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Dear Readers,

Science has played a stellar role in discovering the potential of renewable energy sources, like biofuel, geothermal, solar, wind and hydro and in making renewable energy usable for everything, from complicated processes to commonplace activities. Indeed the exploitation of renewable sources of energy is a path breaker, yet there is always scope for innovative technologies to make these sources affordable and user friendly.

We are all aware that renewable energy can play a vital role in mitigating the degradation of the environment. In fact renewable energy has already started making a visible impact in our country’s energy mix. With a present installed capacity of over 25,000 MW of grid-connected renewable power, India today, stands among the top five countries of the world in terms of renewable energy capacity. Renewable power represents about 12 per cent of the total installed electricity generation capacity in India. The Ministry of New and Renewable Energy (MNRE) aims at accelerating the deployment of renewable energy with a target of around 30,000 MW of renewable power, by 2017. In January 2010, the MNRE launched the Jawaharlal Nehru National Solar Mission (JNNSM) and at present with the setting up of about 1,000 MW of solar power capacity, the first phase of the Mission is nearing completion.

Currently, though most residential societies, commercial establishments, institutions, markets etc., are still dependent upon diesel generating sets (gen-sets) to supply electricity as a backup during the non-availability of grid power, it is pertinent to note that today, the cost of solar electricity is cheaper than that of electricity generation from these diesel gen-sets. Hence it is worthwhile to supplement diesel based electricity with electricity from solar and other renewable sources.

This issue of Akshay Urja promises its readers a wealth of information on different renewable energy sources. It has contributions from people who have been involved with RE technology which is trying to bridge the gap between knowledge and the inspiring vision of setting the world free from its sole dependence on fossil fuels, and the glitches of pollution and environment degradation. The articles on India’s wind power potential, small hydro power, geothermal energy, microalgae as potential biofuel source, biochar as a substitute for P-Fertilisers etc. will give the readers exciting insights into technology which is eco-friendly, enhancing efforts towards a cleaner, greener environment.

I wish all our readers a happy reading!

Arun K Tripathi
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I would like to subscribe to the magazine, Akshay Urja, as I am very passionate about solar energy and its impact. Also since it is published by the Ministry of New and Renewable Energy (MNRE), I feel that this would be the best medium of knowledge I can have.

Shivali Pandya Thakar
Borivali (W), Mumbai

I am working at the Renewable Energy Department, College of Technology and Engineering (CTAE), Udaipur. I always participate in kisan melas, exhibitions and demonstrations organised for kisans. I also assist students of B.E, M.E and Ph.D in their projects. I request you to kindly mail the Akshay Urja magazine regularly, so that everyone here may be benefited by the informative articles published in it.

Dinesh Kr. Agrawal
Udaipur, Rajasthan

With reference to the Akshay Urja magazine, I am very pleased to inform you that I have read the online version of the same in your portal and am very impressed by the magazine, as it covers all the aspects of renewable energy including the emphasis on setting up an enabling environment for solar technology penetration as well as biodiesel generation techniques etc. Our school has set up an ‘eco club’ to spread awareness and save the environment and towards this endeavour, the magazine will be very helpful in our future projects. I request you to oblige us by sending this magazine.

Rajesh Kumar Chandel
Principal, Gyan Ganga, International School, Jabalpur

I would like to introduce myself as an Assistant Manager (Environment) based in Kolkata. I am very interested in new and renewable energy sources and have found your magazine very informative and useful. I wish to subscribe to your magazine. Please let me know of the procedure and formalities for subscription.

Rohan Kumar Mahto
Kolkata, West Bengal.

With reference to the Akshay Urja magazine, I am very pleased to inform you that I have read the online version of the same in your portal and am very impressed by the magazine, as it covers all the aspects of renewable energy including the emphasis on setting up an enabling environment for solar technology penetration as well as biodiesel generation techniques etc. I request you to regularly send me a printed copy of this bi-monthly newsletter.

Dr. D. Raja Jebasingh
Assistant Professor, Arachalur, Tamilnadu.
The wind energy sector holds an enormous potential to capture the energy market in India.

Small hydro power does not require the construction of large dams and is free from problems of rehabilitation or deforestation.

Pune Municipal Corporation has taken a remarkable step in developing a municipal solid waste biogas plant.
Spain Visit by High Level Indian Delegation

An Indian delegation lead by Gireesh Pradhan, Secretary, Ministry of New and Renewable Energy, visited Spain to observe the solar thermal power plants. The delegation met with Protermosolar, a leader in the concentrated solar power (CSP) industry on 18 April. Pradhan impressed with the solar thermal plants, declared in his speech India’s strong commitment towards generating solar energy (both photovoltaic and solar thermal energy). Regarding the ongoing Solar Mission programme of India, Pradhan stated that he was convinced that the first set of 500 MW CSP plants will be a success. Luis Crespo, General Secretary, Protermosolar and President of European Solar Thermal Electricity Association (ESTELA), expressed confidence about the commitment of Indian companies promoting these projects.

Protermosolar and ESTELA have agreed to assist India in terms of both technology development and plant deployment and have offered to provide a well-rounded system that will give all necessary information and advice to the Indian Government. India has embarked on a programme of generating 10,000 MW of solar power. Of this, 3000 MW will be supported by a mechanism that assures guaranteed off take at a fixed price for 15-25 years. The balance 7000 MW will be funded by tradeable renewable energy certificates (RECs) that distribution companies will be obliged to buy from solar power producers.

www.evwind.es, 20 April 2012

Gujarat Planning Rooftop Solar Power Policy for Households

The State of Gujarat is considering a ‘rooftop’ solar power plant policy to enable its people to produce their own electricity and earn money by selling surplus power and feeding it into the grid, as declared by Narendra Modi, Gujarat’s chief minister, on 19 April.

Gandhinagar, being developed as India’s first model solar city, already has solar rooftop systems with capacities ranging from 1 kW to 150 kW at more than 150 locations, aggregating to a capacity of 1.39 MW. These cover a total of two acres of roof-top area, providing 1 per cent of the total energy consumption in the State capital. Recently, the state government floated a 5 MW solar rooftop systems programme on PPP (purchasing power parity) model in the capital. This is now being extended to five more cities and towns. Modi added that the said technology has reduced the cost of solar power production from Rs 15 to Rs 8.5 per unit in the last few years, making it affordable and at par with gas-based power. An ambitious 605 MW solar power project spread across 10 districts is now underway and Modi said that the policy would make the people self-reliant in power generation. This would help them rent out their roofs for installation of such plants thereby helping them earn extra income and improve their living standards. The solar project has created an additional 30,000 jobs in the State.

www.thehindubusinessline.com, 19 April 2012

Now Green Feeder Vehicles for Metro

In an eco-friendly initiative, a fleet of battery-powered, pollution-free vehicles were inducted into Delhi’s transport on April 27, 2012 to provide commuters with feeder services from metro stations. The service, modelled on the lines of similar services in Tokyo, New York and Berlin, was launched by chief minister, Shieila Dikshit.

To start with, the first cluster will comprise 25 such vehicles and will operate between the Malviya Nagar metro station and the Select City Walk mall at Saket in South Delhi. The promoter of the project, Green Wheels Pvt. Ltd., a subsidiary of the Argentum Group, said that they plan to introduce a total of 5,000 such vehicles, branded as G-Rik, within the next 15 months and negotiations are underway with various government agencies.

Ajay Singh, Chairman, Argentum Group said that the new service
is aimed at bridging the last mile connectivity to major vantage points in the city. These eco-friendly electric vehicles will usher in a world class mode of travel, and provide for a more efficient, faster and better quality public transport system. The vehicles will be directly managed and operated by Green Wheels. To ensure a hassle-free ride for commuters, the company has put in place a ticketing system with a fixed fee of Rs 10 per passenger per ride.

www.thehindu.com, 28 April 2012

200 MW PV Charanka Park Inaugurated; 600 MW commissioned

At the inauguration of the Charanka Solar Park in India, photovoltaic projects nearly worth 605 MW were handed commissioning certificates by Gujarat chief minister, Narendra Modi under the Gujarat Solar Policy. These projects have been completed, but have not been grid connected, due to the lack of transmission infrastructure in the State. The Gujarat Solar Park, set up with an investment of nearly Rs 9,000 crore on a 2,669 acre plot of wasteland in village Charanka in Patan district, is the largest part of the State’s power project with 200 MW of operational capacity. The overall capacity of the Solar Park, when it expands to 5,000 acres, would be 500 MW by 2014, making it the largest solar farm in Asia. The entire solar power project would produce 30 lakh units of clean energy daily, capable of electrifying 10 lakh households, and save 10 lakh tonnes equivalent of carbon dioxide emissions annually.

Further, at the ceremony, Naoki Sakai, senior energy specialist from the Asian Development Bank (ADB) announced that US $500 m would be made available to the State for solar development. Peter Haas, U.S. Council General, from the U.S. Consulate at Mumbai committed a further $ 500 m dollars to be used for solar and clean energy development in India.

www.pv-magazine.com, 19 April 2012

J&K to have First Wind Power Project at Reasi

Jammu and Kashmir is set to have its first wind power project in the State and a site in the mountainous Reasi district has been found suitable. Officials of the Jammu and Kashmir Energy Development Agency (JAKEDA) reported that the proposed project will come up at a site called Bidda in Reasi district that has high wind potential. To study the wind potential and feasibility of such projects in the State, two wind masts were installed at Ijara in Baramulla district and at Bidda. As per the tests, there is wind potential of about 336 W/m² at 50 m height. A project with a capacity of around 10 MW is being envisaged in the first stage. In order to ensure development of the Bidda site, a draft MoU has been prepared and forwarded to the National Hydro Power Corporation (NHPC). Officials at the JAKEDA added that the major criterion for developing a wind farm is to first assess the wind potential. Wind power projects will be taken up when it is approved by the Centre for Wind Energy Technology (C-WET).

ibnlive.in.com, 19 April 2012

Chennai Readies to Give Country its Solar Atlas

Chennai is getting ready to give India its own solar atlas, which will have details on levels of solar energy radiation in various cities in the country. A team of experts set up by the Ministry of New and Renewable Energy, is working on updating the data of solar energy radiation received from 50 existing automatic solar radiation monitoring centres, of which seven are in Tamil Nadu, and the rest are spread across the country from Ladakh in Kashmir to Chitradurga in Karnataka. There are plans to set up another 60 data centres for this project. The Director of the Solar Radiation Assessment Cell in Chennai, G. Giridhar, stated that the data in the atlas will prove useful for the government and commercial investors, who can learn of potential solar zones in India and invest wisely in specific projects to tap the energy. The ministry is also working on the proposal to make this data available, at a price, to corporates looking to invest in renewable energy as a business and
wanting to set up solar farms in India. This Solar Census Project is the first of its kind in the world to use solar spots to assess potential energy zones. www.deccanchronicle.com, 20 April 2012

Solar Power All Set to Light Up Border Areas

Border areas of Punjab are all set to go solar as the Punjab Energy Development Authority (PEDA) is planning to install a large number of solar-powered streetlights and water heating systems in public buildings in the Gurdaspur, Amritsar, Tarn Taran and Ferozepur districts. While 90 per cent of the cost of installing these systems in public buildings, including colleges, schools, hospitals and gurudwaras, would be borne by the PEDA, the remaining 10 per cent would be taken care of by local bodies like panchayats and nagar panchayats.

The PEDA has plans to install close to one lakh biogas units in rural areas by the year (2012-13). The Authority has been providing a subsidy of 30 per cent to those switching over to biogas plants. As many as 48,904 of such units have already been set up. PEDA has installed solar powered systems at the Parliament House and has been asked to install an 85 kV solar plant at the Rashtrapati Bhawan, at a cost of Rs 3 crore. Plans are on to set up a similar system at the Punjab Governor’s house in Chandigarh, as well. www.tribuneindia.com, 27 April 2012

West Bengal to Launch New Renewable Energy Policy

In a bid to encourage efforts to harness the potential of renewable energy sources, the government of West Bengal is planning to introduce a new renewable energy policy. As stated by MK De, Principal Secretary, Department of Power and Non-Conventional Energy Sources, the policy, the draft of which has already been prepared and is awaiting approval, will be based on cogeneration and generation of electricity by using renewable energy sources. The proposed policy intends to encourage investment in renewable energy sources, like wind energy, solar energy, biomass etc, by way of granting various concessions to willing investors. At present, renewable energy accounts for 2.5 per cent of the total consumption in West Bengal. De pointed out that grid-connected large solar plants following the guidelines of the Jawaharlal Nehru National Solar Mission (JNNSM), were not the only normative directive for generation of solar energy, and that the State intends to enhance solar power generation through rooftop installations. In line with this, the State Regulatory Commission has already started focussing on installation of domestic rooftop solar plants. www.power-eng.com, 26 May 2012

Government Allots Rs 270 Crore for Solar-Powered Rickshaws

In an effort to ‘go green’, the Samajwadi Party (SP) government of Uttar Pradesh, in its upcoming budget, intends to create an initial provision of Rs. 270 crores, devoted to solar powered rickshaws. Announcing this, the State Minister of Urban Development, Azam Khan said that the government was in talks with several companies like Scooter India, Hero and Bajaj to manufacture the rickshaws. The State has an estimated 1.75 lakh rickshaw pullers and envisages to provide a solar-powered, motorised rickshaw free of cost to each. All rickshaws registered before 15 March 2012, when the SP government was formed, will be replaced in phases. Since each rickshaw is expected to cost around Rs 1 lakh, the scheme will involve an expenditure of Rs 1,750 crore. The rickshaws will be fitted with a motor that runs on a battery which can be charged either through solar power or at battery charging centres that will be set up at various places in the city. www.indianexpress.com, 26 May 2012

Haryana to Invest Rs 230 crore in Five Biomass Power Projects

The Haryana government plans to set up five biomass power projects at a cost of Rs. 230 crore, to generate
about 51 MW of power. A spokesman of Department of Renewable Energy (HAREDA) stated that two of these projects were near completion, adding that the State’s four micro-hydro power projects have also started power generation. These include a 6 MW power project in Dadupur, Yamuna Nagar, a 2 MW project in Gogripur, Karnal, a 1.4 MW project at Musapur, Karnal and another project of 1.4 MW at Khukhni Karnal, costing Rs 58 crore, Rs 22 crore and Rs 16 crore, respectively. He also said that a total of 164 MW of power is being generated in the State through renewable energy sources and 93.9 MW power generation has been added currently. Furthermore, to create awareness about renewable energy devices and energy conservation, HAREDA has set up 21 energy parks at the district level incurring a cost of Rs 1.80 crore.

**Thirteen Additional Biofuel Information Centres Soon**

According to the Chairman of the Karnataka State Biofuel Development Board (KSBDB), Y. B. Ramakrishna, Biofuel Information Centres will be set in all the districts of Karnataka in the next three months. Speaking at the University of Agricultural Sciences (UAS), Bangalore, Ramakrishna said that 13 more centres will be added to the existing 17. Besides providing information on biofuels, these centres will be equipped to collect different types of non-edible oil seeds, extract oil with a seed crushing capacity of 500-600 kg per day and produce 100 to 150 litres of biodiesel per day. The biodiesel produced will be blended with petrol and diesel and used in several vehicles belonging to the Board and the University and the de-oiled cake will be used/sold as organic manure. At present, Karnataka has the capacity to produce 135 million litres of ethanol from molasses, which will be increased to 200 million litres by this year end. He added that Karnataka is the first State in the country to formulate a biofuel policy, create a task force and constitute a board for the promotion of biofuel.

On the occasion, Chief Minister D. V. Sadananda Gowda inaugurated a national workshop on Rural Agriculture Work Experience (RAWE) Programme and launched the biofuel park website. The workshop was jointly organised by the University of Agricultural Research (UAS), Bangalore, and the Indian Council of Agricultural Research and Biofuel Development Board. Informing about the RAWE programme, Vice-Chancellor of University of Agricultural Sciences, Dr. K. Narayana Gowda explained that under the programme, the students are given rigorous orientation on various issues and problems, which will help provide them with real time opportunities to work on complete crop season through various extension methods.

**Solar Mission Completes 89 per cent of Capacity Goal**

The National Solar Mission whose goal is to install 20,000 MW capacity of solar energy by 2020, has commissioned 89 per cent of its allotted capacity in its first stage, informed government officials. The government had signed power purchase agreements (PPA) with 28 solar power developers for 140 MW solar photo voltaic (PV) projects in January 2011, out of which 125 MW of capacity stands commissioned currently. The progress is commendable as most of the projects are commissioned and delayed projects given one month extension with a part of their bank guarantee encashed, informed Tarun Kapoor, Joint Secretary, Ministry of New and Renewable Energy. For the solar thermal sector, PPAs have been signed for 27 projects for a capacity of 470 MW to be included in the first batch. They would be commissioned by May 2013. The NTPC- Vidyut Vyaapar Nigam (NVVN) which executes the bidding and trades power with the developers, is satisfied with the result. However, the concerned party would be stricter than before with the mission guidelines and will work more closely with the developers of the second batch informed a senior official of NVVN.
Hawaiian Utility Turns to Biomass as Clean Power Source

Hawaii Electric Light Company (HELCO) has entered into a 20-year agreement to purchase 21.5 MW of biomass power on Hawaii Island from Hu Honua Bioenergy, a deal requiring approval from the state Public Utilities Commission. Hu Honua Bioenergy is converting a former sugar mill into an electric generation plant using biofuel including locally grown biomass, such as eucalyptus. The facility will consist of a biomass fuel yard, steam boiler, turbine and generator. The previous plant used sugar cane waste and later, coal. Estimates are that Hu Honua will be able to supply about 10 per cent of the island’s electricity needs. The plant is anticipated to be completed approximately 18 months after refurbishment begins.

Hu Honua’s facility will supply us firm renewable energy at prices that are stable and not tied to the unpredictable world oil market and that is good for the customers, informed HELCO President Jay Ignacio. He also added that with the addition of Hu Honua to the HELCO power grid, over 50 per cent of the island’s electricity will be provided by renewable resources. Hu Honua estimates that its plant...
will replace about 250,000 barrels of oil per year. It will employ 28 to 30 persons once in commercial operation.

Hawaii has a clean energy target of 70 per cent renewable energy use by 2030. It is more dependent on crude oil imports than any other state.

www.rechargenews.com, 22 May 2012

**California Expands Solar Thermal Incentives for Low-Income Housing**

California is leading the way for solar hot water with a new solar thermal incentive, this time for low-income single-family properties and multi-family dwellings. California's original CSI (California Solar Initiative) Thermal rebate programme was introduced in 2010 and is perhaps the most generous solar water heating rebate programme in the United States, offering up to $500,000 for commercial properties and up to $1,875 for individual homeowners. Now, California's Public Utility Commission (PUC) has introduced another incentive that targets low-income housing and individuals named 'The CSI-Thermal Low-Income Programme'. In terms of numbers, the low-income programme provides customers of Pacific Gas and Electric Company (PG&E), San Diego Gas & Electric (SDG&E), and Southern California Gas Company (SoCalGas) with up to $3,750 in rebates - double the regular rebate. For multi-family dwellings, such as apartment buildings, nursing homes, and assisted living homes, owners can receive up to $500,000. The top figure differs from the regular programme in that owners will receive a 50 per cent higher rebate for the natural gas displaced by the solar power system. As the programme grows and more installations come up, the rebate amount will decrease for both programmes, and so will the price of installing solar water heating systems.

s olarmakescents.net

18 April 2012

**German Solar Power Output Sets World Record**

German solar energy production reached a world record of more than 20 GW of output, according to the Institute of the Renewable Energy Industry in Germany. The World of Renewable Energy Industry (IWR) in a press release reported that solar power stations in Germany, at peak times produced as much as 22,000 MW of power. Last year, in reaction to the Fukushima disaster, the German government decided to phase out nuclear power over the course of 11 years while shutting down the seven oldest nuclear plants immediately. A federal study showed that renewable energies could provide more than 30 per cent of the electricity needs in Germany, practically substituting all of nuclear power. A 2000 law guaranteeing fixed rates to producers has resulted in a quick growth of renewable energy in Germany over the last decade.

www.theepochtimes.com, 29 May 2012

**Solar Powered Boats Being Made in Rome**

A small company called Tamarack Lake Electric Boat Company in Rome, is marketing the first recreational solar powered boat named 'Loon' that is soaking up rays and replenishing energy. Monte Gisborne, the owner of Tamarack Lake Electric Boat Company remarked that it would make perfect sense as the suitable time to go boating is sunny days which would also mean that there is a great opportunity to go solar which is what this boat is all about. Gisborne says he plans to start manufacturing the solar boats for market within the month. According to him, it is a culmination of world politics, and a change in the perception of solar power, high gas prices and environmental awareness, all of which play a part in making it a good time for launching this product coupled with the fact that boaters are beginning to look for something different. Even without a gas engine the ‘Loon’ can reach speeds rivaling a typical pontoon boat. Presently about 1000 W is generated, which is roughly a quarter of the total power available for the motor. The energy used is constantly being replaced by the sun and the four solar panels on the roof produce energy at a rate of up to more than 700 W, guaranteeing miles of quiet, environment friendly boating.

www.renewableenergyworld.com, 3 May 2012
WAY FORWARD FOR INDIA’S WIND POWER BY 2020

India ranks 5th in installed capacity of 17.53 GW, but has higher generation mix of wind generated electricity penetration than USA and China. India’s wind power potential is higher at higher hub heights and the REC, CDM route with IPPs would keep the wind blowing, if there is sustained political and societal will.

Dr S Gomathinayagam
India today, ranks fifth in total wind power installed capacity in the world with over 17.5 GW (MNRE, May 2012), while China and USA stand at 1st and 2nd positions, with levels above 65 GW and 49 GW respectively (REN 21, 2012). Though the gap is rather large and even though per capita consumption of electricity in India is much lower than the leaders, India’s wind-electricity mix in total generation of electricity is 3 to 4 per cent (Berkley Lab, 2010) which is actually way ahead of China with 2 per cent and USA with a little over 2.5 per cent. This, in addition to the overall renewable energy mix of 12 per cent with around 25 GW from all renewable sources (nearly 17.5 GW i.e., 70 per cent being wind) out of the net generation capacity of about 206 GW (CEA, 2012), is no mean achievement for a country with a population of a billion, in a democratic multi-party and a multi-cultural, socio-economic and geo-political system.

The wind power generation capacity in India, as per the official estimates by the Centre for Wind Energy Technology (C-WET) long term wind resource measurement programme, is 49.13 GW. It is pertinent to note that the declared potential is based on measured wind data, at different locations in India, at various heights, ranging from 20 m to 50 m masts. This was further substantiated by a detailed international collaborative project, while developing an Indian wind atlas, using a Mesoscale Model developed for India by RisØ, Denmark which was validated by the C-WET using the available measured data in India. The potential of 49 GW is calculated with respect to 2 per cent land availability at windy locations and pertains to a 50 m hub height level of the wind turbines.

Presently due to technological advancements, large wind turbines with higher hub heights in the range of 80-100 m with larger rotor diameters up to 102 m are available in the Indian market. The Indian Wind Atlas released in April 2010, notes that when wind speed is increased along the height; and, the potential of 49 GW at 50 m level, is extrapolated to 80 m standard hub height; the projected wind potential using the same 2 per cent land availability will be in the order of 102 GW. With greater per cent of land availability, ‘grid evacuation and logistical road infrastructural developments’ and possible exploitation of offshore wind potential there is all likelihood for additional alternative possibilities.

This higher potential (102 GW) existing in India has not been officially declared owing to the lack of validation of the mesoscale (otherwise known as a variant of numerical weather prediction - NWP) models with actual mast based measurements at 80 m level. In addition, the earlier declaration of wind potential in India had not systematically considered land use, land cover pattern and actual land

Even though per capita consumption of electricity in India is much lower than China and USA, India’s wind electricity mix in total generation of electricity is 3 to 4 per cent which is ahead of them.
availability considering water bodies, agricultural land, forest coverage and other environmentally protected areas. To scale up and give a realistic potential, the government of India, particularly the Ministry of New and Renewable Energy (MNRE) has initiated a project to conduct a realistic assessment considering tangible land availability for wind farming using Geographic Information Systems (GIS) in seven wind potential states - Tamil Nadu, Karnataka, Andhra Pradesh, Maharashtra, Madhya Pradesh, Gujarat and Rajasthan at a 100 m level facilitating the validation of mesoscale based results indicated in the Wind Atlas.

The MNRE in the twelfth five year plan (2012-2017) has envisaged a growth capacity addition of 30,000 MW of renewable energy power with as much as 15,000 MW by wind alone. This should push the net installed capacity of wind to 32,000 MW. The growth in wind energy sector has been all time high in the last financial year to somewhere around 2430 MW which has reached to over 3196 MW by the end of this financial year. The trend is obvious when one looks at the statistics of the Clean Development Mechanism.
Another major government initiative is the removal of the Wind Power Density (WPD) cap of 200 W/sq.m which was prescribed to ensure viability and techno economic feasibility of the wind power projects. (CDM) projects - where wind forms a major slice of the total renewable energy based CDM projects - 72 per cent. With 21 per cent of all of the world’s CDM projects in its kitty, India ranks second in the world.

The current policies of the government viz. accelerated depreciation, generation based incentives, customs/excise duties exemption and years of tax holidays and preferential tariff rates for wind generation are likely to sustain the growth of the wind sector. Even though the accelerated depreciation benefits have been reduced to 15 per cent since April 2012, first year in 12th Five year plan, the Independent Power Producer (IPP) mode of execution and the number of CDM projects in wind and the associated Foreign Direct Investments (FDI) through IPPs are likely to boost the growth of wind sector further.

Another major government initiative is the removal of the wind power density (WPD) cap of 200 W/sq.m which was prescribed to ensure viability and techno economic feasibility of the wind power projects with the then available wind turbine generators (WTGs). Since April 2011, to set up wind power projects in areas having low or moderate wind power potential, with modern technology enabled wind turbines of higher hub heights in the range of 80-120 m, the cap of 200 W per sq.m WPD has been removed by the MNRE. This is likely to augment the growth of wind power in newer sites and newer states in India. Fig. 1 is self explanatory on what is the need of the hour for India-specific low wind regime turbines. Fig. 2 gives the growing capacity utilisation factor with larger MW class wind turbines operating in India.

The declaration of the need to have compulsory Renewable Purchase Obligations (RPOs) in various states and its rigorous implementations as an exclusive wind RPO, if enforced, may further increase the rate of growth of the wind energy sector through Renewable Energy Certificates (RECs). Since the REC declaration in March 2011, India has seen a significant increase in the number of RECs with month-on-month growth registered both in terms of price and volumes of RECs traded at the Indian Energy Exchange (IEX) and Power Exchange of India Ltd. (PXIL). The last REC trading session had more than 137 participants and the price per unit was as high as Rs. 3000 per unit -proving that with close monitoring by the Centre and states, the RECs will certainly help in meeting the set targets.

Last but not the least are the focussed deliberations on ‘smart grid technologies’ and the Renewable Regulatory Fund (RRF) under the National Load Despatch Centre, (NLDC) set up by the Ministry of Power as well as MNRE. The proliferation of renewable energy usage across India and the growing contribution of wind power, necessitates the move towards smart grid technologies to allow greater penetration of this source of energy and to exploit the full potential of wind generated electricity with on-grid/off-grid small wind energy (hybrid-solar) systems (SWES) application of wind turbine generators with net-metering. This will enable several millions to have access to electricity in either the grid connected or the distributed generation mode.

The SmartGrid Week 2012 meeting (when) concluded in Bengaluru, indicated that India is one of the twelve active contributing members of the International Smart Grid Consortium (ISGC). India has even set up an Indian Smart Grid Task Force (ISGTF) and a forum called the Indian Smart Grid Forum (ISGF), whose activities showcase the growth potential of renewables as a whole and wind energy in particular.

Smart grid technologies are beneficial because with the merger of integrated communication and information technology, an electricity delivery system from the point of generation to the point of consumption including variable rates of billing such as time of day, costing of power is facilitated through the smart grid. With the shift to smart grid, the Ministry of Power is envisaging reliable and cheaper power supply, shifting the peak away from costly power and access to sustainable power for all and the end of load shedding. That wind energy is clean, green and cost competitive is amply clear. If greater stress is laid on net metering, the affluent can switch to rooftop wind power with possibly solar as hybrid to pump into the national grid and add to the wind generation which can then reach the needy.

The author is Executive Director, Centre for Wind Energy Technology, Chennai. E-mail: ed@cwet.res.in
Recent research shows that biodiesel from microalgae is one of the most promising renewable biofuel with the potential to completely displace petroleum-derived transport fuel without adversely affecting the supply of food and other crop products - keeping the environment clean at the same time.

Microalgae
Fuel Source for the Future

The global economy thrives on energy. Currently, India is the sixth largest consumer of energy in the world, and will be the third largest by 2030, with its rising population and consequent consumption of power. At the same time, the country is heavily dependent on fossil sources of energy for most of its demand. Due to the limited crude oil reserves, India meets about 72 per cent of its crude oil and petroleum product requirements through imports, which are expected to expand further in the coming years. The continued use of fossil fuels is not sustainable, as they are finite resources and their combustion will lead to increased energy-related emissions of greenhouse gases. This
has necessitated the aggressive pursuing of alternative energy sources – solar, wind, biofuel, small hydro and more. Biodiesel derived from oil crops is also a potential renewable alternative to petroleum. However due to the various issues biodiesel from oil crops and animal fats is not an ideal choice. Moreover it cannot satisfy even a small fraction of the existing demand for transport fuel. Recent research shows that biodiesel from microalgae is the most promising renewable biofuel with the potential to completely displace petroleum-derived transport fuel without adversely affecting the supply of food and other crop products, all this while keeping the environment clean. In fact the oil productivity of many microalgae like Botryococcus braunii and Schiochytrium greatly exceeds the oil productivity of the best oil producing crops.

**Microalgae**

Algae are the most robust organisms on earth, able to grow in a wide range of conditions and are prominently found in water bodies or damp places. Algae are used as food, as biofilters to remove pollutants from wastewater and as indicators of environmental change. They are also used in space technology and in laboratory research. Commercially, algae are cultivated for cosmetics, pharmaceuticals, nutraceuticals, and for aquaculture purposes. Algae are made up of prokaryotic as well as eukaryotic cells. All algae have plastids to carry out photosynthesis like plants. Chemically, algae contain proteins, carbohydrates, fats and nucleic acids in varying proportions. Depending on their type, the proportion of fatty acids in the overall mass of some algae may be up to 70 per cent. It is this fatty acid (oil) that can be extracted and converted into biodiesel.

Algae can be cultivated by two means i.e. ponds and photobioreactors. Algae capture light energy through photosynthesis and convert inorganic substances into simple sugars using the captured energy. For carrying out photosynthesis, algae need sunlight, CO₂ and water. Open ponds and lakes can be used for cultivation. Algae is the third generation feedstock for biodiesel with higher yield than second generation crops. Its yield is about 50 ton of biodiesel per hectare per year against 2 ton for competing feedstock such as jatropha. Its lipid content is also very high and better than any other crop. Its oil yield per unit area of cultivation can be further increased and a lot of research is currently on going in this field. Making biodiesel from algae oil is similar to the process of making biodiesel from any other oilseed and one can use the same conversion processes to generate biodiesel. Pilot projects forecast that algae can provide more than 10,000 gallons of biodiesel per hectare per year. Recent advances in oil extraction and transesterification could reduce the cost of making biodiesel from plant oils. There may be some challenges in converting algae oil into biodiesel using the transesterification process owing to the high free fatty acid (FFA) of algae oil.

**Using Photobioreactors**

A photobioreactor is a controlled and closed system that enables high productivity of algae. It is a closed system where all the growth requirements of algae cultivation are controlled according to the requirement. The following parameters are generally followed for the growth of algae; temperature 16-27°C, salinity 12-40 g/l, light intensity 1,000-10,000 lux (depending on volume and density), photoperiod (light: dark, hours) 16:8 (min) 24:0 (max) and pH 7-9. Photobioreactors facilitate a much better control of the culture environment such as carbon dioxide supply, water supply, optimal temperature, efficient exposure to light, culture density, pH levels, gas supply rate, mixing regime, etc. The various types of photobioreactors available are tubular reactors (horizontal and vertical), flat panel reactors, vertical column reactors, bubble column reactors, air lift reactors, stirred tank photobioreactors and immobilised bioreactors. Tubular photobioreactors are widely used for the mass cultivation of algae. Cultivation of algae in controlled circumstances gives higher productivity. Photobioreactors greatly improve productivity through their design: the use of clear plastic tubing for efficient and volumetric distribution of light; air lift pumps to keep the algae in suspension; mechanism for gaseous exchange; pH and growth sensors. In photobioreactors, the key systems include: light source, optical transmission system, air handling system, reaction area – the reaction mixing system, gas exchange system (CO₂ injection valve, oxygen release system), nutrient system (feeding tank), filtration system.
It is reported that algae yield 30 times more energy per acre than land crops such as soybeans and some estimate even higher yields up to 15000 gallons per acre.

(algae collection filters to remove algal biomass), sensing system (oxygen & CO₂ sensors, temperature sensor, ph sensor, light sensor, conductivity sensor), electrical systems and instrumentation systems.

Algae harvesting
Algae are separated from the growing medium and then dried and processed to obtain biofuel. Harvesting methods depend primarily on the type of algae. The most common harvesting processes are flocculation, micro-screening and centrifugation. Selection of easy to harvest strains is important to ensure efficient and relatively inexpensive harvesting. Algal oil can be extracted using mechanical methods (expression/expeller press, ultrasonic-assisted extraction) or chemical methods (hexane solvent method, soxhlet extraction, supercritical fluid extraction).

Biofuel from algae
It is reported that algae yield 30 times more energy per acre than land crops such as soybeans and some estimate even higher yields up to 15000 gallons per acre. It keeps the earth clean and free from pollution as these algal biodiesel fuels help to utilise a resource that is available in abundance just waiting to be harnessed and exploited. Various forms of biofuel from algae are shown in Fig 1.

The procedure for the preparation of methyl esters varies from oil to oil depending upon each one’s chemical composition and FFA content, shown in Fig 2.

The first step is to remove water from oil by increasing its temperature to 120 °C for about 5 to 10 minutes. Then it is allowed to cool and mixed with sodium hydroxide and methanol by stirring - sodium methoxide is produced. Clean oil is heated to 60°C for 5 minutes, mixed with the sodium methoxide and the mixture is transferred to an ultrasonic or mixer equipment for the agitation of the solution for 30 minutes after which it is cooled and separated. Microalgae produce lipids in the form of triacylglycerols (TAGs). Comparatively, algae produce more oil than any other oilseeds which are currently in use. Many microalgal species can be induced to accumulate substantial quantities (more than 60 per cent of their own biomass) of lipids. Microalgae have the highest oil yield among various oil plants. It can produce up to 100,000 lts oil per hectare per year, whereas palm, coconut, castor and sunflower produce up to 5950, 2689, 1413 and 9521 per hectare per year, respectively.

Algae biodiesel characteristics
Algae biodiesel has many positive characteristics making it a fuel that is sustainable and great for use. Firstly it has no sulphur content. It has superior lubricating properties, reducing the wear and tear of the fuel system - increasing the life of the fuel injection equipment. Algae biodiesel has more aggressive solvent properties than petrodiesel and even dissolves varnish residue. Biodiesel has about 5-8 per cent less energy density than petrodiesel, but with better lubrication and combustion efficiency, its overall fuel efficiency decrease is only about 2 per cent. The cloud point, or temperature at which pure biodiesel (B100) starts to gel, is about 32°F. A blend of B20 (20 per cent biodiesel, 80 per cent 0251t petrodiesel) generally does not gel in cold weather. Various additives will lower the gel point of B100. Biodiesel’s flash point is 266°F, significantly higher than petrodiesel’s at 147°F, or gasoline’s at 52°F. Biodiesel reduces particulate matter by 47 per cent as compared to petrodiesel and reduces the solid carbon fraction on the particulate matter while increasing the amount of oxygen. It has higher yields and hence lower costs. The most significant benefit however is in the yield of
algal oil, and hence biodiesel. According to some estimates, the yield of oil from algae is 200 times more than that of the best-performing plant/vegetable oils. Soybean produces less than 50 gallons of oil per acre and rapeseed generates less than 130 gallons per acre while algae can yield up to 10,000 gallons per acre. Algae can grow practically in every place where there is enough sunshine. The biodiesel production from algae also has the beneficial by-product of reducing carbon and NOx (oxides of nitrogen) emissions from power plants, if the algae is grown using exhausts from the power plants. Algae produces a lot of polyunsaturates, which tend to decrease the stability of biodiesel. But polyunsaturates also have much lower melting points than monounsaturates or saturates, thus algal biodiesel would have much better cold weather properties than many other bio-feedstock. Since one of the disadvantages of biodiesel is their relatively poor performance in cold temperatures, it appears that algal biodiesel might score well on this point. Table 1 shows the comparison of biodiesel from microalgae.

**Microalgae has the highest oil yield among various oil plants. It can produce up to 100,000 lts oil per hectare per year, much higher than palm, coconut, castor and sunflower.**

**SWOT analysis**

A Strengths-Weaknesses-Opportunities-Threats (SWOT) analysis indicates that higher strength lies in the generation of algae culture on a large scale. The coastal stretch of India is long, measuring 7,500 kms, and is capable of generating massive amounts of algae. According to experts the country can become self-sufficient in liquid fuel if even 2-3 per cent of India’s total land is utilised for algae farming and since the opportunity of algal cultivation in the Indian context is very high many research institutes have started work on the same. Besides production, this process is useful in the generation of rural employment for the cultivation, processing and use of the microalgae. Additionally animal feed can also be generated from the waste. However, there are roadblocks in the process. Firstly, microalgae have high water content (80 to 90 per cent); and therefore, not all energy conversion processes of biomass can be applied to microalgae. Secondly, not all algae are capable of producing enough oils, and only those species which are capable of producing more than 50 per cent dry weight of extractable oil, are mainly used. Botryococcus braunii contains an unusually high level of hydrocarbons (upto 80 per cent of the dry mass), making it a great option as a primary biofuel source. Hence the selection of the right kind of algae culture is essential. However recent developments in biological sciences (recombinant deoxyribonucleic acid (DNA) technology) and the availability of user friendly technology may overcome these problems. Another issue is that first generation biofuels (bioethanol) compete with food production and create the ‘food versus fuel’ controversy. But second-generation biofuels derived from non-food sources like jatropha, karanj, microalgae, microbial sources, lignocellulosic biomass and bio-ethers are much better options for addressing energy security and environmental concerns. Among the second generation biofuels, micro-algal biofuels appear to be the most promising. However there are hurdles like the absence of Indian microalgal database available to facilitate a selection of the best strains. To solve this problem scientists from across the country, belonging to a consortium of nine laboratories, are working on an ambitious project called the ‘New Millennium India Technology Leadership Initiative’ (NMITLI), to develop a viable and scalable process of producing biofuel from microalgae, undertaken by the Council of Scientific and Industrial Research (CSIR), New Delhi.

*The authors are Prof. and Head and Research Scholar, Department of Pharmaceutical Technology; National Institute of Pharmaceutical Education and Research, Punjab, respectively. Email: ucbanerjee@niper.ac.in*

<table>
<thead>
<tr>
<th>Properties</th>
<th>Biodiesel from microalgae</th>
<th>Diesel fuel</th>
<th>ASTM* Biodiesel standard</th>
</tr>
</thead>
<tbody>
<tr>
<td>Density (per kg)</td>
<td>0.864</td>
<td>0.838</td>
<td>0.86 - 0.90</td>
</tr>
<tr>
<td>Viscosity(mm²per s)</td>
<td>5.2</td>
<td>1.9 - 4.1</td>
<td>3.5 - 5.0</td>
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<tr>
<td>Flash point(°C)</td>
<td>115</td>
<td>75</td>
<td>Min. 100</td>
</tr>
<tr>
<td>Solidifying point(°C)</td>
<td>-12</td>
<td>-50 to 10</td>
<td>-</td>
</tr>
<tr>
<td>Cloud point(°C)</td>
<td>-11</td>
<td>-3.0 (max-6.7)</td>
<td>Summer max zero Winter max ≤ 15</td>
</tr>
<tr>
<td>Acid value (mg KOH per gm)</td>
<td>0.374</td>
<td>Max 0.5</td>
<td>Max 0.5</td>
</tr>
<tr>
<td>Heating value (MJ per kg)</td>
<td>41</td>
<td>40 - 45</td>
<td>-</td>
</tr>
<tr>
<td>H/C ratio</td>
<td>1.81</td>
<td>1.81</td>
<td>-</td>
</tr>
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*American Standards Testing Measurements*
Perspectives on Biohydrogen Production

Hydrogen has desirable characteristics and its energy content makes it the fuel of the future. With a fast paced economy and heavy dependence on fossil fuels for meeting energy requirements, a new formula of creating hydrogen using biomass is a technological advancement as well as a challenge.

S Seshadri and V Shashirekha

The energy sector has assumed significant importance in developing countries due to the ever-increasing energy needs of the growing population and India is no exception. Continuous use of fossil fuels is now recognised as unsustainable due to their depleting supplies, contributions to global warming and acid rain, which consequently affects the earth’s climate, land, vegetation and aquatic ecosystems.

Hydrogen ($H_2$) has been tipped as one of the more suitable energy carriers from the technological and environmental perspective of the 21st century, particularly within the context of sustainable development. Hydrogen has several desirable characteristics - it is a colourless, odourless, flammable gas, which is low in density when compared to other gases and disperses rapidly into the atmosphere. It is gaining importance due to its high energy content i.e. 120.7 KJ/g which is the highest energy content per unit mass among known fuels. It is recyclable, non-polluting, yields only water after combustion and has high conversion efficiency. These characteristics make hydrogen the fuel of the future.

Hydrogen can be used for power generation, heating and also for transport applications. It is possible to use it in internal combustion engines, directly or mixed with diesel and compressed natural gas or directly as a fuel in fuel cells to produce electricity. The advantages are the fact that hydrogen use results in nearly zero emissions and it opens up the possibility of decentralised production on the basis of a variety of fuels. However, despite energy content per unit mass being high - energy content per unit volume of hydrogen is rather low. And the challenges in the storage of hydrogen for civilian applications are greater. There is a common worldwide understanding that hydrogen cannot play a major role without considerable research, technological innovation and cost reduction in its production and storage.

Sources and Methods of Hydrogen Production

Hydrogen can be derived from a variety of energy sources. A variety of process technologies can be used, including chemical, biological, electrolytic, photolytic and thermo-chemical etc. Theoretically, hydrogen can be derived from any hydrocarbons such as oil, coal, petrol, natural gas, methanol and propane as well as biomass and organic wastes. The most common industrial methods for producing hydrogen include steam reformation of natural gas, coal gasification and splitting water with electricity typically generated from fossil fuels. Other methods for producing hydrogen exist but are still being researched which include thermal conversion of water using heat from nuclear or solar thermal power stations; hydrogen production using algae; and, using waste gases from landfills or water treatment plants.

Biohydrogen production

Among various hydrogen production processes, biohydrogen production technology has the unique possibility of using...
renewable energy sources like biomass (Table 1). Biohydrogen technologies provide a wide range of approaches including direct and indirect photolysis, photo-fermentation, and dark-fermentation and are known to be less energy intensive, for they can be carried out at ambient temperature and pressure.

**Table 1. Modes of biohydrogen production with groups of bacteria**

<table>
<thead>
<tr>
<th>Mode</th>
<th>Aerobic/anaerobic process</th>
<th>Groups of bacteria</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fermentative</td>
<td>Strict anaerobes</td>
<td><em>Clostridium</em> <em>Sp.</em>, <em>Caldicellulo</em> <em>struoptor</em> <em>saccharolyticus</em></td>
</tr>
<tr>
<td></td>
<td>Facultative anaerobes</td>
<td><em>Enterobacter aerogenes</em>, <em>Escherichia coli</em>, <em>Citrobacter Sp</em></td>
</tr>
</tbody>
</table>
| Photosynthetic | Oxygenic                  | *Cyanobacteria* - *Anaebena variabilis*, *Nostoc punctiforme*  
|              |                            | *Green algae - Chlamydomonas reinhardtii*                   |
|             | Anoxygenic                | *Rhodobacter* *sphaeroides*, *Rhodospirillum rubrum*        |

While biological methods mainly include photosynthetic and fermentative hydrogen production, these are associated with the activity of two very common enzymes (hydrogenase and nitrogenase), and the shortlist of candidates targeted for focused study represents fermentative bacteria, photosynthetic microbes such as cyanobacteria, microalgae and purple bacteria. Hydrogen production by direct photolysis occurs in photosynthetic microorganisms like green algae that convert sunlight into useful, stored chemical energy by the following general reaction: \(2H_2O/2H_2 \rightarrow O_2\). Indirect photolysis occurs in *Cyanobacteria* that can synthesise and evolve hydrogen through photolysis through a two phase process: \(12H_2O \rightarrow 6CO_2/C_6H_{12}O_6 \rightarrow O_2\), followed by \(C_6H_{12}O_6 \rightarrow 12H_2O/12H_2 \rightarrow 6CO_2\). Hydrogen production through photo-fermentation occurs in purple non-sulphur bacteria, catalysed by nitrogenase under nitrogen-deficient conditions using light energy and reduced compounds (organic acids): \(C_6H_{12}O_6 \rightarrow 12H_2O/12H_2 \rightarrow 6CO_2\). Hydrogen production by dark-fermentation is carried out by anaerobic bacteria, grown in the dark on carbohydrate-rich substrates (Fig.1). Fermentation reactions can be operated at mesophilic (25 - 40°C), thermophilic (40- 65°C), extreme thermophilic (65- 80°C), or hyperthermophilic (>80°C) temperatures. While direct and indirect photolysis systems produce pure hydrogen, dark-fermentation processes produce a mixed biogas containing primarily hydrogen and carbon dioxide (CO₂), but which may also contain lesser amounts of methane (CH₄), carbon monoxide (CO), and/or hydrogen sulphide (H₂S) that presents technical challenges with respect to the use of hydrogen for various applications. Among these hydrogen production methods, dark fermentation from organic wastes seem to be the most promising and environmentally friendly method as it combines hydrogen generation with waste treatment.

A number of studies have been carried out all over the world to produce biohydrogen from various sources including industrial waste waters. However, most of the systems, though they have achieved hydrogen production using individual cultures/microbial consortia, still look for technological improvisation to make hydrogen yield levels commensurate to the inputs and expenses involved in the process and identification/development of a proper system to utilise the hydrogen efficiently and economically (Table 2).

**Challenges and Perspectives in biohydrogen production**

Biological hydrogen production (BHP) is the most challenging area of biotechnology and it is perceived worldwide as a developmental process that requires extensive biotechnological interventions through considerable research and technological innovations. Technical challenges that face biohydrogen production includes selection of microbes, conversion efficiencies, feed stock types and their availability, identifying the right conditions, molecular understanding, engineering applications and the need to safely integrate hydrogen production systems with hydrogen purification, storage and technologies for efficient utilisation.

While biomass gasification can utilise renewable feed stocks derived from agricultural and/or forestry residues, these processes generate a variety of gaseous, and in some cases liquid residues also as co-products which require attention. The inefficiency in photo biological hydrogen production needs to be addressed to decrease the factor by at least 15 times through optimisation of sunlight conversion efficiency. This calls for developments in systems for improved sunlight collection and transfer and improved photo
bioreactor development. Identification and mobilisation of lignocellulosic biomass feed stocks is an important R&D issue which requires substrate modification including development and optimisation of pre-treatment techniques.

A major challenge in biohydrogen production by both dark and light fermentation is the improvement in the rate and the yield of hydrogen production. The microbiological part has to be addressed for the following - sensitivity of hydrogenase enzyme to hydrogen partial pressure and oxygen that severely decreases the efficiency of the process; scaling up competition with other microorganisms under non-sterile conditions; amenability for metabolically engineered processes etc. Fermentation of sugars, starch, or cellulose by anaerobic microorganisms can generate equal molar amounts of hydrogen and CO₂ at low pressure and density, the gas stream with significant amounts of water vapour and the spent waste all requires to be addressed in situ thus making the bioprocess more economically viable.

Hydrogen can be used in either internal combustion engines or fuel cells. Since fuel cell applications are not commercially standardised yet and a distribution infrastructure for hydrogen cannot be realised in the short term, efficient in situ bio-hydrogen use options have to be explored. Clubbing hydrogen and methane production through twin fermentation systems and effective use of H₂/CH₄ mixture is another option.

**Conclusion**

Cost effective bio-hydrogen production is still in its nascent stage and a number of issues still have to be addressed. Among these, utilisation of organic load, use of starch rich solid wastes industrial wastewaters with pre-treatment, forms an attractive approach for biohydrogen production in the future. The development of a sequential or combined hybrid bioprocess for hydrogen and methane production would prove to be viable in the long run. However, some major aspects need indispensable optimisation including identification of a suitable substrate, suitable pre-treatment method/s, development of ideal microbial culture/consortia that can convert the substrate efficiently to hydrogen and methane, suitable hybrid bioreactors to achieve the desired results etc. Future biological hydrogen production also depends on economic considerations, social acceptance, and developments in hydrogen and hydrogen associated energy use system.

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R P Saini
The biggest challenge being faced by the hydropower industry is to evolve a cost-effective innovative concept for the design of hydro turbines and station layout.

Performance Testing of SHP Plants
The MNRE has been laying considerable emphasis in recent years, on the satisfactory performance of new SHP stations, linking them to financial incentives for the developer. The requirements of a satisfactory performance include a good overall performance, that the weighted-average efficiency of generating units is at least 75% and the station is giving 80% of the projected generation for a minimum of 3 months in continuation. Besides, the Government of India (GOI) also intends bringing about total transparency in contracts between the owner, contractor and equipment suppliers in order to ensure healthy competition entirely based on the quality of services and products. To meet these objectives, the GOI has made the testing and evaluation of SHP stations mandatory, for the purpose of verifying their performance and release of the subsidy. The objective of such an exercise is to optimise energy production, gather inputs for decision-making on life extension of these plants e.g. rehabilitation or upgradation of older plants, confirmation of performance guarantees after rehabilitation, upgrade or initial construction, etc. The data generated will have a significant impact on the cost of the test and, hence, the willingness of the owner to go for such a test. Any recently installed/commissioned SHP station needs to be tested to confirm that all its parts and systems are performing correctly and that the generating units are operating efficiently. This requires professional skills and expertise which is not generally available with power station owners. Even the cost of hiring such expertise and the necessary test equipment from commercial test houses are prohibitive. To meet these challenges, and to improve the quality and performance of SHP stations in the country, the MNRE issued a notification (July 2003) linking its subsidy support for SHP projects to their performance. The AHEC, at the Indian Institute of Technology, Roorkee (IITR) was identified as the test agency for performance evaluation where necessary infrastructural facilities were created with support from MNRE. More than 100 SHP plants have already been tested for their performance by the AHEC.

Micro Hydro Plants For Rural Development
The concern of global warming has imposed new restraints on the production of electricity and accordingly, emphasis is being laid upon ecofriendly energy sources for sustainable development, and this is attracting more attention to micro-
electricity or motive power can be used for agro-processing and for other small scale industries. Providing electricity supply has led to the reduction in the amount of wood and other biomass used and is leading to an improvement of environment and health. This development will also help in generating employment opportunities and will improve the socio-economic conditions of the villages.

However, the situation is also ridden with certain disadvantages. The high initial capital cost of micro hydro schemes is an impediment to the expansion of hydropower in developing countries having acute fund problems. Further, small projects suffer from the problems of scale and high cost per kW. An isolated micro hydro is unable to meet the year-round demand for electricity due to poor expertise available for its operation and maintenance. As SHP sites are not standardised, big manufacturers are not interested in manufacturing of micro hydro turbines. The turbines in the micro hydro range can be locally manufactured, but manufacturers do not have adequate facilities to manufacture these types of turbines as well as any standard procedures. The poor maintenance of the turbine in terms of its misalignment with the generators, results in the failure of bearing and ultimately results in the shut down of the turbine.

Higher capital costs involved are the major constraint in the development of micro hydro plants (MHPs). Cost reduction and local technology availability require physical involvement at the micro level. However, power generated through MHP plants can be used for powering various livelihood activities (Fig. 2). The AHEC had put up various livelihood activities in 10 MHP plants which were established by the village community in 2 districts (Chamoli and Bageshwar) of Uttarakhand.

Development of Water Mills
The good news is that the development of water mills has resulted in poor maintenance, poor output and low revenue collection making the plant uneconomical.

Topography, flow regime and volume of the river streams, geological conditions of the site, etc., being variables, make each installation unique. As SHP sites are not standardised, big manufacturers are not interested in manufacturing of micro hydro turbines. The turbines in the micro hydro range can be locally manufactured, but manufacturers do not have adequate facilities to manufacture these types of turbines as well as any standard procedures. The poor maintenance of the turbine in terms of its misalignment with the generators, results in the failure of bearing and ultimately results in the shut down of the turbine.

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Development of Water Mills
The good news is that the development of water mills has
helped overcome a majority of the constraints discussed above. In the hills, water mills commonly known as 'gharats', have a significant role in utilisation of mechanical power from water streams, mainly, for grinding purposes. These mills operate under head range of 2 to 10 m with an average 1.5 kW mechanical outputs. The efficiency is extremely low and does not provide enough economic incentives to the mill owners. In the Himalayan ranges, from Kashmir to Arunachal Pradesh, thousands of water mills are used for grinding cereals. In hilly, remote areas, mechanical power is required for agro-processes like milling etc. to improve productivity. The demand for electricity for basic lighting, in such areas is becoming a priority. Based on the survey of water mill sites, it is found that these micro hydro power sites have capacity upto 5 kW and may be considered as appropriate resource to meet the energy demands of the people. Though there is a lack of readily available turbines (improved water mills), this has encouraged the development of cost effective designs of standard water mills. In the light of the scope of the upgradation of water mills in the Himalayan and sub Himalayan regions, the development of scientific designs for water mills has been taken up by the AHEC with the financial support of the MNRE and Department of Science and Technology, GOI. The improved water mill (Fig. 3) is capable of grinding 3-4 times more grain than traditional water mills. In addition, a simple machine capable of producing up to 10 kW of mechanical power for driving agro-processing machines directly and for generating electricity if connected with an alternator has also been developed. The turbine is the ‘open cross flow’ type which has an ‘over hung’ configuration. The weight of the machine is much lighter and can be easily transported at the site.

Based on these standard designs, local manufacturers have started fabricating water mills and several of them have had the performance of the turbines tested by the AHEC. Thus hydro power is making its presence felt in a small yet powerful way.

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Geothermal Energy

Heat has been retained within the earth since the birth of the planet. This heat is exploitable and the essay outlines possibilities of tapping geothermal energy from various locations spread around India.

Rajesh Sharma

Geothermal energy, distributed globally in geologically specialised zones, has become a reliable and inexhaustible source of energy. Hot springs have been used as a source of earth energy since time immemorial. Electricity was first produced from geothermal steam in 1904 at Larderello, Italy. At present, about 60 countries utilise geothermal energy for societal benefits and about 20 produce electricity from geothermal source systems. High geothermal activity is generally associated with convergent or divergent plate boundaries, which characteristically are locales for the higher geothermal gradient and high heat flow, and because of the high seismic activity, high tectonic movement and enhanced magmatism confined to these tectonic zones - linked geothermal systems are also existent in these areas. In addition, magmatic rocks, active tectonic and the presence of specific minerals like
Springs have been used as a source of earth energy from historical times, and the electricity from it was first produced as geothermal steam in 1904 at Larderello, Italy.

uranium may cause in geothermal springs to occur in an area. All these geological processes lead to subsurface high heat flow. The attributes of this geothermal system are the emergence of springs of hot water and at times, of steam. The physical parameter of geothermal springs can be measured, and the chemical composition of their water can be determined which also helps to calculate the source area temperature. In addition, micro-droplets of trapped fluid have been used for understanding the paleo-temperatures in the geothermal fields. Shallow to deep drilling can be employed to obtain the thermal log, subsurface temperature contouring, geophysical monitoring, heat flow and discharge –recharge information.

There are about 300 hot springs in India distributed from Himalaya to West Coast to the Son-Narmada lineament to Eastern Ghats in Orissa. Although there was an early start for the study of geothermal resources by Schlagintweit, Oldham, Holland, Heim and Gansser in the nineteenth and early twentieth century, yet planned work in the form of the geothermal atlas of India was published by Geological Survey of India (GSI) only in 1991. Subsequently in 2002, the GSI compiled the geothermal energy resources of India in the form of a special publication. Classical comprehensions on the concepts of geothermal resources, their global scenario, exploration techniques and corridors have been presented by Gupta (1980) and Gupta and Roy (2007).

The geothermal provinces of the orogenic belts in India are the Himalayan geothermal province including northeastern syntaxis and the Andaman-Nicobar geothermal province. Among the non-orogenic geothermal provinces of Central and Peninsular India, significant are the Son-Narmada lineament, East and north Indian provinces, West coast, Godavari and Damodar valleys and the Cambay basin geothermal province. The basic work including identification of the area of thermal signatures, geology of the geothermal field, measuring surface temperatures and estimating base temperatures, analysis of hot water etc., have been carried out on many of the Indian hot springs by different organisations and institutions though significant efforts have been made mainly by the GSI. Conventional methods of Na-K-Ca (sodium/potassium/calcium) thermometry and silica thermometry have been largely employed to reveal the base temperatures, and in limited cases, isotopic compositions of water are also determined. Reasonably detailed investigations have been conducted on selected geothermal fields such as Puga, Chhumathang, Manikaran and Sarguja geothermal fields. Herein, geohydrological studies, geophysical surveys, discharge rate, availability of recharging water and water chemistry, tritium concentration have been investigated. In some cases the isotope systematic have been applied to understand the geothermal systems. Drilling has also been employed at selected sites to comprehend subsurface geology, structure, and thermal logging in the boreholes. Major geothermal fields showed abnormally high geothermal gradients. This might be because of the still cooling magmatic bodies and the shear heated rocks.

Distribution of hot water springs in the Himalayas show that a majority of them are located along the main lineaments almost throughout their strike lengths. Although numerous small hot springs are clustered here, about half a
There are about 300 hot springs in India distributed from the Himalaya to the West Coast to Son-Narmada lineament to the Eastern Ghats in Orissa.

dozen significant geothermal fields are recognised, which include Puga and Chhumathang in Ladakh, Tattapani and Manikaran (Beas and Parbati valleys) in Himachal, Tapoban, Bhapkund, Kali valley geothermal fields in Uttarakhand. Also the valleys of major rivers in northwest Himalaya (Fig. 1) consist of many hot water springs particularly near Central Himalaya. A general decrease in the temperatures of hot waters in the springs in the Himalayas from north to south is evident. The oxygen isotope in hot water from the Puga geothermal field suggests the high rock water interaction and one can infer the possibility of subsurface movement of water in high geothermal gradient. The sulphur isotopic values for the sulphur collected from two of the hot springs in Kumaun match with the sulphide minerals found in an adjacent locality.

The current evolving view proposes that meteoric water percolating through the lineaments gets heated at depth and subsequently ascends to the surface in the form of a hot water spring. Such a concept is also supported by the occurrence of hot water spring at or near the river bed in many of the areas. But all the tectonic planes do not consist of appreciable geothermal activity. The clustering of these springs in the region of active tectonics, occurrences of leucogranites near many of the hot springs, and the evidences of trapped metamorphogenic fluids leads to the inference that multifaceted reasons may be involved in the evolution of geothermal systems. The temperature measured at site of the hot springs water varies from about 25°C to extrusion of water-steam mixture at boiling temperature. The base temperatures are also found varying from about 50°C to above 225°C. Although hot water springs in valley fills are common, however, in many cases they are located at the river bed resulting in mixing of river water as soon as the hot water comes to the surface. This causes difficulty in measuring the hot water temperature at the site of emergence. River water may also permeate in the cavity of hot water spring. The mixing of descending meteoric water is yet another diluting phenomenon. Despite all this, geothermal systems deserve attention due to updated studies aiming at their utilisation. The use of geothermal energy largely depends on the temperature, pressure, quality of geothermal fluids and the estimated/visualised life of the geothermal system.

Among the non orogenic geothermal fields, the Son-Narmada-Tapti-lineament is promising wherein about 35 hot springs have been identified. Although the temperatures of hot water here is generally low (<50°C), but in the prominent geothermal fields at Sarguja in Chhattisgarh the temperature of hot water ranges upto boiling point. A detailed investigation has been carried out on the Tattapani hot springs of Sarguja by the GSI and Oil and Natural Gas Corporation (ONGC). Geology and subsurface geology was established, geothermometry-geochemistry of water and gas, and the geophysical surveys were carried out. Borehole data of this geothermal system was used to draw lithologs, thermal logs and temperature contours. Based on these studies, establishment of a power plant was recommended. Further, Khed, Rajwadi, Ganeshpuri and Unabdeo are some significant geothermal systems consisting of a number of geothermal hot springs in Maharashtra. The hot springs in Rajasthan, Gujarat, Andhra, Karnataka, Tamil Nadu and Kerala generally show temperature of thermal water below 50-60°C. Their thermal energy can be utilised for industrial purposes and for tourism. However, the geothermal energy from the elevated temperature hot water springs associated with the Cambay graben (Sabarmati rift) is promising.

Many of the hot springs are sites for tourism such as Chavalpani hot spring near Pachmarhi in Madhya Pradesh and Tattapani in Himachal Pradesh, and a few others are located at places of religious importance like Badrinath, Manikaran etc. The hot water of some of the springs consists of dissolved sulphur and minerals making it therapeutic and of medicinal value. A few such hot springs are found in Garhwal and Kumaun Himalaya, and many are found in Sikkim wherein the significant ones are at Phuruchachi, Yumthang, Borang and Ralang. Overall, the geothermal systems of India are promising and invite attention for greater detailed studies. However skilled manpower and a multi-parametric approach are required. The drilling set for the study and exploration of geothermal resources have been generally shallow and a deeper drilling may be helpful. Studies on paleo-temperatures and variation in temperature over the past years would be useful. The discharge rate of hot water and the availability of water recharging the hot spring are significant for evaluating the continuum in geothermal energy.

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BIOCHAR
An Effective Substitute for P-Fertilisers

With energy demands growing at a frenetic pace, alternative sources of energy with their tag of sustainable use are becoming highly sought after to fill the gap between supply and demand. Apart from other renewable sources, energy from biodegradables today has great potential and efficiency to measure up to meet this growing demand.

G P Nagori

Fig 1: Overview of experimental plots after 60 days of growth, R&D plots of Ankur Scientific Energy Technologies Pvt Ltd, Gujarat
In a country like India where agriculture is the mainstay of the economy and all efforts are being made to ensure a good crop, fertilisers play a major role in ensuring healthy productivity of a crop. However, chemical fertilisers, though they enhance the quality of the crop and protect it from harm, cause long term side effects on the health of the environment, humans and animals. In such a situation, it becomes imperative that science stresses on the development of eco-friendly, sustainable fertilisers and biochar is one such product. It is carbon rich, produced when biomass, such as wood, crop residues or agro-industry wastes, is heated with little or no available oxygen. In technical terms, biochar is produced by the thermal decomposition of organic material under limited supply of oxygen, and at relatively low temperatures. Gasification is one of the dominant thermal decomposition processes producing gas along with biochar. It is the process of converting solid fuels to a gaseous form and involves drying, pyrolysis, combustion with air, reduction of the product of combustion into combustible gases, (carbon monoxide, hydrogen, methane, some higher hydrocarbons) and inerts, (carbon dioxide and nitrogen). At the end of the gasification reactions, about 6-10 per cent biochar is produced as a by-product. Wood char produced from gasifiers has 7-10 per cent ash and 70-75 per cent fixed carbon. Its calorific value ranges from 5500-6500 kcal/kg and it can be used as fuel in boilers or domestic cook stoves.

Biochar is an excellent soil enhancer and can be a harbinger of hope to increase food security and crop land diversity in areas with severely depleted soils, scarce organic resources, and inadequate water and chemical fertiliser supplies. Biochar is highly porous and improves water quality and quantity by increasing soil retention of nutrients and agrochemicals for plant and crop. Nutrients tend to stay within the soil that is treated with biochar, rather than dissolving into groundwater and causing pollution.

Consider the multiple benefits of biochar on plant growth, systematic studies on application of gasifier biochar on crop were carried out at the R&D plots of Ankur Scientific Energy Technologies Pvt Ltd in Gujarat. (Fig 1) Field experiments were carried out using wheat, considering it contributes to about 60 per cent of the daily protein requirement and more calories to the world diet than any other food crop. As a main staple food, wheat continues to assume greater significance in years to come.

Biochar Characteristics
Biochar produced from the gasifier was analysed for its physio-chemical and nutritional properties. Fig 2 shows the product - biochar. The results of analysis are given in Table 1. Biochar is rich in carbon and has higher values of P$_2$O$_5$ and K$_2$O when compared to farmyard manure (FYM).

Experimental Site, Soil and its Characteristics
The experimental site is located at an altitude of 35.5

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<td>Potassium as K$_2$O, per cent of dry wt</td>
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<table>
<thead>
<tr>
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<th>Values</th>
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<tr>
<td>Available phosphorus (kg P$_2$O$_5$ per ha)</td>
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</tr>
<tr>
<td>Available potassium (kg K$_2$O per ha)</td>
<td>212.50</td>
</tr>
</tbody>
</table>
Biochar is rich in carbon. It has higher values of $P_2O_5$ and $K_2O$ compared to farmyard manure.

metres above mean sea level at Ankur Scientific Energy Technologies Pvt Ltd, Gujarat. The soil of the experimental site was alluvial, sandy loam in texture. A composite soil sample was analysed and the values have been given in Table 2. The soil is neutral in reaction, medium in available $K_2O$ and low in available $P_2O_5$.

Field Experiments

The field experiments were laid down in simple plot design with three treatments replicated three times. The plot size was $3m \times 5m = 15 \ m^2$. The following three treatments were given:

- **T1 (Control)**: No fertiliser was used.
- **T2 (Biochar + Urea)**: 50 kg per ha $P_2O_5$ through biochar and 3 splits of 128 kg per ha N through urea; 1/3 as basal + 1/3 at tillering + 1/3 at milking.
- **T3 (DAP+Urea)**: 50 kg per ha $P_2O_5$ through DAP and 3 splits of 128 kg per ha N through urea; 1/3 as basal + 1/3 at tillering + 1/3 at milking.

Standard agronomical practices were followed in land preparation, fertiliser application, seed sowing, irrigation, after care, harvesting and threshing and the following data was collected during the field experiments:

- **Plant Height**: The plant height of thirty randomly selected shoots in a plot was measured. The measurement was made from the base of the plant to base of the last fully opened/flag leaf at 30, 45 and 60 days and at harvest and expressed in centimetre.
- **Ear Head Length**: Thirty ear heads were randomly selected from the samples collected from each plot. Ear head length was measured from the base to tip of the ear and expressed in centimetre. These ears were threshed to record the number of grains per ear head.
- **1000-Grain Weight**: Grain samples collected from the net plot grain yield were used for recording 1000 grain weight and was expressed in grams.
- **Grain and Straw Yield**: The total biomass yield for each net plot was recorded at the time of harvest. After threshing, grains were separated, cleaned and weighed. Straw yield per plot was worked out by subtracting total grain weight from total biomass for respective treatments. Later the plot yield was converted into kg per ha.

**Plant Growth and Yield**

**Plant Height**: The data on plant height as influenced by different treatments are presented in Fig 3. The plant height progressively increased in all the treatments. However, the growth rate and the total plant height was highest in treatment T2 (Biochar+Urea).

**Ear Length, Grains in Ear and 1000-Grain Weight**

The data on ear length of wheat at harvest, average grains in each ear head and 1000-grain weight for different treatments are shown in Fig 5. All these growth parameters were highest for T2. This indicates the better growth of wheat grains when P fertiliser was replaced by biochar.

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**Fig 3. Plant height at different stages of crop growth**

**Fig 4: Wheat grain of different treatments**

**Fig 5: Wheat grain of different treatments**
lowest parameters were recorded in treatment T1 where no fertilisers were used. The quality of grains of different treatments is shown in Fig 4.

**Grain Yield, Straw Yield and Total Yield**
The grain yield, straw yield and total yield of the crop under different treatments are presented in Fig 6. The minimum straw and grain yields were recorded in control experiment treatment T1 which is obvious as no fertiliser was applied. The grain and straw yield in treatment T3 was 6014 kg per ha and 9441 kg per ha respectively. This is obvious as increase in yield is attributed to the use of recommended dose of fertilisers.

The maximum grain yield of 7112 kg per ha was recorded in the treatment T2 wherein biochar was used as substitute for di-ammonium phosphate (DAP). The grain yield in treatment T2 was about 18 per cent higher than that of treatment T3. Similarly, straw yield at 10308 kg per ha was also significantly higher in T2 compared to T3. The higher yields of grain and straw in T2 compared to T3 may be attributed to the positive effect of biochar. All yield indices indicate that growth was highest in treatment T2 compared to treatments T1 and T3.

**Conclusion**
Studies on biochar have shown that a combined use of biochar and fertilisers have increased grain yield as well as straw yield. There is a great scope for biochar to be used as an alternative to fertilisers. It is a step forward towards flourishing agricultural growth, when there is the urgent need for high yield/production that favours cost cutting and paves the way for a sustainable future that secures the interests of the masses as a whole, and the agricultural sector in the country, in particular.

Application of biochar alone or in conjunction with fertilisers is known to favourably alter the chemical, physical, and biological conditions of some soils thereby increasing the yield. Life cycle analyses show that biochar application in soil can reduce CO₂ emissions. Studies on combined use of biochar and fertilisers application have shown increased yield of wheat and decreased use of fertilisers. If biochar application to soil enables decreased fertiliser use, this may further reduce emissions from the manufacture of fertilisers and would mean financial savings to farmers since the cost of biochar application is less. The future of the agricultural sector in India faces grim circumstances owing to food security and thus methods like biochar will go a long way in heading toward substantial development along with maintaining environmental norms.

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Moving Towards a Green Future

The Gujarat Energy Development Agency or GEDA is playing a stellar role in the development of long term renewable energy and energy efficient technologies in the state of Gujarat.

Daksha Vaja

As the world witnesses a growth in the demand for clean energy, Gujarat recognises green energy as one of its focus sectors. It has emerged as a leader of India’s future energy programme with its constant emphasis on mitigation initiatives by exploiting the clean and green power generation potential of wind and solar energy.

GEDA: The Renewable Mandate and Rationale

The GEDA has been making strides as an organisation in helping Gujarat tap its green energy potential. The following are its mandate:

- Foster the development of sustainable, equitable and resilient energy systems suitable for India’s developing
economy.

- Initiation of change from energy deprivation and dependence to energy autonomy through use of renewable technologies and energy conservation measures.
- Create energy literate citizenry, capable of making wise energy choices.
- Research, development, demonstration and popularisation of renewable energy and energy efficient technologies.

To create opportunity for people to improve their lives by:

- Promoting open and competitive markets for renewable/sustainable energy power projects in Gujarat.
- Supporting companies and other private sector institutions where there is a gap through a single window clearance
- Helping to generate productive jobs and deliver essential services to the renewable energy sector.
- Catalysing and mobilising the promotion and popularisation of sustainable energy technologies through various outreach programmes and projects.

**Gujarat: Renewable Energy Potential**

Gujarat is rich in renewable energy resources. With 300 days’ sunshine and vast tracts of wastelands, even if 1 per cent of the land mass is set aside; it has the potential to generate 10,000 MW of solar power. Its 1600 km coastline, the longest in the country, can generate 10,000 MW of wind power and the 24 million tonnes of biomass produced has the potential to generate 900 MW of electric power. The 200 lakh cattle population can produce 5.6 million cu m of biogas daily at 70 per cent dung collection efficiency that can cater to the cooking gas requirement of 2.8 million families or generate 933 MW of power. Additionally, the tracts of 67 lakh ha of wasteland can yield 67 million tonnes of biomass that has the potential to generate 15000 MW of power. The tidal potential of the sea is at 900 MW and that of the Gulf of Kutch is at 900 MW whilst the energy conservation potential is 23 per cent.

**Gujarat: Realising Solar MW Capacity**

Gujarat has converted its challenges into opportunities and is the first state in India and the fourth province in Asia to set up a separate Department of Climate Change. The State Government of Gujarat took a bold initiative and announced its Solar Power Policy in January 2009, allowing investors to set up MW-scale solar power projects within the State, assuring the purchase of power generated through the solar power plants at a levelised tariff of Rs. 12.58 kW. The price payable was pegged at Rs. 15 per kW for the first 12 years and Rs. 5 for the next 13 years.

The Policy received an overwhelming response from across the globe, resulting in the allotment of capacity close to 1 GW to over 85 national and international developers. And in this continued effort to combat environmental degradation and promoting clean energy, the State has received investments worth Rs. 61289 crore through the 66 MoUs signed at the Vibrant Gujarat Global Investors Summit (VGGIS) for setting up 7761 MW power generation projects in the renewable energy sector.

By December 2011, power purchase agreements (PPAs) for projects aggregating a capacity of 971.5 MW were signed. Of the allotted capacity, as of March 2012, solar power capacity of 600 MW has been commissioned and another 370 MW is likely to be commissioned within the next few months. The State has emerged as the largest solar power producer with its share of 600 MW which is two-thirds of the country’s total generation at 800 MW, as of March 2012.

The Gujarat Solar Park, set up with an investment of Rs 9,000 crore by private companies is spread across a desolate 3,000-acre (1,200-hectare) swath of desert, and can supply 214 megawatts of electricity daily from a single location, making it larger than China’s 200-megawatt Golmud Solar Park. Its foundation stone was laid down in December 2009 and the State government plans to set up solar power manufacturing, assembling, research and development.
facilities in addition to a manpower training institute envisaged to train local people and create job opportunities.

Shri Narendra Modi, Chief Minister, Gujarat inaugurated the Asia's largest solar power park, at village Charanka in Patan district in April 2012. Patan which is home to the Patola textile craft now also houses the solar park. In 10 other districts, where similar but smaller projects were conceived, another 390 MW is being produced using the virtually inexhaustible source of renewable energy.

The 1 GW solar power plants will annually generate 1554 million units of green power, reduce 1.55 million tonnes of carbon dioxide emissions and help avoid the use of 1.09 million tonnes of coal that would have gone into generation of electricity through coal. These power plants would bring in an annual employment generation of 5000 jobs besides other ancillary activities. The average electricity generation is in the range of 5000 - 5500 kW per MW per day, which is close to the estimated generation.

Wind Power: The Big Player
Gujarat with the longest coastline in the country and inland windy sites has a potential of over 10,000 MW of wind power. Over a period of more than 25 years, more than 65 sites have been monitored for wind speed and wind power density, and over 50 sites have been found feasible for harnessing of wind power. In fact, Gujarat was the first to set up the largest demonstration windfarm of 10 MW at Lamba, in Jamnagar in 1990. Demonstration windfarm projects of 16.295 MW were established with financial assistance from the Centre and the state. The experience gained by the early demonstration windfarm led to the formulation of the first of its kind Wind Power Policy in the country, by Gujarat in January 1993 followed by revised policies in 2002, 2007 and 2009. Since then the capacity additions as of March 2012 is 2884.850 MW of wind capacity. These windfarms have generated 13,450 million units of clean energy, as a result, of which the use of 9.4 million tonnes of coal was avoided and carbon dioxide levels were reduced by 13 million tonnes. On the wind technology front, refinements of existing designs have focused on drive-train improvements to reduce costs and increase reliability, on the one hand and enhance the size of wind turbines on the other. Gearless turbines have been introduced by several manufacturers - though at present it is only 10 per cent of total turbines production, it is growing substantially. Other areas of research have included higher grid penetration and expansion, storage and wind forecasting.

Renewable Energy Certificates: Ensuring Trading
The National Renewable Energy objectives require a projected channelising of 115 billion units of renewable power into the grid by 2014-15. Renewable Energy Certificates (RECs) will be a key driver in achieving these objectives. RECs are market-based instruments that provide renewable energy generators, an alternative to the prevailing feed-in-tariff regime. They are also a means for distribution utilities to meet their renewable purchase obligations (RPOs). At a macro level, the launch of the RECs is important for achieving the targeted renewable energy share of 10 per cent by 2015. Gujarat already has over 300 MW of renewable energy grid-connected projects under the REC mode, wherein the power produced is sold to the distribution licensee at the average pool purchase cost of Rs. 2.64 per kW, while the environment attributes are traded in the power exchanges set up for this purpose.

Biomass Power Generation: The Energy Next
Besides solar and wind energy, the State is also committed to harness the biomass energy potential of over 1200 MW. Currently, 31.2 MW of biomass-based power plants based
First State in the country to announce Solar Power Policy with targets and implementation mechanism. The State today leads in the implementation solar power projects.

Sustainable Initiatives: Highlights

- Gujarat aiming to be the solar capital of the world.
- First State in the country to announce a Solar Power Policy with targets and implementation mechanism. The State today leads in the implementation of solar power projects.
- 85 investors signed PPA for setting up 971.50 MW solar power projects.
- Asia’s first 500 MW Solar Power Park at Charanka, District Patan.
- Asia’s first State to set up a separate Department of Climate Change.
- Gandhinagar declared as the Model Solar City by Ministry of New and Renewable Energy (MNRE).
- 604.89 MW of grid-connected solar power projects commissioned.
- A one MW grid-connected solar power plant at village Chandrasan, District Mehsana on the Narmada Canal is an engineering innovation as it serves the triple purpose of generation of clean energy, annually reducing 90,000 litres water evaporation from the canal as well as avoiding use of precious land for the solar power plant.
- 2884.85 MW Wind Power Projects commissioned on the coast of Saurashtra and Kachchh.
- 5 MW Solar PV Roof Top Scheme announced in the cities of Rajkot, Surat, Bhavnagar, Mehsana and Vadodara.
- 31.2 MW capacity biomass projects commissioned in Amreli, Junagadh, Bhavnagar and Vadodara.
- 13.229 MW waste-to-energy power generation projects.
- Institutional biogas plants of 8380 cubic metre per day capacity in various institutions across the State.
- LED Village, Amarpura, Gandhinagar.
- First state to implement energy efficiency in agricultural pumping sector.
- 60 MW load reduction through 11,000 energy efficient pumping sets.
- Bal Urja Rakshak Dal: Since 2004, the GEDA has been annually mobilising a force of 50,000 secondary school students as Urja Rakshaks and 3600 school teachers as Urja Agevan, to make wise energy choices through energy conservation.

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BIOGAS from Kitchen and Food Waste

An experimental biodegradable waste fed biogas plant at a hostel in Tamil Nadu becomes an effective tool to serve the power supply needs of the institution.

P Venkatachalam & S Kulanthaisami, P Subramanian

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eeing the burgeoning fuel requirement for running an institution of its size, the Tamil Nadu Agricultural University (TNAU), decided to look within to find resources to generate fuel for its own energy needs. It was noticed that the institution's hostel's kitchen and dining halls were generating a great deal of food, vegetable and other biodegradable wastes. The usual practice of disposal was to throw it or use it as animal feed. However, this was not economical and was certainly not helping to solve the problem of waste disposal. Thus as an answer to this, a 10 cubic metre kitchen and dining hall waste based biogas plant was installed at the students’
Case Study

hostel (Fig 1). The plant was conveniently located near the waste discharge point of the students’ mess and the daily vegetable and dining waste generated, an average of 20-30 kg and 60-70 kg, respectively, was directed into the plant for processing.

The plant was constructed in brick with a 3.5 m long reinforced cement concrete (RCC) slab in the centre, placed to hold the drum. The whole plant was plastered with a cement-mortar mixture in a ratio of 1:2. The gas holder of 2.2 m diameter and 1.2 m height was fabricated with a 3.16 mm thick mild steel (MS) sheet and a gas outlet pipe was connected with the gate valve. A stirrer arrangement was made within the inlet tank for proper cutting, stirring and mixing of the waste (Fig 2). An inlet pipe made of polyvinyl chloride with a diameter of 30 cm and length of 2.05 m, fixed at an angle of 75° to the horizontal for easy flow of the mixed waste feed, was used.

The plant was loaded after curing it with a mix of 6 tonnes each of cow dung and water to maintain the initial total solid content of 10 per cent. It was allowed to stabilise for 40 days and during this period, it was regularly fed with cow dung and water mixed in a ratio of 1:1. After stabilisation, in the first week, the cow dung usage was reduced to 90 per cent and the kitchen and dining waste was added as the remaining 10 per cent. Subsequently, 10 per cent cow dung was reduced and 10 per cent of waste was increased every week. And by the tenth week, the plant was running 100 per cent on kitchen and dining waste (Table 1).

The average monthly biogas gas production has been observed in the range of 5.61 to 5.84 cubic metre per day and the gas production rate is observed to be constant. The biogas produced is utilised in the hostel kitchen for about 6 to 6½ hours per day for cooking. The rated input capacity of the plant is 70 kg/day and depending upon the availability of the feed, it varies from 50 to 80 kg/day.

The net savings on fuel are estimated to be 3 to 4 LPG gas cylinders per month which means that Rs. 3000 per month towards LPG cost is saved due to the installation of the biogas plant. Annual savings are estimated at around Rs. 36,000. The simple payback period has been worked out to be 3 years. It is by far the best technology for the treatment of kitchen and dining waste because it not only generates energy from waste but also solves the problem of waste disposal.

Table 1. Feed combination of kitchen and dining waste and cow dung.

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<tr>
<th>Kitchen and food waste (%)</th>
<th>Quantity of kitchen and food waste (kg)</th>
<th>Quantity of cow dung (kg)</th>
<th>Water addition (l)</th>
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</table>

The authors are Prof./Head, Associate Prof. (Physics), and Associate Prof., Department of Bioenergy, Agricultural Engineering College, Tamil Nadu. Email: bioenergy@tnau.ac.in
Creating Wealth from Organic Waste

Pune Municipal Corporation has taken a remarkable step in developing a municipal solid waste biomethanation plant that serves not only in generating power but also helps in the organising and disposal of waste in the city.

In today’s energy deficit world, where conventional sources of energy are fast depleting and at a time when recycling and optimum utilisation of resources is the need of the hour, the city of Pune is setting an example through its biomethanation plant. It is a known fact that municipal solid waste (MSW) generation in Pune, is among the highest in Indian cities with an average of 0.400 kg (0.294 - 0.540 kg) of waste being generated per person per day. Pune’s current population is 40 lakh and the city generates about 1300 metric tonnes of MSW per day. The source wise broad composition of solid waste generated in the city is as follows - commercial - 25 per cent; market area - 5 per cent; hotels and restaurants - 25 per cent; and vegetable market - 5 per cent; household - 40 per cent. What’s interesting is that the organic and biodegradable portion of the solid waste is 70 per cent which is a significant consideration in the concept of solid waste management. The basic idea behind setting up a biomethanation plant was to treat the organic waste in a decentralised manner, at its source, in the most environmentally efficient way. Currently, the overall MSW collection and transportation efficiency is 80-90 per cent of which 45 per cent is segregated. The Pune Municipal Corporation or the PMC has allotted separate vehicles for the collection of the segregated wet waste which is 300-350 tonnes per day (Table 1). This helps the PMC save on transportation costs of such wastes to the landfill site which is 22 km away from the model colony area.

| i | Plant capacity | 1X5 TPD per day segregated organic biodegradable municipal solid waste |
| ii | Type of process | Biomethanation through two stage process |
| iii | Biogas generation | 300 Cum/day |
| iv | Electricity generation | 375 kW/day |
| v | Manure generation | 500 kg/day (on 50 per cent moisture basis) |

Table 1. Expected biogas, electricity and manure generation
Success Story

MEDA's Initiative
The Maharashtra Energy Development Agency (MEDA) is constantly striving to promote decentralised biogas generation in Maharashtra in urban as well as rural areas. As a part of its initiative, an official visit of Dr. A. R. Shukla, Advisor, Ministry of New and Renewable Energy (MNRE), along with MEDA officials, to the Model colony plant, was arranged on 20 February 2010. Post this visit, it was decided that all such decentralised biogas plants in urban areas ought to be considered for Central Finance Assistance (CFA) under the Biogas-based Power Generation Programme (BPGP) of the MNRE, to boost the promotion of such projects. The PMC has installed 11 such biogas to power generation plants at various locations in Pune and is planning to set up many more such projects in the city.

Biomethanation Process
A major portion (40-60 per cent) of this waste is organic in nature and can be easily treated by anaerobic digestion. The solid wastes generated in urban areas from vegetable markets, hotels, hostels, kitchen wastes etc. are best suited for this process due to the high moisture content and organic fractions (up to 90 per cent). The total solids in the organic waste decompose rapidly (i.e. are highly putrescible) and therefore these wastes can be treated by the biomethanation process, more commonly called anaerobic digestion.

The biomethanation plant at Model Colony is based on the two-stage anaerobic process. The sizes of the digesters for the first stage and the second stage are decided on the basis of the suspended organic contents of the slurry to be treated. The first stage fermentation is the hydrolysis stage and the second is the methanation and polishing stage. The first stage is designed to give maximum solid retention time for the hydrolysis and the second stage for acidification and biomethanation process operate in the mesophillic range.

In this process, the wet waste generated within the model colony area (from household kitchens, commercial complexes, hotels/restaurants, fruit and vegetable markets wet wastes etc.) is collected and brought to the plant site by the PMC. Though, it is segregated wet waste, it still contains 2-5 per cent non-biodegradable material, such as plastics, glass, metal etc. All such material is removed manually in the first stage, known as ‘fine segregation’. Thereafter, the segregated wet waste is mixed with water in 1:1 proportion and crushed in the shredder to convert it into slurry, before being fed to the primary digester. The slurry is then treated in closed vessels called anaerobic digesters (primary and secondary digesters) where, in the absence of oxygen, microorganisms break down the organic matter into a stable residue, and generate a methane-rich biogas in the process. The generated biogas is cleaned with the help of scrubbers. In the scrubbing process, moisture, hydrogen sulphide and to a certain extent carbon dioxide are brought to an acceptable level and then the purified biogas is stored in a biogas balloon, made up of neoprene rubber. The purified biogas is then supplied to a 40 kVA indigenised biogas engine (run on 100 per cent biogas) to generate electricity. The solid residue which remains after biomethanation process comprising of solid/fibrous material and liquid, is separated in the slurry drying beds. About 50 per cent of the liquid manure is then re-circulated in to the system, as it contains nitrogen and some active anaerobic microorganisms. The fibre contains an organic material, which is being used as manure for the PMC’s public gardens.

Project Components
The project includes the following sections:
- Waste reception and fine segregation section
- Mechanical crushers - 2 nos of 5 HP (horse power)
- Two stage anaerobic reactors - 200 cubic metre. In building-block methodology (BBM) - with aeration, biogas and leachate recirculation facility
- Manure handling section - 35 sq m in BBM
- Biogas collection section - 2 nos of 75 cubic metre each in neoprene rubber with enclosure
- Biogas cleaning system - CO₂ and H₂S scrubbers, pressure vessel and vacuum pump.
- Power generation - 40 kVA, 100 per cent biogas based Indian engine.
- Recirculation system.
- Solar water heating system - 500 lt/day

Advantages
Apart from the fact that the biogas produced is effective in reducing harmful greenhouse gas emissions, the compact design of the plant makes it convenient for use and utilises less footprint area. The treatment of organic solid waste is

The solid wastes generated in urban areas from vegetable markets, hotels, hostels, kitchen wastes etc. are best suited for this process due to their high moisture content and organic fractions (up to 90 per cent).
Table 2. Plant economics (Till 28th February 2012)

1 Total Inputs

1.1 Total wet waste fed to the plant from 1st November 2009 to 31st December 2011. 4000 Tonnes

2 Total Outputs

2.1 Electricity generated (with 22 kW load and 250 street lights). 68000 kWh - operate biogas engine during day as well to generate electricity, which is being used for carrying out feeding operations.

2.2 Total manure generated 340 tonnes

3 Total Savings

3.1 Savings due to electricity generation 68000 kWh X 5.00 Rs./kWh = Rs. 3.4 lakhs

3.2 Savings due to manure generation 340 tonnes X Rs.1000 Rs./tonnes = Rs. 3.4 lakhs

3.3 Savings in transportation of wet waste to the landfill site 4000 tonnes X Rs. 650 Rs./tonnes = Rs. 26 lakhs PMC is currently spending Rs.1300 per tonnes to collect, transport and to dump the waste at Devachi Urli Landfill site. Even if, it is considered that due to this plant they are going to save at least 50 per cent of the transportation cost. The annual savings (for 330 days) works out to Rs. 10.72 lakhs per annum respectively.

3.4 Total Savings Rs. 32.8 lakhs

4 O&M cost for 28 Months Rs. 12.2 lakhs

5 Net savings for 28 months Rs. 20.6 lakhs

6 Net annual savings Rs. 8.82 lakhs

7 Payback period with the current performance / economics. 6½ years from the date of commissioning of the Plant.

Table 3. Month wise details of wet waste fed to the biomethanation plant

<table>
<thead>
<tr>
<th>Month</th>
<th>Feeding Qty.</th>
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<td>4176</td>
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Total 4176 101.46

TPM - tonnes per month

Indirect Benefits

Indirectly too, the benefits for the PMC are many. Apart from providing better hygienic conditions to the citizens of Pune, the plant will go a long way in increasing the operational life of existing sanitary landfill. It will help avoid the release of methane gas (from uncontrolled open dumping at landfill sites) into the atmosphere, which can cause serious environmental damages. In other words it stalls the release of 180 cubic metre of methane (which is 22 times more potent than CO₂) per day into the atmosphere. Further it reduces the release of CO₂ since there is a reduction in the use of transportation fuel. The energy/income positive treatment process ensures self sustainability and the project can avail Clean Development Mechanism (CDM) benefits.

Present Status

The biomethanation plant has been operational since November 2009. The connected electricity load is 22 kW and 250 street lights (mix of 70 / 100 / 250 W lights) in the Model Colony area are lit for 10-11 hours daily. As of 28 February 2011, the biogas engine had completed 7200 hrs. (Table 2.) of operation and generated 68000 kW of electricity. Further, the month wise details of total wet waste fed to the plant by the end of February 2012 are shown in Table 3.

Courtesy: Prafulla Tayde, Maharashtra Energy Development Agency (MEDA). Email: prafullatayde@gmail.com
Solar Electricity at GERMI

Gujarat Energy Research Management Institute (GERMI) has paved a way towards using solar power sustainability by commissioning a 5 MW solar PV project for Gujarat Industries Power Company Limited (GIPCL). 

Gandhinagar, has successfully commissioned a 5 MW solar PV project for Gujarat Industries Power Company Limited (GIPCL), Vadodara, on 26 January 2012. The GIPCL is a Gujarat based electricity generating company whereas the GERMI is a Department of Science and Industrial Research (DSIR) approved research institute engaged in the field of advance level research in petroleum, solar and nuclear energy, climate change and also offers training and consultancy services to the industry. This ambitious project of the GIPCL materialised with strong technical and project management support provided by the GERMI.
The GIPCL solar plant was located atop the external dump at village Nani Naroli, district Surat. The location was at a height of 98 m above mean sea level (MSL) and about 45 m from the surrounding area. Further the dump was essentially a collection of loose soil of mining excavation work and therefore offered very poor load bearing capacity (safe bearing capacity (SBC)<<10). This posed a real challenge to GERMI in designing and executing civil foundations. The module mounting structure had to be customised to adopt a seasonal tracking mechanism so as to enhance the plant's generation. Moreover, unlike the other projects which generally are executed by an Engineering Procurement and Construction (EPC) contractor, the GIPCL project was executed through the 'package route'. The concept of a package route essentially involves helping the project developer gain first-hand experience of constructing a solar project by directly dealing with vendors or original equipment manufacturers (OEM) to supply all key equipment to the end user, namely the project developer. The plant will be assembled by either the project developer or by a contractor appointed by the project developer. It is anticipated that the package route can reduce the margins in between the vendors and the EPC and can significantly reduce total project cost.

Following the GIPCL's requirements, the GERMI designed individual packages, prepared and executed bids for selection of vendors and developed the civil foundation. Further, in order to enhance the energy generating capacity of the said plant, the GERMI designed seasonal tracking structures which would help generate at least 5 to 7 per cent more electricity when averaged out over the entire year. Accordingly, six contractors were awarded the work order to supply key materials and carry out important site activities like civil and building works, erection and commissioning of switchyard and the plant integrator for assembling and finally commissioning the plant.

Thus the entire project was successfully executed through the package route. The plant is now operative since 26 January 2012. It is expected that because of seasonal tracking, this plant will run at a minimum performance of 78 per cent during all weather conditions even after excluding additional generation gain. Thus the plant will export approximately 8496 MW of electricity, offsetting 7646 tonnes of carbon dioxide every year.

It is pertinent to note that despite the exorbitant cost of civil and structural work, there was a reduction of 10 per cent in the final project cost due to the package route. The GIPCL appreciated the GERMI's success in getting the project commissioned well within the tariff regulation period which was due to end on 28 January 2012. The GIPCL has always had a very strong technical team for executing and operating conventional power plants and now in partnership with the GERMI, it is handling solar power projects as well. The GERMI is now looking forward to promote the concept of package route on various projects, to bring down the overall cost of power generation.

Ministry of New and Renewable Energy
"PRAKRITIK URJA PURASKAR YOJNA"

Ministry of New and Renewable Energy, Government of India, is operating 'Prakritik Urja Puraskar Yojna' to encourage original book-writing in Hindi or translation of books in Hindi in the field of New and Renewable Sources of Energy. Under the scheme, there is a provision for prize money. All authors, whether Government employees or Non-Governmental persons, can participate in the scheme.

For further details, please contact Dy. Director (OL), Ministry of New and Renewable Energy,
Block No. 14, C.G.O. Complex, Lodi Road, New Delhi-110003
(Phone No. 24362356) or visit this Ministry's website www.mnre.gov.in
The Ashden India Sustainable Energy Collective (AISEC), a group of 16 India-based winners of the International Ashden Awards for Sustainable Energy believes that practitioner groups such as the AISEC have a critical role to play in bridging the gap between practice and policy. The AISEC members represent a rich body of experience in several areas offering bundled RE solutions for communities. As a part of its endeavour to continue and strengthen its engagement with sustainable energy policies, the AISEC organised three policy round tables between October and December 2011.

The discussions at the round tables highlighted the slow growth of off-grid renewable energy vis-à-vis conventional energy and grid-connected renewable energy, as well as its own inherent potential. The main purpose of the discussions was to identify gaps in off-grid renewable energy (RE) regulation in India, and make practical and implementable recommendations on how to overcome these gaps.

The major barriers for rapid development of off-grid RE in India were identified as: off-grid RE not mainstreamed in Indian energy policy and a public perception that grid electricity is the only acceptable form of electricity; lack of a cogent regulatory framework to mainstream off-grid RE; large subsidies disbursed with little regard to whether they are reaching the target population, incentivising RE or improving energy access; standards for RE devices that are either non-existent or are not suited to spur innovation; no efficient mechanism to make finance available at various levels, for both the end user and entrepreneur; and, energy access not recognised as an essential right and not sufficiently integrated with larger developmental goals.

There is a need to develop standards for off-grid RE products, suppliers and service providers, in consultation with experts from academia, industry associations and field practitioners, to include-standards to reflect consumer-relevant parameters like quality and output e.g., for solar lanterns standards to be based on lumens over the life of the device rather than watt; development of star rating system for RE consumer products like solar lights, solar water heaters and, cook stoves, biogas plants similar to Bureau of Energy Efficiency (BEE) star rating for electrical consumer durables; development of accreditation process for suppliers; rating and monitoring system for service providers to ensure standards in long term servicing of the systems; approved laboratories and institutions to provide third party standard certification for products and services; and, consumer education on the system of standards. Further, technology specificities must be factored in while reviewing and designing incentives – e.g. biomass-based systems may need to have subsidised fuel or a feedstock price escalation clause and small hydro systems will require a significant component for storage. Also region specific incentives for renewables need to factor in local resource endowment. For instance, states with lower solar radiation may be provided a higher level of subsidy to facilitate the diffusion of solar technologies across the country.

An alternative view is to prioritise renewable energy technologies (RETs) for various locations based on resource endowment and then provide incentives in line with these regional RE priorities. Certain end-uses or services may be prioritised based on their importance for the community as well as expected benefits to the community and/or to the environment.

Courtesy: Rekha Krishnan, Independent Researcher, AISEC. Email: rekhak.work@gmail.com
To produce the maximum amount of energy, solar cells are designed to absorb as much light from the Sun as possible. Now researchers from the University of California, Berkeley, have suggested—and demonstrated—a counterintuitive concept: solar cells should be designed to be more like LEDs, able to emit light as well as absorb it.

The Berkeley team presented its findings at the Conference on Lasers and Electro Optics (CLEO: 2012), which was held on May 6-11, 2012 in San Jose, California. "What we demonstrated is that the better a solar cell is at emitting photons, the higher its voltage and the greater the efficiency it can produce," said, Eli Yablonovitch, principal researcher and professor of electrical engineering, University of California, Berkeley.

Since 1961, scientists have known that under ideal conditions, there is a limit to the amount of electrical energy that can be harvested from sunlight hitting a typical solar cell. This absolute limit is, theoretically, about 33.5 per cent. This means that at most, only 33.5 per cent of the energy from incoming photons will be absorbed and converted into useful electrical energy. Yet for five decades, researchers were unable to even come close to achieving this efficiency. In fact as of 2010, the highest anyone had come was just a little over 26 per cent.

Owen Miller, a graduate student at UC Berkeley and a member of Yablonovitch’s group came across a relatively simple solution based on a mathematical connection between absorption and emission of light.

"Fundamentally, it is because there's a thermodynamic link between absorption and emission," Miller says. Designing solar cells to emit light—so that photons do not become 'lost' within a cell—has the natural effect of increasing the voltage produced by the solar cell. "If you have a solar cell that is a good emitter of light, it also makes it produce a higher voltage, which in turn increases the amount of electrical energy that can be harvested from the cell for each unit of sunlight. The theory that luminescent emission and voltage go hand in hand is not new. But the idea had never been considered for the design of solar cells before now," points Miller.

This past year, a Bay area-based company called Alta Devices, co-founded by Yablonovitch, used the new concept to create a prototype solar cell made of gallium arsenide (GaAs), a material often used to make solar cells in satellites. The prototype broke the record, jumping from 26 per cent to 28.3 per cent efficiency. The company achieved this milestone, in part, by designing the cell to allow light to escape as easily as possible from the cell—using techniques that include, for example, increasing the reflectivity of the rear mirror, which sends incoming photons back out through the front of the device.

Solar cells produce electricity when photons from the Sun hit the semiconductor material within a cell. The energy from the photons knocks electrons loose from this material, allowing the electrons to flow freely. But the process of knocking electrons free can also generate new photons, in a process called luminescence. The idea behind the novel solar cell design is that these new photons, which do not come directly from the Sun, should be allowed to escape from the cell as easily as possible.

However, mathematically, allowing the new photons to escape increases the voltage that the cell is able to produce. The work is 'a good, useful way' of determining how scientists can improve the performance of solar cells, as well as of finding creative, new ways to test and study solar cells, says Leo Schowalter of Crystal IS, Inc. and visiting professor at Rensselaer Polytechnic Institute, who is chairman of the CLEO committee on LEDs, photovoltaics, and energy-efficient photonics.

Yablonovitch says he hopes researchers will be able to use this technique to achieve efficiencies close to 30 per cent in the coming years. And since the work applies to all types of solar cells, the findings have implications throughout the field.

Courtesy: www.sciencedaily.com
Air-Powered Car now in India

In 2007, Mumbai, India-based Tata Motors signed a licensing deal with Motor Development International, a French design firm. The idea was to build a car that could run on compressed air. Now Tata says it has tested two cars with the engines. The next step is setting up the manufacturing plants to actually build them.

Compressed air engines aren’t a new idea. The first models were proposed more than a century ago, and they were used in the mining industry for decades before electric motors became commonplace. Even now, compressed air powers all kinds of tools, notably the pneumatic impact wrenches in auto body shops.

A compressed air engine works in a way similar to the internal combustion version: Fuel forces pistons to turn a crankshaft and power the car. The difference is that in a compressed air engine, the pistons are moved by air and not gasoline. Researchers in Sweden have experimented with single-cylinder engines of this type.

One of the problems is power. Air compression alone gets a car moving to only about 30 to 35 miles per hour. So to supplement that, the car could take in more air as it moves faster, using an onboard air compressor. The air compressor could be electric or, more likely, gasoline-powered. But even that would reduce emissions a lot, since the gasoline engine wouldn’t be running at lower speeds.

Range is also an issue. Like all vehicles, an air-powered car can drive only as far as the amount of fuel in its tank. And storing compressed air requires ‘fuel’ tanks that are stronger than steel to contain the thousands of pounds per square inch necessary. On the bright side, compressing air in such a tank is a lot less dangerous than natural gas or hydrogen.

Then there is the issue of filling the car’s tank – most air compressors would take at least a couple of hours to do that. Tata seems to be the only manufacturer that has committed to actually building an air-powered car. Honda unveiled an air-powered concept car in 2010, and a company called Zero Pollution Motors had promised to deliver one to the United States – but that was two years ago. If Tata is successful, it will go a long way in reducing emissions in India – and perhaps freeing cars from fossil fuels completely.

www.news.discovery.com
GREEN PRODUCTS

Building Green announced its tenth annual Top-10 Green Building Products during the 2011 Greenbuild conference in Toronto. The award highlights the most forward-looking products reviewed in Environmental Building News and featured in GreenSpec throughout the year.

Interface FLOR Carpet Tiles with Non-PFC Carpet Fibres

Interface FLOR carpet tiles with non-PFC carpet fibres contain no perfluorinated compounds (PFCs), which are ubiquitous in other carpet products. PFCs do not readily break down in the environment, and their long-term health and environmental effects are under investigation by the U.S. Environmental Protection Agency and other agencies worldwide as potentially hazardous compounds. The carpet tiles can be specified with high post-consumer recycled content and multiple low-emitting adhesive options.

Lifeline PVC-Free Resilient Flooring

Lifeline PVC-free resilient flooring from Upofloor OY (imported by Altro Floors) is made for heavy-traffic commercial spaces yet contains no PVC, plasticisers, phthalates, halogens, or heavy metals. Unlike most commercial resilient flooring, Upofloor has a durable wear layer that minimises the need for maintenance, making it an excellent choice for hospitals, schools, and other buildings where indoor environmental quality is a high priority.

CI-Girt Rainscreen System

The CI-Girt Rainscreen System from Knight Wall Systems helps keep moisture out of commercial building envelopes while permitting continuous insulation over the steel frame—typically an expensive and labour-intensive hand-cutting process when using other rainscreen systems. Since there are no clips, installation time is reduced and there is far less thermal bridging through the insulation.

EonCoat Waterborne Ceramic Coating

EonCoat waterborne ceramic coating from EonCoat is a truly revolutionary commercial and industrial coating. The water-borne coating has two parts—phosphoric acid and magnesium hydroxide (’milk of magnesia’)—that are mixed in the spray valve during installation and set almost immediately. Available in many colours, EonCoat contains no VOCs and no hazardous air pollutants and has zero flame spread—without the use of a flame retardant.

Aqua2use Graywater System

Aqua2use Graywater System from Water Wise Group collects water from the shower, laundry, lavatory sinks, and bath and channels it through a four-stage filtration system into a 21-gallon polyethylene tank to create water suitable for outdoor irrigation. The system’s control box automatically triggers the pump when the tank is filled, to distribute the water to
irrigation lines; it can also be configured in some situations to rely exclusively on gravity flow instead of a pump.

**Cypress Envirosystems’ Analog-to-Digital Wireless Thermostat**

Cypress Envirosystems’ analog-to-digital wireless thermostat allows controls in existing buildings to be fully digitised to achieve significant energy savings. They effectively bring older buildings at par with those in the 21st century, allowing zone-level control and remote management options along with lighting controls and wireless monitoring systems for mechanical equipment. The controls fully integrate with building automation systems and can be installed as a retrofit in less than 30 minutes.

**Ritter XL Solar Thermal System**

The Ritter XL solar thermal system from Regasol USA combines three unique technologies—advanced evacuated tubes, compound parabolic reflectors, and water as a heat-transfer fluid—to create large-scale solar thermal systems for use in commercial, multifamily, or industrial applications that have high hot-water demand. The complex systems use a sophisticated freeze-prevention mechanism and can provide high-temperature water year-round, even in cold climates.

**Mitsubishi Ductless Heat Pumps and Variable-Refrigerant-Flow Systems with Tenant Submetering**

Mitsubishi ductless heat pumps and variable-refrigerant-flow systems with tenant submetering supply efficient heating and cooling for residential and commercial applications with a unique tenant submetering feature. Mitsubishi Electric has been a market leader of the air-source heat pump revolution in recent years—providing efficient systems that significantly outperform older, unitary heat pumps, even at low outdoor temperatures.

**AllSun Trackers**

AllSun Trackers from AllEarth Renewables combine photovoltaic collectors, inverters, and controls with a ground-mounted tracker that uses GPS to follow the sun precisely as it moves across the sky in order to maximise the amount of light hitting the panels. Upon ‘waking’ in the morning, they tilt to the north to dump accumulated snow, and in high wind they move to a ‘stow’ position parallel with the ground to minimise wind resistance.

**Philips EnduraLEDs**

Philips EnduraLEDs from Philips Lighting were engineered as a replacement for the 60W incandescent light bulb and is the first such LED bulb to be Energy Star-qualified. The bulb has a unique yellow appearance when turned off but provides a warm, white light when turned on; its colour temperature is comparable to that of a 60W incandescent bulb. This bulb is currently available in a 12.5W version with a colour rendering index (CRI) of 80, but Philips plans to introduce a 10W version with a CRI of 90 in 2012.

**Light Weight Clay Roofing**

Lightweight Clay Roofing tiles are kiln-fired for unsurpassed aesthetics that will not fade. They are 10 per cent recyclable, have cool roof rated colours, can be locally sourced and their 50 per cent recycled content helps maximise LEED credits without compromising aesthetics, performance or cost.
### FM Rainbow Stations

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### FM (Gold) Stations

<table>
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<tr>
<th>Sr. No.</th>
<th>Stations</th>
<th>Language</th>
<th>Monday Time (hrs.)</th>
<th>Wednesday Time (hrs.)</th>
<th>Friday Time (hrs.)</th>
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<tr>
<td>12.</td>
<td>Lucknow</td>
<td>Hindi</td>
<td>07.02</td>
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<td>Panaji</td>
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<td>15.</td>
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<td>Telegu</td>
<td>10.15</td>
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<tr>
<td>18.</td>
<td>Vishakhapatnam</td>
<td>Telegu</td>
<td>09.30</td>
<td>09.30</td>
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</tr>
</tbody>
</table>

Time into Akshay Urja aur Hum, from July 11th.

Full of information, technical knowhow, prizes and fun - the Ministry of New and Renewable Energy, all set to usher in a clean revolution.
Electrical charges can be negative (−) or positive (+). Opposite charges attract each other while similar charges repel each other. As electrical charges build up on a material, it creates static electricity.

**Background:**
When coal is burned in a power plant, small particles of pollution called soot are produced. Static electricity can be used to capture soot before it leaves the power plant.

**Question**
Can a mixture of salt, sugar and pepper be separated using static electricity?

Possible Hypotheses:
A mixture of salt, sugar and pepper can/cannot be separated.

**Materials**
Sugar, salt, and pepper, small plate, plastic comb, piece of wool

**Procedure**
1. Stroke the comb with wool to give it an electric charge.
2. Put small amounts of sugar, salt, and pepper on a plate. Do not mix them together.
   Beginning a few inches above the plate, move the comb closer to the particles. Observe to see if one type of particle reacts before the others.
3. Record your observations.
4. Repeat the experiment with the salt, sugar, and pepper mixed together.

**What do you see?**
Are the particles attracted to the comb at different heights above the plate? Can you separate a mixture of salt, sugar, and pepper using static electricity? Do you think static electricity could be used to clean the air at a coal-burning power plant?

Send your answers to the Editor and see your name specially flashed on this page.
Algae Biodiesel Website
www.making-biodiesel-books.com
Algae biodiesel fuels are now becoming popular as an alternative fuel to power vehicles. The interest has largely been due to the rising fuel costs of gas and diesel combined with the search for a sustainable source of energy. The new Algae Biodiesel website hopes to help people find the information they are looking for. The main issue facing those interested in producing their own algae biofuels is the lack of information. The website will be able to educate people about algae production for biodiesel.

Geothermal Professionals
www.geothermalprofessionals.com
Geothermal Professionals is an Ohio based, fully integrated and licensed geothermal systems installer, designed to handle all geothermal needs. The website promises to be a one-stop shop for all geothermal energy needs.

Science Omega
www.scienceomega.com
Science Omega showcases news, features and opinions from the fields of science, technology, engineering and mathematics (STEM). The website includes regular news updates to keep one abreast of the latest developments, with insightful feature articles from the best and brightest that the scientific community has to offer. Informed opinion pieces stimulate vigorous debate, and there is the weekly Science Omega Podcast in which the editorial team takes a light-hearted look at all things STEM-related.

Energy: Production, Conversion, Storage, Conservation, and Coupling
By: Yasar Demirel
Hard Cover: 746 pages
Cost: 132.65 Euro
Publisher: Springer London 2012
ISBN No-13: 9781447123712

This book provides a good understanding on the sustainable use of energy in various processes and is an integral part of engineering and scientific studies. It gives a thorough understanding of five main areas of energy and includes 130 examples and over 600 practice problems on topics like energy production and conversion in important physical, chemical, and biological processes, conservation of energy and its impact on sustainability, various forms of energy storage, and energy coupling and bioenergetics in living systems. A solution manual for the practice problems of the textbook is also offered for the instructor.

Renewable Energy: Technology, Economics and Environment
By: Martin Kaltschmitt, Wolfgang Streicher, Andreas Wiese
Hard Cover: 596 Pages
Cost: USD 87
Publisher: Springer, 2010
ISBN: 3642089941, 9783642089947

Design of Smart Power Grid Renewable Energy Systems
By: Ali Keyhani
Hard Cover: 400 pages
Cost: USD 108.75
Publisher: Wiley-IEEE Press, 2011
ISBN: 978-0470627617

Renewable Energy: A Common Sense Energy Plan
By: Brad Linscott
Hard Cover: 252 Pages
Cost: USD 123.00
Publisher: Tate Publishing 2011
ISBN: 978-1-61777-608-3

Renewable Energy: Green Power for a Modern World
By: Holly Simon
Hard Cover: 268 Pages
Cost: USD 21.09
Publisher: Webster’s Digital Services, 2011
ISBN: 978-1241156763
**Forthcoming Events**

### National

**7-10 August 2012**
Bio Diversity Asia 2012, **Place:** JN Tata Auditorium, IISc Campus, Bengaluru, **Organiser:** Biodiversity Asia 2012, **Contact:** 91-80-23635555 or SCBasiasecretariat@atree.org **Website:** www.scbasia2012.org

**21 August 2012**
Global Solar Water Heating Market Transformation and Strengthening Initiative: **Place:** Vigyan Bhavan, New Delhi, **Organiser:** UNDP/GEF, **Contact:** 011-46532333, info.in@undp.org **Website:** www.in.undp.org

**29-1 August-September 2012**
International Conference on Advances in Electrical Engineering and Renewable Technologies, **Place:** Puducherry, India, **Organiser:** Rajiv Gandhi College of Engineering and Technology, **Contact:** Mr.A.Srinivassan +91-9894357018 icaeert@rgcetpdy.ac.in **Website:** www.rgcetpdy.ac.in

**6-7 September 2012**
Wind Power Development forum India, **Place:** New Delhi, **Organiser:** Wind Power energy Update, **Contact:** +44 (0)20 7375 7516 or will@windenergyupdate.com **Website:** www.windenergyupdate.com

**14-15 September 2012**
International Conference on Biodiversity & Sustainable Energy Development, **Place:** Hyderabad International Convention Center, India, **Organiser:** OMICS Group, **Contact:** 650-268-9744 or biodiversity2012@omicsonline.org **Website:** www.omicsonline.org

### International

**21-23 August 2012**
The 4th China Guangzhou International Solar Photovoltaic Exhibition 2012, **Place:** China Import and Export Fair Pazhou Complex- Area A, **Organiser:** Solar Energy Industries Association (SEIA) and The Solar Electric Power Association (SEPA), United States, **Contact:** 541-575-3633 **Website:** www.pvguangzhou.com

**04-05 September 2012**
Chilean International Renewable Energy Congress, **Place:** Santiago, Chile, **Organiser:** Green Power Conferences, **Contact:** Natalia Valencia +44 (0)203 384 6214, natalia.valencia@greenpowerconferences.com **Website:** www.greenpowerconferences.com

**05-06 September 2012**
Awea Regional Wind Energy Summit – New England, **Place:** Portland, Maine, **Organiser:** American Wind Energy Association, **Contact:** 202.383.2500, windmail@awea.org 83.2500 **Website:** www.awea.org

**10-13 September 2012**
Solar Power International 2012, **Place:** Orlando, Florida, **Organiser:** Solar Energy Industries Association (SEIA) and The Solar Electric Power Association (SEPA), United States, **Contact:** Jennifer Samuels (908) 889-8300 x100 **Website:** www.solarpowerinternational.com
Renewables, Global Status Report

Selected Renewable Energy Indicators

<table>
<thead>
<tr>
<th></th>
<th>2008</th>
<th>2009</th>
<th>2010</th>
</tr>
</thead>
<tbody>
<tr>
<td>Global new investment in new renewable energy (annual; figures in billion USD)</td>
<td>130</td>
<td>160</td>
<td>211</td>
</tr>
<tr>
<td>Renewables power capacity (existing, not including hydro; figures in GW)</td>
<td>200</td>
<td>250</td>
<td>312</td>
</tr>
<tr>
<td>Renewables power capacity (existing, including hydro; figures in GW)</td>
<td>1150</td>
<td>1230</td>
<td>1320</td>
</tr>
<tr>
<td>Hydropower capacity (existing; figures in GW)</td>
<td>950</td>
<td>980</td>
<td>1010</td>
</tr>
<tr>
<td>Wind power capacity (existing; figures in GW)</td>
<td>121</td>
<td>159</td>
<td>198</td>
</tr>
<tr>
<td>Solar PV capacity (existing; figures in GW)</td>
<td>16</td>
<td>23</td>
<td>40</td>
</tr>
<tr>
<td>Solar PV cell production (annual; figures in GW)</td>
<td>6.9</td>
<td>11</td>
<td>24</td>
</tr>
<tr>
<td>Solar hot water capacity (existing; figures in GW)</td>
<td>130</td>
<td>160</td>
<td>185 GWth</td>
</tr>
<tr>
<td>Ethanol production (annual; figures in billion litres)</td>
<td>67</td>
<td>76</td>
<td>86</td>
</tr>
<tr>
<td>Biodiesel production (annual; figures in billion litres)</td>
<td>12</td>
<td>17</td>
<td>19</td>
</tr>
<tr>
<td>Countries with policy targets</td>
<td>79</td>
<td>89</td>
<td>96</td>
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<tr>
<td>States/provinces/countries with feed-in policies*</td>
<td>71</td>
<td>82</td>
<td>87</td>
</tr>
<tr>
<td>States/provinces/countries with RPS/quota policies</td>
<td>60</td>
<td>61</td>
<td>63</td>
</tr>
<tr>
<td>States/provinces/countries with bio-fuels mandates</td>
<td>55</td>
<td>57</td>
<td>60</td>
</tr>
</tbody>
</table>

- In the United States, renewable energy accounted for about 10.9 per cent of domestic primary energy production indicating an increase of 5.6 per cent when compared to 2009.
- China added an estimated 29 GW of grid-connected renewable capacity, for a total of 263 GW - an increase of 12 per cent in comparison to 2009.
- At least 20 countries in the Middle East, North Africa, and sub-Saharan Africa have active renewable energy markets.
- Several countries met higher shares of their electricity demand with wind power in 2010, including Denmark (22 per cent), Portugal (21 per cent), Spain (15.4 per cent), and Ireland (10.1 per cent).
- China attracted more than a third of global investment in renewable energy companies during 2010, making it the leader in the second year, consecutively.
- Germany met 11 per cent of its total final energy consumption with renewable sources, which accounted for 16.8 per cent of electricity consumption, 9.8 per cent of heat production (mostly from biomass), and 5.8 per cent of transport fuel consumption. Wind power accounted for nearly 36 per cent of renewable generation, followed by biomass, hydropower, and solar photovoltaics (PV).

Notes: * Feed-in policies total for 2010 also includes early 2011.

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Munich - Germany
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- Subsidy up to 30% of cost available from Government. Higher subsidy for special category including N-E states. Loans at 5% also available from selected banks
- Useful for homes, hotels, hospitals, guest houses, industries & other establishments requiring hot water

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- Please check quality and price before you buy. Wide range of products available. Guidelines on quality and selections for a system also available at website.

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MINISTRY OF NEW & RENEWABLE ENERGY
B-14, CGO Complex, Lodi Road, New Delhi-110003
Helpline No. 1800 233 4477

www.mnre.gov.in