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India's wind power growth in a decade

C R Bhattacharjee

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India's wind power growth in a decade

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Over the last ten years, WEG (wind energy generation) has achieved spectacular progress and bears a special significance for the reason that investments have mainly flown in from the private sectors. Wind power potential in India is envisaged as gross 45 000 MW (megawatt) and technical feasibility has been identified as 13 390 MW based on a survey. Maharashtra has the highest possibility of 3040 MW and the potential is lowest in West Bengal (only 450 MW). During the decade 1995–2004, the total cumulative WEG installation stands at 2483 MW, which is 18.5% of the estimated technically feasible capacity. Tamil Nadu leads all the states with 1362 MW (55%) followed by Maharashtra (407 MW), Karnataka (209.2 MW), Gujarat (202 MW), Rajasthan (178 MW), Andhra Pradesh (98.8 MW), Madhya Pradesh (22.6 MW), and Kerala (2 MW). West Bengal has an installation of 1.1 MW that is likely to increase by three times within a year. Recently in West Bengal, 0.5 MW wind power was incorporated uniquely as a hybrid combination, with a diesel power station in an island controlled automatically at varying wind speed to share load demand. Table 1 indicates the year-wise growth of WEG power.

From Table 1, it is apparent that over this period (1994–2004) there has been a six-fold rise in the installed capacity and a consequent increase in energy generation from 191.3 to 2811 MU (million units) or a growth by nearly 14 times. This is indicative of a gradually improving CUF (capacity utilization factor) from a low beginning of 6.2% in 1994/95 to reaching nearly 14% in 2003/04. Evidently, the growth in generation has gone up from 550 to 1130 MWh (megawatt hour)/ MW (or an improvement higher by 2.5 times). Thus the CUF, which ultimately decides the economics of setting up of a wind farm has gone up during this period, to 15% in 2002/03.

Wind flow varies year-to-year and day-to-day during the windy season. With wind velocity varying, it is difficult to predict generation accurately, but with more and more stations coming up and the inflow of data logged and regularly analysed, it is likely that the forecast on WEG (about probable performance) will be

Table 1 Year-wise growth of wind energy generation power

Year	*Capacity* (MW)	*Addition* (MW)	*Growth* (%)	*Generation MU (million unit)* (%)	*Growth*	*MWh/MW (in thousand)*	*CUF* (%)
1994/95	351	236	205	191.3	102	0.55	6.2
1995/96	733	382	109	496.4	159	0.68	7.2
1996/97	902	169	29	878.4	77	0.97	11.1
1997/98	968	66	7	988.5	12.5	1.03	11.55
1998/99	1024	56	6	1073.3	8.6	1.05	11.96
1999/2000	1167	143	20	1445.8	35	1.24	14.14
2000/01	1340	173	15	1577.0	9	1.18	13.43
2001/02	1628	288	21	1970.9	25	1.21	13.81
2002/03	1870	242	15	2446.8	24	1.31	14.93
2003/04	2483	613	33	2811.1	15	1.13	12.92

approaching better results. New wind farms are being set up within the range of CUF 20%–30% in order to get higher MWh/MW of installation.

WEG has the highest contribution to power generation as compared to other renewable energy sources (Table 2).

Table 2 Power generation from renewable energy sources (MW) as in 2003/04

Wind power	2483 (52%)
Small hydro (up to 25 MW)	1601.02
Biomass power	673.63
Photovoltaic	2.54
Energy recovery from waste	41.43
Total	**4802.22**

However Table 2 does not take into account the contribution of SPV (solar photo voltaics) in water pumping, domestic lighting, solar lantern, etc., which when added will exceed 130 MW under the SPV group.

In the Tenth and Eleventh Five-year Plans, the target for WEG has been fixed as 6000 MW out of the total capacity earmarked from the renewable sector – 10 000 MW. The momentum of WEG development will presumably exceed the limit with nearly 2500 MW already installed till now. There are few positive developments in fostering the growth of WEG. These are as follows.

1 Increasing tower heights.
From 25 m (metres) it is heading towards 75 (for higher wind speed and output) and is 78 m for a 1650 kW set in Tamil Nadu.
2 Unit rating approaching to 1.25–1.65 MW each against an average of 220–230 kW till recently
3 Higher rotor diameter to conform to higher capacity rating, 82 m for a 1650 kW unit

Wind energy, biomass power, and micro-hydel have reached the commercialization stage and amongst them, the prospect of WEG is very promising because wind energy is being generated on a MW scale and is grid-interactive to wheel power from the place of generation to the consumption centre or for sale to the ready market. The energy supply companies would always be interested, as there exists a wide gap between the supply and demand of power. Wind energy now occupies 2% of the market share in the total installed power capacity of the country. This is almost same as that of nuclear power generation as can be seen from Table 3. Besides, wind energy generation has the potential to save conventional fuel and thus protects the environment from emissions to a large extent as is evident from Table 4.

Table 3 Installed power capacity (MW) as on 2003/04)

Thermal	77 968.53
Hydro	29 500
Nuclear	2 720
Wind	2 483.20
Total	**112 672.07**

Table 4 Equivalent saving (in tonnes) of coal and other pollutants by use of wind power

Coal substitution	56 69 769
Sulphur dioxide	92 130
Nitrogen oxide	63 780
Carbon dioxide	141 744 00
Particulates	76 20

Wind energy has the distinction that almost whole of the capacity installation has been driven by government incentives and own commercial characteristics. In recent times, WEG has been the focus of private sector investment encouraged by the system of banking and wheeling, which will get additional boost under new provisions of the Electricity Act, 2003. WEG shows the prospects of attaining 100% growth in capacity addition in the next five years subject to, however, the continuance of the present low interest regime.

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Biogas in India – an overview

Biogas – what is it?

Biogas is produced by municipal and agricultural waste treatment processes. Composed primarily of CH_4 (methane) and CO_2 (carbon dioxide), it is not tapped for useful applications to the maximum extent as part of the effort to reduce greenhouse gas emissions. In light of the rising energy costs, however, and with new funding opportunities available, improved biogas collection and utilization has become economically viable.

Captured from waste water treatment plants and landfills, biogas contains 50%–65% CH_4. This chemical energy can be converted into electrical and thermal energy. Utilization may be on-site, nearby, or at a remote facility. Alternatively, biogas can be processed using one of the several innovative new methods to produce saleable liquefied methane fuel (similar to LNG) or stripped CO_2 gas.

Biomass that is high in moisture content, such as animal manure and food-processing wastes, is suitable for producing biogas using the anaerobic digester technology. Anaerobic digestion is a biochemical process in which particular kinds of bacteria digest biomass in an oxygen-free environment. Several different types of bacteria work together to break down complex organic wastes in stages, resulting in the production of biogas. Low-temperature fuel cells are also used to generate fuel from biogas.

Alternative power source

For relatively large energy users like waste water treatment plants, economics is the driving force behind cogeneration, where a dedicated on-site power system can satisfy both thermal and electrical needs of the plant. Improving biogas collection, and integration into the power system can reduce or even eliminate the plant's dependence on imported natural gas and electricity. In some cases, sufficient biogas is collected during certain seasons to justify the production of excess power for sale to the local utility or excess heat for sale to a neighbouring consumer.

The optimal cogeneration system for a given plant depends on the evaluation of a range of factors, including the plant's location, potential energy customers, and specifics of the waste treatment process (energy demand, storm water impact, and seasonal variations).

A recent report published by Business Communications Company, Inc. *(RE-124B Renewable Bulk Power Sources: World Markets for Biogas and Geothermal Power Plants, 2003)* highlights that animal wastes, which is a growing environmental problem worldwide, are being turned into energy cash cows wherever large concentrations of cattle, swine, and poultry are located. It is a value proposition that municipalities and livestock operations are finding attractive. Regional growth rates approaching the double digits are forecast for this branch of the biogas-fuelled generation industry. Landfill gas also shares this ability to steadily pump electrons into the grid. The equipments used to perform the energy conversion task are the same as those used at waste water treatment plants and anaerobic digester sites such as spark ignited engines, small gas turbines, microturbines, and fuel cells. The report also quantifies the participation each will have in the burgeoning biogas arena.

Commonly used biogas models

Under the NPBD (National Project on Biogas Development) programme, there are various biogas plant models approved by the MNES (Ministry of Non-conventional Energy Sources) for implementation. All these models are based on one of the two basic designs available – floating metal drum type or fixed masonry dome type. Besides, FLEXI, a portable model made of rubberized nylon fabric, has been approved for promotion in the hilly and other terrains. Some of the MNES approved models are as follows.

KVIC floating drum

This model was developed in the early sixties by the KVIC (Khadi and Village Industries Commission). It has an underground cylindrical digester with inlet and outlet connections at the bottom on either side of a masonry wall. An inverted metal drum, which serves as the gas-holder rests on a wedge-type support on top of the digester and as the gas begins to accumulate, the drum starts rising in height. The weight of the drum applies pressure on the gas to make it pass through the pipeline to the point of use. As the gas flows out, the drum gradually moves down. Due to this smooth two-way motion, the gas remains at constant pressure, which ensures the efficient use of gas.

Deenbandhu

The Deenbandhu model, developed in 1984, was probably the most significant development in the entire biogas programme of India, as it reduced the cost of the plant to almost half that of the KVIC model, and brought biogas technology within the reach of even the poorer sections of the population. The cost of reduction has been achieved through minimization of the surface area by joining the segments of two spheres of different diameters at their bases. This structure acts as the digester, and pressure is exerted on the slurry again which is pushed into a displacement chamber. Once the gas is drawn out from the outlet, the slurry again enters the digester. The brick masonry dome, which is fixed, requires skilled workmanship and quality material to ensure no leakage.

Pragati

This model is a combination of the KVIC and Deenbandhu designs. The lower part of the digester is semi-spherical in shape with a conical bottom. However, instead of a fixed dome, it has a floating drum acting as a gas storage chamber. The spread of Pragati model has been confined mainly to the state of Maharashtra.

KVIC plant with ferrocement digester

In order to overcome the problems encountered in the construction of traditional models of biogas plants, alternative construction materials have been tried out and ferrocement is but one of them. Ferrocement is a reinforced concrete made of welded mesh, sand, and cement. Layers of thin steel wire mesh distributed throughout the thickness of the element, are impregnated with rich mortar. Ferrocement as a building material offers several advantages like 10%–15% reduction in cost over KVIC digesters, usage of locally available material and less labour, and little or no maintenance.

KVIC plant with fibre reinforced plastic gas holder

FRP (fibre reinforced plastic) has been used in place of metal in the floating drum gas holder. Contact moulding process, a technique of moulding without the application of external pressure, is adopted to manufacture the FRP. It employs one of the less expensive types of moulds resulting in lower cost for the plant. The major advantage of FRP is its good resistance to corrosion, which saves the recurring expenditure on painting the drum.

Flexi

This is a portable model in which the digester is made of rubberized nylon fabric. The model is particularly suitable for hilly areas where the high transportation cost of construction materials, such as cement and bricks substantially increases the cost of installing the regular type of biogas plants.

Fixed-dome biogas plant

This is a spherical type fixed-dome biogas plant which ensures that minimum energy is wasted when working with waste. The spherical shape of the plant merges the digestion and gas storage spaces to a single dimension, making their construction easier. It also minimizes the surface area for a given volume, thereby reducing the cost while increasing the gas production rate. The plants have been designed for high efficiency and low maintenance.

Benefits of biogas use

Biogas technology makes optimal utilization of the valuable natural wastes including dung, fuelwood, crop wastes, etc. For example, unburnt dung provides nearly three times more useful energy than dung directly burnt, and also produces nutrient-rich manure. The versatility of biogas is its greatest advantage as a source of energy for the rural areas. The other advantages of biogas are as follows.

- As a cooking fuel, it is cheap and extremely convenient. Based on the effective heat produced, a 2 cu. m (cubic metre) biogas plant could replace, in a month, a fuel equivalent of 26 kg if LPG (liquefied petroleum gas) (nearly two standard cylinders), 37 litres of kerosene, 88 kg of charcoal, 210 kg of fuelwood, or 740 kg of animal dung. In terms of cost, biogas is cheaper, on a life cycle basis, than conventional biomass fuels (dung, fuelwood, crop wastes, etc.) as well as LPG, and is only fractionally more expensive than kerosene—the commercial fuels like kerosene and LPG, however, have severe supply constraints in the rural areas.

- To the housewife, biogas is easy to use and saves time in the kitchen; biogas stove has an efficiency of about 55%, which is comparable to that of an LPG stove. Cooking on biogas is free from smoke and soot, and can substantially reduce the health problems, which are otherwise quite common in most rural areas in India, where biomass is the chief source of fuel.
- Biogas can be used through a specially designed mantle, for lighting homes.
- Biogas can partially replace diesel to run IC (internal combustion) engines for water pumping; small industries like floor mill, saw mill, and oil mill. This would not only reduce dependence on diesel, but also help in reducing carbon pollutants, which adversely affect the atmosphere. Dual-fuel engines (80% biogas and 20% diesel) are now commercially manufactured in India.
- Biogas can be similarly used to produce electricity, though this has not been attempted on a large scale in the country so far.

While biogas has multiple benefits at the individual family level, it also has several qualitative and quantitative benefits at the societal level.

- A shift to biogas from traditional biomass fuels results in less dependence on natural resources such as forests, checking their indiscriminate and unsustainable exploitation. Since dung is collected systematically when used in biogas, environment can be kept clean and hygienic.
- The other advantage is that, unlike centralized systems such as thermal power plants and fertilizer factories, which entail huge capital investments and need elaborate distribution networks, biogas plants are decentralized systems which can be installed even in remote areas with very low investments.

Indian fact sheet and government initiatives

The new and renewable energy technologies are making a great revolution mainly in the remote areas, where it is difficult to provide electrical energy through the national grid. The biogas technology, improved biomass stoves, biomass gasifers etc., have provided a new life style to villagers. A total power generating capacity of over 1300 MW (megawatt) has so far been added from renewable energy sources, which, however, constitutes 1.5% of the total installed capacity in the country.

Understanding its importance, the government has taken specific measures to promote biogas usage through the NPBD. The NPBD was initiated in 1981/82 for the promotion of family size biogas plants. The aim of this project was to provide a clean and inexpensive source of energy to rural India. A major achievement has been in the area of cooking energy in rural areas – a total of 12 million family size biogas plants had been planned to be set up in India, of which about 3.4 million were installed till December 2002. During 2003/04, around 1.50 lakh family type biogas plants have been set up. The biogas plants and improved wood stoves presently in use are resulting in a saving of over 13 MT (million tonnes) of fuelwood every year, besides producing 45 MT of enriched organic manure.

Besides, the community and institutional biogas programme has been undertaken since 1982/83, in order to promote community-sized biogas plants, which can be used for power generation in addition to meeting cooking needs. During the Ninth Five-year Plan, till December 2001, about 1100 community-type biogas plants had been set up as against a target of 800.

Achieving the target would result in the estimated saving of about two lakh tonnes of fuel wood equivalent and production of about 18 lakh tonnes of organic manure per year during the life span of about 15–20 years of the plants. Besides, these plants accrue social benefits to rural families in terms of reducing the drudgery of women involved in collecting fuelwood almost daily from long distances, and minimizing health hazards during cooking in smoky kitchens. It is estimated that the construction of 1.5 lakh biogas plants also generated about 5 million person-days of employment for skilled and unskilled workers in the rural areas during 2003/04.

To propagate the large-scale use of biogas technologies, financial subsidy is provided for the installation of biogas plants on a turnkey basis with free maintenance for the first three years. Under the NBP (National Biogas Programme), CFA (central financial assistance) is being extended for various items and activities—(i) a fixed central subsidy is being provided based on the categories of beneficiaries and areas, (ii) turnkey job fee, (iii) an additional central subsidy is given for linking the cattle dung-based plant with a sanitary toilet, wherever feasible, (iv) repair charges for old non-functional plants, (v) service charges and staff support, (vi) regular conduction of training courses, and (vii) communication and publicity.

The RBI (Reserve Bank of India) and NABARD (National Bank for Agriculture and Rural Development) have been supporting the biogas programme right from the beginning. Detailed guidelines are available with both commercial and co-operative banks for financing family type biogas plants. Under the agricultural priority area, NABARD is providing an automatic refinancing facility to commercial banks for loan amounts disbursed for biogas plants. A three-tier monitoring system is in place. The first tier is self-monitored by the state governments and nodal agencies. The second tier is inspection of biogas plants by BDTCs (Biogas Development and Training Centres) and the MNES' regional offices. The third tier of monitoring is evaluation by independent agencies. The final reports of the concurrent monitoring of the biogas programme taken up during 2001/02 through four independent organizations, namely, TES (Techno Economic Service), New Delhi; AFC (Agricultural Finance Corporation), Mumbai; NEITCON (North Eastern Industrial and Technical Consultancy Organization Ltd), Guwahati; and TERI (The Energy and Resources Institute), Bangalore, indicated an overall average functionality of 87.9% plants at the national level.

Some success stories

Fixed-dome biogas plant for rural households

The team from TERI has brought about innovative biogas plant technology by introducing a spherical type fixed-dome biogas plant to ensure that minimum energy is wasted when working with waste. Based on renewable energy, the plant has low running cost and a high energy-efficiency. The family sized biogas plant with a capacity of 2 cu.m, costs 9000 rupees. The first such plant was installed and monitored in the village of Dhanwas, Haryana. The plants have been designed for high efficiency and low maintenance. The spherical type fixed-dome biogas plant easily meets the cooking, lighting, and power generation needs of the family.

5 MW power project based on municipal solid waste

The project has been supported by MNES by through a capital subsidy of 15 crore rupees and is being executed by Asia Bio-energy Pvt. Ltd, Chennai. The plant is based on high rate biomethanation technology, developed, and commercialized by Entec, Austria. It consists of five major systems viz. segregation, biomethanation, biogas storage, power generation, and organic fertilizer production. The plant has been designed to process 500–600 tonnes per day of MSW (municipal solid waste) of Lucknow city, for production of 50 000 cu. m of biogas and about 75 tonnes per day of organic fertilizer. The biogas produced is fed to five biogas engines to generate 5 MW of grid quality power. It has already been commissioned and presently over 1 MW of power is being fed to the grid everyday.

0.15 MW power project utilizing vegetable market and slaughterhouse waste

The plant is based on the biomethanation of 20 tonnes per day of mixed wastes (that is, 16 tonnes of vegetable market waste and 4 tonnes of slaughterhouse waste) generated in the VMC (Vijayawada Municipal Corporation). Sewage from the nearby treatment plant is also being used for dilution of the mixed waste in the plant. The plant was commissioned in February 2004 and is expected to generate about 1600 cu. m of biogas and 5 tonnes of organic manure daily, on its complete stabilization. The biogas so produced is being used in a 145 kW (kilowatt) imported biogas engine for generation of electricity, which the VMC proposes to feed into the state electricity grid.

0.5 MW power project based on slaughterhouse solid waste

Hind Agro has a 100% export-oriented modern integrated abattoir-cum-meat processing plant at

Aligarh. The project for biomethanation of slaughterhouse solid wastes will produce about 4000 cu. m of biogas per day to generate 0.5 MW power by utilizing 50 tonnes per day solid wastes after the slaughter of 1600 buffaloes everyday. The plant is being installed by RSB Japan on turnkey basis under the technical supervision of Central Leather Research Institute, Chennai.

0.3 MW power project utilizing vegetable market wastes

The biomethanation plant being installed at the KMC (Koyembedu Market Complex), Chennai is expected to treat about 30 tonnes of vegetable market wastes per day for the generation of about 0.3 MW of power. The estimated generation of biogas from the plant is about 2500 cu. m, besides the generation of about 9–10 tonnes of organic manure having a moisture content of 25%–30% per day. The biogas produced will be utilized to run a 230 kW imported gas engine having in-built cogenerating unit for the generation of electricity and thermal energy.

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eNREE invites contributions

eNREE is meant for ENVIS members and all stakeholders interested in advancing, promoting, and sharing the knowledge in renewable energy and environment in India and abroad. We sincerely welcome your help in enriching this newsletter by sending us articles, case studies, etc. and also welcome feedback on the contents of the newsletter to help us make it more informative and rich in content.

Please send in your contributions to

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Current research on renewable energy and Environment

*Chandrasekar B and Kandpal T C. 2005. **Effect of financial and fiscal incentives on the effective capital cost of solar energy technologies to the user.** *Solar Energy* **78**(2): 147–156
Educational Consultants India Ltd, EDCIL House, 18 A, Sector 16A, Noida – 201 301, India

The development and dissemination of solar energy technologies in India has been aided by a variety of policy and support measures. One of the promotional measures is the provision of financial and fiscal incentives such as capital subsidy, low interest loan, and accelerated depreciation related income tax benefits to the users on the purchase of solar energy technologies. In this study an attempt has been made to determine the effective capital cost of solar energy technologies to the user with the provision of financial and/or fiscal incentives. Results of exemplifying calculations for domestic and industrial solar water heating system, a solar home lighting system and a solar drying system have been presented and discussed. (5 figures, 7 tables, 19 references)

*Kannan G K, Gupta M, and Kapoor C J. 2005. **Estimation of gaseous products and particulate matter emission from garden biomass combustion in a simulation fire test chamber.** *Atmospheric Environment* **39**(3): 563–573
Centre for Fire, Explosive, and Environment Safety, Defence Research and Development Organization, Brig S K Majumdar Marg, Timarpur, New Delhi – 110 054

Air quality in many of the cities in India is gradually deteriorating due to various activities. One such activity is open burning of garden biomasses in cities. This study was aimed at estimating the emissions from various types of garden biomasses namely grass, leaves, twigs, and mixtures of these three in a controlled SIFT chamber. Although the particulate emission (1.51 g/kg) was lowest from grass, the particle size distribution indicates that the emission contains 10% of fine particulates (<2.5 μm) and significant quantity (70%) of respirable fraction (<10 μm). On the other hand leaves, though generating 32.3 g/kg of particulate matter, contained major portion in the non-respirable range (around 40%). CO_2 (carbon dioxide) emissions from leaves (1064.6 g/kg) and twigs (897.3 g/kg) are significantly lower than the emission from mixture (1423 g/kg) of equal proportion of these two. A similar trend is followed in case of carbon monoxide and nitrogen oxides emissions. However, hydrocarbon emission followed a reverse trend of emitting high emission load (11.4 g/kg) in the mixture of leaves and twigs than their individual type (2.4 g/kg (leaves) and 0.2 g/kg (twigs). The toxicity indices for all categories were very low (0.06–0.12). However, out of the five categories grass was found to have the lowest toxicity index (0.06) followed by mixtures (1:1:1) having 0.07. The particulate matter emission load computed for the cities of India shows that the leaves and grass contribute 97 tonnes/day and 4.5 tonnes/day of particulate emissions. Among gaseous pollutants CO_2 emission was the highest, as the computed values were 3212 tonnes/day from leaves and 92 tonnes/day from grass. (7 figures, 5 tables, 30 references)

*Khoiyangbam R S, Kumar S, Jain M C, Gupta N, Kumar A, Kumar V. 2004. **Methane emission from fixed-dome biogas plants in hilly and plain regions of northern India.** *Bioresource Technology* **95**(1): 35–39
Division of Environmental Sciences, Indian Agricultural Research Institute, New Delhi – 110 012, India

CH_4 (methane) emissions from the slurry displacement chambers of different fixed dome type biogas plants (capacity 2m^3) installed in hilly and plain regions of northern India were quantitatively estimated. The slurry temperature in the biogas plants in the hilly areas of Himachal Pradesh at an altitude of 1300 m above mean sea level remains below the lower mesophilic range (16–25 °C) during most part of the year. Difference in the ambient temperature under the two climatic conditions of hills and plain regions affects the CH_4 flux. CH_4 fluxes from the plants ranged between

7 and 120 $gm^{-2}d^{-1}$. In the northern plain, temperature remains warm (21–33 °C) throughout the year except during winter (December to January) when there is a steep fall. Seasonal emission of CH_4 ranged between 10 and 178 $gm^{-2}d^{-1}$. The annual average CH_4 emission from the biogas plants in plain areas was 83.1 $gm^{-2}d^{-1}$ as compared to 43.1 $gm^{-2}d^{-1}$ in the hilly areas. Annual contribution per plant to the global CH_4 budget from a fixed-dome biogas plant (capacity 2 m^3) in the plain region of northern India was 53.2 kg as compared 22.3 kg in the hilly area. (4 figures, 1 table, 11 references)

*Singh K J and Sooch S S. 2004. **Comparative study of economics of different models of family size biogas plants for the state of Punjab**. *Energy Conversion and Management* **45**(9–10): 1329–1341
Office of Director (Farm), Punjab Agricultural University, Ludhiana – 141 004, Punjab, India

Biogas, the end product of anaerobic digestion of cattle dung, can successfully supplement the cooking fuels in the countryside areas of India. The economics of family size biogas plants was studied, and three prevalent models, that is, KVIC (Khadi Village Industries Commission), Janta, and Deenbandhu, were compared. For all the capacities varying from 1 to 6 cubic metres, the cost of installation and the annual operational cost was highest for the KVIC model followed by the Janta and Deenbandhu models of biogas plant. For all models, as the capacity of the biogas plant increased, the cost of installation and annual operational cost increased proportionally. The payback period was highest for the KVIC model followed by the Janta and then the Deenbandhu models. For all the models, as the capacity of the biogas plant increased, the payback period decreased exponentially with the exponential character being the highest for the KVIC model, followed by the Janta and the Deenbandhu models. For all the capacities, the Deenbandhu model of biogas plant was the cheapest as far as the cost of installation, annual operational cost, and payback period was concerned. (3 figures, 12 tables, 8 references)

*Ravindranath N H, Somashekar H I, Dasappa S, Reddy J C N. 2004. **Sustainable biomass power for rural India: case study of biomass gasifier for village electrification**. *Current Science* **87**(7): 932–941
Centre for Sustainable Technologies, Indian Institute of Science, Bangalore – 560 012, India

The performance and impact of a decentralized biomass gasifier-based power generation system in an unelectrified village is presented. In Hosahalli village, Karnataka, India, lighting, drinking water, irrigation water, and flour-milling services are provided using power derived from the biomass gasifier-based power generation system. The system consists of a 20 kW (kilowatt) gasifier-engine generator system with all the accessories for fuel processing and electricity distribution. The biomass power system has functioned for over 14 years (1988–2004) in Hosahalli village (population of 218 during 2003), meeting all the electricity needs of the village. Lighting and piped drinking water supply using biomass electricity, was provided for over 85% of the days during the past six years. The fuel, operation, and maintenance cost ranged from 5.85 rupees/kWh (kilowatt hour) at a load of 5 kW to 3.34 rupees/kWh at a load of 20 kW. Technical, social, economic, and management-related lessons learnt are presented here. (2 figures, 8 tables, 16 references)

*Dasappa S, Paul P J, Mukunda H S, Rajan N K S, Sridhar G, Sridhar H V. 2004. **Biomass gasification technology: a route to meet energy needs**. *Current Science* **87**(7): 908–916
Department of Aerospace Engineering, Indian Institute of Science, Bangalore – 560 012, India

This paper addresses a distributed power generation system that has evolved at the IISc (Indian Institute of Science), Bangalore. The technological and field-related experience pertaining to open top re-burn down draft biomass gasification system coupled with the internal combustion engine or thermal device are brought out. The gasifier reactor design uses dual air entry – air nozzles and open top to

help in establishing a thick high temperature zone to remove the contaminants in the product gas. Further, a gas clean-up system is deployed to refine the gas to ultra-pure quality. These elements are integrated with other sub-systems, namely feedstock preparation, ash handling, water treatment, process automation, and other accessories to form an independent power producer. Based on this technology there are over 30 units operating in India and abroad, with an accumulated capacity of over 20 MW. Over 80 000 hours of operation of these systems have resulted in a saving of about 350 tonnes of fossil fuel, implying a saving of about 1120 tonnes of CO_2 – a promising candidate for CDMs (clean development mechanisms), other than reduction in toxic gases like nitrogen oxides and sulphur oxides. (12 figures, 1 table, 38 references)

Mukhopadhyay K. 2004. **An assessment of a biomass gasification-based power plant in the Sunderbans**. *Biomass and Bioenergy* **27**(3): 253–264
Centre for Development and Environmental Policy, Indian Institute of Management Calcutta, Joka, D H Road, Kolkata – 700 104, India

A continued thrust towards the wider use of renewable energy devices at domestic, commercial, and industrial levels not only results in greater awareness but also significant installed capacities. The energy requirement in India is steadily increasing and this requirement is met both by commercial and renewable energy sources. India being a tropical country, renewable energy is seen as an effective option for ensuring access to modern energy services. So the objective of the present study is to evaluate the socio-economic and environmental impact of the BGBPP (biomass gasification-based power plant) in the Chottomollakhali islands of Sunderbans set up by the WBREDA (West Bengal Renewable Energy Development Authority). Four villages of the Chottomollakhali islands are benefited with electricity from the power plant, which serves 225 consumers comprising household, commercial, and industrial sectors. A simple cost–benefit analysis has been used to estimate the impact of the BGBPP. The findings of the study indicate that BGBPP has made a very positive impact on the life of the villagers of the island. This has led to increased economic activities, more profitable turnover for the commercial consumers, and improved quality of life for the household sector. All of them have shown willingness to pay a higher price to get 24 hours of power supply. From the cost–benefit analysis it has been found that the benefit–cost ratio, internal rate of return, and pay back period of the project are 1.68, 19% and 7 years, respectively. (2 figures, 11 tables, 8 references)

*Kishore V V N, and Bhandari P M, Gupta P. 2004. **Biomass energy technologies for rural infrastructure and village power – opportunities and challenges in the context of global climate change concerns**. *Energy Policy* **32**(6): 801–810
**The Energy and Resources Institute, Darbari Seth Block, I H C Complex, Lodhi Road, New Delhi – 110 003, India*

The potential and role of biomass resources in the developing countries for addressing global climate change concerns are highlighted in this paper, using India as a case study. Promotion of technologies, which use biomass more efficiently, is seen as a key strategy to integrate the concerns of both the developing and the developed countries. The role of various biomass technologies for improving rural infrastructure and village power is discussed in detail. A vision of establishing and running a chain of rural energy service companies, operating with a basket of devices and technologies, under the general provisions of CDM, is examined for commercialization and mainstreaming of biomass technologies, which have achieved reasonable levels of maturity. (3 figures, 4 tables, 15 references)

*Pohekar S D, Soni M S, and Ramachandran M. 2004. **A review of wind energy developments in India**. *International Journal of Global Energy Issues* **21**(3): 276–286
*Mechanical Engineering Group, Birla Institute of Technology and Sciences, Pilani – 333 031, Rajasthan, India

Climate change, dwindling reserves of fossil fuels, and shortage of electricity have prompted the government to give an impetus to renewable energy sources. Wind energy, with an average growth rate of 30%, is the fastest growing source of renewable energy in the world. India has a potential capacity of over 45 000 MW (megawatt) out of which 1869 MW has been extracted from this eco-friendly source. India stands fifth in wind energy development in the world. Policy and fiscal initiatives for realization of the estimated potential already exist. This paper discusses an overview of wind assessment, monitoring, development, and environmental impact in India. Financial interventions and state policies on commercialization are also presented with a view to identifying the barriers for further commercialization. (10 figures, 3 tables, 13 references)

Anon. 2004. **Competitive advantages of wind energy for textile industries.** *Textile Magazine* **46**(1): 107

Wind energy can offer various competitive advantages for the textile industries in India, especially in the context of globalization. The availability of a cheaper form of electricity will be beneficial for India to survive in the global competition. Grazing lands in Gujarat can be used for the production of wind energy, and this is also seen as a unique way for the diversification of the state. Wind energy is pollution free, and it has played an important role in Tamil Nadu's industrial growth. In the initial stages, the plants for producing wind energy should be set up within the state itself. In the future, the wind energy may be produced in one state and utilized by another. The easy availability of bank loans, initiatives by big industries to set up plants, and the introduction of national power policy, will help increase wind power production.

*Singh S, Bhatti T S, Kothari D P, Singh S. 2004. **Indian scenario of wind energy: problems and solutions.** *Energy Sources* **26**(9): 811–819
*Centre for Energy Studies, Indian Institute of Technology, New Delhi – 110 016, India

For developing countries like India, wind turbines offer an attractive source for power production. The country's current generating capacity is about 105 000 MW (as of 31 March 2001), but this needs to be doubled in the next 10–15 years to meet a situation of 'power on demand'. Both central and state agencies, and various private and public sector companies are now considering the installation of wind farm projects for power generation. Wind farm projects with a capacity of 990 MW have already been installed by private companies for power generation. As a result of the initiatives taken by the government to promote wind energy, different states are now supporting the wind power companies and investors with liberal policy initiatives, though there are minor irritants that have to be sorted out. The government has taken some recent measures to eradicate these irritants and promote wind power in India. This article reviews the current status of wind energy, the various hindrances in its smooth development, the initiatives taken by the government to remove them, and future development prospects of wind energy in India. (19 references)

*Aggarwal R K and Chandel S S. 2004. **Review of improved cookstoves programme in Western Himalayan state of India**. *Biomass and Bioenergy* **27**(2): 131–144
* Dr Y S Parmar University of Horticultural Forest, Nauni, Solan – 173 230, Himachal Pradesh, India

The status of NPIC (National Programme on Improved Cookstoves) in Himachal Pradesh, the Western Himalayan Indian state, is presented in this paper. The lessons learnt from the success and failures in the implementation of the programme are highlighted. The research and development efforts of the Technology Back-Up Centre, in developing energy-efficient space-heating metal stoves for high-altitude regions of the state are described. The feedback survey indicates that these improved stoves based on traditional stove designs are more acceptable to people. The study shows that NPIC needs to continue with new vigour in the ecologically fragile Himalayan region for the protection of forests and health of women. A new approach for the implementation of NPIC is outlined which includes a massive awareness campaign about harmful impact of smoke emissions, improved ventilated kitchen designs, introduction of alternate cooking and space heating technologies, including passive solar house technology for space heating in extreme cold climates. (6 figures, 9 tables, 7 references)

D'Sa Antonette and Murthy K V N. 2004. **LPG as a cooking fuel option for India**. *Energy for Sustainable Development* **8**(3): 91–105
International Energy Initiative, 25/5 Borebank Road, Benson Town, Bangalore – 560 046, India

The use of clean fuels such as LPG (liquefied petroleum gas) instead of biomass-based fuels used for cooking in India would be beneficial in several ways. However, only about 33.6 million or 17.5% of all Indian homes use LPG as their primary cooking fuel, with 90% of rural homes still dependent on some form of biomass. Hence, this paper considers the possibility of enhancing the household use of LPG. From an overview of the cooking fuels used in India, it focuses on LPG, analysing the factors affecting current demand and projecting future scenarios. Salient features of the LPG supply and distribution system are also discussed. On the basis of the existing situation, barriers to increasing LPG use – in particular, the problems regarding affordability, pricing, and reliable distribution – have been identified. In this context, experiences with the expansion of household LPG use in other countries and a programme in India have been considered. Finally, on the basis of the challenges recognized, suggestions have been made regarding the policies through which the problems can be overcome. (2 figures, 10 tables, 23 references)

Mahat I. 2004. **Rural energy planning and policies in Nepal: gender perspectives**. *Resources, Energy, and Development* **1**(January): 19–41
Mahat Niwas, Jwagol, Kupondole, Lalitpur, Nepal

Women in rural Nepal are heavily involved in managing household energy systems. They spend a large proportion of their time and energy in collecting firewood and processing food grain. Being the primary users and managers of household energy, women are very careful in ensuring efficient energy use. Indeed, they possess indigenous knowledge and skills in energy production and management. Despite this reality, Nepal's planners and policy-makers – who are usually male – rarely consider rural energy problems from the perspective of women. Rural energy interventions are planned and designed with the aim of saving fuel rather than that of reducing human drudgery or opening up new development opportunities for women and men. This paper analyses the issues and challenges facing Nepal's rural energy sector, and makes some policy recommendations with a focus on gender-based plans and policies. A gender-sensitive planning framework indicating long-term goals, medium-term objectives, and relevant indicators has been designed to provide planners with a basis to integrate gender into rural energy planning and policies. (3 tables, 48 references)

Moitra N. 2004. **An insight into the oil-prone precursors of fossil fuels for selection of exine-rich, high hydrogen biomass, its pyrolysis, and product evaluation as fuel**. *Energy Sources* **26**(14): 1363–1368
Block E, Flat 101, Aishwarya Lake View Residency, 191, 6th Cross, Kaggadaspura, C V Raman Nagar, Bangalore – 560 093, India

Wood and lignocellulosic biomass can be converted to liquid, solid, and gaseous fuel by thermal degradation, but the liquid fuel obtained has a very low calorific value as compared to conventional fuel oil. In contrast to the earlier studies on pyrolysis of wood, municipal solid waste, etc., the present study has been conducted after assessing the oil-yielding constituents of fossil fuels derived from plant sources. This paper presents the findings of a study involving the selection of exine-rich, high hydrogen biomass, its pyrolysis, and product evaluation as fuel. With a scientifically grounded approach to the selection of oil-prone biomasses using the process of slow pyrolysis in a laboratory-scale set-up, the results obtained are encouraging: 10%–17% bio-oil, 38%–50% char, 14%–25% ammoniacal liquor, and 12%–28% gas. The uniqueness of the work presented lies in the selection of biomass, which has high hydrogen content and is oil prone in nature. Interestingly, the liquid fuel obtained has a high calorific value, falling in the range of conventional fuel oil. (3 tables, 8 references)

Srivastava S P. 2004. **Fuel cells energy source for the 21st century and beyond**. *Dew Journal* **13**(12): 17–21
Indian Oil R&D Centre, Faridabad, Haryana – 121 001, India

Fuel cell technology for power generation and automotive application has now reached at the demonstration level in Europe, Germany, Japan, and US. For applications such as defence and space where cost is not the consideration, fuel cells are well established. Indian fuel cell research has been in its infancy. In view of the typical environment issues involved in India, it would be desirable in the first phase to develop fuel cell-powered small engines suitable for 2/3 wheelers, domestic, business centre generators etc., which are the major sources of air pollution in a time-bound-basis, involving equipment manufacturers and researchers. In the second phase, fuel cell-powered stationary powered plants could be developed. (3 figures, 7 references)

Ghose M K. 2004. **Effect of opencast mining on soil fertility**. *Journal of Scientific and Industrial Research* **63**(12): 1006–1009
Centre of Mining Environment, Indian School of Mines, Dhanbad – 826 004, India

In the process of opencast mining, several changes occur in the physical, chemical, and microbiological properties of soil as a result of mining and storage. The inability to preserve top soil is one of the basic hindrances to the restoration of mined land. The acute problem in preserving mine soil is discussed in this paper. Every year large areas are continually becoming unfertile in spite of efforts to grow vegetation on the degraded mined land. One large opencast coal project of the Eastern Coalfields Ltd is investigated to assess the deterioration of soil properties due to stripping and stockpiling. Different age classes of mine soil dumps are identified for the study. Mine soil characteristics of the dumps are compared with those of unmined soil and analysed critically to evaluate the deterioration of soil properties with respect to the time of stockpiling. The changes in soil quality were found to be drastic in the first year and continually deteriorating every year, (and ultimately the soil became unfertile).
(5 tables, 23 references)

Dewan K K, Mustafa M, and Saxena P. 2004. **Neighbourhood schools: a paradigm to combat pollution and save energy**. *Journal of Transport Management* **28**(3): 415–430
Department of Mathematics, Jamia Millia Islamia, New Delhi – 110 025, India

This paper highlights the need for a policy approach by the government sector to provide a uniform framework of the facilities in the education system to every child. The study lays an emphasis on the fact that such a framework would lead to a reduction in the vehicular density on the roads and a fall in the pollution level. It outlines a strategy to achieve an environment-friendly and fuel saving transport system. The thrust of the study is to conserve energy by restructuring the education system. (4 figures, 7 tables, 24 references)

Padmanaban S. 2004. **What Indian states can do to promote energy efficiency**. *The Bulletin on Energy Efficiency* **5**(2): 7–11
USAID, American Embassy, Chanakyapuri, New Delhi – 110 021, India

With the rapid increase in industrialization and urbanization there has been a corresponding increase in the cost of energy supplies, adverse environmental impact of run-away energy development, and poor financial and technical performance of state power utilities. There is an immediate need for a cheap, environmentally sound, and efficient option to energy supply. There is also a need to strengthen the capacity of state-level agencies to plan and execute energy efficient programmes in their respective states. Such a development will greatly enhance the effectiveness of the Energy Conservation Act, 2001. The success of such state-level programmes will lie in the extent to which states are able to combine the regulatory and policy aspects of energy efficiency programme design with the market delivery of energy efficiency services by state public and private enterprises and businesses. (2 figures)

Anand I S. 2004. **Indigenous technology for pico-hydel single-phase power generation scheme in India**. *The Bulletin on Energy Efficiency* **5**(2): 16–19
O-20/B, Jangpura Extension, New Delhi – 110 014, India

An appropriate, indigenous technology that can produce electricity from small hydro in a decentralized and stand-alone mode holds immense potential of electrifying rural and remote regions in India. This paper discusses the implementation of this technology in the state of Karnataka. Field data on the pico-hydel system with two types of controllers prove the viability of using such systems for further installation. Uncontrolled turbines or pumps as turbines may be used. Self-excited induction generators are found to be ideal as they are rugged, cheap, and user-friendly. The reliability of the system centres on the reliability of the electronic load controllers, which must be rugged and failure proof. (4 figures, 4 tables, 2 references)

*Shukla S K, Sorayan V P S, and Gupta S K. 2004. **Parametric studies of passive/active solar stills by using modified convective mass transfer relations**. *International Journal of Ambient Energy* **25**(4): 212–220
**Centre for Rural Development and Technology, Indian Institute of Technology Delhi, Hauz Khas, New Delhi – 110 016, India*
<shail_shukla@hotmail.com>

In this paper the effects of design parameters – namely water depth, absorptivity of basin liner and water mass, bottom insulation thickness, and collector area for passive and active solar still – have been studied using two sets of values of the constants C and n, by using inner and outer glass cover temperatures of the solar stills for a typical day under Delhi climatic conditions. The studies have been based on the basic energy balance equations of different components of passive and active solar stills taking into account modified values of C (= 0.075) and n (=1/3) for convective mass transfer for both the systems. The results obtained in the present case are in accordance with the results reported earlier. (10 figures, 1 table, 14 references)

*Mohalik N K, Singh R V K, Sural G, Barnwal R P, Pandey J, Singh V K. 2004. **Environmental impact of coal mine fire during excavation of developed galleries by opencast method**. *The Indian Mining and Engineering Journal* **43**(11): 30–35
**Mine Fire Division, Central Mining Research Institute, Dhanbad – 826 001, India*

Presently about 80% of the coal in India is being produced from opencast mines. The opencast mine in India is either virgin coal seam or underground developed seam in shallow depth. Earlier, most of the coal mines were developed underground and are presently being excavated by the opencast method to increase the production, especially in the Jharia coalfield. The spontaneous heating/fire has occurred in the galleries of developed pillars due to intrinsic characteristics of coal and mining operation. Fire in the developed galleries affects the normal production during excavation by the opencast method and also causes direct loss of equipment, environmental pollution, and loss of the country's precious coal reserves. It releases noxious gases, heat, smoke, dust, and poses a serious health hazard. Fire in mines also causes direct loss of equipment, and damage to the surface structure. The objective of this paper is to assess the causes of coal mine fire in opencast workings of developed galleries and suitable suggestive measures for controlling and combating the intensity of the fires. (2 tables, 11 references)

Puri S. 2004. **RE in India: what does 2004 have in store?** *Refocus* **5**(1): 22–24
Winrock International India, 1, Navjivan Vihar, New Delhi – 110 017, e-mail: <sunil_pr@hotmail.com>

In this paper the issues related to progress of RE (renewable energy) in India in the year 2004 are discussed in relation to the government policies and industrial trends. Industries are expecting the government to provide an increase in the rate of depreciation for solar and wind plants from the present level of 80% to 100% and exempt the renewable sector from minimum alternate tax. The industry is also asking for a reduction of import duties on solar panels. (5 figures)

*Bhagwan R J and Reddy D N. 2004. **Reliability evaluation of a grid-connected wind farm: a case study of Ramgiri Wind Farm in Andhra Pradesh, India**. *Proceedings of the Annual Reliability and Maintainability Symposium:* 659–662
**Department of Electrical Engineering, Vasavi College of Engineering, Ibrahimbagh, Hyderabad – 500 031, India <jbhagwanreddy@rediffmail.com>*

The application of renewable energy in electric power systems is growing rapidly due to increasing public concern for adverse environmental impacts, escalation in energy costs, and shortage of fossil fuels associated with the use of conventional energy sources throughout the world. Wind energy resources are being increasingly recognized as cost-effective generation sources in bulk power generation. In the modern age, there is a need for failure-free electric supply. This leads to a demand for reliable supply, since most of the electricity failures occur due to insufficient generation. Generation system reliability evaluation has become the most important component of power system reliability. This paper presents the results of a case study concerning reliability evaluation of Ramgiri Wind Farm in Andhra Pradesh, India. It consists of several 250 kW wind electric generators connected to the grid. The unit-wise data was collected for two years and the failure and repair rates were presented. The evaluation used the method of sequential addition algorithm through a computer program in 'C' language. From the results, one can go for system planning for certain base loads and addition of wind turbine generators, and selection of wind site. (2 figures, 2 tables, 10 references)

*Ashraf I, Chandra A, and Sodha M S. 2004. **Techno-economic and environmental analysis for grid-interactive solar photovoltaic power system of Lakshadweep islands**. *International Journal of Energy Research* **28**(12): 1033–1042
**Centre for Energy Studies, Indian Institute of Technology Delhi, Hauz Khas, New Delhi – 110 016, India e-mail: <chandra@ces.iitd.ernet.in>*

The Lakshadweep group of islands in the Arabian Sea is one of the two major groups of islands in India. In these islands the main source of electricity is diesel generators, the diesel being transported from the mainland to produce over 9 MW of electricity. Considering the remoteness of the island, and the polluting nature of the existing plants, it is desirable to adopt a strategy to utilize the available potential of non-polluting renewable energy sources for these ecologically sensitive islands. A techno-economic and environmental analysis for grid-interactive solar photovoltaic power system of the union territory of Lakshadweep islands is presented in this paper. It also examines the pollution aspect of power generation through diesel generator set and highlights the environmental benefits in using solar energy. Experiences of grid-interactive solar photovoltaic power systems installed recently in different islands are discussed and suggestions have been made for improving its efficiency and performance. (1 figure; 7 tables, 15 references)

Technological developments

Wood-fuelled CHP technology

Northern Ireland's renewables technology developer Exus Energy has signed its first major licensing contract, for the manufacture and sale of its innovative wood-fuelled CHP (combined heat and power) system in Japan, with TSK Ltd, a large Japanese industrial company. The two partners believe that there is a significant potential for this technology in Japan, with its cold winters, high electricity prices, and growing environmental awareness. While more than half of Japan is covered in forests, this abundant raw material has proved difficult to harvest, because it is often found in remote, mountainous areas. Exus Energy's wood-fuelled CHP system may be the answer, as the system is a self-contained unit, which can be located in relatively inaccessible locations. Exus has a number of wood-fuelled CHP systems at various stages of development, including one providing heat and electricity at the prestigious BedZED site in London. The company is now commercializing the technology.

Renewable Energy World 2004, **28**(7): 28

Hydrogen from biomass

Researchers at IOWA State University are working on hydrogen generation from bagasse using a thermally ballasted gasifier. The aim of the project is to optimize the performance of an indirectly heated gasification system that converts switch-grass into a gas rich in hydrogen for powering fuel cells. Researchers have developed a thermally ballasted gasifier that uses a single reactor for both combustion and pyrolysis. In this unit, instead of spatially separating these processes, they are temporarily isolated. The producer gas is not diluted either with nitrogen or the products of combustion. The heat released during combustion at 850 °C is stored as latent heat in the form of molten salt sealed in tubes that are immersed in the fluidized bed. During pyrolysis, which takes place between 600 °C to 850 °C the reactor is fluidized with steam or recycled producer gas instead of air. The heat stored in the phase change material is released during this phase of the cycle to support endothermic reactions of the pyrolysis stage.

Bioenergy News 2004, **8**(1): 9

Solar concentrator system

Sandia National Laboratories and Stirling Energy Systems of Phoenix will build six new solar dishes that will make a 150 kW power plant. Each dish has 82 dish-shaped mirrors, which generate electricity by focusing solar rays onto a receiver that transmits the heat energy to an engine. The engine is filled up with hydrogen and as gas heats and cools, its pressure rises and falls. The change in pressure moves the piston inside the engine, producing mechanical power, which in turn, drives a generator to make electricity. The six systems will provide electricity for 40 homes, and research is being carried out to find a solution to integrate them as well as improve systems reliability and performance. Each unit will cost about US $50 000. However, the cost will come down to allow the cost of electricity to be competitive with conventional fuel technologies.

Refocus 2004, November–December: 11

Bio-digestion technology

A UK-based company has developed an innovative, cost-effective, and environmentally sustainable bio-digestion technology to address the problems of organic waste treatment, which in turn will reduce greenhouse gas emissions. The process uses a low energy multi-tank-based waste treatment and energy production technique that produces renewable energy in the form of CH_4 (methane) gas and other commercially valuable by-products. High quality monitoring and gas compression equipments have been procured for this purpose. The CH_4 gas will be used as vehicle fuel, or for generating electricity, while the by-product–carbon dioxide–will be used as a solvent in the food, drinks, and electronic industry.

Refocus 2004, May–June: 17

GAIL plans to extract gas from lignite

GAIL (Gas Authority of India Ltd), along with Canada-based Ergo Exergy Technologies, had signed a memorandum of cooperation on 18 February 2005 for jointly developing underground coal/lignite gasification projects. GAIL and Ergo will jointly implement a pilot project for lignite gasification in the Barmer district of Rajasthan. It will take 12 months to commence production. The gas from the project will be used for a 5 MW (megawatt) power project, which will be scaled to 750 MW if the pilot project is successful. The site was chosen for the pilot project, as lignite fields are present nearby. Mannargudi in Tamil Nadu has also been identified as a potential location for a similar project, a company executive said. The cost per MBTU (million British thermal units) (a thousand cubic metres equal 40 MBTU) of such synthesized gas would be less than the price of imported natural gas. It would also be competitive in comparison to gas produced from coal from open cut mines.

Business Standard, 21 February 2005

Low energy extraction process

LEEP (low-energy extraction process) is a high-efficiency mobile process for removal of organic pollutants from soil, sediments, and sludges. The matrix can contain particle sizes down to the submicron range and water concentration from a few percent up to 90%. It is a low-pressure process operated under a nitrogen blanket at near ambient conditions. The contaminants are leached from the solids with a hydrophilic (capable to bind or absorb water) leaching solvent and are then concentrated in a hydrophobic (incapable of dissolving in water) solvent by liquid extraction or distillation. While the leaching solvent is recycled internally, the concentrated contaminants are removed from the process for off-site disposal.

Details available at <http://www.techknow.org/search/remediation/RemBrows.cfm>, last accessed on 29 March 2005

Web updates

Database of State Incentives for Renewable Energy

http://www.dsireusa.org/

The DSIRE (Database of State Incentives for Renewable Energy) is a comprehensive source of information on state, local, utility, and selected federal incentives that promote renewable energy. The searchable database covers information like tax incentives for solar electric and other renewables, alternative-fuels vehicles, and energy conservation. The database is a graphical presentation of data, tables, and other information.

Solar Energy International

http://www.solarenergy.org/

SEI (Solar Energy International) provides education and training to decision-makers, technicians, and users of renewable energy sources including practical use of renewable energy technologies that includes electricity from sun, wind, or water through conducting workshops, programmes, etc. SEI also provides the expertise to plan, engineer, and implement sustainable development projects. The site is a rich collection of books, videos, and software related to renewable energy and sustainable building technologies. It also publishes a monthly e-newsletter.

Energy Ideas Clearinghouse

http://www.energyideas.org/

This website offers content-rich searchable databases for technical information on renewable energy regarding solar, biomass, geothermal, distributed generation, wind, hydro, and other renewable resources. The database covers articles, documents, fact sheets, reports, etc., in an easily, downloadable form.

CleanEnergy

http://www.CleanEnergy.de/

CleanEnergy is a worldwide directory of clean and renewable energy-related companies, products and news on biomass, photovoltaic, solar thermal, hydrogen, wind, geothermal, and fuel cell. It also provides links to other websites and information on forthcoming events.

China Renewable Energy Information Network

http://www.newenergy.org.cn/english/index.asp

This network in the new and renewable energy field covers information on solar, wind, biomass, geothermal, ocean, hydrogen, and small hydro renewable energy resources. The site is a collection of news, technology, publications, documents, and glossary of terms. The site also hosts a bulletin board on the field.

Canadian Solar Industries Association

http://www.cansia.ca/
The CSIA (Canadian Solar Industries Association) is a national organization supported by the Government of Canada, industry members, and the public to promote renewable energy applications in the country. The site hosts a rich collection of resources including news, events, directory, photo gallery, opportunities, government initiatives, educational materials, publications, etc.

British Wind Energy Association

http://www.bwea.com/
The BWEA (British Wind Energy Association) is the trade and professional body for the UK (United Kingdom) wind industry to promote the use of wind power in and around the UK, both onshore and offshore. The website provides detailed information on wind, tidal and wave energy, events, news, and links to other sites. The site also holds debate in the relevant field.

Forthcoming events

27–29 April 2005
Loews L'Enfant Plaza Hotel
Washington D C, **USA**

7th Annual small fuel cells 2005: small fuel cells for portable applications
The Knowledge Foundation Inc, 18 Webster Street, Brooklyn, MA 02446-4938, USA
Tel. (617) 232-7400 • *E-mail* custserv@knowledgefoundation.com
Website http://www.knowledgefoundation.com/

5–7 May 2005
Business Design Centre, London, **UK**

Clean Energy Technology and Investment Expo
LPB Events Ltd, 18 King Edward Buildings, 629, Fulham Road, London, SW6 5UH
Tel. (44) 20 77 51 9998 • *Fax* (44) 20 77 51 9996
E-mail enq@clean-energy-expo.com
Website http://www.clean-energy-expo.com

8–12 May 2005
National Hotel, Havana, **Cuba**

Hypothesis VI
Dr Antonio Valdes, Hydrogen Power Theoretical Engineering Systems International Symposium, 21 and O Streets, Havana, Cuba
Tel. 53 7 203 0778 • *Fax* 53 7 202 9372
E-mail avaldes@geprop.cu • *Website* www.hypothesis.ws

15–20 May 2005
Quebec City, **Canada**

Fuel cells science, engineering, and technology 2005
The Electrochemical Society Inc., 65 South Main Street, Pennington, NJ 08534-2839, USA
Tel. 609 737 1902 • *Fax* 609 737 2743
E-mail ecs@electrochem.org • *Website* http://www.electrochem.org/

29–31 May 2005
Bonn, **Germany**

Second world renewable energy forum: renewing civilization by renewable energy
EUROSOLAR e.V., Kaiser-Friedrich-Street 11, D-53113 Bonn, Germany
Tel. +49-(0) 228-362 373 / 362 375 • *Fax* +49-(0) 228-361 279 / 361 213
E-mail inter_office@eurosolar.org, info@wcre.org
Website www.eurosolar.org, www.wcre.org

7–8 June 2005
Minneapolis, Minnesota, **USA**

Fuel Cell 2005: conference and exhibit on advancements in fuel cell applications and technology
Marsha Hanrahan, Fuel Cell Magazine, 1300 Nicollet Mall, Minneapolis, Minnesota 55403
Tel. 612 370 1234 • *Fax* 612 370 1463
E-mail marshah@infowebcom.com
Website http://www.fuelcell-magazine.com/fc_conf_index.htm

13–17 June 2005
Uppsala, **Sweden**

ISOHIM: 2nd International Symposium on Hydrogen in Matter
Academic Conferences, P O Box 7059, SE-750 07 Uppsala, Sweden
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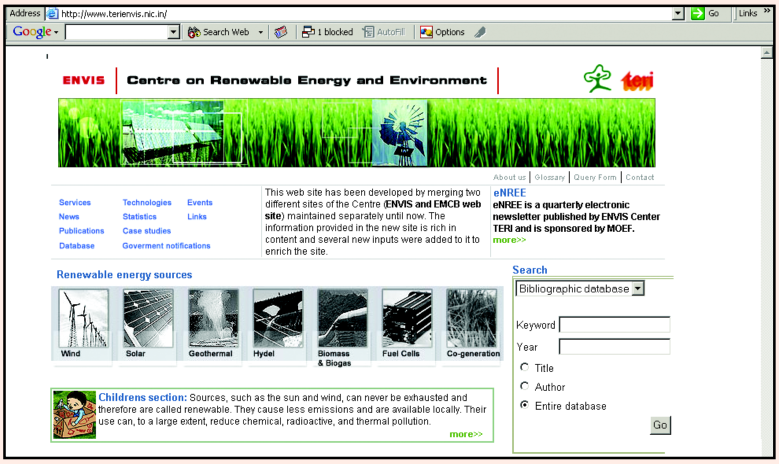
ENVIS Centre on Renewable Energy and Environment

A knowledge gateway



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To work towards saving the environment by understanding its myriad facets, the ENVIS (Environmental Information System) network was established under the MoEF (Ministry of Environment and Forests), Government of India, in December 1982. The objective was clear and urgent: work towards bridging the data gaps by developing an environmental information system that will help disseminate information to decision-makers, scientists, and other stakeholders.

The ministry selected certain institutions/ organizations, universities, academic/research bodies in state governments, corporate houses, and NGOs as ENVIS centres, based on their excellence in research activities. Each centre would work on a specialized subject from the vast expanse of environmental studies available.

TERI became the host to the ENVIS Centre on Renewable Energy and Environment in July 1984. The mandate for the TERI centre is to collect, collate, store, retrieve, and disseminate information on renewable energy and environment as well as to support and promote research and development. The Institute has also hosted the EMCB (Environment Management Capacity Building) Node on Renewable Energy and Environment since 2000/01, a sub-component of ENVIS that aims to build capacity through the development and maintenance of a web site that serves as an information clearing house.

This new-look, revamped website has helped achieve just what the centre set out to do display a world of information at a glance. TERI's ENVIS Centre and the EMCB Node have been actively engaged in resource generation, data collection, problem recognition and provision of solutions, capacity building, and information dissemination. Rich in content that is constantly updated, the site does an impressive job of plugging information gaps that existed in the renewable energy and environmental sectors. Besides, it draws the attention of the Indian scientific community, a fact that becomes evident from the hundreds of technical queries received through the website. Here's a snapshot of some of the main features of the site.

- Regular sections – news, events, statistics, etc. – provide updates on the environmental impact of power, renewable energy, transport, pollution control technologies, hazardous waste management, and other related subjects spanning local and national boundaries.
- Recently developed renewable energy technologies and case studies are added attractions.
- Review articles from the Centre's premier publication *TIDEE* (*TERI's Information Digest on Energy and Environment*) enrich the knowledge base of the scientific community by providing information on the latest developments in energy and environment.
- *eNREE* (*E-Newsletter on Renewable Energy and Environment*), a quarterly, non-priced, electronic newsletter (also uploaded on the site) highlights recent issues in the sector.
- The search function for the bibliographic database and the directory of experts can further be screened through categories such as title, author, etc. The online bibliographic database includes bibliographic records of selected fields from 1991 onwards, covering over 11 000 records. The centre is also building up an exhaustive Directory of Experts on Renewable Energy and Environment.
- The colourful and lively children's section, *Edugreen*, lives up to its tag line—'making environmental learning fun for the young'.

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