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## People participation in the promotion of biogas technology: a case study from western Uttar Pradesh, India

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## Biomass power generation and environmental impact

India recognized the potential role of renewable energy as an alternative energy source quite early, and has initiated one of the largest renewable energy programmes of the developing world, with a dedicated ministry (Ministry of Non-conventional Energy Sources) at the national level to guide the government policies and programmes.



## Current research on renewable energy and development

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## Technological developments

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# People participation in the promotion of biogas technology: a case study from western Uttar Pradesh, India

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## Abstract

Biogas has been widely accepted by the rural community in India as a renewable, energy-efficient technology as it provides clean fuel and fulfils the basic domestic energy requirements of cooking, water heating, and lighting. In India, the estimated potential for construction of family-size biogas plants is 12 million. However, even two decades after the launch of NPBD (National Project on Biogas Development), only about 30.6% of the estimated potential has been exploited by the end of December 2004. The paper examines the knowledge sharing and communication process for awareness generation, motivation, technology transfer, and capacity building of communities. It also analyses the ensuing benefits in terms of fuel saving, mitigation of women's drudgery, reduced pressure on biomass, increased availability of organic manure, and improved health conditions of the people. The paper highlights the replication of TERI biogas model in the area by locally trained masons and local back-up support.

## Introduction

The domestic sector in India is responsible for about 45% of the total primary energy use, a large share of which is through non-commercial/biomass fuels. Biomass fuels constitute the predominant source of energy, especially for cooking applications. However, more than 60% of Indian households depend upon these traditional sources of energy for meeting their energy needs (TEDDY 2003/04). Of the total fuel consumed in the domestic sector, the share of fuelwood is the highest, that is, 75.6% of the total fuel consumption. The latest NSSO (National Sample Survey Organization) report indicates that more than 90% of rural households continue to use firewood, coal, and dung cakes (NSSO 2001).

Under the given circumstances, one of the most significant challenges in the rural energy

sector is to maintain a sustainable supply of biomass fuels. Another strategy would be to increase the efficiency of biomass fuels. In terms of rural energy consumption, biogas as a technology, can not only increase the efficiency of biomass fuel (cattle dung), but also provide several other benefits. However, for long-term sustainability, it is important to generate understanding of the technology among communities and to enable local repair and maintenance by way of developing skills among the local people.

## National Project on Biogas Development

Over the years, biogas has gained popularity and has become the largest and most prominent amongst the rural renewable energy programmes being implemented by the Government of India. The dissemination of biogas plants began in 1981 with the launch of NPBD. The programme offered several benefits such as provision of clean energy in the form of gas, reduced pressure on dwindling fuelwood supplies and prevention of indiscriminate deforestation, elimination of smoke-filled cooking environment, reduction of drudgery involved in fuelwood collection, prevention of eye infections, improvement in rural sanitation, and making available enriched organic manure for fertilization. MNES (Ministry of Non-conventional Energy Sources) adopted a decentralized multi-agency and multi-model implementation strategy under the NPBD. Under the programme, of the estimated potential of 12 million family-size biogas plants, at the end of December 2004, only 3.67 million plants had been set up, which shows a coverage of 30.6% of the estimated potential. A study for monitoring of biogas plants installed from April to December 2002 was carried out through the regional offices of MNES, which indicated that overall functioning of plants is 86% (MNES 2002/03).

The use of these biogas plants results in the saving of 4.4 million tonnes of fuelwood and producing 45 million tonnes of manure per year.

### Target area

The project was carried out in the villages of block Gunnaur, district Budaun (Uttar Pradesh). The selection of villages was carried out with the help of TCSR (Tata Chemicals Society for Rural Development), which is a part of TCEL (Tata Chemicals Ltd), Babrala, Uttar Pradesh. The names of villages selected to carry out the biogas installation programme are given in Table 1.

**Table 1** Geographical area and population of selected villages

Revenue village	Area (hectares)	Population (number)
Baghau	522	1930
Dadpur	164	626
Mehua Hasan Ganj	627	2832
Pawari	367	1883

**Source** Details available at <<http://Budaun.nic.in>>, last accessed on 23 July 2005

The households were using traditional cookstoves, which produce large quantities of smoke due to their low burning efficiency. Biogas was introduced as a substitute for providing clean fuel and to keep the environment clean, apart from providing other benefits.

### Approach and project implementation

The project study aimed at disseminating biogas technology for conservation of fuelwood as well as providing a cost effective, convenient, and clean fuel. The approach focused on obtaining feedback on the performance of biogas plant, creating awareness, building local capacities for repair and maintenance, quality installation, and monitoring.

A feasibility survey had been carried out for assessing the potential of biogas plants, energy consumption pattern, and causes for the failure of Deenbandhu biogas plants in the villages earlier. Additionally training was provided to create a backup support for continuation of the technology, and management and monitoring of plants. Post-evaluation survey was also carried out in the villages.

Building awareness is the key strategy for providing knowledge among people so that they

can understand the working of the technology, expenditure involved, etc. An awareness generation campaign was carried out in the form of village meetings including technology demonstration, distribution of pamphlets and technical write-ups among the people, and open discussion forums for knowledge sharing. This helped in clarifying their doubts, explaining benefits and performance of the plants, etc.

Since the people had had a bad experience with the Deenbandhu model, they were not open to suggestions regarding the benefits of biogas plants, which became dysfunctional within six months of installation. However, a village meeting was held and the apprehensions of local people were dispelled. They were encouraged to consider construction of biogas plants for the villages, which has to be an appropriate biogas model instead of the previously installed model. The TERI model, which has performed well in different agro-climatic regions in India, was suggested, and a decision was made to introduce it in these villages. Thereafter, the households were selected on the basis of availability of sufficient dung, uninterrupted source of water throughout the year, proper space for construction, and willingness to share the cost. The local people were not only provided with information on the technical aspects related to the TERI model but also given field demonstration in the villages. This process helped in the final selection of the TERI model. Thereafter, two TERI biogas models were constructed by master masons in two different villages with the aim of showing the functional aspects of the model and motivating people to take the right decision in setting up the plant.

A feasibility survey for assessing the potential was carried out to choose suitable beneficiaries. Information concerning cattle population of the interested beneficiaries of biogas plants was collected in the selected villages. The selection of beneficiaries was made on the basis of the potential of dung availability, sufficient sunny space close to the kitchen and cattleshed for the installation of biogas plant, availability of water throughout the year, and their willingness to contribute to the plant cost. However, the source of water was mainly hand pump in all the interested households. Thus, 24 households showed willingness to have the plant (Table 2).

**Table 2** Distribution of beneficiaries who expressed willingness to install the biogas plants

Village	Number of beneficiaries	Number of cattle	Distance from plant to kitchen (metre)
Baghon Madayan	5	5-6	3-8
Dadpur	3	6	3-5
Mehua Hasan Ganj	12	5-6	5-8
Pawari	4	6	4-6

Source Village survey

The training need was felt because there were no trained masons in and around the selected villages (according to TCSRDR) for construction of biogas plants. Even so, the construction of biogas plants in a village was done by TCSRDR without creating back-up support for repair and maintenance at the local level. The emphasis of the training programme was to develop a tool at the local level so as to generate employment. Therefore, institutional mechanisms were created by way of developing skills for construction, repair, and maintenance among local masons; and skills for operation and servicing among users. A training programme for masons on construction, operation, repair, and maintenance of biogas plants was conducted by TERI at Babrala, Uttar Pradesh.

The trained masons in villages constructed the plants under the supervision of TERI staff. Thus, 10 TERI models of biogas plants were installed in five villages. However, more households showed willingness to install the plants when the villagers

found the plants to be working efficiently (Photo 1).

Thereafter, 12 biogas plants were installed in four villages. The beneficiaries shared the cost of the plant, which was equivalent to 50% of the total cost after government subsidy. The total cost of TERI biogas plant (2 m<sup>3</sup> capacity) was estimated at 8000 rupees. Twenty nine per cent cost was availed as a subsidy from the government while the balance was shared equally between the beneficiary and TCSRDR.

Commissioning of the plant was done through the biogas plant beneficiaries under the supervision of TERI staff. The beneficiaries were advised to arrange for about three tonnes of dung for 2-m<sup>3</sup> capacity of plant, and water in the same quantity. A mixture of dung and an equal proportion of water (1:1) was prepared by stirring in the mixing tank and fed into the plant. Three persons were involved for half a day to commission the plant.

TERI staff had monitored all the plants for a month after commissioning. The households were requested to record information pertaining to daily dung input, problems encountered, and observations. In addition to this, TERI staff carried out measurements of the gas produced, and checked pressure to find out leakage, if any, in all plants.

### Project benefits

The construction of plants would help the user families in various ways in addition to protecting them from environmental and health hazards. The use of biogas has led to an overall improvement in the standard of living. However, many people

apart from those in the villages under study have also been influenced by the programme. The project delivers both quantitative and qualitative advantages to the rural people. The qualitative benefits are described in Table 3.

### Qualitative benefits

In the households using biogas for cooking applications, the time spent in cooking or



Photo 1 Housewife cooking on biogas plant

**Table 3** Benefits of biogas technology application

Type	Benefits
Fuelwood conservation	The households observed that they save about 3–4 kg/day of dung cake (TERI 2001), which was used for cooking applications.
Reduced indoor air pollution	Reduction in smoke which affects the lungs
Availability of rich organic manure for field crops	The use of slurry reduces the use of chemical fertilizers. The use of biogas slurry increases crop yield by 6.5% to 16%. (Pal <i>et al.</i> 1996)
Reduced emission of CO (carbon monoxide) and CO <sub>2</sub> (carbon dioxide)	Use of these biogas plants will reduce the emission of CO and CO <sub>2</sub> .
Replacement of fuelwood	Total fuelwood replacement equivalent to the use of gas was found to be 12.71 tonnes per annum

preparing food items, preparation of dung cakes, and cleaning of blackened vessels of ash, etc., had reduced considerably. This time could be used for other beneficial activities. In addition to this, there are also economic benefits in terms of reduction of labour for fuel collection and savings in purchase of fuel, etc. Biogas is a clean fuel in the form of gas, the use of which will provide a clean and healthy environment in the house.

### Conclusion

In the selected villages, 22 biogas plants of 2 m<sup>3</sup> capacity were constructed and commissioned successfully, the use of which will save an equivalent of 12.71 tonnes of fuelwood per annum and reduce smoke emissions in the kitchen. Users were trained from villages in the construction, operation, commissioning, and repair and maintenance of biogas plants. After installation of 10 biogas plants in the previous phase, 12 more have been installed due to proper awareness, knowledge sharing, and installation of suitable biogas model. People's feedback on the functioning of plants was found to be highly satisfactory.

### Acknowledgements

I would like to express my sincere gratitude to Ms Alka Talwar, Manager, Tata Chemicals Society for Rural Development, Babrala (Uttar Pradesh),

for providing an opportunity to undertake the project. I am grateful to Dr R K Pachauri, Director-General, TERI, New Delhi for providing encouragement and support. I am also thankful to Mr I H Rehman, Associate Director, TERI for providing suggestions during the course of project implementation.

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# Biomass power generation and environmental impact

## Introduction

India recognized the potential role of renewable energy as an alternative energy source quite early, and has initiated one of the largest renewable energy programmes of the developing world, with a dedicated ministry (MNES [Ministry of Non-conventional Energy Sources]) at the national level to guide the government policies and programmes.

In India, population growth coupled with the absence of enough awareness regarding the availability of efficient fuel options, and higher costs, has led to the continued dependence of most rural households on biomass fuels for cooking energy, despite the fact that it produces lower efficiency. Biomass energy is largely used in rural areas, with cooking as its dominant end use activity. Fuelwood is one of the dominant biomass energy used in India, followed by crop waste and dung cakes (TERI 2004) Annual demand of these non-commercial fuels has been shown in Table 1. The data suggests that although fuelwood consumption decreases steadily over the years, it still remains the leading energy fuel in India. The reasons of the dependency are: low income level in rural households, low price of fuelwood, non-availability of alternatives, lack of awareness, and easy accessibility of rural populations to forests.

In this context, it is heartening to mention that improved education, government promotional measures, and NGOs' participation at different stages, have fostered usage of firewood in the negative direction. Apart from fuelwood, biomass energy consists of cattle dung and agricultural waste, used on a large scale as domestic cooking fuel in rural areas (Table 2).

**Table 1** Annual demand for biomass fuels (1994/95 to 2004/05)

Fuel type	1994/95	1999/2000	2004/05
Fuelwood (MT)	145.0	117.3	61.3
Agricultural waste (MT)	44.6	36.1	18.9
Dung cakes (MT)	79.4	64.3	33.6

**Note** MT – million tonnes

**Source** TEDDY 2003/04

## Biomass power generation and its benefits

The nodal ministry, MNES estimated the technical potential of total availability of renewable energy sources to be 102 GW (gigawatt). The dominant potential as estimated for various sources is: ocean 50 GW, wind (20 GW), and biomass (17 GW). According to Ravindranath and Hall (1995), the total power generation potential is estimated to be 142 GW, with biomass power accounting for 57 GW. A detailed assessment of biomass power potential in India has shown that by dedicating only 15 Mha (million hectares) (five per cent of geographic area at a woody biomass productivity of eight tonnes/hectare/year) to biomass production, the power generation potential could be estimated to be around 25 GW. Further there is a potential for additional grid-connected megawatt-scale systems estimated at 16 GW. Thus, the total feasible potential is estimated to be 41 GW from dedicated energy plantations. The study further showed that kilowatt-scale systems installed at the level of village or a cluster of villages could generate about 100 TWh (terawatt-hours) of electricity to meet all the rural electricity demands.

Dedicated land availability in India is estimated to be 66–130 Mha. Thus, less than 30% of the current degraded land is adequate to produce woody biomass sustainably, to meet all the rural electricity requirements as well as to feed into the national grid.

The Ninth Five-year Plan focused on the promotion of biomass-based power generation through demonstration programmes and financial incentives like interest subsidy. The target set for biomass-based power generation, including bagasse cogeneration, was 314 MW, however, the cumulative achievement was around 290 MW. The cumulative installation has been shown in Table 3.

The government planned to continue the promotion of biomass power generation during the Tenth Five-year Plan also with the target of installing 700 MW through biomass and bagasse cogeneration as per the estimation of the Planning Commission in 2002.

**Table 2** Fuel consumption pattern in rural households

Fuel	2001/02		2006/07		Share (%)
	Quantity	Calorific replacements ('000 tonnes)	Quantity	Calorific replacements ('000 tonnes)	
Coal/soft coke (thousand tonnes)	400	600	400	600	0.25
Kerosene (thousand kilolitres)	1 863	11 551	2 290	14 198	6.06
Biogas (million cubic metres)	1 360	4 760	2 040	7 140	3.05
Dung cake (thousand tonnes)	94 858	28 457	98 709	29 613	12.64
Crop wastes (thousand tonnes)	38 959	23 765	40 882	24 938	10.65
Firewood (thousand tonnes)	17 316	132 875	210 508	157 748	67.35
<b>Total</b>	—	202 008	—	234 237	100.00

Source TEDDY 2003/04

**Table 3** Biomass power and cogeneration status in India

Project status	Biomass power		Cogeneration		Total	
	MW	Number	MW	Number	MW	Number
Commissioned	234	45	379	50	613	95
Under implementation	297	43	347	39	644	82

Note MW - megawatt

Source TEDDY 2003/04

Biomass-based power plants are ideal for decentralized applications in rural areas, where either it is expensive to extend the grid or the power demand is low. Agro residues as well as biomass from the agro-processing industries could be used for power generation using biomass gasifiers. Till 31 March 2004, the total installed capacity of biomass gasifiers was 58 MW. During the Ninth Plan, gasifier systems of about 42 MW equivalent had been installed; the target set was equivalent to 40 MW. The present Tenth Plan has a target of 50 MW.<sup>1</sup>

While comparing efficiency of non-commercial fuels used for cooking, it has been found that fuelwood provides an efficiency of 13%–16%, dung cakes 8%, charcoal 16%, while biogas stoves provide an efficiency of 55%.

## Government initiatives

Of all the renewable energy resources biomass is the largest, most diverse, and most readily exploitable source of energy. Biomass can be converted to high-energy combustible gas for use in internal combustion engine for mechanical or electrical applications. This is done through a two-stage process of biomass gasification. In the first phase, biomass undergoes partial combustion to generate gas and charcoal. In the second, charcoal reduces to a producer gas consisting of carbon monoxide and hydrogen as also other gases such as nitrogen. The producer gas can be used in internal combustion engines for mechanical applications such as lifting water and electricity generation.

Gasifiers are readily available in capacities ranging from 20 kW to 500 kW to multi-megawatt. Indigenously developed technology for biomass gasifiers, though readily available from a few manufacturers, is still in the demonstration stage in various parts of India. MNES is promoting gasifiers for electrical as well as thermal applications. In recent years, the country has taken up several such programmes to promote biomass-based electricity systems such as biomass gasifiers, biomass combustion, and cogeneration. The biomass gasification programme involves the promotion of gasifiers through a market approach

<sup>1</sup>Details available at, <<http://www.mnes.nic.in>>, last accessed on 10 September 2005

for mechanical, thermal, and electrical applications with a focus on village electrification. MNES provides financial assistance for preparing project reports for assessing feasibility and for seeking funding for biomass gasifier-based village electrification projects. Till March 2004, the total installed capacity of biomass gasifiers was 58 MW, with 22 new systems commissioned in Gujarat and West Bengal, having a total capacity of 4845 kW. MNES also provides financial incentives at a fixed rate of about 30% of the cost of a gasifier for thermal application and 60% of the cost for mechanical and electrical applications. For rural electrification projects, the assistance is about 75% (MNES 2004).

MNES also launched the National Biomass Power Programme to establish the techno-economic feasibility for power generation from biomass materials of different types including straw, stalk, stems, husk, forestry residues, and biomass from dedicated energy plantation. The combustion technologies could include combustion, gasification, and incineration. In this case also MNES is providing adequate funding for preparation of feasibility studies, and subsidy for demonstration as well as commercial projects. MNES further provides several fiscal incentives such as accelerated depreciation, income tax holiday, exemption or reduction in customs duty, central excise duty, central sales tax, and general sales tax. State governments also provide several financial and fiscal incentives for such projects. However, investors have to pay some other taxes, follow government procedures, and obtain clearances and approvals from different agencies. A large number of biomass-based assessment studies and subsequent power generation projects have been carried out in different parts of India. The total commissioned capacity of biomass-based power till March 2004 was 234 MW.

The total bagasse-based cogeneration installed capacity as on March 2004 was 379 MW. However, the installed capacity so far is marginal compared to the potential of 3500 MW since India is the largest producer of sugar in the world—production of sugar generates huge quantity of bagasse (MNES 2001). A break-up of bagasse cogeneration potential is given in Table 4.

**Table 4** Bagasse-based cogeneration potential

State	Potential (MW)
Andhra Pradesh	200
Gujarat	200
Karnataka	300
Maharashtra	1000
Punjab	150
Uttar Pradesh	1000
Others	300
<b>Total</b>	<b>3500</b>

Source MNES (2001)

In bagasse-based cogeneration, MNES provides financial incentives including grants and soft loans. Several innovative schemes have been initiated by the MNES to promote cogeneration in sugar mills, but response from sugar mills is still not very encouraging. The major constraints in setting up of cogeneration projects are high costs, lack of attractive policies, and power purchase costs. In addition, high working capital to run the biomass power plant is also considered as one of the limiting factors. Off-seasonal operation of cogeneration projects is a critical issue that affects the viability of a bagasse cogeneration plant.

### Socio-environmental impacts

Renewable energy provides an enormous opportunity for India in meeting its energy needs as well as helping its efforts to protect the environment. It is therefore, necessary to understand the environmental implications of biomass use as an energy source (Ravindranath, Rao, Natarajan, *et al.* 2000).

- Contribution to deforestation and forest degradation, leading to loss of biodiversity and soil degradation
- Atmospheric pollution due to emission of GHGs (greenhouse gases) during combustion of wood, with its implications for climate change
- Release of pollutants leading to domestic health hazards
- Loss of nutrients due to combustion of cattle dung and crop residues

In the past, reports have repeatedly indicated a high order of unsustainable firewood consumption in Indian forests and urban plantations. With every passing decade, the gap between fuelwood consumption and sustainable production increases rapidly. The Forest Survey of India's study in 1997 has shown the gap as 207 million cubic metres, which leads to land degradation as well as deforestation. Adverse environmental effects of fuelwood use are due to unsustainable extraction from environmentally sensitive areas, which can lead to degradation of watershed and catchment areas, loss of biodiversity and habitat, etc. On the other hand, unavailability of fuelwood can adversely affect living standards, employment, and consumption. The adjustment may negatively impact the working pattern, family nutrition and health, as well as the environment, agricultural productivity, and incomes.

The capacity of bio-energy to meet energy needs and to deliver socio-economic and environmental benefits has been established before through national-level assessments and studies. These assessments have shown that dung and leaf litter-based biogas systems could meet all the rural cooking energy requirements leading to conservation of about 200 MT fuelwood. Besides, small-scale biomass gasifier of capacity 20–200 kW at the village level could generate upto 100 TWh electricity enough to meet the rural energy needs. Further, adoption of bio-energy would enable us to reap benefits in social, economic, and environmental aspects. These benefits include

- Local employment generation in villages
- Improvement in the quality of life
- Participation of the local institute at the village level in planning, implementation, and management of bio-energy systems

- Local environmental benefits such as land reclamation and pollution control
- Global benefits such as reduction in GHG emissions
- Conservation of fuels (kerosene, diesel) leading to reduction in petroleum imports
- Savings of national revenue in subsidies
- Stabilization of the national grids

Reduction in forest clearing for fuelwood through biogas and improved stove programmes would contribute to biodiversity conservation. Raising energy plantation in degraded lands for biomass power projects with appropriate species choice and density, and leaving a fraction of degraded land for forest succession, will also significantly contribute to conservation and promotion of biodiversity outside the forest ecosystems.

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## Abstracts

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

\*EdCIL (Educational Consultants India Ltd), EdCIL House, 18 A, Sector 16A, Noida – 201 301, India

In recent years, 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.

(7 tables, 6 references)

Sundaresan S. 2005. **Solar home systems: offering credit and ensuring recovery.** *Refocus* 6(1): 38-41

Studies have concluded that provision of credit would contribute to widespread deployment of SHS (solar home systems) among populations otherwise deprived of access to modern electricity services. Paradoxically, offering credit also represents a significant source of risk to the

creditors, given the nature of the product and specifics of the market. Pre-payment systems could offer a way out of this impasse, and programme designers could do well to pay greater attention to the development, testing, and deployment of such systems. (8 references)

Gupta R\* and Tiwari G N. 2005. **Modelling of energy distribution inside greenhouse using concept of solar fraction with and without reflecting surface on north wall.** *Building and Environment* 40(1): 63-71

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A considerable portion of the solar radiation falling on transparent north wall/roof inside an east-west-oriented greenhouse is lost due to low-altitude angle of sun during winter months. Replacing the transparent north wall with a reflecting surface can increase solar radiation on the floor of the greenhouse. The effect of vertical and inclined reflecting north wall on distribution of solar

radiation on the floor of greenhouse has been studied for five different locations in India: Chennai, Delhi, Jodhpur, Kolkata, and Srinagar. Evenspan greenhouse (6 m×4 m×3 m) has been considered for the present study. The proposed model can also be used to determine the distribution of solar radiation for any other place and shape of the greenhouse. (8 figures, 2 tables, 11 references)

Pohekar S D and Ramachandran M. 2004. **Multi-criteria evaluation of cooking energy alternatives for promoting parabolic solar cooker in India.** *Renewable Energy* 29(9): 1449-1460

CREED (Center for Renewable Energy and Environment Development), BITS (Birla Institute of Technology and Science), Pilani – 333 031, India

In this paper, the policy formulation for substitution of cooking energy with renewables is addressed in multi-criteria context. A survey is conducted to know the perceptions of different decision-making groups on present dissemination of various cooking energy alternatives in India. Nine cooking

energy alternatives are evaluated on 30 different criteria comprising technical, economic, environmental/social, behavioural, and commercial issues. PROMETHEE (Preference Ranking Organization Method for Enrichment Evaluation), a multi-criteria decision-making

method of outranking nature is used to rank the alternatives. It is found that liquefied petroleum gas stove is the most preferred device, followed by kerosene stove, solar box cooker, and PSC (parabolic solar cooker). A sensitivity analysis is

also carried out for identifying potential areas for improvement of PSCs. On the basis of results, strategies for promoting widespread use of PSCs are formulated. (1 figure, 3 tables, 26 references)

Banerjee R. 2006. **Comparison of options for distributed generation in India.** *Energy Policy* 34(1): 101-111  
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This paper reviews the different technological options available for DG (distributed generation), their current status, and evaluates them on the basis of cost of generation and future potential in India. The non-renewable options considered are internal combustion engines fuelled by diesel; natural gas; and micro-turbines and fuel cells fired by natural gas. The renewable technologies considered are wind, solar photovoltaic, biomass gasification, and bagasse cogeneration. The cost of generation is dependent on the load factor and discount rate.

Gas engines and bagasse-based cogeneration are found to be the most cost-effective DG options while wind and biomass gasifier-fired engines are viable under certain conditions. PEM (polymer electrolyte membrane) fuel cells and micro turbines based on natural gas need a few demonstration projects and cost reductions before becoming viable. A strategy involving pilot projects, tracking of costs, and dissemination of information is likely to result in DG meeting 10% of India's power needs by 2012. (7 figures, 6 tables, 23 references)

Latha K M\* and Badarinath K V S. 2005. **Seasonal variations of black carbon aerosols and total aerosol mass concentrations over urban environment in India.** *Atmospheric Environment* 39(22): 4129-4141

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Aerosol optical properties are one of the important global geophysical variables required in climate modelling studies. In the present study, changes in the response of near-surface aerosol properties and their association with meteorological parameters have been studied. Diurnal variations of BC (black carbon) aerosols showed a gradual build up in BC concentration from morning, a sharp peak between 7:00 AM and 9:00 AM almost an hour after the local sunrise, and a broad nocturnal peak from 21:00 PM to 2:00 AM. Total aerosol mass concentration showed positive correlation with air temperature and wind speed. Diurnal variation of coarse mode and accumulation mode particles showed a

nocturnal high and daytime low. Aerosol mass size distribution showed possibly a multi-modal size distribution over the study area. Coarse mode particle loading was observed to be high during summer and accumulation mode particles were observed to be high during winter. Seasonal variations of BC aerosol mass concentration showed high concentrations during dry season and low concentrations during the monsoon season. Monthly average AOD (aerosol optical depth) values gradually increased from January to April and then decreased after May. The average share of BC to the total mass concentration has been observed to be 15%. (15 figures, 1 table, 32 references)

Radulovic V. 2005. **Are new institutional economics enough? Promoting photovoltaics in India's agricultural sector.** *Energy Policy* 33(14): 1883-1899

*Department of Geography and Development Studies Institute, London School of Economics, Houghton Street, London WC2A 2AE, UK*

Solar PV (photovoltaic) technology can be used for rural electrification. Currently, policy-makers

are seeking ways to expand markets for off-grid PV from SHS to enhance income generation and

contribution to social development. This paper explores the role of the state in promoting such market growth. As a start, the state must improve institutions, thus echoing popular recommendations based in NIE (new institutional economic) theory that are currently touted by the World Bank and other large development agencies. Yet, NIE's framework may be insufficient because it fails to offer viable solutions to overcoming political barriers that contribute to technological path dependency. The author highlighted a case study in Punjab, India, where an agricultural PV water-pumping programme

showed promising signs of successful market penetration in its first three years of operation. The programme was beginning to penetrate market entry for PV pumps via competition between PV providers. However, the Government of India achieved this feat by providing subsidies to farmers. Based on findings, the author suggested that states should look beyond NIE's framework to expand and improve PV markets in productive uses by accounting for political constraints, assessing how PV technology can improve development goals, and cultivating locally appropriate service delivery models. (4 figures, 1 table, 72 references)

**Kumar A and Kandpal T C. 2005. Solar drying and CO<sub>2</sub> emissions mitigation: potential for selected cash crops in India. *Solar Energy* 78(2): 321-329**  
*Centre for Energy Studies, Indian Institute of Technology Delhi, Hauz Khas, New Delhi - 110 016, India*

An attempt to estimate the potential of solar crop drying for some selected cash crops in India has been made in this paper. The amount of cash crops that can be dried by solar dryers and the required aperture area of solar dryers has been estimated. Estimates for unit cost of solar drying for

different crops have also been worked out. The potential of net fossil CO<sub>2</sub> (carbon dioxide) emissions mitigation due to the amounts of different fuels that would be saved by solar drying has been estimated along with the unit cost of CO<sub>2</sub> emissions mitigation. (4 tables, 25 references)

**Kumar R and Umanand L. 2005. Estimation of global radiation using clearness index model for sizing photovoltaic system. *Renewable Energy* 30(15): 2221-2233**  
*Centre for Electronic Design and Technology, Indian Institute of Science, Bangalore - 560 012, India*

A methodology for developing a simple theoretical model for calculating global insolation on a horizontal surface is described in this paper. The input parameters to the model are the latitude of the desired location and the amount of total precipitable water content in the vertical column at that location. Both the parameters are easily measurable with an inexpensive instrument such as GPS (global positioning system). The principal idea behind the paper is to have a model that could be used for designing a PV system quickly and within reasonable accuracy. The model in this paper has

been developed using measured data from 12 locations in India covering the length and breadth of the country over a period of 9–22 years. The model is validated by calculating theoretical global insolation for five locations and comparing them with the measured insolation values for these five locations. The model is further validated by comparing the calculated and measured values of the insolation. The deviation was less than 20% between the values. This gives the credibility of the model and the methodology used for developing the model. (6 figures, 4 tables, 10 references)

**Khoiyangbam R S, Kumar S, Jain M S, 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<sub>4</sub> (methane) emissions from the slurry displacement chambers of different fixed-dome type biogas plants (capacity 2 m<sup>3</sup>) installed in the

hilly and plain regions of northern India were quantitatively estimated. The slurry temperature in 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 affects the CH<sub>4</sub> flux. CH<sub>4</sub> fluxes from the plants ranged between 7 g m<sup>-2</sup> d<sup>-1</sup> and 120 g m<sup>-2</sup> d<sup>-1</sup>. In the northern plain, temperature remains warm (21–33 °C) throughout the year except during winter. Seasonal emission of CH<sub>4</sub> ranged between

10 g m<sup>-2</sup> d<sup>-1</sup> and 178 g m<sup>-2</sup> d<sup>-1</sup>. The annual average CH<sub>4</sub> emission from the biogas plants in plain areas was 83.1 g m<sup>-2</sup> d<sup>-1</sup> as compared to 43.1 g m<sup>-2</sup> d<sup>-1</sup> in the hilly areas. Annual contribution per plant to the global CH<sub>4</sub> budget from a fixed-dome biogas plant in the plain region of northern India was 53.2 kg (kilogram) as compared to 22.3 kg in hilly areas. (4 figures, 1 table, 11 references)

Bhattacharya S C, Salam P A, Runqing H, Somashekar H I, Racelis D I, Rathnasiri P G, Yingyuad R. 2005. An assessment of the potential for non-plantation biomass resources in selected Asian countries for 2010. *Biomass and Bioenergy* 29(3): 153–166  
Energy Field of Study, School of Environment, Resources, and Development, Asian Institute of Technology, P O Box 4, Klongluang, Pathumthani – 12120, Thailand

This paper presents a synthesis of assessment of the energy potential of non-plantation biomass resources in five Asian countries: China, India, Philippines, Sri Lanka, and Thailand. It is based on the detailed national-level studies carried out in these countries under the ARRPEEC (Asian Regional Research Programme in Energy, Environment, and Climate). The national-level studies were undertaken to estimate the energy potential of (i) primary residues, (ii) secondary and processing residues, (iii) animal manure,

(iv) municipal solid wastes, and (v) fuelwood released through efficiency improvement and substitution by other fuels. The sustainable potential of non-plantation biomass resources in 2010 in China, India, Philippines, Sri Lanka, and Thailand is estimated to be about 8.90, 8.77, 0.97, 0.14, and 0.82 EJ (exajoule), respectively. The potential is estimated to be about 17%, 45%, 34%, 33%, and 14% of the projected total energy consumption in 2010, respectively, in these countries. (11 tables, 16 references)

Ravindranath N H, Somashekar H I, Nagaraja N S, Sudha P, Sangeetha G, Bhattacharya S C, Salam P A. 2005. Assessment of sustainable non-plantation biomass resources potential for energy in India. *Biomass and Bioenergy* 29 (3): 178–190  
Centre for Sustainable Technologies, Indian Institute of Science, Bangalore – 560 012, India

In India, fuelwood, crop residues, and animal manure are the dominant biomass fuels, which are mostly used in the rural areas. However, they produce very low efficiencies when compared with other high-energy fuels such as liquefied petroleum gas. Industrial and municipal (urban) residues such as waste water, MSW (municipal solid wastes), and crop residues such as rice husk and bagasse can also be used for energy generation. In this paper, the potential of energy

from crop residues, animal manure, MSW, industrial waste water, and biomass fuels that can be conserved for other applications through efficiency improvement is discussed. The total potential of energy from these sources in 1997 is estimated to be equivalent to 5.14 EJ, which amounts to a little more than a third of the total fossil fuel use in India. The energy potential in 2010 is estimated to be about 8.26 EJ. (14 tables, 26 references)

Kannan G K, Gupta M, and Kapoor J C. 2004. Estimation of gaseous products and particulate matter emission from garden biomass combustion in a simulation fire test chamber. *Atmospheric Environment* 38(39): 6701–6710  
Centre for Fire, Explosive, and Environment Safety, Defence Research and Development Organization, Timarpur New Delhi – 110 054, India

Open burning of garden biomass in cities gradually deteriorates air quality. This study was

aimed to estimate the emissions from different types of garden biomass, namely grass, leaves,

twigs, and their mixtures in a controlled SIFT chamber. Though the particulate emission ( $1.51 \text{ g kg}^{-1}$ ) was lowest from grass, the particle size distribution indicates that the emission contains 10% of fine particulates ( $<2.5 \mu\text{m}$ ) and about 70% of respirable particulate matter ( $<10 \mu\text{m}$ ). On the other hand, leaves, though generating  $32.3 \text{ g kg}^{-1}$  particulate matter formed about 40% non-respirable matter.  $\text{CO}_2$  (carbon dioxide) emission from leaves ( $1064.6 \text{ g kg}^{-1}$ ) and twigs ( $897.3 \text{ g kg}^{-1}$ ) was significantly lower than the emission from a mixture ( $1423 \text{ g kg}^{-1}$ ) of equal proportion of these two. A similar trend is observed in case of carbon monoxide and nitrogen oxide emissions. However, hydrocarbon

emission followed a reverse trend of emitting high emission load ( $11.4 \text{ g kg}^{-1}$ ) in the mixture of leaves and twigs than their individual type ( $2.4 \text{ g kg}^{-1}$  (leaves) and  $0.2 \text{ g kg}^{-1}$  (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 the mixture (1:1:1), having 0.07. The particulate matter emission load computed for the cities of India shows that leaves and grass contribute 97 tonnes and 4.5 tonnes  $\text{day}^{-1}$ , respectively. Among the gaseous pollutants,  $\text{CO}_2$  emission was the highest, as the computed values were 3212 tonnes  $\text{day}^{-1}$  from leaves and 92 tonnes  $\text{day}^{-1}$  from grass. (7 figures, 5 tables, 30 references)

## Technological developments

### Renewable energy technology to offset emissions and improve road safety

The IHT™ (Inter-seasonal Heat Transfer) technology that uses the surfaces of motorways to collect and store energy for heating and cooling roads and buildings throughout the year began official trials in August 2005. The technology uses underground energy reservoirs and hidden heat pumps to turn solar energy collected via the tarmac motorway road surface into useable power. IHT is a low-cost, low-maintenance process that collects solar energy and stores it for use in heating buildings or road surfaces in winter and cooling in summer. It uses standard building industry components, and will thus keep winter roads dry thereby reducing motorway maintenance and improving road safety. Besides, IHT technology could also make a significant contribution to reducing global warming by cutting fossil fuel use.

*Refocus 2005, 6(4): 7*

### Green power from chicken litter

Gasification has the potential to provide a cost-effective, environmentally benign disposal option for wastes such as chicken litter while providing heat, power, fuel (such as hydrogen), and fertilizer. The GTI (Gas Technology Institute)

has successfully demonstrated that chicken litter can be gasified to produce hydrogen and generate electricity using an SOFC (solid oxide fuel cell). As part of the project, GTI conducted a test to demonstrate the suitability of chicken litter as a low-BTU (British thermal units) fuel for the SOFC. The fuel gas was produced in a bench-scale fluidized bed gasifier operated at  $1550^\circ\text{F}$  with the chicken litter feed. Air and steam were used as the gasifying media. A five-cell SOFC stack was operated at  $1470^\circ\text{F}$  on the slipstream from the gasifier. A ZnO (zinc oxide)-based sorbent bed was used to remove  $\text{H}_2\text{S}$  in the fuel gas prior to entering the SOFC stack. An average power density is about 40% of that obtained from reformed natural gas due to this low-BTU ( $80 \text{ BTU/ft}^3$ ) fuel. Post-test disassembly confirmed no carbon deposition on the SOFC nickel anode and did not indicate any unusual state of the stack active components.

Details available at <http://www.gastechnology.org/>, last accessed on 15 July 2005

### Researchers make advances in wind energy generation

Engineers at the University of Alberta have created a wind energy generator that could be used to power their own homes. The traditional problem with harnessing wind energy has been the high cost and the low return of energy,

especially for small-scale generators. Besides, current small-scale wind energy generators require wind speeds of at least 18 km/h (kilometres per hour) to generate any power, but the new device could be used in low-wind environments, such as 10 km/h. The present open loop control system of the new generator can be built with a few, simple electronic components that are cheap and easy to find, use, and repair. The system can transfer even light winds into electric energy. The generator was designed and tested and possibly will be in the market soon.

The generators could be used at remote locations outside of the city, where the power supply is more expensive and less abundant.

Details available at <<http://www.physorg.com>>, last accessed on 18 July 2005

### **Catalyst support structures facilitate high-temperature fuel reforming**

The catalytic reforming of liquid fuels offers an attractive solution to supplying hydrogen to fuel cells while avoiding the safety and storage issues related to gaseous hydrogen. Researchers at the University of Illinois at Urbana-Champaign have developed porous support materials that can withstand the rigors of high-temperature reforming of hydrocarbon fuels. The catalyst support structures have a high surface area, are stable at high temperatures, and possess a low pressure drop, which are a must for effective hydrocarbon fuel reforming. To fabricate the supports, the researchers begin the experiment by placing a polydimethylsiloxane mould onto a flat surface, forming a channel about 500 microns wide that is open at both ends. A slurry, containing polystyrene spheres that are 50 nanometres to 10 microns in diameter, is allowed to flow into the channel from one end by capillary action. Once the slurry reaches the other end of the channel, the spheres begin to pack together and the packing process continues towards the inlet end. After the packing process is completed, remaining solvents are removed, which leaves a sacrificial template consisting of a bed of closely packed spheres. Next, the researchers fill the spaces between the spheres with a low-viscosity, pre-ceramic polymer-based liquid. After low-temperature curing, the mould is removed, leaving a stable, freestanding structure. Lastly,

the cured ceramic precursor is pyrolysed at 1200 °C for two hours in an inert atmosphere. The polystyrene spheres decompose during pyrolysis and the end result is a silicon carbide or silicon carbonitride replica with a tailored structure of interconnected pores. To demonstrate the use of these materials as catalyst supports, the researchers coated samples of the porous structure with ruthenium. The structure was then incorporated within a stainless steel housing, where it successfully stripped hydrogen from ammonia at temperatures up to 500 °C.

Details available at <http://www.physorg.com>>, last accessed on 27 July 2005

### **Solar powered housing complex**

India's first solar powered housing complex will come up at Rajarhat, a new township near Kolkata. The West Bengal Renewable Energy Development Authority in association with a local real estate company would develop 24 green energy houses. The solar powered system installed on each house would generate 250 kWh (kilowatt hour) per month. The house owners would be eligible to get 250 kWh free and a subsidy of Rs 0.4 would be levied for each unit of power consumed thereafter till the next 200 kWh.

*PV News 2005, 24(8): 6*

### **India's first bio-diesel power plant in Madhya Pradesh**

India's first bio-diesel power plant will come up in Madhya Pradesh by November. The plant is being set up by the Madhya Pradesh Urja Vikas Nigam under a central government plan to electrify rural areas. The plant will come up in the Bansdhari village of Mandla district. The plantation for bio-diesel plants (*Jatropha*, locally known as *ratanjot*) has already started in various areas of Mandla on 10 hectares (one hectare is about 2.5 acres; one acre is 4840 square yards) of land. The plant will generate 15 kW of power and will give sufficient power for lighting two electric bulbs, a fan, and a tubewell in a household.

*Business Standard, 6 August 2005*

### **Conversion of water to hydrogen gas**

Chemists at the Air Force Research Laboratory are several steps closer to teasing hydrogen fuel

from water using man-made molecular devices that collect electrons and use them to split hydrogen from oxygen. Electrons are negatively charged particles that allow atoms to react and form bonds. The researchers were able to use light to initiate electron collection and deliver the electrons to the catalyst site where they can be used to reduce water to hydrogen.

Details available at <<http://www.physorg.com>>, last accessed on 29 August 2005

### **Haryana implements solar technology**

The Department of Renewable Energy, Haryana has implemented SPV technology, which enables the direct conversion of sunlight into electricity without the use of moving parts and without causing any pollution. Haryana now intends to promote SPV domestic lighting system, SPV street lighting system, SPV power pack, etc. For procuring SPV home lighting system, the central government is providing for 50% of the expense or Rs 2400, whichever is less. A new scheme on demonstration and promotion of solar devices/system, in urban areas is being launched to create awareness among the beneficiaries. The SPV water-pumping programme is being launched to meet the irrigation needs of the farmers.

### **Oxidation catalyst could reduce diesel emissions**

A new application of silver hollandite could make a big impact in diesel emissions control. Researchers at the PNNL (Pacific Northwest National Laboratory), United States have developed an inexpensive method of synthesizing nano-sized silver hollandite and have found that the material has unique catalytic properties that can completely oxidize nitrogen oxides, CO (carbon monoxide), and hydrocarbons. These chemical reactions caused by silver hollandite are key to reducing pollutants in diesel engine emissions. PNNL researchers have also discovered that silver hollandite is an excellent low-temperature sulphur oxide absorbent. Unlike most oxidation catalysts, which can be easily poisoned by sulphur oxides, silver hollandite maintains its catalytic activity even while it ages by absorbing sulphur oxides.

Details available at <<http://www.eurekalert.org>>, last accessed on 23 August 2005

### **Nanotechnology for recovery and reuse of spilled oil**

The recent hurricane disaster has resulted in an oil crisis. Apart from the shortage there are reports of oil spills. The ISC (Interface Science Corporation) has announced that the company is launching its proprietary oil remediation and recovery application utilizing nanotechnology for this purpose. The use of treated material absorbs about 40 times its weight in oil, far exceeding existing commercially available remediation materials. Because water is completely rejected by the ISC material, the oil can be recovered for use, a substantial benefit in oil spill cleanup efforts. The new oil cleanup solution uses patented Self-Assembled Monolayer technology. The technology was recently announced and is of extreme importance. This highly effective material shall help mitigate the environmental and health impacts caused by the approximate 3000 worldwide annual oil spills. This technology is a path-breaking one in the oil spills recovery and remediation process. Apart from being eco-protective, it is also useful as most of the spilled oil is recovered.

Details available at <<http://www.torconsult.com>>, last accessed on 9 September 2005

### **Zinc powder to drive hydrogen car**

A revolutionary method of using concentrated solar energy for producing hydrogen in a clean, safe, and inexpensive way was developed by a cooperation of scientists from France, Israel, Sweden, and Switzerland. This new method, based on the production of pure Zn (zinc), may enable an easier and quicker move to a hydrogen-based economy thus reducing the need for depleting petroleum and its polluting side effects.

Since Zn is a relatively abundant metal, and is the fourth among all metals in world production, it can be considered a natural choice for producing hydrogen. However, the current industrial production of pure Zn from ZnO (zinc oxide) is highly energy intensive and concomitant to pollution. In the new method, ZnO is mined and transported to the solar heating facility where it is mixed with small amounts of coal and put inside the solar furnace located on top of a high tower. A large array of heliostats (computer-guided highly reflective mirrors)

follows the sun around the sky and reflects the light to a hyperbolic mirror located inside the solar tower producing highly concentrated heat inside the solar furnace. At a temperature of above 1200 °C, ZnO breaks down into Zn and oxygen, which in turn recombines with the carbon to create CO as a minor by-product. Zn is then cooled down to create a fine powder, which can be safely handled and transported. In order to produce hydrogen from Zn powder a much simpler process is performed where Zn is mixed with water at a temperature of 350 °C (662 F). The oxygen inside the water recombines with the Zn to produce ZnO once again and the by-

product is pure hydrogen. This process has many advantages over the existing ways of producing hydrogen. First and foremost it uses a renewable form of energy, the sun. Furthermore the main material required for the process is the relatively inexpensive ZnO, which is almost completely recycled back by the end of the process. Another important advantage is that the hydrogen could be produced where it is needed, at the local fuel station instead of transporting large amounts of explosive hydrogen across the country.

Details available at <<http://www.isracast.com>>, last accessed on 11 September 2005

## Web updates

### Energy Efficiency and Renewable Energy

<http://www.eere.energy.gov>

EERE (Energy Efficiency and Renewable Energy) information centre functions under the Department of Energy, US (United States) and works to strengthen America's energy security, environmental quality, renewable energy usage, and economic vitality in public-private partnerships to enhance energy efficiency and productivity. The website is a gateway to hundreds of website links and thousands of online documents on energy efficiency and renewable energy. Besides, the site also hosts different sections on news, technologies, events, various national programmes, renewable energy information, and a customized information centre.

### International Solar Energy Society

<http://www.ises.org/>

ISIS (International Solar Energy Society) is a multi-faceted, global organization having clearly defined goals, extensive communication networks, and real world projects. ISIS brings together industry, science, and politics in support of renewable energy technologies. The website contains publications on renewable energy technology and policy. It also contains a

worldwide information system in the field of renewable energy.

### Energy Development Co-operative

<http://www.unlimited-power.co.uk/>

The online shopping centre EDC (Energy Development Co-operative) Ltd, provides the latest solar energy and wind power technologies, and solar and wind energy services at excellent prices. This site provides an online energy catalogue and ordering system. It also provides links to other websites.

### Solar Energy International

<http://www.solarenergy.org/>

The SEI (Solar Energy International) assists in planning, and provides education and technical assistance in the field of renewable energy technologies. It provides online education, training, technology transfer programme, and project on renewable energy. The website contains a newsletter and links to other related websites.

### Fuel Cell Information System

<http://www.ds-leipzig.de/fuelcell.html>

The site provides information about European fuel cell applications in the energy supply sector, the new strategy, types, characteristics,

conferences, and workshops. It also contains project information, reading materials, and links.

### **Biomass: power generation technology**

[http://www.nrel.gov/research/industrial\\_tech/power.html](http://www.nrel.gov/research/industrial_tech/power.html)

This section of the National Renewable Energy Laboratory website provides information on biomass used for power production including biomass gasification for power production and cogeneration of steam. This website also provides links to other biomass technological project websites.

### **National Hydrogen Association**

<http://www.ttcorp.com/nha/>

The National Hydrogen Association fosters the development of hydrogen technologies and their utilization in industrial and commercial applications, and promotes the transition role of hydrogen in the energy field. The website contains codes and standards, events, commercialization plan for hydrogen applications, publications list, and sourcebook for hydrogen applications. It also provides links to related websites.

## **Forthcoming events**

3–6 October 2005  
Singapore

### **WHTC (World Hydrogen Technology Convention) 2005**

WHTC 2005 Registration Manager, 73 Bukit Timah Road, Rex House, Singapore – 229 832

*Tel.* +65 6330 6834 • *Fax* +65 6336 2123

*E-mail* [eventmanager@whtc2005.com](mailto:eventmanager@whtc2005.com) • *Website* [www.whtc2005.com](http://www.whtc2005.com)

4–6 October 2005,  
Westminster, London,  
UK

### **Ninth Grove Fuel Cell Symposium**

Gill Heaton, Grove Fuel Cell Conference Secretariat, Hillside Cottages, Wheatley Road, Islip, Oxford OX5 2TF, UK

*Tel.* +44 1865 373 625 • *Fax* +44 1865 375 855

*E-mail* [grovefuelcell@elsevier.com](mailto:grovefuelcell@elsevier.com) • *Website* [www.grovefuelcell.com](http://www.grovefuelcell.com)

6–7 October 2005  
Berlin, Germany

### **Fourth European Conference on Green Power Marketing 2005**

Green Power Marketing GmbH, Weberstrasse 10, 8004 Zurich, Switzerland

*Tel.* +41 44 296 87 09, • *Fax* +41 44 296 87 02

*Website* [www.greenpowermarketing.org](http://www.greenpowermarketing.org)

13–15 October 2005,  
Shanghai, China

### **15th International Photovoltaic Science and Engineering Conference**

Worldwide Exhibitions Service, Room 801, Block B, No 580 Nanjing (W) Road, Nanzheng Building, Shanghai – 200 041, China

*Tel.* +86 21-52340653, • *Fax* +86 21-52340649

*E-mail* [srexpo@sh-wes.com](mailto:srexpo@sh-wes.com)

17–21 October 2005,  
Paris, France

### **14th European Biomass Conference and Exhibition: biomass for energy, industry, and climate protection**

WIP-Munich, Sylvesterstr 2, 81369 Munich, Germany

*Tel.* +49 89 720 12735 • *Fax* +49 89 720 12791

*E-mail* [wip@wip-munich.de](mailto:wip@wip-munich.de) • *Website* [www.wip-munich.de](http://www.wip-munich.de)

2–5 November 2005,  
Melbourne, Australia

### **Fourth World Wind Energy Conference and Renewable Energy Exhibition 2005**

C/o The Meeting Planners, 91-97 Islington Street, Collingwood, Victoria, Australia, 3066

*Tel.* +61 3 9417 0888 • *Fax* +61 3 9417 0899

*E-mail* [wwec2005@meetingplanners.com.au](mailto:wwec2005@meetingplanners.com.au) • *Website* [www.wwindea.org](http://www.wwindea.org); [www.wwec2005.com](http://www.wwec2005.com)

14–18 November 2005,  
Palm Springs, California,  
USA

### **2005 Fuel Cell Seminar**

Fuel Cell Seminar Headquarters, c/o Courtesy Associates, 2025 M Street, Suite 800, Washington, DC 20036

*Tel.* +202 973 8671 • *Fax* +202 331 0111

*E-mail* [fuelcell@courtesyassoc.com](mailto:fuelcell@courtesyassoc.com) • *Website* [www.fuelcellseminar.com](http://www.fuelcellseminar.com)

22–25 November 2005,  
Zaragoza, **Spain**

**Second EHEC (European Hydrogen Energy Conference) 2005**

Stephanie Heng, European Hydrogen Association, Avenue Marcel Thiry 204, B-1200, Bruxelles

*Tel.* 322 774 9630 • *Fax* 322 774 9690

*E-mail* [info@h2euro.org](mailto:info@h2euro.org) • *Website* [www.ehec.info](http://www.ehec.info)

9–11 February 2006,  
Hyderabad, **India**

**ICORE 2005: International Congress on Renewable Energy for Sustainable Development**

Sri P Srirama Raju, Convenor, ICORE 2006, SESI A P Chapter, Plot No. 30, Road No. 5, Jubilee Hills Society, Hyderabad – 500 033

*Tel.* +91-40-5597 7554, 2360 8892 • *Fax* +91 40 2354 713

*E-mail* [sesiapchapter@yahoo.com](mailto:sesiapchapter@yahoo.com); [raju\\_dc@yahoo.com](mailto:raju_dc@yahoo.com); [info@icore2006hyd.com](mailto:info@icore2006hyd.com)

*Website* [www.icore2006hyd.com](http://www.icore2006hyd.com)

15–16 February 2006,  
Essen, **Germany**

**Third International German Hydrogen Energy Congress 2006**

H2CONGRESS.de, Anna Bremer, Am Technologiepark 1, D-45307, Essen

*Tel.* +49 (0) 201/172 1260 • *Fax* +49 (0) 201/172 1779

*E-mail* [contact@h2congress.de](mailto:contact@h2congress.de) • *Website* [www.h2congress.de](http://www.h2congress.de)

## 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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# ENVIS Centre on Renewable Energy and Environment

A knowledge gateway

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



<http://www.terienvs.nic.in>

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'.