**

Made of rubberized nylon fabric, the bag-type biogas plant is a portable unit, which can be conveniently placed at any location. The appropriate model is selected on the basis of technical requirements such as location, distance between kitchen and cattle shed, availability of dung and water, and preferences of the beneficiaries.

Table 1 lists the model household biogas plants and appliances approved for promotion under the National Biogas Programme.

**Standard capacity**

For family-type biogas plants, approved models are available for 1–6 m³ and 1–10 m³ capacities for fixed-dome and floating-drum plants, respectively. The commonly used capacities of these models are 1–4 m³ (Table 2).

**Cost**

The cost of installation varies according to the model and size of the plant. The average estimated cost of the most popular Deenbandhu model is given in Table 3. The cost of a biogas plant increases by about 30% in hilly areas and by 50%–60% in the north-eastern region of the country.

**Training**

Construction of biogas plants is a skilled job. Hence, the scheme has a provision of providing training to the masons and trainers for construction and maintenance of biogas plants. A total number of 11 Development and Training centres have been setup in different R&D Institute/University to tackle trainings for masons and users. This also provides opportunity for employment to rural people.

**Financial incentives**

Under the National Biogas Programme, central subsidy is available to users of different categories and areas for setting up biogas plants (Table 3).

**Provision of loans**

The RBI (Reserve Bank of India) and NABARD (National Bank for Agriculture and Rural Development) support the biogas programme. Detailed guidelines are available with both commercial and cooperative banks for financing family-type biogas plants under the Agricultural Priority area. NABARD provided automatic refinancing facility to commercial banks for loan amounts disbursed for biogas plants.

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**Table 1 Model household biogas plants/appliances approved for promotion under the National Biogas Programme**

<table>
<thead>
<tr>
<th>Model - Design guidelines</th>
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<tbody>
<tr>
<td>I. Fixed-dome biogas plant</td>
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<tr>
<td>1) Deenbandhu model with brick masonry Code practices (second revision) IS 9478:1989 of the BIS, New Delhi</td>
<td>MNRE State Implementing Agencies Web site: mnre.nic.in</td>
</tr>
<tr>
<td>2) Deenbandhu ferrocement model with in situ technique</td>
<td>MNRE State Implementing Agencies Web site: mnre.nic.in</td>
</tr>
<tr>
<td>3) Pre-fabricated RCC fixed-dome model</td>
<td>MNRE State Implementing Agencies Web site: mnre.nic.in</td>
</tr>
<tr>
<td>II. Floating drum biogas plant</td>
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<tr>
<td>1) KVIC floating metal drum type Code practices (second revision) IS 9478:1989 of the BIS, New Delhi</td>
<td>MNRE State Implementing Agencies Web site: mnre.nic.in</td>
</tr>
<tr>
<td>2) KVIC type plant with ferrocement Code of practices IS 12986:1990 of BIS, New Delhi</td>
<td>MNRE State Implementing Agencies Web site: mnre.nic.in</td>
</tr>
<tr>
<td>III. Pragati model</td>
<td></td>
</tr>
<tr>
<td>IV. Bag-type biogas plant</td>
<td></td>
</tr>
<tr>
<td>Bag type biogas plant – Flexi model</td>
<td>Swastik House, Khadi Pune – 411 003 Maharashtra</td>
</tr>
<tr>
<td>V. Appliances</td>
<td></td>
</tr>
<tr>
<td>ISI marked (BIS Code IS-8749:1998) Burners with minimum 55% thermal efficiency</td>
<td>See Box No. 1 for details</td>
</tr>
</tbody>
</table>

**Table 2 The average estimated cost of the most popular Deenbandhu model**

<table>
<thead>
<tr>
<th>Plant capacity</th>
<th>Cost per plant (in rupees)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 m³</td>
<td>7000</td>
</tr>
<tr>
<td>2 m³</td>
<td>9000</td>
</tr>
<tr>
<td>3 m³</td>
<td>10 500</td>
</tr>
<tr>
<td>4 m³</td>
<td>12 500</td>
</tr>
</tbody>
</table>

**Table 3 National Biogas Programme: central subsidy for different categories and areas for setting up biogas plants (2009/10)**

<table>
<thead>
<tr>
<th>Category/area</th>
<th>Central subsidy per plant</th>
</tr>
</thead>
<tbody>
<tr>
<td>North-eastern states and Sikkim (except plain areas of Assam)</td>
<td>Rs 11 700</td>
</tr>
<tr>
<td>Plain areas of Assam</td>
<td>Rs 9 900</td>
</tr>
<tr>
<td>Jammu and Kashmir, Himachal Pradesh, Uttarakhand (excluding Terai region), Nilgiris of Tami Nadu, Bardar Kurnong and Kalimpong sub-divisions of Darjeeling, Sunderbams, and Andaman and Nicobar Islands</td>
<td>Rs 4500 (restricted to Rs 3500 for 1 m³ fixed dome type)</td>
</tr>
<tr>
<td>Scheduled caste, scheduled tribe, desert districts, small and marginal farmers, landless labourers, Terai region of Uttarakhand, Western Ghats, and other notified hilly areas</td>
<td>Rs 3500 (restricted to Rs 2800 for 1 m³ fixed dome type)</td>
</tr>
<tr>
<td>All others</td>
<td>Rs 2700 (restricted to Rs 2100 for 1 m³ fixed dome type)</td>
</tr>
</tbody>
</table>
Repair and servicing facility
The government pays a job fee of Rs 800 per biogas plant constructed on turnkey basis with three years’ warranty for trouble-free functioning of the plant in central subsidy is also provided for repair and revival of family-type biogas plants that are at least five years old and have developed structural defects thereafter.

Courtesy: MNRE, Government of India

Manufacturers of biogas burners
M/s Sunflame Industries (P) Ltd
Shed No. 2, Plot No. 38
P O Amar Nagar, Faridabad – 121 003

M/s Batra Investments Pvt. Ltd
14/1, Mathura Road
P O Amar Nagar
Faridabad – 121 003

M/s Gas and Chemical Industries (P) Ltd
14/1 Mathura Road
Faridabad – 121 003

M/s Baroda Appliances
866/A, GIDC Makarpura
Baroda – 10

M/s Sweet Home Appliances Pvt. Ltd
3-E/16, BIPET
Faridabad – 121 001

M/s Tuli Domestic Appliances
30-A, Old Industrial Area
Alwar – 301 001

M/s Associated Engineering Works
Tanuku – 534 211
Andhra Pradesh

M/s Mitasos Appliances Pvt Ltd
Plot No. 63, Sec. 6
Faridabad – 126 006

M/s Agriculture Associates
Station Road
Alwar (Rajasthan)

M/s Malhotra Engineering Company (P) Ltd
572-B, Nangloi
New Delhi – 110 041

M/s Rupak Enterprises
1/46 Vishwash Nagar, Shahdra
New Delhi – 110 032

Bhawana Industries
8-A, Industrial Development Colony
Kunjipura Road, Kamal – 132 001, Haryana

M/s Mech-Ci-Co.
1-7, GIDC Industrial Township
Vatva, Ahmedabad – 382 445

Inter Gas Appliances Pvt. Ltd
C-113, Sector-2
Noida – 201 307, Uttar Pradesh

Inviting articles for Akshay Urja

Akshay Urja publishes news, articles, research papers, case studies, success stories, and write-ups on RE. Readers are invited to send material with original photographs and statistical data. The photographs should be provided on hard copy or as high resolution (minimum 300 DPI) files on a CD. Akshay Urja will pay suitable honorarium for each published article of about 1500 words and upwards on RE. Readers are invited to send material (composition of various lignocellulosic biomass hydrolysate including wood, grass, forest residues, agricultural residues, pulp and paper mill wastes, and municipal solid wastes can be used for bioethanol production. Among these resources, agricultural residues, such as sugarcane bagasse, dominate in terms of tonnage and can serve as feedstock. Sugarcane bagasse is plentiful in tropical and sub-tropical regions such as Brazil, India, Thailand, and the southern USA. Other lignocellulosic feedstocks include agricultural residues such as compost, corn stover, wheat, and rice straw; industrial residue such as pulp and paper processing waste; and energy crops such as switch grass.

Lignocellulosic materials are comprised of lignin, hemicellulose, and cellulose in varying proportions. The general composition of lignocellulosic biomass is cellulose (35%-50%), hemicellulose (20%-35%), polyphenolic lignin (10%-25%) and other extractable components. The utilization of both cellulose and hemicellulosic monosaccharides like hexose and pentose present in a typical lignocellulosic biomass hydrolysate (composition of various lignocellulosic biomass is shown in Table 1) is essential for the economical production of ethanol. Therefore, microorganisms that are able to ferment both glucose and xylose are most desirable for an efficient bioconversion of biomass to ethanol.

Lignocellulosic biomass is the most abundant renewable resource on earth.
ethanol. The bioethanol production from lignocellulosic biomass requires two essential steps: saccharification of lignocellulosic biomass to fermentable sugars and fermentation of sugars to ethanol.

Worldwide, bioethanol is currently produced by fermentation of monomeric sugars by mesophiles, which ferment the sugars at 25–37 °C. These mesophiles have certain limitations in fermenting pentose sugars produced from lignocellulosic biomass. However, the thermophiles have certain advantages over mesophiles, which could be exploited for ethanol production. Solvent tolerance, energy savings through reduced cooling costs, higher saccharification and fermentation rates, continuous ethanol removal, and the reduced risk of contamination have stimulated a search for thermophilic or thermostolerant yeasts. Less energy is required for mixing and product recovery in thermophilic fermentations because of lower viscosity, surface tension, higher vapour pressure, and increased solubility of organic compounds.

This article describes the saccharification of sugarcane bagasse by acid treatment followed by sugar recovery from the hydrolysate by ion exchange chromatography and fermentation of sugars in batch and continuous mode with recycle of thermophilic yeast, Kluyveromyces sp. IPE453 in the temperature range of 50 °C.

### Table 1 Composition of various lignocellulosic raw materials

<table>
<thead>
<tr>
<th>Raw materials</th>
<th>Glucose (%)</th>
<th>Mannose (%)</th>
<th>Galactose (%)</th>
<th>Xylose (%)</th>
<th>Arabinose (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Corn stover</td>
<td>39.0</td>
<td>0.3</td>
<td>0.8</td>
<td>14.8</td>
<td>3.2</td>
</tr>
<tr>
<td>Wheat straw</td>
<td>36.6</td>
<td>0.8</td>
<td>2.4</td>
<td>19.2</td>
<td>2.4</td>
</tr>
<tr>
<td>Rice straw</td>
<td>41.8</td>
<td>1.8</td>
<td>0.4</td>
<td>14.8</td>
<td>4.5</td>
</tr>
<tr>
<td>Sugarcane bagasse</td>
<td>38.1</td>
<td>--</td>
<td>1.1</td>
<td>23.3</td>
<td>2.5</td>
</tr>
<tr>
<td>Rice hulls</td>
<td>38.1</td>
<td>3.0</td>
<td>0.1</td>
<td>14.0</td>
<td>2.6</td>
</tr>
</tbody>
</table>

### Materials and methods

Microorganisms and culture conditions

The strain used for ethanol production, *Kluyveromyces* sp. IPE453, was grown in salt medium containing 0.15 g/l (gram per litre) di-sodium hydrogen ortho phosphate, 0.15 g/l potassium di-hydrogen ortho phosphate, 2.0 g/l ammonium sulphate, 1.0 g/l yeast extract, and 10 g/l glucose with pH 5.5 at 45 °C. Fermentation was carried out in a medium prepared in hydrolysate containing 0.15 g/l di-sodium hydrogen ortho phosphate, 0.15 g/l potassium di-hydrogen ortho phosphate, 1.0 g/l ammonium sulphate, and 1.0 g/l yeast extract.

### Results and discussion

Hydrolysis of sugarcane bagasse

The sugarcane bagasse powder was collected from sugar mill. It was hydrolysed by sulphuric acid treatment in two stages. In the first stage hydrolysis, the sugarcane bagasse was soaked in 2%–10% w/w sulphuric acid with a solid-to-liquid ratio of 1:10 to 1:4.2. The temperature in the digester was maintained at 100 °C for an hour and agitation in the reactor was maintained 1000 rpm. The aqueous phase was separated from the residual bagasse followed by its washing to collect xylose-rich hydrolysate-rich stream.

In second stage hydrolysis 18%–65% w/w sulphuric acid was added to residual bagasse taken from first stage hydrolysis. The temperature in the digester was maintained at 80 °C for 1 hour and agitation was maintained 1000 rpm. The aqueous phase was separated from the residual bagasse followed by its washing to collect glucose rich hydrolysate rich stream.

Hydrolysis of starch biomass

Hydrolysis of different starch biomass like soluble starch, cassava, tapioca, sweet sorghum, and maize was performed in 1 litre flasks containing 5% starch biomass in 200 ml 0.05 M acetate buffer (pH 5.0) and 100 ml crude enzyme (5.29 mg/ml). All the flasks were incubated at 80 °C and monitored at an interval of 2 hours until the total starch was hydrolysed.

Recovery of sugars from hydrolysate

The sugars from the bagasse hydrolysate were recovered by ion exchange chromatography using strong anion and weak anion resins in the ratio of 5:1 to 1:1. A glass column with 100 cm length and 3 cm diameter was packed with 700 g resins. The bagasse hydrolysates obtained in the first stage of hydrolysis contained sugar concentration of 35 g/l and sulphuric acid concentration of 60 g/l. In the second stage of hydrolysis, it contained sugar concentration of 80 g/l and sulphuric acid concentration of 200 g/l. The hydrolysate was passed through the column with flow rate ranging from 4 to 17 ml/min. The acid was retained in the column and sugars were eluted through the column. The column was regenerated with water to recover the acid and the acid solution was recycled back for hydrolysis of fresh sugarcane bagasse.

### Table 2 Sugars and furfural (percentage of bagasse) recovered in first stage hydrolysis at different acid concentrations

<table>
<thead>
<tr>
<th>Acid concentration (g/l)</th>
<th>Solid to liquid ratio</th>
<th>Xylose(%)</th>
<th>Glucose (%)</th>
<th>Furfural (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>1:10</td>
<td>9.2</td>
<td>0.6</td>
<td>0.12</td>
</tr>
<tr>
<td>4</td>
<td>1:8</td>
<td>13.6</td>
<td>0.9</td>
<td>0.16</td>
</tr>
<tr>
<td>6</td>
<td>1:8.8</td>
<td>19.6</td>
<td>1.4</td>
<td>0.23</td>
</tr>
<tr>
<td>8</td>
<td>1:8.3</td>
<td>23.1</td>
<td>4.4</td>
<td>0.31</td>
</tr>
<tr>
<td>10</td>
<td>1:8.4</td>
<td>25.2</td>
<td>4.6</td>
<td>0.41</td>
</tr>
<tr>
<td>12</td>
<td>1:8.2</td>
<td>26.4</td>
<td>4.6</td>
<td>0.63</td>
</tr>
</tbody>
</table>

Analytical methods

Reducing sugars in media and fermented broth were determined by DNS (di-nitrosalicylic acid) method. Ethanol was determined by using gas chromatography using a Chemito 8600 Refinery Gas Analyser with a 4-m-long and 1/8 diameter Porapack column with Chemosorb 80/60. Sample was injected at 120 °C, and the oven temperature and flame ionization detector temperature was 150 °C and 200 °C, respectively, using helium as a carrier gas. Ethanol was also determined by colorimetry method. Furfural was measured by Double Beam UV-VIS Spectrophotometer 2600 at 277nm.

### Table 3. The maximum 33% sugars were recovered at acid concentrations ranging from 4 to 17 ml/min.

<table>
<thead>
<tr>
<th>Acid concentration (g/l)</th>
<th>Solid to liquid ratio</th>
<th>Xylose(%)</th>
<th>Glucose (%)</th>
<th>Furfural (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>1:10</td>
<td>9.2</td>
<td>0.6</td>
<td>0.12</td>
</tr>
<tr>
<td>4</td>
<td>1:8</td>
<td>13.6</td>
<td>0.9</td>
<td>0.16</td>
</tr>
<tr>
<td>6</td>
<td>1:8.8</td>
<td>19.6</td>
<td>1.4</td>
<td>0.23</td>
</tr>
<tr>
<td>8</td>
<td>1:8.3</td>
<td>23.1</td>
<td>4.4</td>
<td>0.31</td>
</tr>
<tr>
<td>10</td>
<td>1:8.4</td>
<td>25.2</td>
<td>4.6</td>
<td>0.41</td>
</tr>
<tr>
<td>12</td>
<td>1:8.2</td>
<td>26.4</td>
<td>4.6</td>
<td>0.63</td>
</tr>
</tbody>
</table>

The air/N₂ flow in proper ratio was controlled in the bioreactor for in situ recovery of ethanol. The process was performed at different dilution rates, cell mass concentration, and temperatures. The pH and agitation were controlled at 50 °C and 200 rpm respectively.
Continuous fermentation process with recycling the cells

The sugarcane bagasse was fed into the bioreactor with a dilution rate of 0.075/h and 0.1/h at 45–60 °C. The highest ethanol yield and productivity of 42% and 2.3 g/l/h, respectively, was obtained at 45 °C and 0.1/h. At 50 °C, air/N₂ was passed through the bioreactor for in situ recovery of ethanol at different conditions as shown in Figure 2. The overall ethanol yield on the basis of total fermentable sugars present in hydrolysate in continuous fermentation with cell recycle at 50 °C was 35%–38% with ethanol productivity of 0.216–1.86 g/l/h. Almost 90% of ethanol was recovered during fermentation on stripping by air/N₂ and five times concentrated ethanol was obtained as compared to ethanol in fermented broth.

Simultaneous liquefaction and saccharification of starch biomass

Different starchy biomass like soluble starch, cassava starch, tapioca starch, sweet sorghum, and maize were hydrolysed by thermoamylase isolated from Geobacillus sp. IPTN at 80 °C as shown in Figure 3. The total starch for each substrate was hydrolysed in 20 hours as shown in Figure 1. The final ethanol concentration in broth was 10.2 g/l with ethanol yield of 35% and productivity of 0.52 g/l/h.

Enzyme hydrolysis of starch base biomass at 80 °C

The thermoamylase was found very effective for hydrolysing different types of starch biomass with a considerable yield at high temperature.

Conclusion

The overall yield of fermentable sugars in acid treatment was 65%–80% (w/w) of total cellulose and hemicellulose present in sugarcane bagasse under different operating conditions. The overall ethanol yield on the basis of total fermentable sugars present in hydrolysate was obtained 35% in batch process with ethanol productivity of 0.52 g/l/h at 50 °C. The overall ethanol yield on the basis of total fermentable sugars present in hydrolysate in continuous fermentation with recycling the cells at 50 °C was 35%–38% with ethanol productivity of 0.216–1.86 g/l/h. Almost 90% of ethanol was recovered during fermentation on stripping by air/N₂ and five times concentrated ethanol was than ethanol in broth. The thermoamylase was found very effective for hydrolysing different types of starch biomass with a considerable yield at high temperature.

10 hours. The sugar yield on tapioca and sweet sorghum were obtained at 81.7% and 58%, respectively.

Ethanol production from cassava hydrolysate

Fermentation was carried out with cassava hydrolysate in batch mode by free cells of Kluyveromyces sp. IPE453 as shown in Figure 4. The total sugar in hydrolysate was consumed in 138 hours with productivity of 0.09 g/l/h. The ethanol yield was obtained at 45% on the basis of fermentable sugars and the overall ethanol yield on dry cassava basis was 33%. The dry cell mass was almost constant through out the fermentation.

Table 3 Sugars and furfural (percentage of bagasse) recovered by second hydrolysis at different acid concentrations

<table>
<thead>
<tr>
<th>Acid concentration (%)</th>
<th>Acid (%) (w/w) (acid/sugar)</th>
<th>Glucose (%)</th>
<th>Xylose (%)</th>
<th>Furfural (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>18</td>
<td>50</td>
<td>6</td>
<td>3.5</td>
<td>0.21</td>
</tr>
<tr>
<td>26.4</td>
<td>75</td>
<td>9.7</td>
<td>2.5</td>
<td>0.16</td>
</tr>
<tr>
<td>53.8</td>
<td>100</td>
<td>14.5</td>
<td>4.64</td>
<td>0.14</td>
</tr>
<tr>
<td>65</td>
<td>125</td>
<td>18</td>
<td>3.34</td>
<td>0.11</td>
</tr>
</tbody>
</table>

Figure 1 Ethanol production in batch mode by Kluyveromyces sp. IPE453 in sugarcane bagasse hydrolysate at 50 °C

Figure 2 Continuous fermentation with cell recycle at 50 °C and air/N₂ stripping in sugarcane bagasse hydrolysate by Kluyveromyces sp. IPE453

Figure 3 Enzyme hydrolysis of starch base biomass at 80 °C by thermoamylase produced by Geobacillus sp. IPTN

Figure 4 Ethanol production in batch mode by free cells of IPE453 from cassava hydrolysate.

Figure 5 Manual extraction of furfural from corn stover at 45 °C in 90% ethanol. The furfural concentration in hydrolysate was 0.11 mg/l and 0.19 mg/l after 10 hours of hydrolysis.
**MULTIPURPOSE SOLAR OVEN**

DR S H SENGAR AND DR A K KURCHANIA
Department of Renewable Energy Sources, Maharana Pratap University of Agriculture and Technology, Udaipur – 313 001

**Introduction**

Solar drying and cooking are a feasible proposition in most parts of India where solar radiation is quite abundant. India receives on an average of 5 kWh/m²/day for about 300 days per year. This energy can be utilized for various thermal applications, including drying and cooking. Solar energy appliances are employed for various uses for single operation and they remain idle when not in use. If the solar appliances are developed to perform more than one function, their versatility and reliability can be increased without reducing the quality of the products or polluting the environment. Keeping this in view, a multipurpose solar oven has been designed, developed, and tested at the Department of Renewable Energy Sources, College of Technology and Engineering in Udaipur, Rajasthan. This oven is capable of cooking food and drying food products and vegetables for meeting the requirement of about 5–6 people.

**System description**

This solar oven is based on hotbox principle and has two reflectors. It consists of a collector unit with a net effective area of 0.36 m² as shown in Figures 1 and 2. It is fundamentally based on two-process—hotbox principle through the application of solar energy and natural circulation of dried air from dryer. It consists of a closed chamber (front glazing), black metallic absorber, insulation, drying chamber, trays, reflectors, and inlet/outlet openings with lids. It was designed and fabricated at the Department of Renewable Energy Sources at CTAE, Udaipur, for drying and cooking. Three plenum chambers of sizes 350 mm × 600 mm × 140 mm; 350 mm × 600 mm × 160 mm; and 350 mm × 600 mm × 50 mm are provided below the drying tray for air circulation. The chambers are also painted dull black from the outside to receive solar insolation. Three perforated wire mesh trays of size 560 mm × 290 mm are provided for supporting the material to be dried. The inlet-outlet openings are provided with lids for airflow, which can be opened and closed according to need. Food products are kept in the trays for drying and air circulation is maintained by the openings provided at the top and the bottom. Two reflectors of size 350 mm × 600 mm are hinged at either side of the box for increasing the temperature inside chamber. While using the unit as cooker, if the openings are closed with the help of lids and the whole device becomes airtight. In this condition, the food products kept in the container inside the chamber can be easily cooked. Castor wheels are provided for the easy movement of the unit. It is installed facing the south direction with an inclination of 40 °C from the horizontal.

**Result and discussion**

The multipurpose cook stove was tested extensively as dryer and cooker by measuring the stagnation air temperature in the chamber. The performance rating of the solar cooker was carried out in accordance with IS 13429(part3):1992 (2). Corresponding figures of merit Figure 1 and 2 with and without heat-up conditions were also measured.

The solar hotbox was also tested for drying of rewetted maize. Drying of rewetted grains is required for removing their husks to make various products in rural areas. The time required to dry up to certain moisture content level was also measured. The stagnation temperature in multipurpose cook stove is more when the side reflector is used for both drying as well as cooking.

The results of the experiment carried out on drying and cooking of food materials are presented in Tables 1 to 3.

**Solar insolation**

The solar insolation recorded during drying process is shown in Table 1. The solar insulation ranged from a minimum of 220 W/m² to a maximum of 723 W/m². The maximum solar insolation of 723 W/m² was recorded at 1 p.m. of the day. This is due to higher incidence of solar radiation at noon.
The stagnation temperatures in multi-rack solar hot box may be due to appropriate insulation thickness and heat tightness of the cover plate. The calculated value of figure of merit (F1) in solar hot box is 0.119. The trend of increase in water temperature in hot box is shown in Table 3. The maximum stagnation temperatures in multi-rack solar hot box is about 33.5 °C and 58 °C respectively. The maximum temperature of 58 °C was recorded at 2 p.m. of the day at the level of tray 2; the temperature of 31 °C at the bottom tray was the lowest, though it tended to increase in upper trays. The maximum temperature of 58 °C was obtained in the uppermost tray.

Cooking Temperature
The increase in the stagnation temperature with reflector in cook stove is shown in Table 1. The increase in stagnation temperatures without mirror reflector in solar hot box is shown in Table 3. The maximum stagnation temperatures in multi-rack solar hot box may be due to appropriate insulation thickness and heat tightness of the cover plate. The calculated value of figure of merit (F1) in solar hot box is 0.119. The trend of increase in water temperature in hot box is given in Table 4. The time duration for raising water temperature from 60 °C to 90 °C in the hot box is 120 minutes. Cooking trials have also been conducted—0.5 kg of rice in 1 litre of water and 0.25 kg of split green gram (washed) was cooked in one and a half hours in winter and about one hour in summer.

The performance of hot box was observed throughout the year for stagnation temperature and water temperature. The maximum temperatures achieved are given in Table 4. The maximum stagnation temperature of 119 °C and water temperature of 93.25 °C were obtained in month of March.

Energy conservation and pay back period
By analysing the duration of bright sunshine hours, it has been estimated that cook stove is capable of drying and cooking for about 280 days in a year at Udaipur.

The energy required for cooking and drying is about 2.3 MJ of fuel equivalent per meal and drying. Multipurpose cook stove is capable of drying and cooking for about six persons, and it will save 50% of fuel per time. Therefore, it saves 1.15 MJ of energy per meal. Accordingly, energy saving per year was calculated and its pay back period was estimated without considering interest, maintenance, and so on.

Conclusion
The performance of multipurpose cook stove was comparable with a commercial fuel used for cooking and drying operations. The relatively short pay back period (1.3 to 2.6 years) shows that it is economical.

Acknowledgement
Authors are highly thankful to Ministry of Non-conventional Energy Sources for providing the financial assistance to carry out the research work. They are also thankful to the Department of Renewable Energy Sources, College of Technology and Engineering, Udaipur for providing all sorts of required facilities for the study.
Development of Renewable Energy Technologies in India

The Role of BHEL

S R AWASTHI
General Manager (Project Management), BHEL, New Delhi

Global warming is emerging as one of the biggest challenges of this century. One of the main reasons for this is the emission of GHGs (greenhouse gases). The main source of GHGs is thermal power plants based on fast-depleting fossil fuels. Hence, there is a pressing need to go for renewable energy sources since they get replenished fast—solar, wind, hydro, biomass, and so on.

BHEL Initiatives

BHEL (Bharat Heavy Electricals Ltd) realized the importance of renewable energy sources as early as in the 1980s and took initiatives in the in-house development, manufacture, and supply of a range of renewable energy products and systems. BHEL developed a range of renewable energy products and systems like:

- Solar water heaters
- Solar cells, modules, and panels
- Solar lantern
- Wind electric generators
- FBC boiler for agricultural biomass
- Battery-powered road vehicles
- Fuel cells, and so on

BHEL is one of the few organizations that have helped in making the country free from the compulsions of importing power equipment. Practically, every third house out of four in India is supplied power generated from BHEL sets. Today, the company not only plays a key role in meeting indigenous need of conventional power plant equipment but also holds impressive record of their export.

BHEL has ventured in difficult and inaccessible terrains to establish technology in power-starved areas of the country. Looking beyond business interests, BHEL has focused on remote and inaccessible areas in the Sunderbans delta, Lakshadweep, and Andaman and Nicobar islands. The solar power plants commissioned by BHEL have heralded a new era in the lives of the islanders. BHEL commenced the manufacture of SPV (solar photovoltaic) cells and modules at its Bangalore plant in 1983. Subsequently, it set up standalone as well as grid-interactive SPV plants in remote areas. The company offered solar power plants ranging from few kilowatt-peaks to megawatt sizes. The company has modern manufacturing facility for semiconductor processes and fabrication lines for solar cells and PV modules and systems. This facility has been augmented to 8 MWp per year. So far, BHEL has supplied more than 21 MWp of solar equipment/systems.

BHEL’s SPVs consist of 125 mm and 156 mm crystalline silicon cells and 10–170 Wp-capacity modules/packs. These products are designed and manufactured in a state-of-the-art facility and are certified by the Solar Energy Centre (MNRE, Government of India) and Electronic Technology Development Centre in India. These have also been design-qualified and type-test-certified by Joint Research Centre, Ispra in Italy, for IEC-61215 standards, which are recognized by international clients. Along with upgraded line, BHEL is manufacturing and supplying 225 and 270 Wp PV modules to cater to large rating solar power plant application.

In a recent initiative, BHEL and BEL (Bharat Electronics Ltd) signed a MoU to explore a 250-MW joint manufacturing facility for SPV cells, modules, and silicon wafers. The two companies will look for suitable vendors or partners for technology and supply of raw materials such as polysilicon. The joint venture, worth Rs 3500 crore, will cater to the

Table 1 Indian RE scenario and BHEL’s contribution

<table>
<thead>
<tr>
<th>Source/System</th>
<th>Estimated potential</th>
<th>All India achievement as on 31 March 2009*</th>
<th>BHEL’s contribution</th>
</tr>
</thead>
<tbody>
<tr>
<td>PV Power (grid) &gt;25 kWp</td>
<td></td>
<td>2.12 MWp</td>
<td>1.5 MWp</td>
</tr>
<tr>
<td>Small Hydro (up to 25 MW)</td>
<td>15 000 MW</td>
<td>2430 MW</td>
<td>550 MW</td>
</tr>
<tr>
<td>Wind Power</td>
<td>45 195 MW</td>
<td>10 242 MW</td>
<td>66 MW</td>
</tr>
<tr>
<td>Water Heating Systems</td>
<td>140 million m² collector area</td>
<td>2.9 million m² collector area</td>
<td>53 000, 0.1 million m² collector area</td>
</tr>
<tr>
<td>Solar lanterns</td>
<td></td>
<td>730 000</td>
<td>115 000</td>
</tr>
<tr>
<td>SPV Pumps</td>
<td></td>
<td>7148</td>
<td>450</td>
</tr>
<tr>
<td>SPV Street Lighting System</td>
<td></td>
<td>70 474</td>
<td>3600</td>
</tr>
<tr>
<td>SPV Home Lighting System</td>
<td></td>
<td>450 000</td>
<td>1216</td>
</tr>
<tr>
<td>PV System for Rural Radio Phone for DoT</td>
<td>—</td>
<td>30 220 sets</td>
<td></td>
</tr>
<tr>
<td>BHEL has also contributed 16 MWp in standalone SPV systems and 1.5 MWp in SPV power plants/packs.</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Indian Scenario

The Indian scenario in renewable energy and BHEL’s contribution is given in Table 1.

Solar Energy

The sun provides enough energy in one minute to cater to the global energy needs for one year. India receives 5000 trillion kWh of solar energy per year.

Solar Photovoltaic

In line with its CSR initiatives, BHEL paid special attention to the development of remote and inaccessible areas in the Sunderbans delta, Lakshadweep, and Andaman and Nicobar islands. The solar power plants commissioned by BHEL have heralded a new era in the lives of the islanders. BHEL commenced the manufacture of SPV (solar photovoltaic) cells and modules at its Bangalore plant in 1983. Subsequently, it set up standalone as well as grid-interactive SPV plants in remote areas. The company offered solar power plants ranging from few kilowatt-peaks to megawatt sizes. The company
Table 2 The SPV-based power plants supplied by BHEL

<table>
<thead>
<tr>
<th>Description and quantity of ordered equipment</th>
<th>Order placed by</th>
</tr>
</thead>
<tbody>
<tr>
<td>(i) 100-kWp SPV grid-interactive power plant at Kiltan Island</td>
<td>Jharkhand State Tribal Cooperative Development Corporation Ltd</td>
</tr>
<tr>
<td>(ii) 50-kWp SPV standalone power system at Birula Island</td>
<td>HPCL, Mumbai</td>
</tr>
<tr>
<td>Grid interactive power plant at (i) 150 kWp at Kadmat Island</td>
<td>Chhattisgarh Renewable Energy Development Agency</td>
</tr>
<tr>
<td>(ii) 100 kWp at Miricoy Island</td>
<td>Kamataka police</td>
</tr>
<tr>
<td>(iii) 100 kWp at Agatti Island</td>
<td>Chhattisgarh State Electricity Board</td>
</tr>
<tr>
<td>(iv) 100 kWp at Kavaratti Island</td>
<td>NTPC, Rihand</td>
</tr>
<tr>
<td>(v) 100 kWp at Andrott Island</td>
<td>11.9 kWp standalone SPV plant at Jarah Chetwa Village at Sonbhadra District, Uttar Pradesh</td>
</tr>
<tr>
<td>(vi) 100 kWp at Kalpeni</td>
<td>30 SPV based power plants supplying to police stations aggregating to 67.5 kW</td>
</tr>
<tr>
<td>(vii) 100 kWp at Amnisi</td>
<td>9 SPV standalone power systems aggregating to 36 kW</td>
</tr>
<tr>
<td>(viii) 100 kWp at Tushkali</td>
<td>25 SPV grid interactive power plant installed at APTRANSCO HQ</td>
</tr>
<tr>
<td>(ix) 50 kWp hybrid system (50 kWp SPV + 2 x 60 kW DG) at Bangaram</td>
<td>APGENCO-APTRANSCO</td>
</tr>
<tr>
<td>Grid interactive (with standalone facility) power plant at Neil Island</td>
<td>100 kWp SPV grid interactive power plant installed at APTRANSCO Headquarters</td>
</tr>
<tr>
<td>(ii) 50 kWp SPV grid interactive (with standalone facility) power plant at Havelock Island</td>
<td>ANERT, Thrissur Vattukkarypuraam</td>
</tr>
<tr>
<td>SPV Stand Alone Power Plants at (i) 55 kWp at Moosuri Island</td>
<td>25 kWp SPV grid interactive power plant installed at KSEB HQ</td>
</tr>
<tr>
<td>(ii) 110 kWp at Moosuri Island—St.-II</td>
<td>ESD, Bangalore</td>
</tr>
<tr>
<td>(iii) 110 kWp at Rakhalpur</td>
<td>30 kWp SPV grid interactive power plant</td>
</tr>
<tr>
<td>(iv) 110 kWp at Tushkali</td>
<td>HRDI, Noxida</td>
</tr>
<tr>
<td>(v) 110 kWp at Kaylapara</td>
<td>65 kWp SPV grid standalone power plant</td>
</tr>
<tr>
<td>(vi) 55 kWp at Daulpur</td>
<td>SinFort, New Delhi</td>
</tr>
<tr>
<td>(vii) 55 kWp at Pathankali</td>
<td>25 kWp SPV grid standalone power plant</td>
</tr>
</tbody>
</table>

SPV systems for seismological equipment
SPV systems for battery charging in rural telephone exchanges
SPV systems for navigational aids
Solar power plants (stand alone, grid interactive)
Hybrid (PV Mains or PV Diesel) power plants
Rooftop and building integrated PV

Lighting system
The Rudrapur plant started manufacture of solar lanterns since 1992/93 and supplied over a lakh lanterns. BHEL supplied a large number of PV street lighting systems, home lighting systems, and school lighting systems to Tamil Nadu Electricity Board, Karnataka Electricity Board, various Islands, Tamil Nadu Energy Development Agency, Maharashtra Energy Development Agency, Pondicherry, Itanagar, and so on.

Table 2 The SPV-based power plants supplied by BHEL (continued...) (coninued...)

B) SPV power plants with rating < 15 kWp (major orders)

<table>
<thead>
<tr>
<th>Order placed by</th>
<th>Description and quantity of ordered equipment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Jharkhand State Tribal Cooperative Development Corporation Ltd</td>
<td>174 SPV standalone power systems aggregating to 614 kW</td>
</tr>
<tr>
<td>HPCL, Mumbai</td>
<td>50 x 5.94 kWp SPV standalone system for fuel outlets</td>
</tr>
<tr>
<td>Chhattisgarh Renewable Energy Development Agency</td>
<td>26 SPV standalone power systems aggregating to 130 kWp</td>
</tr>
<tr>
<td>Kamataka police</td>
<td>300 grid-connected solar power packs for police stations aggregating to 67.5 kW</td>
</tr>
<tr>
<td>Chhattisgarh State Electricity Board</td>
<td>9 SPV standalone power systems aggregating to 36 kW</td>
</tr>
</tbody>
</table>

Water heating systems
BHEL developed flat collector-type SWHS (solar water heating system) in 1985/86. In the course of development, required changes were made in the processes and materials. A dedicated facility was established at Rudrapur, Uttarakhand, to manufacture SWHS, solar lanterns, and other such products. At present there are more than 100 manufactures of SWHS with flat plate collectors in the country.

Battery-powered road vehicles
BHEL developed battery-powered vehicles through in-house R&D (research and development). BHEL has supplied about 450 BPRVs (battery-powered road vehicles) generally to public sector undertakings and few in the private sector. BHEL also developed special purpose tailor-made VVIP coaches for various zoos and so on. Further, as a part of improvement, on-board charging facility of the batteries was added. BHEL supplied BPRVs to various customers such as Delhi Development Authority, Agra Development Authority, IIT Chennai, Pathankot in Jammu and Kashmir, and the Parliament House.

Small hydro
BHEL started design and manufacture of hydroelectric equipment at Bhopal and Hardwar in 1966. It had the responsibility of assimilating the collaborator’s technology of hydroelectric equipment. Looking at the total hydropower potential in India, BHEL’s contribution as on 31 March 2009 was 365 sets totalling 16.996 MW. BHEL has not limited itself to higher/medium rating machines but has also addressed the mini/micro/small hydro needs of the utilities for special areas as well as the growing export market for solar products. The BHEL supply range covers the following.

- Rural SPV lighting (street and home lighting)
- Solar water pumping
- SPV railway distant signalling
- SPV system for microwave repeater stations and rural radio phones
- SPV systems for offshore platforms
Wind power
For over a decade, wind energy has been the fastest growing renewable energy source in India. BHEL took the extraordi-
nary initiative in the field of wind electric generator when its technology was in the primitive stage of wind electric generator. To harness wind power at high as well as low wind speeds, BHEL has developed both the options as per customer specifications. The company has successfully designed, manufactured, and tested a 200 kW/50 kW, 6/8 pole dual speed wind electric induction generator.

Developmental activities
Amorphous Silicon: Gurgaon R&D in SPVs first started at BHEL’s Bangalore plant. Subsequently, a world class R&D facility was developed at Gurgaon to carry out research in the field of mono, multi, and thin-film silicon photocells. BHEL has developed 6” x 6” size modules, one of the biggest in the world. It also has the facility to develop suitable texturizing technology.

FBC boiler
More than 70% of India’s population depends on agriculture, which results in huge biomass waste. The economically viable conversion of biomass into energy has been a challenge. BHEL accepted this challenge and developed a 10 MW rice straw-based FBC (fluidized bed combustion) boiler for the first time in the country. This project was jointly funded by MNES (Department of New Energy Systems), Punjab State Electricity Board, along with BHEL.

Fuel cell
In 1988, BHEL became the first company in India to take up fuel cell-related projects in the R&D division in Hyderabad. India’s largest ever 50 kW PAFC power pack was tested at BHEL R&D during December 2000. BHEL acquired focus on areas that do not have access to the grid, a 100-kW hybrid system integrating wind, SPV, and diesel has been commissioned at Kavadakallu in Anantpur district in Andhra Pradesh. This technology, developed for the first time in the country by BHEL’s Corporate Research and Development Division, is undergoing field trials for low and high wind applications with a provision of automatic changeover.

Building integrated SPV laminates
A process for glass-to-glass and glass-to-tedlar lamination has been developed at BHEL’s SPV development centre ASSCP for making semi-transparent and opaque laminates for integrating with windows, canopies, and roofs of buildings. This will allow natural light to permeate, minimizing dependence on electric lights, in conformity with ‘green building’ concepts. These have been put on a room in the BHEL’s ASSCP.

Conclusion
BHEL, apart from taking initiatives in the field of renewable energy, has been developing new technology and products to demonstrate and build up the confidence of the entrepreneur to enter these areas like solar lanterns, solar heaters, WEG, and battery-powered road vehicles.

Key contributions
The major contributions of BHEL to renewable energy have been:

- HPCL: BHEL supplied SPV systems to M/s HPCL to illuminate and run the company-owned petrol dispensing stations smoothly, irrespective of grid power outage. The design takes care of four dispensing stations to work for at least four hours, even when the grid power is not available.
- Lighting: BHEL was the first to commission India’s largest 105 kW standalone SPV power plant at Mousuni Island in South 24-Parganas district in West Bengal on 5 April 2003. It was aimed to fulfill electricity and drinking water need of 700 homes.
- Transportation: With inherent technological strength, BHEL took development of BPRV buses as a project at BHEL, Bhopal. After several engineering/manufacturing trials, first bus was rolled out in early 80s. Improvements continued in load capacity, charging intervals, and a modern BPRV took shape.
- Tsunami crisis – emergency supply of solar lanterns: During Tsunami crisis, BHEL sent 6 solar lanterns through air to Andaman against government order to serve lighting needs of people when the established power systems were wrecked.
- Smart Card: A novel method of selling electricity has also been adopted at Mousuni Island by employing prepaid energy meters on trial basis. Energy is being sold through smart cards to selected customers.
Solar Village - Iqbalpur

Village Iqbalpur is located near the famous Sultanpur Bird Sanctuary. It is about 15 km from Gurgaon, and comprises of about 120 families engaged in farming and related activities, such as dairying and animal husbandry. Though located near Gurgaon, the village is not different from any other remote village as far as electricity is concerned. It faces several power cuts at crucial hours.

The Sultanpur branch of GGB (Gurgaon Gramin Bank), after getting a call from its corporate office, decided to popularize SHLS (Solar Home Lighting Systems) in its operational area. Initially, it was a stupendous task to motivate the people of nearby villages to install SHLS. So, to demonstrate the utility and effectiveness of SHLS, the branch decided to install a system in its own premises so that villagers can themselves see and realize the advantages of SHLS.

The Village Pradhan of Iqbalpur also visited the Sultanpur Branch. The Branch Manager convinced him about the utility and working of SHLS. Together, they decided to hold a meeting in the village and demonstrate the SHLS. So, to demonstrate the utility and effectiveness of SHLS, the branch decided to install a system in its own premises so that villagers can themselves see and realize the advantages of SHLS. Subsequently, a demonstration was organized in the village with the assistance of TATA BP Solar Pvt. Ltd. Apart from the demonstration of the working of the systems, the credit scheme of the Bank for purchase of such systems was also explained in detail. Initially, about 10 units were installed. Soon, other villagers also came forward to install SHLS with the financial assistance provided by the Sultanpur Branch of GGB. Collateral-free, hassle-free, and without-margin credit facility was extended under ‘GGB Saur Vidyut Scheme’ of the bank. Now every household in the village has installed a SHLS.

GURGAON GRAMIN BANK’S ‘SAUR VIDYUT SCHEME’
Major attractions and specialties
1. GGB provides loan to its existing and new customers to purchase TATA BP Solar Home Lighting System on easy conditions and at cheaper interest rates.
2. Loan amount: up to 85%-95% of the total cost
3. Repayment of loan: up to 5 years
4. Service charges: up to Rs 100 only
5. Security: Supervision of solar lighting systems
6. Guarantor: a reputed person
Vishal Paper Industries generates its own power from biomass

Vishal Paper Industries, situated at Village Khusrupur in Patiala, Punjab, produces different types of writing and printing papers. The total production capacity is about 100 tonnes per day. The steam requirement for the company is around 12 tonnes per hour and the power requirement is about 4 MW. Due to irregular supply of power, the company has installed a 5.4 MW biomass co-generation (non-bagasse) project to meet their full requirement of power and steam, which is saving a large quantity of conventional electricity and diesel for the operation of their paper mill. The project is utilizing about 200 tonnes per day of rice husk. The pressure of steam boiler is 65 bar, and the turbine is of back pressure type, so as to extract steam also for their process requirement.

The total cost of the project is about Rs 130 million. The project was commissioned in August 2008 and is running satisfactorily. The energy generated is being utilized for captive use to meet their total heat and power requirement. With the installation of 5.4 MW co-generation project, the paper mill has become self-dependent for its captive energy requirement. The payback period of project is about 5 years.

Yangthang Village of Leh runs on small hydropower

Khaltse is a very remote village of district Leh, which is 15 km from Saspol and 75 km from Leh, located on the road leading to Himshok Village. Ladakah is situated in the Indus Valley region of Ladakah range of Karokram Mountains within a complex network of Himalayan Mountains. Minor ranges exhibit no pattern in terms of the direction of alignment. These ranges are drained by a number of rivers, which eventually end up in Indus River. Some of the peaks surrounding the village rise beyond 16,000 feet and are permanently snow-covered.

A 25 KW Micro Hydel Project was formally commissioned on 19 June 2008 at a cost of Rs 1.621 million on Yangthang stream. The project was completed within a period of one year and remained on trial before it was formally commissioned. The project provides electricity to 35 households. The area was devoid of electricity, except few households that had solar units for lighting 2–3 CFLs (compact fluorescent lamps). A Village-level Energy Committee was constituted, which has taken up the responsibility of management, maintenance, and repair after the project was handed over to the Committee. Two grass-root engineers were trained for running the project. This hydropower has the least impact on the environment. Each beneficiary contributes Rs 50 per month, which is shared among the two grass-root engineers.

Beyond lighting, the Village Energy Committee plans to install local industry for processing agriculture crops, steel works, irrigation, and so on. Presently, they have to go to Leh for milling and other such services. The village also has a small wool processing unit at home level, which could be augmented with power spinning machine. It will enable them to process a larger quantity of wool, and spinning a pashmina can also be done at home.

Giriraj Rice Mill powered by rice husk

Giriraj Rice Mill is situated at Bamumpara in Burdwan District of West Bengal. The production capacity of the mill is 80,000 tonnes of paper per annum. In the process, the rice mill requires both electricity and steam. Due to irregular supply of power and frequent cuts, the mill has installed an 800 KW rice husk-based co-generation project for captive use to meet their full requirement of power and steam. This is saving a large quantity of conventional electricity and diesel for the operation of the rice mill. The project is utilizing about 70 tonnes per day of rice husk, which is available from their own rice mill. The pressure of the boiler is 32 bar, and the turbine is of back pressure type, so as to extract steam for their process requirements.

The project was commissioned in May 2008 and is running satisfactorily. The energy generated is being utilized for captive use to meet their total steam and power requirements.

With the installation of the 800 KW co-generation project, the rice mill has become self-dependent for its energy requirement. The payback period of the project is about four years. The performance of the project has encouraged a number of other rice mills in the state of West Bengal to install similar projects.
Shaping the future with the sun

Central Electronics Ltd

S K SANGAL
Executive Director, CEL

Introduction

CEL (Central Electronics Ltd) is a Public Sector Company under the Ministry of Science and Technology, Government of India. CEL is the nation’s pioneer in the field of SPV (solar photovoltaics), and has the most modern plant to manufacture solar cells and modules at Sahibabad (Uttar Pradesh) located on the outskirts of Delhi. CEL’s SPV technology is state-of-the-art and its products test qualify to international standards ‘IEC 61215 (Edition-II)’, certified by TUV Rheinland, Germany. CEL has developed many innovative solar products suitable for rural as well as industrial applications. CEL is actively engaged in the implementation of Rural Village Electrification programme through solar energy for more than two decades now. CEL’s mission is to achieve excellence in technology and manufacturing of solar cells and modules and be a market leader in solar energy.

Phases of SPV technology development in the company

CEL’s activities in the area of SPV can be broadly broken up into the following macro-milestones (Table 1).

- 1976–80: R&D phase
- 1981–86: Pilot plant operation and demonstration programme
- 1986–91: Volume production and semi-commercial operation
- 1991 onwards: Commercial operation
- 2005: Capacity expansion and modernization of manufacturing plant

In view of the so-called ‘oil crisis’ in 1973, CEL was given a mandate to indigenously develop the technology to harness solar energy in 1976 (as India is blessed with abundant sunshine) and within a year, CEL successfully developed the first solar cell.

CEL carried out extensive in-house R&D efforts to develop the process technology to manufacture solar cells and modules. The technology is being continuously upgraded to improve on efficiency and yield. Starting from a meagre 5% efficiency on 25 mm diameter solar cells in 1977, it is now manufacturing solar cells of 156 mm x 156 mm size with more than 16% efficiency. This has been achieved through the installation of modern machines, adopting latest production techniques including anti-reflection coating and optimization of process parameters. Today, CEL has the capability to manufacture up to 225 Wp modules including BIPV (building integrated photovoltaic) modules.

Milestones in the development of solar cells and modules in CEL are given in Table 2.

Development of SPV applications: CEL’s contribution

The activities at CEL include the development of SPV applications particularly suitable to Indian conditions. CEL has developed for the first time in India, various models of solar home lighting systems; solar street lighting systems; portable solar lanterns; solar water pumps; and solar-powered systems for community centres, schools, rural health centers, and so on, to meet the rural energy needs.

CEL also developed solar-powered systems for stand alone very low power TV transmitters, communication towers, and processing of 156 mm x 156 mm crystalline silicon wafers.

Table 1 CEL’s activities in the area of SPV

<table>
<thead>
<tr>
<th>Year</th>
<th>Area</th>
</tr>
</thead>
<tbody>
<tr>
<td>1976–80</td>
<td>R&amp;D phase</td>
</tr>
<tr>
<td>1981–86</td>
<td>Pilot plant operation and demonstration programme</td>
</tr>
<tr>
<td>1986–91</td>
<td>Volume production and semi-commercial operation</td>
</tr>
<tr>
<td>1991 onwards</td>
<td>Commercial operation</td>
</tr>
<tr>
<td>2005</td>
<td>Capacity expansion and modernization of manufacturing plant</td>
</tr>
</tbody>
</table>

Table 2 Milestones in solar cell/module process development

<table>
<thead>
<tr>
<th>Year</th>
<th>Milestone</th>
</tr>
</thead>
<tbody>
<tr>
<td>1977</td>
<td>Development of first indigenous solar cell</td>
</tr>
<tr>
<td>1978</td>
<td>Development of first indigenous solar PV module</td>
</tr>
<tr>
<td>1981</td>
<td>Pilot plant production of solar cells and modules</td>
</tr>
<tr>
<td>1983</td>
<td>Incorporation of screen printing technology in solar cell processing</td>
</tr>
<tr>
<td>1986</td>
<td>Incorporation of lamination technology for PV module assembly</td>
</tr>
<tr>
<td>1991</td>
<td>Start of commercial scale production</td>
</tr>
<tr>
<td>1994</td>
<td>Increase in cell efficiency using LGBC (Laser Grooved Buried Contact) technology</td>
</tr>
<tr>
<td>1997</td>
<td>Incorporation of diffusion by screen printing for solar cell processing for uniform doping</td>
</tr>
<tr>
<td>1998</td>
<td>Test certification of PV modules as per IEC61215 by JRC, ISPRA, Italy</td>
</tr>
<tr>
<td>2000</td>
<td>Process optimization for achieving more than 15% solar cell efficiency</td>
</tr>
<tr>
<td>2005</td>
<td>Capacity expansion of manufacturing to 15 MWP</td>
</tr>
<tr>
<td>2006</td>
<td>Achieving more than 16% solar cell efficiency</td>
</tr>
<tr>
<td>2008</td>
<td>TUV Certification for PV modules as per IEC 61215 (Ed-4)</td>
</tr>
<tr>
<td>2009</td>
<td>Processing of 156 mm x 156 mm crystalline silicon wafers</td>
</tr>
</tbody>
</table>
offshore oil platforms, and railway signalling and safety equipment. To meet the requirement of the Indian Army, ‘Foldable Solar Battery Chargers’ were designed and developed conforming to their stringent quality standards.

Major projects in India
During 2001/02, CEL electrified 90 tribal villages in Dantewara District of Bastar Region (Chhattisgarh), spread over a very large area in deep forests. The Ministry of Tribal Affairs and the Ministry of New and Renewable Energy, Government of India, funded the project jointly. With the success of this project, programme of Remote Village Electrification was initiated. Based on the above experience, a large number of electrification projects have been taken up by CEL in Jammu and Kashmir, Punjab, Haryana, Uttarakhand, Uttar Pradesh, Jharkhand, Kerala, Assam, Manipur, and other north-eastern states.

Under the National Drinking Water Mission, CEL developed and installed Deepwell solar pumps to provide drinking water in a large number of problem villages in the country. CEL also developed 1 HP and 2 HP solar powered surface centrifugal pumps suitable for irrigation for small and marginal farmers and installed in a large number of villages throughout the country. The first 200 kWp standalone rooftop solar power plant has also been installed and commissioned for BKES (Brahma Kumaris Educational Society).

Electrification of remote villages in Afghanistan
In 2006, CEL executed a prestigious project for electrification of 101 remote villages in Afghanistan under extremely hostile conditions. Similar projects have been undertaken for technology demonstration in Nepal, Bhutan, Myanmar, Mongolia, Namibia, Senegal, Burkina Faso, Cuba, Colombia, and many other countries. The people in these countries have become familiar with the use of solar energy and its benefits. They are themselves installing the solar equipment supplied by CEL and these systems have resulted in the upliftment of children and women folk.

Technology export
Apart from transferring the PV manufacturing technology to associates in India, CEL has also transferred its technology for manufacturing PV modules to Syria and Sudan. This is probably the first of its kind ‘technology export’ from India under the ‘South–South Co-operation’ programme. Similar agreements are under progress for Mozambique and other African countries.

The milestones in various applications developed/achievements are given in Table 3.

Sun: our inspiration
CEL is committed to harness the benign source of solar energy and to reach the under privileged population bereft of energy in India. CEL’s endeavour to improve the quality of life of people in remote un-electrified villages goes on.

Table 3 Milestones/achievements in solar applications

<table>
<thead>
<tr>
<th>Year</th>
<th>Project Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1981</td>
<td>First solar PV operated radio set in Jammu and Kashmir</td>
</tr>
<tr>
<td>1984</td>
<td>Solar foldable modules for defence applications</td>
</tr>
<tr>
<td>1989</td>
<td>Development of 25 kWp SPV–diesel hybrid power plant</td>
</tr>
<tr>
<td>1993</td>
<td>Solar water pumping systems under the National Drinking Water Mission</td>
</tr>
<tr>
<td>1996</td>
<td>Installation of 200 kWp rooftop solar power plant for BKES</td>
</tr>
<tr>
<td>1997</td>
<td>Solar electrification of 90 tribal villages in Bastar Region of Chhattisgarh state</td>
</tr>
<tr>
<td>1998</td>
<td>Installation of 50 kWp solar power plant at Taj Mahal, Agra</td>
</tr>
<tr>
<td>2004</td>
<td>Design and installation of BIPV modules (25 kWp) for Punjab Energy Development Agency in Chandigarh</td>
</tr>
<tr>
<td>2005</td>
<td>Transfer of technology to manufacture SPV modules to Ministry of Science and Technology, Government of Sudan</td>
</tr>
<tr>
<td>2006</td>
<td>Installation of 200 kWp rooftop solar power plant for BKES</td>
</tr>
<tr>
<td>2007</td>
<td>Solar electrification of 101 villages in Afghanistan</td>
</tr>
<tr>
<td>2009</td>
<td>Installation of 50 kWp solar power plant at Raeathapati Bhawan</td>
</tr>
</tbody>
</table>

Inviting advertisements for Akshay Urja

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

<table>
<thead>
<tr>
<th>Advertisement area</th>
<th>Tariff (rupees)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Inside Front Cover</td>
<td>40 000</td>
</tr>
<tr>
<td>Inside Back Cover</td>
<td>40 000</td>
</tr>
<tr>
<td>Full Page</td>
<td>25 000</td>
</tr>
</tbody>
</table>

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The interested organizations may write to:

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Ministry of New and Renewable Energy

Block – 14, CGO Complex, Lodhi Road, New Delhi – 110 003

Tel. +91 11 2436 3035 or 2436 0707 • Fax +91 11 2436 3035 or 2436 1298

E-mail aktripathi@nic.in
Interview with

Mr Debashish Majumdar
Chairman and Managing Director, IREDA

Debashish Majumdar is the Chairman and Managing Director of IREDA (Indian Renewable Energy Development Agency), a financial institution set up by the Government of India that finances projects related to renewable energy and energy efficiency. An engineer from Indian Institute of Technology, Delhi, Mr Majumdar’s experience spans over 30 years in the field of renewable energy. He has been with IREDA for over eleven years. Akshay Urja team talks to him about his journey, his achievements, and the future of IREDA and the renewable energy sector.

Q.1 You assumed the office of Chairman and Managing Director of IREDA almost two years back. Could you kindly sum up the major achievements of your organization at this stage?

A: First of all, I have been the acting MD since December 2004 and have assumed charge as the Chairman and Managing Director of IREDA in June 2007. In 2004, when I took charge as acting MD, IREDA’s operations were not in a very healthy state. It was plagued with high levels of NPAs (Non-performing Assets) and low sanctions. Even disbursements stood at an abysmally low level of around Rs 2900 million. From that dismal situation, IREDA has steadily gone through a healthy transformation and has achieved disbursement levels of around Rs 7700 million in 2008/09. Sanctions during the year have also grown substantially to around Rs 15000 million. This year, we hope to do much beyond that both in terms of sanctions and disbursements, while bringing down NPAs to a negligible level. Our growth of originations is at a base figure of 2003. In the past few years is more than 25%, in spite of the current global financial crisis.

Q.2 You have just moved into a new office ambience. So, what are the newer initiatives that are on their way to progressive implementation?

A: First of all, new office ambience is not what creates new initiatives. New initiatives flow from overall strategies, the need to reach out to new customer groups, access to new products, and the need to respond to regulatory changes. In this regard, IREDA has consistently taken steps to maintain its leadership role as a dominant player in the renewable energy space. We have broadened our portfolio to include financing of energy efficiency and conservation projects, and medium and large hydro power projects. Innovative schemes have also been introduced for providing bridge financing for bagasse cogeneration projects, seeking loans under the Sugar Development Fund. In order to expand IREDA’s reach and increase market penetration, it has also entered into Memorandums of Understanding with the Power Finance Corporation and PTC Financial Services Ltd. Special efforts have also raised the resources at competitive rates even at times when favourable conditions did not exist in the financial markets. For the first time, IREDA has also raised resources to the tune of Rs 1000 million through taxable bonds that are listed in the stock market.

Q.3 IREDA has made the maximum loan disbursements in the area of wind energy in comparison to other renewable energy areas so far. How long is this trend going to continue and for what reasons?

A: Requirement for loans would obviously depend upon the projects being set up by investors. Power generation through wind energy as a renewable energy investment is favoured amongst project promoters. As long as power producers and project developers find investments in wind to be attractive, loans in this sector would continue to be high. Wind sector would continue to find favour because of the intrinsically high cost of solar projects and the risks associated with some of the newer technologies. We are presently discussing with Asian Development Bank for a specialized fund for financing solar energy pilot projects. Based on the success of the pilot projects, larger funds can be structured.

Q.4 IREDA has been rated high as per the performance indicators set up by various multilateral and bilateral funding agencies. When do we expect to break a new ground, for example any fresh line of credit for the solar energy commercialization programme?

A: IREDA has been very successful in attracting specific and targeted lines of credit from various multilateral and bilateral sources. Some of these lines of credit had soft terms, but generally, these are mainly long-term credits whose costs are some what less than commercial borrowings. We have recently signed a line of credit with KfW, Germany, for 50 Million Euro. We are also in the final stages of discussions for another line of credit from them for about 20 Million Euro which is specifically aimed at removal of barriers in the biomass sector. We are also in discussion with JICA, Japan and AFD, France for various lines of credit. Financing of solar energy projects would necessarily require funds at very low interest rates. It is a proven fact that the intrinsically high cost of solar projects and the risks associated with some of the newer technologies. We are presently discussing with Asian Development Bank for a specialized fund for financing solar energy pilot projects. Based on the success of the pilot projects, larger funds can be structured.

Q.5 IREDA has been at the forefront of advancing soft loans for a variety of activities, be it manufacturing or system installation etc. Its appraisal skills are intrinsically acknowledged. But has there been a real problem of customers who had their loan applications appraised heading for other financial institutions thus leading to precious loss of both time and resources at IREDA?

A: Firstly, there never has been a real problem on this count. It is true that few loan applicants have obtained sanctions from IREDA but have decided to obtain loans from other lenders. This is a normal business practice and choice of lender would depend upon the terms and conditions associated with the loan.

Q.6 The generation-based incentive for setting up solar thermal and solar PV based power plants has been a much talked about affair in the recent times. Could you please share the likely outcome of this scheme with our readers at this point of time?

A: The GBI has sown the right seeds. The most important outcome is that several states like Gujarat, Rajasthan etc. are clearly able to recognize the sun as a great resource and are able to identify the immense opportunity that solar energy can create along with the vast tracts of the barren land. These states have accordingly announced favourable policies to attract investments in the solar energy sector.

Q.7 You have been a strong votary of recommending an enhanced utilization of various RE technologies in different sectors of our economy. Which sectors in your perception are going to be the leading platforms as far as actual deployment of such technologies is concerned?

A: That’s a difficult question because technologies keep changing with time. However, as evident even now wind would continue to have a leading edge over others for obvious reasons that I have mentioned earlier. In the medium term, there is likelihood of strong competition from the solar thermal power generation technologies subject to successful deployment of the first few plants. Another sector that would consolidate itself would be small hydro but these projects require long gestation period and are often technically complex from an implementation view point.

Q.8 Finally, what message would you like to give to the readers of Akshay Urja?

A: I would like to remind all readers of Akshay Urja that each one of us must sincerely participate and contribute our mite in ensuring sustainable development through the clean and green route of renewable energy. If we really want to do good for this Earth and our future generations, we must always keep in mind the old saying that “We have not inherited this Earth from our forefathers but have only borrowed it from our children”. It is a great responsibility on each one of us. We must recognize this and act accordingly.
National Workshop on Village Energy Security Programme

TERI (The Energy and Resources Institute) organized a National Workshop on the Village Energy Security Programme at India Habitat Centre, New Delhi, on 9–10 June 2009.

The workshop included representatives from State Nodal Agencies, existing and prospective project implementation agencies of VESP projects, Village Energy Committee members of VESP projects, non-governmental organizations, Panchayati Raj institutions, community and rural development agencies, forest departments, MNRE, Ministry of Power, and so on.

Mr Ajit K Gupta, former adviser and head of VESP, mentioned that India is facing major challenges in ensuring energy access to its rural population. Though one of the major challenges have been faced in setting up of the VESP projects and their sustainable operation through community participation, the projects have motivated the community (especially the youth) to develop their skills to operate the installed power generation systems in almost all the VESP test projects.

The village Energy Committee presidents mentioned that they had been running the systems well and due to the proper training, capacity building, and time to time refresher courses of training, technical maintenance of the systems are being done. Organizations like BERI, UNDP-GEF, ARTI (Appropriate Rural Technology Institute), SKG Sangha, Krishi Gram Vikas Kendra, DESI Power shared their experiences of running various decentralized rural energy initiatives. The participants discussed the convergence issues of various rural electrification initiatives in India and deliberated the way forward.

Director of TERI, talked about how the high economic growth of India is putting a huge pressure on all our energy resources. India provides non-commercial energy in the form of traditional biomass used at very low efficiencies. Based on this, a concept of providing energy security through biomass in villages has been evolved by the MNRE (Ministry of New and Renewable Energy). The objective is to go beyond mere electrification per se and meet the total energy requirements of the country.

Mr Leena Srivastava, the Executive Director of TERI, discussed the way forward.

Biomass is an important renewable energy source, as it contributes around 30% of total primary energy consumed in the country. Bulk of our present rural energy consumption comes from non-commercial energy in the form of traditional biomass used at very low efficiencies. Based on this, a concept of providing energy security through biomass in villages has been evolved by the MNRE (Ministry of New and Renewable Energy). The objective is to go beyond mere electrification per se and meet the total energy requirements of villages including cooking, lighting, motive power, and electricity generation.

Dr Priti Kumar, Task Team Leader, Biomass for Sustainable Development of the World Bank gave a special address to share the Bank’s experience of working in the programme. She said the idea was to develop biomass energy-based interventions focusing on sustainability to learn lessons from the technology options, consumer acceptability, financial arrangements, institutional sustainability, and so on to scale it up to a lager operational phase.

Dr N P Singh, Advisor of MNRE, mentioned that about 15,000 MW grid power from renewable energy – about 9% of the total grid power in the country – has been installed. Mr Marki Loya, Director of APEDA, gave a presentation on various renewable energy schemes that are under implementation in the state. He also requested more participation of DAC members in these schemes. During the interaction sessions, the DACs presented their views, and highlighted the benefits of renewable energy and existence of DACs.

The project has been executed in association with APEDA (Arunachal Pradesh Energy Development Agency) and DHPD (Department of Hydro Power Development) of Government of Arunachal Pradesh. The MNRE (Union Ministry of New and Renewable Energy) has said that out of the 1483 villages that need to be electrified, 425 villages are covered through 46 ongoing small hydro power projects. The remaining 1058 villages were proposed to be covered within a span of two years.

APEDA provides solar lighting systems to 5000 houses in the border villages of Arunachal Pradesh

About 5000 houses in the villages situated on the border of the northeastern state of Arunachal Pradesh have been provided with solar home lighting systems. This electrification is being done under the Prime Minister’s Special Package on illumination/electrification of all border villages of the state through solar, hydro, and micro-hydel systems. A total of Rs 275.58 crore will be spent on the project in three years. Within the next one month, another 800 houses will be illuminated under the scheme, and the remaining villages would all be covered under the chairmanship of Deputy Commissioner and members from various state government departments and non-governmental organizations.

On 29 May 2009, a one-day orientation-cum-training programme of DAC members of Arunachal Pradesh on renewable energy was organized at the capital city of Itanagar by APEDA. The programme was attended by Deputy Commissioners of West Kameng, Tirap, Dibang Valley, Upper Subansiri; ADCs of East Siang and West Siang; and more than 60 members of DACs.

Speaking on the occasion, Dr N P Singh, Advisor of MNRE, mentioned that about 15,000 MW grid power from renewable energy – about 9% of the total grid power in the country – has been installed. Mr Marki Loya, Director of APEDA, gave a presentation on various renewable energy schemes that are under implementation in the state. He also requested more participation of DAC members in these schemes. During the interaction sessions, the DACs presented their views, and highlighted the benefits of renewable energy and existence of DACs.
Solar Power: Free power for the future

MANASWINI SHARMA, Class 9th, Chinmaya Public School, New Delhi

The world’s energy sources are slowly declining, as our supply of fossil fuels grows scarce. Since fossil fuels are non-renewable, we will have no other source of energy to depend on unless we find another solution. Oil and gas are running short, and although coal is readily available, it is harmful to the environment. Engineers need to come up with a solution that people will actually use, while at the same time be beneficial to the earth’s ‘health’. In other words, they need to find the light at the end of the tunnel. Although many possibilities are readily available for engineers, such as wind power and ocean currents, they should focus on solar energy. Solar energy is an ideal solution to the current crisis because there is a plentiful supply, it’s an all-purpose energy source that’s safe for humans, and it’s affordable.

Obviously, solar energy comes from the sun, but what does that mean for us? Unlike oil and gas, which will eventually ‘die out’, solar energy will always be ‘in stock’. Although not as profuse in some areas as others, all places are adequately supplied with solar power. The sun gives us 10,000 times as much energy as we actually use. Instead of wasting precious resources such as oil and gas, why not use a resource that never runs out? If solar energy is virtually everywhere, why not take advantage of what it has to offer?

Not only is solar energy in ample supply, it is also useful and safe for mankind. Solar energy has the ability to power calculators, watches, and houses, and heat greenhouses, large buildings, and swimming pools. It can be converted into heat and electricity through PV (photovoltaic) devices, and can power your microwave so that you can have your lunch! Even Honda, a car company, has been involved in the making of PV devices. Although not economically feasible at present, solar energy can also power cars. When this is developed, we could make the world a healthier place to live and make many more scientific breakthroughs.

Unlike oil, solar energy has little to no negative effects on the environment, such as releasing CO₂, which will eventually grow scarce. Since fossil fuels are non-renewable, we will have no other source of energy. We cannot depend on fossil fuels and non-renewable energy sources forever. Solar energy provides a clean and efficient source of power, and it is time that scientists took solar energy seriously as a major resource of energy for the future. Until then, we need to concentrate on what we have now, and use it wisely. Remember: it’s not only what we use, but also how we use it.

To solve the climate crisis, the world must make a wholesale shift to renewable energy technologies. With surging growth in emerging markets, this transformation takes on even greater urgency. The challenges – and opportunities – are immense. Selling Solar considers how such a shift might happen. Focusing on the case of solar photovoltaics, it shows, how at the start of the 21st century, this technology began to diffuse rapidly in select emerging markets, after years of struggling to take off. What were the initial barriers to diffusion? How were they overcome? Who did it? And how can this success be replicated?

Selling Solar is a hybrid in many senses. It not only devotes many of its pages to the empirical case of solar, but also tries to bring some theoretical foundation to the case. It delves deep into the details of solar energy diffusion and tries to step back and generalize about renewable energy diffusion more broadly. It identifies the transformative power of entrepreneurs and the key role of policy-makers in providing the right incentives. It builds on the author’s earlier experiences in academic research and also tries to bring a practitioner’s eye to the matter.

The melding of different objectives and perspectives will make this book appealing to a whole range of people. This book belatedly tries to give the readers examples of where businesses have been trying to bring cleaner energy technology to the market, and diffuse it on a large-scale basis in emerging markets and where policy-makers stepped in to either assist this process or hamper it. Drawing on literature on innovation diffusion and entrepreneurship, the author answers these questions, showing how entrepreneurs affected profound technological change not just through the solar systems they sold, but through the example they set to both new market entrants and policy-makers. In analysing how this happened, this book offers important lessons for the diffusion of a range of renewable energy technologies in emerging markets, and for the advancement of the sector as a whole. This book is written from the perspective of someone who has both influenced and analysed the diffusion of solar energy in emerging markets. It is essential reading for anyone who believes in a renewable energy future and wants it sooner rather than later.

Reviewed by Ambika Shankar
The Renewable Energy Handbook: a guide to rural independence, off-grid, and sustainable energy
Kemp W H. D. 2005
Canada: Artiset Press
The Renewable Energy Handbook focuses on the unique requirements of off-grid living and contains chapters on energy conservation; heating and cooling; backup power; domestic water heating; wireless communications; photovoltaic, wind, and microhydro energy generation; battery selection; and inverters.
ISBN: 978-097-33233-20
Price: $22.76

The Homeowner’s Guide to Renewable Energy: achieving energy independence through solar, wind, biomass, and hydropower
Chiras D B. D. 2006
Canada: New Society Publishers
The Homeowner’s Guide to Renewable Energy gives readers sufficient knowledge to hire and communicate effectively with contractors and, for those wanting to do installations themselves, it recommends more detailed manuals. With a complete resource listing, this well-illustrated and accessible guide is a perfect companion for illuminating the coming dark age.
ISBN: 978-086-57153-63
Price: $21.24

Solar energy
Solarbuzz is an international solar energy research and consulting company. The mission of Solarbuzz is to be the leading SPV (solar photovoltaic) energy consultancy in the world. Through the website, the user can get information on Global Solar Market and Supply Developments, access to solarbuzz research and consultancy services, or connect to Solar Energy Companies Worldwide. The website also provides world solar energy news, weekly newsletter on solar energy, and information on solar energy products.

International Association of Hydrogen Energy
The International Association of Hydrogen Energy stimulates the exchange of information in the hydrogen energy field through its publications and sponsorship of international workshops, short courses, and conferences. In addition, the association endeavours to inform the general public of the important role of hydrogen energy in the planning of an inexhaustible and clean energy system. The website provides organizing information, technical papers on hydrogen safety and other topics, events, news, and links related to hydrogen energy.

Alternative fuels and advanced vehicles data center
The AFDC (Alternative Fuels and Advanced Vehicles Data Center) is a comprehensive clearing house of data, publications, tools, and information related to advanced transportation technologies. Sponsored by the US Department of Energy’s clean cities initiative and technically administered by the National Renewable Energy Laboratory, the AFDC hosts more than 3000 documents, interactive tools that help fleets and consumers make transportation decisions, and a wealth of information to educate the public on alternative fuels and advanced vehicles. The educational tools and information featured in the AFDC are geared toward helping consumers and fleets reduce petroleum consumption.

Internet resources

http://www.afdc.energy.gov/afdc
http://www.solarbuzz.com
http://www.iahe.org

Fourth South Asia Renewable Energy Conference 2009
29 July 2009, Hotel Le Meridien, New Delhi
The Associated Chambers of Commerce and Industry of India 1, Community Centre, Zomipurp Kalasch Colony New Delhi – 110 048 Tel. +91 11 4655 0555 Fax +91 11 4653 6481/82 E-mail energy@assoccham.com Web www.assoccham.org/4asia

Third Renewable Energy Finance Forum
20–21 November 2009, Mumbai
Maria Ferreiro E-mail mferreiro@euromoneyplc.com

Empower India 2009
20–22 August 2009, Mumbai, India
Urvanar Foundation 128, Azam Chambers Tardeo, Mumbai - 400 034 Tel. 022 6596 9852, 2353 1695 Fax 022 2351 1825 E-mail empower@urja.org.in Web www.urja.org.in Event website www.empowerindia.com

World Hydrogen Technologies Convention
26–28 August 2009, ITD Delhi

Renewable Energy India Expo 2009
10–12 August 2009, New Delhi
Rajneesh Khatkar Exhibitions India Group 217 B, (2nd Floor), Oldkhasia Industrial Estate Phase III, New Delhi – 110 020 Tel. +91 11 4279 5000/054 Fax +91 11 4279 5098/99 E-mail rajneeshk@eigroup.in

International
Wind Expo 2009
2–4 September 2009, Panama City, Panama
Av. Terranova 1091-2 Guadalajara México Tel. +52 33 3817 8300 Fax +52 33 3817 8758 Web http://www.windexpo.org/2009/ing/index.html

ISES Solar World Congress 2009
11–14 October 2009, Johannesburg, South Africa
Tel. +27 12 807 7171 Fax +27 86 559 4753 E-mail info@swc2009.co.za Web http://www.swc2009.co.za/

Solar Power 2009
27–29 October 2009, Anaheim, California, USA
Tel. 1 202 857 0898 Fax 202 682 0559 E-mail ebrown@solarelectricpower.org

Congress on Alternative Energy Applications
2–6 November 2009, Kuwait
Dr Salah Almudh’hi Web http://www.cc2009kuwait.org/

The Renewable Energy Handbook unfocused on the unique requirements of off-grid living and contains chapters on energy conservation; heating and cooling; backup power; domestic water heating; wireless communications; photovoltaic, wind, and microhydro energy generation; battery selection; and inverters.

Purchase
Price: $16.47

The Homeowner’s Guide to Renewable Energy: achieving energy independence through solar, wind, biomass, and hydropower

Purchase
Price: $22.76

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Price: $21.24

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Purchase
Price: $16.47
# Renewable energy at a glance in India

<table>
<thead>
<tr>
<th>S. No.</th>
<th>Source/system</th>
<th>Estimated potential</th>
<th>Achievement as on 30 June 2009</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Power from renewables</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>A Grid-interactive renewable power</td>
<td>(MW)</td>
<td>(MW)</td>
</tr>
<tr>
<td>1</td>
<td>Wind power</td>
<td>45 195</td>
<td>10 386.00</td>
</tr>
<tr>
<td>2</td>
<td>Bio power (agro residues and plantations)</td>
<td>16 881</td>
<td>736.10</td>
</tr>
<tr>
<td>3</td>
<td>Bagasse cogeneration</td>
<td>5 000</td>
<td>1 134.73</td>
</tr>
<tr>
<td>4</td>
<td>Small hydro power (up to 25 MW)</td>
<td>15 000</td>
<td>2454.67</td>
</tr>
<tr>
<td>5</td>
<td>Energy recovery from waste (MW)</td>
<td>2 700</td>
<td>59.91</td>
</tr>
<tr>
<td>6</td>
<td>Solar photovoltaic power</td>
<td>—</td>
<td>2.12</td>
</tr>
<tr>
<td></td>
<td>Sub total (A)</td>
<td>84 776</td>
<td>14 772.53</td>
</tr>
<tr>
<td></td>
<td>B Captive/combined heat and power/distributed renewable power</td>
<td></td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>Biomass cogeneration (non-bagasse)</td>
<td>—</td>
<td>170.78</td>
</tr>
<tr>
<td>8</td>
<td>Biomass gasifier</td>
<td>—</td>
<td>165.16</td>
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<tr>
<td>9</td>
<td>Energy recovery from waste</td>
<td>—</td>
<td>34.06</td>
</tr>
<tr>
<td></td>
<td>Sub total (B)</td>
<td>—</td>
<td>378.00</td>
</tr>
<tr>
<td></td>
<td>Total (A+B)</td>
<td>—</td>
<td>15 142.53</td>
</tr>
<tr>
<td></td>
<td>II Remote village electrification</td>
<td></td>
<td>5 453 villages/hamlets</td>
</tr>
<tr>
<td></td>
<td>III Decentralized energy systems</td>
<td></td>
<td></td>
</tr>
<tr>
<td>10</td>
<td>Family-type biogas plants</td>
<td>120 lakh</td>
<td>41.27 lakh</td>
</tr>
<tr>
<td>11</td>
<td>Solar photovoltaic systems</td>
<td>50 MW/km²</td>
<td>120 MWp</td>
</tr>
<tr>
<td></td>
<td>i. Solar street lighting system</td>
<td>—</td>
<td>70 474 nos</td>
</tr>
<tr>
<td></td>
<td>ii. Home lighting system</td>
<td>—</td>
<td>450 000 nos</td>
</tr>
<tr>
<td></td>
<td>iii. Solar lantern</td>
<td>—</td>
<td>730 000 nos</td>
</tr>
<tr>
<td></td>
<td>iv. Solar power plants</td>
<td>—</td>
<td>8.91 MW</td>
</tr>
<tr>
<td></td>
<td>v. Solar photovoltaic pumps</td>
<td>—</td>
<td>7 148 nos</td>
</tr>
<tr>
<td>12</td>
<td>Solar thermal systems</td>
<td>140 million m²/collector area</td>
<td>2.90 million m²/collector area</td>
</tr>
<tr>
<td></td>
<td>i. Solar water heating systems</td>
<td>—</td>
<td>6.57 lakh</td>
</tr>
<tr>
<td></td>
<td>ii. Solar cookers</td>
<td>—</td>
<td>1347 nos</td>
</tr>
<tr>
<td></td>
<td>Wind pumps</td>
<td>—</td>
<td>0.89 MW eq</td>
</tr>
<tr>
<td></td>
<td>Aero generator/hybrid systems</td>
<td>—</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Awareness programmes</td>
<td></td>
<td></td>
</tr>
<tr>
<td>16</td>
<td>Energy parks</td>
<td>—</td>
<td>511 nos</td>
</tr>
<tr>
<td>17</td>
<td>Aditya Solar Shops</td>
<td>—</td>
<td>284 nos</td>
</tr>
<tr>
<td>21</td>
<td>Renewable energy clubs</td>
<td>—</td>
<td>521 nos</td>
</tr>
<tr>
<td>22</td>
<td>District Advisory Committees</td>
<td>—</td>
<td>560 nos</td>
</tr>
</tbody>
</table>

MW – megawatt; kW – kilowatt; MWp – megawatt peak; m² – square metre; km² – kilometre square

4.5 MW Sarbari small hydro power project in Himachal Pradesh
Government of India
Ministry of New and Renewable Energy

Announces Scheme on

Roof Top Solar Photovoltaic (SPV) Systems

for reducing diesel consumption in commercial establishments institutions, government buildings, shopping malls, hotels, hospitals, nursing homes, industry & housing complexes facing power shortage during the day time

Benefits

- Estimated pay back period: 5-6 years
- Life: 20-25 years
- No air and noise pollution
- No moving parts and little maintenance
- A 100 kWp capacity Roof Top system could save up to 50,000 litres of diesel in a year

Financial Support

- @ Rs. 100 per peak watt of SPV modules used, subject to a maximum of 40% of the cost of system, to non-profit making organizations
- @ Rs. 75 per peak watt of SPV modules used, subject to a maximum of 30% of the cost of system, to profit making organizations who can also avail accelerated depreciation; and
- Roof top systems could be with or without grid connectivity. Support will be available for systems in the range of 25 – 100 kWp of SPV module capacity. Smaller capacity systems (not less than 10 kWp) may be considered on case to case basis.

Details of the scheme are available on the website of the Ministry: www.mnre.gov.in. Proposals may be submitted to the Ministry in prescribed format through concerned state nodal agencies. (List available on the website) and also online to the Ministry (akvarshney@nic.in).

Ministry of New and Renewable Energy
Block No.14, CGO Complex, Lodi Raod
New Delhi-10003
Telephone No:01124360885

Dr. Farooq Abdullah
Union Minister for New and Renewable Energy