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Prospects of non-conventional energy in India

Conventional energy sources like coal and petroleum are getting depleted at an alarming rate in the world. Now, non-conventional sources of energy are getting importance since they can contribute towards reduction in dependency on fossil fuels.

Constraints in growth of solar power

Solar power in India, in particular through SPV (solar photovoltaic) technology route, promises high prospect viewed from fairly good irradiation in many parts of the country.

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Ministry of Environment and Forests,
Government of India

The Energy and Resources Institute

Prospects of non-conventional energy in India

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Introduction

Conventional energy sources like coal and petroleum are getting depleted at an alarming rate in the world. Now, non-conventional sources of energy are getting importance since they can contribute towards reduction in dependency on fossil fuels. Renewable energy sources assume special significance in India when viewed in the context of the geographic diversity and size of the country, not to mention the size of its rural economy. Since renewable energy resources are diffused and decentralized, they are more appropriate as local energy systems to meet the ever expanding and diversified energy needs. In this perspective, they offer numerous possibilities for meeting the basic energy needs of the rural poor. This apart, they also offer significant possibilities for job creation. Such jobs would also help arrest migration from rural to urban areas.

Non-conventional energy also provides national energy security at a time when decreasing global reserves of fossil fuels threatens the long-term sustainability of the Indian economy. Energy security is an issue not only at the national level but also at the local level. This means that a remote village will not need to depend on mostly erratic energy supply for far flung areas but will be in a position to meets its own demand through indigenous energy resources. The use of such technologies, which on the one hand enables consumers to use traditional fuel more efficiently and on the other hand utilize locally appropriate renewable energy resources, provides a certain level of energy security to these users.

The Department of Renewable Energy Sources, Government of India has estimated that these sources are expected to cover nearly 30% of the level of energy demand by 2020 AD. In terms of coal replacement, the total energy generation/saving from sources of energy will be 250.17 MT (million tonnes). Of this, biogas plants will generate 47.88 MT, energy plantation 47.50 MT, biomass 30.94 MT, and solar thermal systems 20 MT. Other sources like wind and small hydro projects are also expected to contribute to this changeover. The potential of renewable energy technologies with programme wise physical target and achievement made during the Tenth Plan has been summarized below.

Energy sources

Solar energy

With about 200 clear sunny days in a year, India's theoretical solar power reception, just on its land area is about 5 EWh/year (that is, 5000 trillion kWh/year = 600 TW). The daily average solar energy incident over India varies from 4 to 7 kWh/m^2 with about 2300–3200 sunshine hours per year depending upon location. This is far more than current total energy consumption. For example, even assuming 10% conversion efficiency for PV modules, it will still be 1000 times greater than the likely electricity demand in India by the year 2012.

The recent developments in the solar energy sector have shown that power units of 5 MW are technically feasible. Design for a 30-MW solar thermal power station has already been completed in our country. The cost of power from solar plants of large capacity is already competitive with diesel-based thermal power plants. In the area of solar photovoltaic, the cost of power is expected to come down with the technological development and bulk production. With the development of amorphous silicon technology and thin-film solar cells, it is expected that this system will be viable in the next few years. A substantial part of the energy requirements of industry, agriculture, and community services and household sector can be met by the solar thermal system like solar hot water system, solar air dryers, solar stills, solar refrigerators, and solar cookers. It is proposed to meet 20 MTCR of such energy requirement from various systems by the year 2015.

The amount of solar energy produced in India is merely 0.5% compared to the other energy resources. The grid-interactive solar power was merely 2.92 MW. India has implemented various programmes through research and demonstration at various institutions to put up field demonstration units with a view of gathering

Table 1 Achievements under various projects and programmes

Scheme/projects/ programmes	Units	Estimated potential (MWe)	2005/06 Target	2005/06 achievement	2006/07 Target	2006/07 achievement	Tenth Plan Target	Tenth Plan achievement
Grid-interactive								
Wind power	MW	45 195*	450	1716.20	1000	1742.10	2200	5426.40
Small hydro (up to 25 MW)	MW	15 000	130	120.80	160	149.00	550	536.83
Bio-power (agri-residue)	MW	11 881	—	—	—	—	—	510.00
Ocean thermal	MW	50 000	—	—	—	—	—	
Cogeneration-bagasse	MW	5 000***	160	163	215	228.10	725	759.33
Waste-to-energy	MW							
MSW-to-energy		1 700	10	—	30	—	70	—
IW- to-energy		1 000	—	1.75	—	17.43	—	46.58
Distributed renewable power								
Village electricity programme	Number of villages	—	2 000	293	1 000	610	7 500	2 617
Biogas plants	No. (in lakh)	—	0.66	0.61	1.00	0.96	5.68	5.60
Improved cookstoves	Nos.	—	—	—	—	—	—	120 m
Biomass power/ cogeneration								
Non-bagasse	MW	19 500	—	—	—	—	—	34.30
Biomass gasifiers	MW	—	10	9.52	2.00	1.00	37.00	75.85
Solar photovoltaic programmes								
SPV home light	Nos	—	42 000	9 727	60 000	23 033	202 000	10 7904
SPV lanterns	Nos	—	100 000	885	30 000	31 000	185 000	67 259
SPV street lighting	Nos	—	0	367	1 250	4 659	1 250	12 589
SPV power plants	kWp	—	350	00	400	00	1 475	373.40
SPV pumps	Nos	—	500	222	300	66	3 600	2 568
Solar thermal energy								
Solar water heating system	Collector area m	—	400 000	400 000	400 000	400 000	105 000	995 000
Solar cookers	Nos	—	35 000	19 769	22 000	16 209	162 000	70 978
Wind pumps	Nos	—	100	96	100	69	650	387
Hybrid system	kW	—	150	99.04	150	123.69	72500	483.09

*Potential based on areas having wind power density greater than 200 w/m^2.
** Technically feasible hydro potential of all sites
*** With new sugar mills and modernization of existing ones.
Note Wind energy potential could be more than 10 times the above according to an estimate of Centre for Wind Energy Technology. Integrated Energy Policy has projected capacity addition of 30 000 MW from wind by the year 2032.
Not all the total energy potential may be suitable for grid-interactive power for technical/or economic reasons.
Source Ministry of New and Renewable Energy, Government of India

performance data under actual field conditions and commercializing the systems for large-scale utilization through extension programmes. Twenty-five kilowatt power generating system using point focusing concentrating collectors has been completed at Salojipally in Andhra Pradesh. Based on the design developed under a funded research project, three solar houses in three typical climatic zone of the country in Jodhpur, Srinagar and Delhi have been established.

The use of solar power is attractive but the question of storage of solar energy will be an important consideration. However, no efficient large-scale storage has yet been developed.

Energy from biomass and cogeneration

The amount of biomass, timber plants, organic wastes, and so on that accumulates in the world in just one year can yield as much power as all proven reserves of coal, oil, and gas taken together. The general device enabling the use of biomass is to ferment it with the help of micro-organisms. As a result, biogas is produced consisting mostly of methane. Burned at the power station it yields only carbon dioxide and water that are both environmentally harmless.

In India, biomass holds considerable promise as 540 MT of crop and plantation residues are produced every year, a large portion of which is either waste or used inefficiently. Conservative estimates indicate that even with the present utilization pattern of these residues and by using only the surplus biomass materials, estimated at about 150 MT, about 17 000 MW of distributed power could be generated. It is also estimated that 1000 hectares of land can generate 3 MW of power. Energy plantation will therefore be coupled with power generating units based on gasifiers from integrated energy-cum-power projects, which will provide fuelwood as well as power.

Biogas plants

The cultivated areas, where refuge from plant growing and stock-breeding are easily available, the generation of power by means of methane digestion has been received increasing attention in the last few years. As the most suitable ones, chaff, corn stalk, beet leaf, flax straw, cereal straw, and manure should be mentioned. With a proper processing of such refuse, gas of high value can be produced containing about 65% methane and 35% carbon dioxide. The gas is collected in the tanks, can be used by the means of a gas engine, for the generation of electric power and if need be, for the production of industrial steam. The substances remaining after gas extraction becomes nitrogen enriched and can be used in intensive farming for soil improvement. The gas can also compress and stored.

Presently, about 12 million biogas plants are in use in our country, which covers 120 million improved cookstoves. However, it is not provide a satisfactory answer to the power problems of rural communities. Indian Agricultural Research Institute is engaged in research to improve a family size biogas plant of 100 cubic feet daily capacity for lighting (4 to 5 cubic feet of gas/hour for a gas lamp) and cooking (10 cubic feet of gas/hour/burner). At its current stage of development, however, the biogas unit is too expensive for the average villagers.

It is estimated that 2000 MW of power can be generated only from sugar-based agricultural waste. About 22 million rural households, out of current estimated number of 130 million rural households in the country, could meet their energy requirement through biogas. On the average, 4 cubic metres of gas per day is required per household. It is planned to install 25 million biogas plants in the country by 2012. The installation will also include community and institutional biogas plants.

Company-generation units are equipped for the combined production of heat and electricity. Small units mainly use rotary gas burner motors, adopted for running on gas fuels. The dominant fuel is natural gas but alternative fuels are becoming more common especially the various form of biogas. Biogas can be obtained from biogas stations, constructed mainly around sewage treatment plants, communal waste dumps or agricultural establishments centred on livestock rearing. Economic advantages of company-generation is that instead of producing only heat by burning biogas in boilers, it offers the chance of producing electricity that can be used for our own consumption.

Wind power

The ancient historical literatures show that the wind energy machines were present in Persia in the ninth century AD. In the later middle ages, wind powered machines were developed and widely used in Europe for pumping water, grinding grains, and doing certain small industrial jobs. In the 19th century, they were adopted for generating small quantity of electricity.

The wind energy is currently making a significant contribution to the installed capacity of power generation and is emerging as a competitive option. In India, the onshore wind power potential has been assessed at 45 195 MW assuming 1% of land availability for wind power generation in the potential areas. However, the technical potential is limited to only 13 000 MW assuming 20% grid penetrations.

The development of wind power in India began in the 1990s and has significantly increased in the last few years. Although a relative newcomer to the wind industry compared with Denmark or the US, a combination of domestic policy support for wind power and the rise of Suzlon (a leading global wind turbine manufacturer) have led India to become the country with the fourth largest installed wind power capacity in the world after Germany, USA, and Japan. The first 2-MW wind turbine was installed at Chettikulam Tirunelveli district, Tamil Nadu, which is the largest unit size installation in Asia.

As on July 2008, the installed capacity of wind power in India was 8697 MW, mainly spread across Tamil Nadu 3873, Maharashtra 1756, Karnataka 1011, Rajasthan 539, Gujarat 1253, Andhra Pradesh 123, Madhya Pradesh 126, Kerala 12.5, West Bengal 2, and other states 1.6 MW.

The advantage of wind power is that the routine maintenance and running repairs of equipments is very low. The serious disadvantage is that the force of the wind varies from place to place. This necessitates storage of energy, which makes it costly. Such power plants may be used for more remote locations where transport of fuels would be difficult. However, small battery chargers and wind electric generators can meet the power requirements of defense, paramilitary forces, railways, small rural communities and remote inaccessible areas where wind potential exist. A large number of this system is proposed to install in Eleventh Plan with a total capacity/save energy up to 10 500 MW.

Geothermal energy

The use of geothermal energy for the generation of electricity has been known for half a century but recent years have been a rapid spread of this application. The first turbine, with a capacity of 250 kW was installed in 1912 at Laderello in Italy and today this plant produces over 2000 million units a year, supporting power for not only two-thirds of the entire Italian railway system but to a variety of other industries as well.

Geothermal energy is the natural heat generated within the earth. Volcanoes, hot springs, geysers, and fumaroles are natural clues as to the presence of geothermal resources near the surface and perhaps where economic drilling operations can trap their heat and pressure. About 10% of the world's landmass contains accessible geothermal resources and could provide several million quads of energy annually.

Geothermal manifestations are widespread in India in the form of 340 hot spring sites. Large tracks of hot groundwater with 15–20 degree temperature over mean ambient values and high bottom hole temperature (140–200 °C) recorded in many of the boreholes drilled in various sedimentary basins for hydrocarbons are known to exist. These manifestations are localized in the Himalayan Valley, Cambay fault, Talta Pani (MP), and many other places in Gujarat. Cambay fault is one of the promising areas. ONGC is formulating a programme for harnessing geothermal energy.

The studies on geothermal energy sources indicate that the installation of less than 1000 kW is not likely to be economic. However, this can be a cheap source of energy. A project is under implementation by CEA at Puga Valley in Ladakh to access the scope for harnessing the potential available there for power generation purpose.

Tidal power

The vast amount of energy involved in the rise and fall of the tides has long been known to be a potential source of power. Tidal power or tidal energy is a form of hydropower that converts the energy of tides into electricity or other useful forms of power. This energy can be extracted by creating a reservoir or basin behind a barrage and then passing tides water through turbines in the barrage to generate electricity. It is extremely site specific, requires mean tidal differences greater than four metres and also favourable topographical condition, such as estuaries or certain types of bays in order to bring down costs of dams, and so on.

Since India is surrounded by sea on three sides, its potential to harness tidal energy has been recognized by the Government of India. Potential sites for tidal power development have already been located. The most attractive locations are the Gulf of Cambay and the Gulf of Kutchha on the west coast where the maximum tidal range is 11 metres and 8 m with average of 6.77 m and 5.23 m, respectively. The Ganga delta in Sundarbans in West Bengal also has good location for small-scale tidal power development. The maximum tidal range in Sundarbans is approximately 5 m with an average of 2.97 m. The identified economic tidal power potential in India is of the order of 8000-9000 MW with about 7000 MW in the Gulf of Cambay, about 1200 MW in the Gulf of Kachchh, and less than 100 MW in Sundarban. The Kutchha tidal power project with an installed capacity of about 900 MW is estimated to cost about Rs 100 crore generating electricity at about 90 paise per unit.

Energy from urban and industrial waste

A study by MNRE says that there is a potential of generating 2500 MW of power from urban, municipal, and industrial wastes in big cities in the next two or three years. About 40 000 MT of solid waste and 5000 million cubic metres of liquid water is generated every year in the urban areas of the country, which can be suitably recycled for power generation, according to the study brought out by leading industry body ASSOCHAM. According to an estimate, about 1500 MW of power could be generated from urban and municipal wastes and an additional 1000 MW could be secured from industrial wastes in the country by 2010.

A total of 52 projects with an aggregate capacity of about 95 MW on energy recovery from urban and industrial wastes have so far been taken up in ten states. Seven projects with a capacity of 19.50 MW have been completed in five states. These projects are based on urban wastes like municipal solid waste, vegetable market waste, biogas at sewage treatment plants, and cattle dung. Ten states in the country have projects based on industrial waste with a total capacity of 72.19 MW equivalent. These projects use waste from distillery, abattoir, slaughterhouses, food processing and paper units, tannery, and so on.

As per the latest estimate of MNRE, there are presently 4378 urban agglomerations and towns in the country of which 423 towns and cities have a population exceeding 1 lakh. Of these, there are 35 urban agglomerates and cities with a population of over one million urban households generating 42 MMT/annum of solid waste at the rate of 0.115 MMT/day and 6000 million cubic metre/annum of liquid waste. The estimated potential of MSW (municipal solid waste) to energy is given below.

Period	*Projected MSW generation* (TPD)	*Potential for power generation* (MWe)
2007	148 000	2550
2012	215 000	3650
2017	304 000	5200

Source MNRE, Government of India

The estimated installed capacity potential for recovery of energy from industrial waste is currently about 1300 MWe, which is expected to rise to 1600 MWe by 2012 and 2000 MWe by 2017. Industry-wise estimated installed capacity potential for recovery of energy is as follows.

Industry	*Potential in years* (MWe)		
	2007	*2012*	*2017*
Sugar	363	453	567
Pulp and paper	58	72	90
Sago/starch	24	30	37
Maize starch	105	132	164
Distillery	503	628	785
Dairy	69	77	96
Others	165	206	258
Total	**1287**	**1598**	**1997**

Source MNRE, Government of India

Small hydropower

SHP (small hydropower) is one of the most environmentally benign forms of energy generation available to us today. This system captures the energy in the flowing water and converts it to usable energy. It has little or no environmental impact and can provide a range of energy services especially in rural areas. It can be applied to satisfy low-to-medium-voltage electric needs such as lighting or telecommunication and to provide motive power for small industries.

The world estimated potential of small hydro is about 180 000 MW. India has as an estimated potential of about 15 000 MW. Of this, 4554 potential sites with an aggregate capacity of 11 356 MW have been identified. The development of this energy source is one of the thrust areas of power generation from renewables in the MNRE. The ministry is encouraging development in the state sector as well as through private sector participation in various states. In the last 10–12 years the capacity of these projects up to 3 MW has increased four fold from 63 MW to 240 MW. In the Tenth Plan, the ministry has fixed the target to add 550 MW and achieved 536 MW. The break-up has been shown below.

Year	Target (MW)	Capacity addition during the year (MW)	Cumulative SHP installed capacity (MW)
2002/03	80	80.39	1519.28
2003/04	80	84.04	1603.32
2004/05	100	102.31	1705.63
2005/06	130	120.80	1826.43
2006/07	160	149.10	1975.59 (602 projects)

Source MNRE, Government of India

A target adding about 1400 MW during the Eleventh Plan (2007–12) has been fixed by the ministry. About 649 MW (219 projects) are under implementation.

Thirteen states namely Himachal Pradesh, Uttar Pradesh, Punjab, Haryana, Madhya Pradesh, Karnataka, Kerala, Andhra Pradesh, Tamil Nadu, Orissa, West Bengal, Maharashtra, and Rajasthan have announced policies for setting up commercial SHP projects through private sector participation. Over 800 sites of about 2000 MW capacity have already been offered/allotted in these states. Over 110 SHP projects aggregating 444 MW have already been commissioned by the private sector. The top 10 potential states and their achievement are as follows.

State	*Number of sites*	*Potential* (MW)	*Achievement* (MW)	*Commissioned by the private sector* (MW)
Himachal Pradesh	323	1624	141.61	28.5
Uttaranchal	354	1478	75.67	6
Jammu and Kashmir	201	1207	111.87	-
Karnataka	258	652	416.50	280
Maharashtra	234	1,160	209.33	6
Kerala	252	514	98.12	-
Tamil Nadu	147	338	89.70	-
Madhya Pradesh	85	336	51.16	-
Uttar Pradesh	211	267	25.10	-
Arunachal Pradesh	286	254	-	110
Punjab				7.75
West Bengal				6

Source MNRE, Government of India

For development of SHP projects, the Ministry has approved grant for renovation of Jali (6 x 350 kW) and Rongnichu II (5 x 500 kW in Sikkim, Rinchington (2 × 1000 kW and little Ranjit 92 × 1000 kW) in West Bengal and Nogli (2 × 250 + 4 × 500 kW; Chaba (3 × 250 + 2 × 500 kW), Chakki (2 × 100 kW) in Himachal Pradesh, and Dzuza (8 × 500 kW) in Nagaland. The renovation work in these projects has already started and is likely to be completed by the next year.

Capacity addition programmes

The aim for the Eleventh Plan is a capacity addition of 15 000 MW has been fixed by the MNRE. By the end of the plan, the power capacity would be 25 000 MW accounting 12.5% and contributing about 5% to the electricity mix. Similarly, a capacity addition of about 30 000 MW is envisaged for the Twelfth and Thirteenth plans. By the end of Thirteenth plan period, the capacity is likely to reach 55 000 MW, comprising 40 000 MW wind power, 66 500 MW small hydro power, 7500 MW biogas, and 1000 MW solar power, which would correspond to a share of 5% in the then electricity mix. The Eleventh Plan programmes are proposed for rationalization with several rationalized or clubbed together for effective targeting and operational ease. These programmes are (a) grid interactive and distributed renewable power, (b) renewable energy for rural application, and (c) renewable energy for urban, industrial, and commercial applications. The proposals have been shown below.

Grid interactive and distributed capacity in MW

Resource	*Up to Ninth Plan*	*Up to Tenth Plan*	*Eleventh Plan*	*Twelfth and Thirteenth*	*Total*
Wind power	1667	5333	10 500	22 500	40 000
SHP	1438	522	1400	3140	6500
Bio-power	368	669	2100*	4363	7500
Solar power	—	—	1000**	—	1000
Total	**3473**	**6524**	**15 000**	**30 003**	**55 000**

Cogeneration: 1200; Biomass power: 500;
Urban waste-to-energy: 200; Industrial waste-to-energy 200 MW
**Solar power (grid interactive/DRPS) 50 and DRPS (example solar) 950 MW

Proposal for rural application

For remote villages/hamlets	
Remote village lighting	9000 villages/hamlets
Village energy security test projects	1000 villages
Common component for cooking/ supplementary motive power	10 000 villages/hamlets

For all villages	
Solar thermal system— flat plate	15 lakh m²
—concentrating	1 lakh m²
Family type biogas plants	20 lakh

Proposal for urban, industrial, and commercial applications

Solar thermal system/ devices	
Water heating	9.50 million m²
Drying	0.25 million m²
Other (steam generation)	0.25 million m²
Municipal corporation incentive	10
Energy-efficient building	50 lakh square metre floor area
Akshay Urja shops	2000
Cities with RPOs	100

Source MNRE, Government of India and Distributed Renewable Power Sources

The Government of India has also set a goal of electrification of 18 000 remote villages and meeting 10% of the country's power supply through renewable energy by the year 2012. These targets are in addition of those fixed for others RE devices or programme including establishing one million biogas plants, one million SPV systems for lighting, 8000 SPV pumps for irrigation, 10 000 SPV generators, stand-alone SPV power plants, solar water heating systems, solar-air heating systems, solar cookers including large steam cooking systems, 360 energy demonstration parks, and establishing more solar retail outlets and solar passive buildings among other projects.

Conclusion

Generation of electricity by tidal and geothermal power is being done in some places but the technology has not yet developed to utilize to any desired extent. Biomass has been a major source of energy in the third world countries. However, for commercial exploitation, it may be a fairly good option for oil (or coal) to a limited extent in the less developed countries. Technological development in solar, wind, small hydropower, and biomass industries are possible but do not seem to be economically attractive at the present time and in any event can not supply a very significant proportion of the country's energy needs. In India, it is now widely accepted that while intensive efforts should be continued in the field of biogas, solar, and similar technologies to meet the energy requirement of rural communities, it is necessary to introduce and implement a minimum energy need programme in backward and remote areas. Such a programme would cover social forestry, biogas, improved chulhas, wind energy, and other locally available forms of energy in order to meet the total energy requirement of rural communities. This pattern of economic and social development should take in to account the eco-development, utilization, and rebuilding of resources base of soil, water, plants, and animal life. India, with 17% of the world population and just 0.8% of the world's known oil and natural gas resources is going to face serious energy challenge in the coming decade. Energy produced using fossil fuels is the major contributor to GHG emissions. Hence, transition to a low-carbon energy economy is the real solution for mitigating the impact of climate change.

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Constraints in growth of solar power

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Solar power in India, in particular through SPV (solar photovoltaic) technology route, promises high prospect viewed from fairly good irradiation in many parts of the country. The desert area is presumed to have potential of nearly 150 000–200 000 MW. Generally, solar power resource is estimated at 25–30 MW/square kilometre. This point is highly appreciated, but yield at the ground level is yet to be perceptible. Nevertheless, on demonstrative scale or for providing lights in the remote areas especially in places where grid connectivity is not feasible in near future, SPV is encouraged under liberal subsidy format. To harness SPV power as commercial venture, backed by incentive-oriented financial packages being common in developed countries, is yet to take off, despite the fact that attempts in this line have been initiated a year back and the Solar Mission happens to be the first item in Prime Minister's policy on Climate Change.

In the context of policies and incentives announced a year back, worth mentioning progress in SPV electrification in commercial scale is not visible, notwithstanding the necessity for this, as emerging great resource to encounter global warming and to share substantial part of the load demand in days to come. Of all renewable resources, potential of solar power is almost unending which is the driving force for fast growth in developed countries like, Germany, USA, Japan, and Spain. Nonetheless, reason for a thresh hold in this case deserves a penetrating analysis calling for (i) detailed insight into future power scenario, (ii) resources at the disposal, and (iii) their comparative economics not regardless of utmost need for arresting greenhouse gas emission. However, a broad overview might not be out of place with the objective to invite attention of policy planners for substantial contribution from solar power in a network of power system continuously demanding larger energy input, triggered by economic stimulus attributable to high GDP growth, ostensibly, ignoring on-going recession as a temporary phase of little significance. A thrust in SPV power is foreseen as compulsion in face of number of reactionary forces to increase global warming and search for tapping dependable resource for vital part to play in meeting future rising demand above 300 000 MW, against about 100 000 MW now, more so, for limitations on nuclear and hydro power, poor quality of coal, and too little hydrocarbon deposit.

SPV power is victim of high cost due to expensive price of basic equipment, that is, solar modules comprising 65%–70% of overall project expenditure. With large manufacturing capacity building up in many countries, including China of late, the gap between demand and supply of modules is narrowing down to facilitate easy availability and price reduction. Annual growth rate of SPV is above 30% and likely to continue refuting high cost and financial stringency world over. Almost from nothing, in last 7 years world installation in grid connected systems has exceeded 15 000 MW against negligibly small figure of 2 MW in this country.

Because of SPV power costing nearly five times the conventional type and invariable hurdles being faced in marketing, innovative mechanism has set in for rewarding entrepreneur of SPV power plants through high feed-in-tariff for supply to the grid, thus promising fair return within a reasonable time. Coupled with this gain in tax payment, wind power has come up remarkably this way only.

Steps to lower down chargeable unit cost to ultimate consumer within affordability even on injecting comparatively a small quantity of highly priced SPV power in a vast network of common grid refers to interactions on fronts, for example, (a) R&D on technological innovations on cost reduction of modules mainly; (b) devising intelligent and financial packages through attractive feed-in-grid tariff and tax concessions; (c) raising capacity of manufacturing plants; and (d) encouraging megawatt-level field applications by setting up power plants to gain experience on operation, maintenance, grid parity, and commercialization. The framework of policy in this country conforms to these objectives, but devoid of adequacy, comprehensiveness, and pragmatic approach.

The Government of India in the last part of financial year 2007/08 announced payment of subsidy for maximum amount of Rs 12/unit for a period of 10 years for grid-connected SPV power subject to a cap that total price to be paid to the entrepreneur should not exceed Rs 15 including grid-tariff payable by utilities to be decided by ERC (electricity regulatory commissions) at the state levels. Tariff fixed by state ERCs varies from about Rs 4 to Rs 12 in different states, thus restricting subsidy payment from Government of India between Rs 11 in the upper side to downwards at Rs 3. It was anticipated that 50-MW capacity addition would come up by the end of Eleventh Plan. Minimum and maximum capacities of plant to be set up by entrepreneurs, overall capacity in a state, eligibility to claim benefits, mode of payment of subsidy, and so on involves a circuitous process with lot of hassles. Though a year has passed since policy announcement, state ERCs have also approved feed-in-tariff and applications poured in for about 3000 MW with stipulations of investment of nearly Rs 60 000 crore to imply wide opening to economy on manufacturing, services, and employment, not a single MW has yet been added. It is unfortunate considered from the viewpoint that gestation period of a SPV power plant is only six months. However, exception is a 2-MW plant being set up in West Bengal in the state sector.

The main reason for ineffectiveness lies in the low overall tariff of Rs 15/unit. An SPV power plant, even in places of highest solar irradiation of about 65 units/day/kWp, at this tariff hardly satisfy favourable viability criterion to assure a payback period of about seven years on capital investment of Rs 20 crore/MW at 20:80 equity:debt ratio under high interest rate regime prevailing in the country. Depreciation benefit as offered in case of wind and other renewable resources has been withdrawn, which would have otherwise invited profit-making industrial and commercial houses to venture in this line to set off taxes on profit similar to wind power in the country. Some of the state regulators have imposed additional cap in terms of total installed capacity in the state, so much so that the overall rise in tariff due to integration of high rate of SPV power in the supply system does not raise overall tariff by additional Rs 1 paise/unit. Under present conditions, although blessed with plenty of sun, country's progress in SPV electrification is in predicament and calls for bold steps on reviewing the policy on SPV tariff.

In existing national grid network of 150 000 MW with peak demand of about 100 000 MW, generation contributes to about 800 billion units annually at a cost between Rs 3 and Rs 3.50/unit. This vast grid network should be allowed to absorb 200 MW of SPV power each year generating 0.25 billion units at Rs 20/unit (against Rs 15/now), which will not raise overall cost of generation by more than Rs 0.005 paise over the generation cost. Coal-based utilities as polluter to environment contributing to 65% of total generation should be persuaded to pay for Rs 500 crore for 0.25 billion units at the rate of Rs 20 on account of incentives to SPV entrepreneurs. This amount will have marginal and negligible impact on their overall generation cost to affect selling price to down stream supply organizations in transmission/distribution. Suggestive figure Rs 20 per unit for SPV with accelerated depreciation benefit envisages an assured return with payback period of seven years under present monetary market conditions. It will sound attractive to the entrepreneurs who are plenty in numbers eager to enter into new venture. These two steps will promote SPV by leaps and bounds for multiple functions of arresting greenhouse gas emission, a solution to power problem and a boost to the economy as has been case in Europe and USA. While initial period of assured purchase should stipulate 10-year period in order to facilitate loan repayment, thereafter to be reduced in conformity with standard practice of tariff determination. The tariff rate should be reviewed in every two years within first 10 years so to reduce this with fall in price of per MW cost of installation of SPV. World forecast says within a decade, SPV will attain competitiveness on its annual downward slide in price while conventional power has been moving upwards due to number of factors.

Delay-prone un-remunerative existing incentive system invariably calls for a review in consultations with technologists and industrial houses to devise viable alternative for SPV power to grow to the extent of 50 000 MW by 2031 in the context of the prediction that country will need about 800 000 MW of installations by then to meet the growing demand in a vibrant economy. By then, coal, gas, hydro, nuclear, wind, and biomass as common resources, without substantial contribution from solar power, will be inadequate to serve energy demand; besides unrestricted fossil-fuel-based power will further endanger threats on greenhouse gas emission.

Current research on renewable energy and development

Patil P D and Deng S. 2009. **Optimization of bio-diesel production from edible and non-edible vegetable oils**
Fuel **88**(7): 1302–1306
Chemical Engineering Department, New Mexico State University, P O Box 3001, MSC 3805, Las Cruces, NM 88003, USA

Bio-diesel production from different edible and non-edible vegetable oils was compared in order to optimize the bio-diesel production process. The analysis of different oil properties, fuel properties, and process parameter optimization of non-edible and edible vegetable oils was investigated in detail. A two-step and single-step transesterification process was used to produce bio-diesel from high FFA (free fatty acid) non-edible oils and edible vegetable oils, respectively. This process gives yields of about 90%–95% for *Jatropha curcas*, 80%-85% for P. glabra, 80%–95% for canola, and 85%–96% for corn using KOH (potassium hydroxide) as a catalyst. The fuel properties of bio-diesel produced were compared and were found to be in accordance with ASTM standards for bio-diesel. (5 figures, 1 table, 28 references)

Sharma A K. 2009. Experimental study on 75-kWth downdraft (biomass) gasifier system
Renewable Energy **34**(7): 1726–1733
Mechanical Engineering Department, D C R University of Science and Technology, Murthal (Sonepat), Haryana – 131 039, India

Experimental study on 75 kW_{th}, downdraft (biomass) gasifier system has been carried out to obtain temperature profile, gas composition, calorific value, and trends for pressure drop across the porous gasifier bed, cooling–cleaning train and across the system as a whole in both firing as well as non-firing mode. Some issues related to re-fabrication of damaged components/parts have been discussed in order to avoid any kind of leakage. In firing mode, the pressure drop across the porous bed, cooling–cleaning train, bed temperature profile, gas composition, and gas calorific value are found to be sensitive to the gas flow rate. The rise in the bed temperature due to chemical reactions strongly influences the pressure drop through the porous gasifier bed. In non-firing mode, the extinguished gasifier bed arrangement (progressively decreasing particle size distribution) gives much higher resistance to flow as compared to a freshly charged gasifier bed (uniformly distributed particle size). The influence of ash deposition in fired-gasifier bed and tar deposition in sand filters is also examined on the pressure drop through them. The experimental data generated in this article may be useful for validation of any simulation codes for gasifiers and the pressure drop characteristics may be useful towards the coupling of a gasifier to the gas engine for motive power generation or decentralized electrification applications. (11 figures, 2 tables, 21 references)

Gopinath A, Puhan S, and Nagarajan G. 2009. **Theoretical modelling of iodine value and saponification value of bio-diesel fuels from their fatty acid composition**
Renewable Energy **34**(7): 1806–1811
Internal Combustion Engineering Division, Department of Mechanical Engineering, Anna University, Chennai – 600 025, Tamil Nadu, India

Bio-diesel is an alternative fuel consisting of alkyl esters of fatty acids from vegetable oils or animal fats. The properties of bio-diesel depend on the type of vegetable oil used for the transesterification process. The objective of the present work is to theoretically predict the iodine value and the saponification value of different bio-diesels from their fatty acid methyl ester composition. The fatty acid ester compositions and the above values of different bio-diesels were taken from the available published data. A multiple linear regression model was developed to predict the iodine value and saponification value of different bio-diesels. The predicted results showed that the prediction errors were less than 3.4% compared to the available published data. The predicted values were also verified by substituting in the available published model, which was developed to predict the higher heating values of bio-diesel fuels from their iodine value and the saponification value. The resulting heating values of bio-diesels were then compared with the published heating values and reported. (5 figures, 8 tables, 5 references)

Mohan S V, Mohanakrishna G, Goud R K, Sarma P N. 2009. Acidogenic fermentation of vegetable-based market waste to harness biohydrogen with simultaneous stabilization
Bioresource Technology **100** (12): 3061–3068
Bioengineering and Environmental Centre, Indian Institute of Chemical Technology, Hyderabad, Andhra Pradesh – 500 007, India

Vegetable-based market waste was evaluated as a fermentable substrate for hydrogen production with simultaneous stabilization by dark-fermentation process using selectively enriched acidogenic mixed consortia under acidophilic microenvironment. Experiments were performed at different substrate/ organic loading conditions in concurrence with two types of feed compositions (with and without pulp). Study depicted the feasibility of hydrogen production from vegetable waste stabilization process. Hydrogen production was found to be dependent on the concentration of the substrate and composition. Higher hydrogen production and substrate degradation were observed in experiments performed without pulp (23.96 mmol/day [30.0 kg COD/m^3]; 13.96 mol/kg CODR [4.8 kg COD/m^3]) than with pulp (22.46 mmol/day [32.0 kg COD/m^3]; 12.24 mol/kg CODR [4.4 kg COD/m^3]). Generation of higher concentrations of acetic acid and butyric acid was observed in experiments performed without pulp. DEA (data enveloping analysis) was employed to study the combined process efficiency of system by integrating hydrogen production and substrate degradation. (4 figures, 2 tables, 33 references)

Sheth P N and Babu B V. 2009
Experimental studies on producer gas generation from wood waste in a downdraft biomass gasifier
Bioresource Technology **100**(12): 3127–3133
Chemical Engineering Group, BITS (Birla Institute of Technology and Science), Pilani – 333 031, Rajasthan, India

A process of conversion of solid carbonaceous fuel into combustible gas by partial combustion is known as gasification. The resulting gas, known as producer gas, is more versatile in its use than the original solid biomass. In the present study, a downdraft biomass gasifier is used to carry out the gasification experiments with the waste generated while making furniture in the carpentry section of the institute's workshop. *Dalbergia sisoo*, generally known as sesame wood or rose wood is mainly used in the furniture and wastage of the same is used as a biomass material in the present gasification studies. The effects of airflow rate and moisture content on biomass consumption rate and quality of the producer gas generated are studied by performing experiments. The performance of the biomass gasifier system is evaluated in terms of equivalence ratio, producer gas composition, calorific value of the producer gas, gas production rate, zone temperatures, and cold gas efficiency. Material balance is carried out to examine the reliability of the results generated. The experimental results are compared with those reported in the literature and are found in well accordance. (5 figures, 4 tables, 27 references)

Sahoo P K and Das L M. 2009
Combustion analysis of jatropha, karanja, and polanga based bio-diesel as fuel in a diesel engine
Fuel **88**(6): 994–999
Centre for Energy Studies, Indian Institute of Technology, New Delhi – 110 016, India

Non-edible filtered Jatropha (*Jatropha curcas*), Karanja (*Pongamia pinnata*), and Polanga (*Calophyllum inophyllum*) oil-based monoesters (bio-diesel) produced and blended with diesel were tested for their use as substitute fuels of diesel engines. The major objective of the present investigations was to experimentally access the practical applications of bio-diesel in a single cylinder diesel engine used in generating sets and the agricultural applications in India. Diesel; neat bio-diesel from jatropha, karanja, and polanga; and their blends (20 and 50 by v%) were used for conducting combustion tests at varying loads (0%, 50%, and 100%). The engine combustion parameters such as peak pressure, time of occurrence of peak pressure, heat release rate, and ignition delay were computed. Combustion analysis revealed that neat polanga bio-diesel that results in maximum peak cylinder pressure was the optimum fuel blend as far as the peak cylinder pressure was concerned. The ignition delays were consistently shorter for neat jatropha bio-diesel, varying between 5.9 sec and 4.2 sec crank angles lower than diesel with the difference increasing with the load. Similarly, ignition delays were shorter for neat karanja and polanga bio-diesel when compared with diesel. (3 figures, 4 tables, 15 references)

Ale B B and Shrestha S O B. 2009. Introduction of hydrogen vehicles in Kathmandu valley: a clean and sustainable way of transportation
Renewable Energy **34**(6): 1432–1437
Department of Mechanical Engineering, Pulchowk Campus, Institute of Engineering, Tribhuvan University, Nepal

Air quality of Kathmandu valley, the capital of Nepal, was becoming more critical due to the substantial increase in the conventional fueled vehicles in the valley each year. The bowl-like topography and generally low speeds of wind during the dry seasons create poor dispersion conditions, augmenting the air pollution problem further. The pollution is expected to quadruple by 2020 from the 2005 level in as business as usual scenario. The main source of the pollution in the valley is motor vehicle emissions. The paper highlights the different level of air pollution and emission reductions by introducing hydrogen fuel vehicles in Kathmandu valley. The entire fleet of vehicles in the valley can be fueled by hydrogen produced from the national hydroelectricity of Nepal using only less than 50% of its surplus energy. This will reduce about 700 000 tonnes of carbon emission in the valley in 2020. In addition, production of hydrogen using the surplus hydroelectricity of Nepal will improve load factor of the grid, and save a substantial amount of hard currency used to import the petroleum fuel in the country. As Nepal is one of the countries in the world with the most hydropower potential, with 80 000 MW potential capacity, hydrogen production is renewable, sustainable and pollution free. (19 figures, 1 table, 6 references)

Ahmed M I, Hrairi M, and Ismail A F. 2009. **On the characteristics of multistage evacuated solar distillation**
Renewable Energy **34**(6): 1471–1478
Department of Mechanical Engineering, International Islamic University Malaysia, P O Box 10, 50728 Kuala Lumpur, Malaysia

This paper proposes a new multistage evacuated solar distillation system that was designed to increase the productivity and improve the efficiency of the simple solar still. The solar still works by virtue of the higher evaporation rate under vacuum conditions. A mathematical model for the system was developed and used to optimize the system design. Fluent software was used to simulate the simultaneous heat–mass processes of the still. NASTRAN software was used for the

structural analysis. The system components were fabricated and the overall system was assembled. The preliminary results showed a significant improvement of the overall productivity. Indeed, the total productivity of the solar still is affected very much by changing the internal pressure. The productivity decreased as the pressure increased due to the lower evaporation rates at the higher pressure values. The influence of the characteristic height variation on the still's estimated productivity was found to be very strong. As the height increases the productivity decreases significantly. (14 figures, 17 references)

Rao S S and Murthy B K. 2009. A new control strategy for tracking peak power in a wind or wave energy system

Renewable Energy **34**(6): 1560–1566

Department of Electrical Engineering, National Institute of Technology, Warangal – 506 004, Andhra Pradesh, India

This paper proposes a novel control strategy for tracking peak power in a wind or wave energy system using a squirrel cage induction generator. It eliminates wind speed measurement or estimation and uses a simple scalar technique by exploiting the cubic nature of the power curve. The method works even when air velocity is varying dynamically. (11 figures, 20 references)

Menikpura S N M and Basnayake B F A. 2009. New applications of 'Hess Law' and comparisons with models for determining calorific values of municipal solid wastes in the Sri Lankan context

Renewable Energy **34**(6): 1587–1594

Solid Waste Management Research Unit, Department of Agricultural Engineering, Faculty of Agriculture, University of Peradeniya, Peradeniya, Kandy Central 20400, Sri Lanka

The present study conducts experimental validation of existing models and determination of the accuracy of the results. The results of models were different to experimental values due to high ash contents in the wastes. These differences were reduced by adjusting the reported elemental compositions, which were applied to the modified Dulong model. Accuracy improved when 'Hess Law' was applied to determine 'energy of formation', which was found to be inversely proportional to bomb calorimeter values. A further refinement was made with 'formation coefficients', which gave very accurate experimental values. A host of new information can be obtained from energy of formation, like improved characterization of wastes, validating experimental results. The latter led to the astonishing prediction of the possibility of replacing 2.5% of the present total energy consumptions or 42% of electricity consumption in Sri Lanka with efficient WTE plants. Thus, further extension of application of the Hess Law will have a futuristic outlook in improvement and development of efficient technologies while improving and protecting the environment. (5 figures, 6 tables, 21 references)

Varun I K and Bhat R P. 2009. LCA of renewable energy for electricity generation systems: a review

Renewable and Sustainable Energy Reviews **13**(5): 1067–1073

NIT, Hamirpur (HP) – 177 005, India

Sustainable development requires methods and tools to measure and compare the environmental impacts of human activities for various products (goods and services). Providing society with goods and services contributes to a wide range of environmental impacts. Environmental impacts include emissions into the environment and the consumption of resources as well as other interventions such as land use. LCA (life cycle assessment) is a technique for assessing environmental loads of a product or a system. The aim of this paper is to review existing energy and CO_2 life cycle analyses of renewable sources based electricity generation systems. The paper points out that carbon emission from RE (renewable energy) systems are not nil, as is

generally assumed while evaluating carbon credits. Further the range of carbon emissions from RE systems have been found out from existing literature and compared with those from fossil fuel based systems, so as to assist in a rational choice of energy supply systems. (7 tables, 46 references)

Murthy M V R. 2009. **A review of new technologies, models, and experimental investigations of solar driers**
Renewable and Sustainable Energy Reviews **13**(4): 835–844
Department of Mechanical Engineering, Osmania University College of Engineering, Osmania University, Hyderabad – 500 007, India

An attempt is made to review various aspects of solar driers applied to drying of food products at small scale. Popular types of driers in Asia–Pacific region, and new types of driers with improved technologies are discussed. The open sun drying and some alternate solutions are presented. The various aspects considered for modeling and experimental investigations carried out on various food products are also presented. Finally, the performance evaluation of the drier is discussed in detail. It is found that there is a shorter way of estimating the performance of a drier. (12 figures, 60 references)

Baiju B, Naik M K, and Das L M. 2009
A comparative evaluation of compression ignition engine characteristics using methyl and ethyl esters of Karanja oil
Renewable Energy **34**(6): 1616–1621
Centre for Energy Studies, Indian Institute of Technology Delhi, New Delhi – 110 016, India

This paper investigates the scope of utilizing bio-diesel developed from both through the methyl as well as ethyl alcohol route (methyl and ethyl ester) from karanja oil as an alternative diesel fuel. The major problem of using neat karanja oil as a fuel in a compression ignition engine arises due to its very high viscosity. Transesterification with alcohols reduces the viscosity of the oil and other properties have been evaluated to be comparable with those of diesel. In the present work, methyl and ethyl esters of karanja oil were prepared by transesterification using both methanol and ethanol. The physical and chemical properties of ethyl esters were comparable with that of methyl esters. However, viscosity of ethyl esters was slightly higher than that of methyl esters. Cold flow properties of ethyl esters were better than those of methyl esters. Performance and exhaust emission characteristics of the engine were determined using petrodiesel as the baseline fuel and several blends of diesel and bio-diesel as test fuels. Results show that methyl esters produced slightly higher power than ethyl esters. Exhaust emissions of both esters were almost identical. These studies show that both methyl and ethyl esters of karanja oil can be used as a fuel in compression ignition engine without any engine modification. (8 figures, 5 tables, 13 references)

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, and so on, 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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Technology scan

ISRO technology to drive bus

Launch vehicles equipped with cryogenic engine working on liquid hydrogen as fuel and liquid oxygen as oxidizer have been in use to deliver the satellite payloads into their designated orbits. However, there have been no serious global efforts to exploit this technology for hydrogen fuel cell development. However, ISRO (Indian Space Research Organization) is now close to achieving a breakthrough in developing and qualifying a hydrogen fuel cell for operating a bus. ISRO has fallen back on some of the technological elements developed for India's homegrown cryogenic engine stage that will be flight-tested in a GSLV (Geosynchronous Satellite Launch Vehicle) mission slated for 2009. GSLV flights that were accomplished till now carried a Russian supplied upper cryogenic stage. The Indian cryogenic stage, which will replace the Russian supplied upper stage in the three-stage GSLV, features a regenerative cooled engine capable of generating a thrust of 69.5-kN in vacuum. The hydrogen fuel cell system used by ISRO is not exactly the cryogenic technology. It is ISRO's expertise in handling liquid hydrogen, which has given a push to the project aimed at developing a hydrogen fuel cell system for use in transportation sector.

The Tribune, 5 December 2008

Solar table lamps for rural students

HAREDA (Haryana Renewable Energy Development Agency) has come up with an innovative scheme to provide LED (light-emitting diode)-based solar table lamps called 'Shikshadeep' to the students who are facing difficulty in studying due to power shortages in the rural areas. Shikshadeep was basically a portable lighting device, which would work for four to five hours daily. The lamp and battery would be warranted for a period of five years whereas the solar panel would be warranted for ten years. The approximate cost of one such lamp would be Rs 1600. HAREDA has also decided to provide one solar educational kit per school in all 3000 secondary schools of the state on demonstration basis to popularize photovoltaic technology among the students. The cost of these kits would be shared by the state and central governments in the ratio of 50:50.

The Hindu, 2 January 2009

Punjab plans agri-waste use to produce power

The Punjab government has chalked out an ambitious plan to generate power from agriculture waste by setting up co-generation power plants at all the state-owned cooperative sugar mills. The concept aims to involve the private sector on a BOOT (build, own, operate, and transfer) basis at its nine sugar mills. The private sector companies, through cooperative societies in the state, will purchase agriculture waste including paddy straw to generate power through the biomass project. All these plants will be functional by the end of 2010. The Punjab Sugarfed has signed an MoU (memorandum of understanding) with private parties to set up co-generation plants and for the modernization and upgradation of all the sugar mills on a BOOT basis.

The Financial Express, 5 February 2009

Haryana's first solar village

Iqbalpur village of Gurgaon district has become the first Haryana village covered 100% by solar home-lighting systems. The village has achieved this distinctive status with persistent efforts of the Gurgaon Gramin Bank, which has worked in collaboration with the Bharatiya Vikas Trust, Manipal, Karnataka, and Tata BP Solar India. The bank provided 100% loan facility for the installation of solar home-lighting systems.

The Tribune, 18 February 2009

Biggest renewable power project in Jharkhand soon

JREDA (Jharkhand Renewable Energy Development Agency) is readying to launch the biggest biomass-generated power project in the country in 2009/10. The project, on completion, will provide electricity to five lakh poor households in the state at an affordable price.

To begin with, about 100 power units dependent on biomass will come up in five to six districts of Jharkhand. Each unit will generate 100 kW, sufficient to light up about 5000 households in a cluster of villages. JREDA has so far identified four districts – Pakur, Chatra, Latehar, and Gumla – to be covered under the project. Two more districts might be added based on the number of cooperatives in a particular location.

The Financial Express, 18 February 2009

'Wind Atlas' in the works

The centre is in advanced stages of getting an 'Indian Wind Atlas' commissioned, which would identify windy locations across the country, and thereby, enable better harnessing of resources by project developers in the future. The atlas is being prepared by the Centre for Wind Energy Technology in association with the RISO National Laboratory of Denmark, which has taken up three pilot areas covering different topography and climate types across the country. Currently, while much of the wind capacities are focused on India's eastern coastline and parts of the Western Ghats, the wind atlas is aimed at harnessing more wind potential areas, including the North East and the northern Himalayan zone, besides offshore locations along the coastline. The wind monitoring data collected from these pilot areas is being used to validate mathematical model, results of which will be used in preparation of the atlas.

The Hindu Business Line, 20 February 2009

Less-polluting autos to be built in the city by 2010

UNIDO (United Nations Industrial Development Organization) has signed an agreement with the ICHET (International Centre for Hydrogen Energy Technologies) in New Delhi to build, operate, and financially support a fleet of 15 three-wheelers that would run on hydrogen and thus help build a vehicle, which is pollution-free and environment friendly. The signatories to the MoU include the IIT (Indian Institute of Technology), Delhi, Mahindra and Mahindra and the UNIDO regional office for South Asia, the Ministry of New and Renewable Energy, the CSIR, and the Indian Oil Corporation.

The Asian Age, 13 March 2009

Conversion of CO_2 into methanol

Scientists are continuously working on to find an alternative to fossil fuels using the carbon dioxide as an alternative fuel. Scientists at the Singapore-based IBN (Institute of Bioengineering and Nanotechnology) are striving to make the mass production of methanol more cost-effective.
This will result in reducing the amount of carbon dioxide released in the earth's atmosphere.
Scientists at the IBN have achieved an unparalleled feat by transforming carbon dioxide into methanol. Methanol is a widely used form of industrial feedstock and clean-burning biofuel.
At the IBN, scientists successfully made carbon dioxide react with a stable organocatalyst called NHC (N-heterocyclic carbene). This reaction took place under mild conditions in dry air. Further, the researchers used a combination of silica and hydrogen known as hydrosilane. Hydrosilane is added to the NHC-activated carbon dioxide, which is converted into methanol through hydrolysis. This carbon dioxide reduction is efficiently catalysed by NHCs even at room temperature.

<www.alternative-energy-news.info>, last accessed on 28 April 2009

Plastic solar cells

Plastic solar cells are lightweight, flexible, and most important, cheap to make. Researchers from a few institutions claim to have made polymer solar cells with record-breaking efficiencies.
These cells still aren't good enough to compete with silicon. Plastic solar cells, no matter how well designed, have intrinsic limits dictated by the polymers that make up their active layer.
The polymers made so far can only absorb relatively narrow bands of light. It is possible to boost their power-conversion efficiency by stacking films of polymers designed to pick up different bands of light. However, this approach has a major disadvantage since layering is self-defeating because fabrication costs goes up.
Recently, the researchers reported on polymer solar cells that convert about 6.1% of the energy in sunlight into electricity inching a bit closer to the 10% that they say will be needed to gain a significant foothold in the market.

MIT Technology Review, 30 April 2009

Web updates

Alternative Technology Association

http://www.ata.org.au/

A non-profit community group that aims to use and promote environment-friendly technology, including renewable energy sources such as the sun, wind, and water; building with natural materials and conserving energy. The site hosts related news, web shops, events, publications, advocacy information, links, and project details.

American Wind Energy Association

http://www.awea.org/

AWEA (American Wind Energy Association) advocates the development of wind energy as a reliable, environmentally superior energy alternative in the United States and around the world. The site is a rich collection of resources including news, events, legislations, policy briefs, and publications.

Florida Solar Energy Centre

http://www.fsec.ucf.edu/en/

FSEC (Florida Solar Energy Centre) is the largest and most active state-supported renewable energy and energy efficiency research, training, and certification institute in the United States. The site provides research information on selected areas, consumers listing, news, publications, and several documents.

Green Power Network

http://apps3.eere.energy.gov/greenpower/about/index.shtml

The GPN (Green Power Network) is operated and maintained by the National Renewable Energy Laboratory for the US Department of Energy. The GPN provides news and information on green power markets and related activities. The site provides up-to-date information on green power providers, product offerings, consumer protection issues, and policies affecting green power markets. It also includes a reference library of relevant papers, articles, and reports.

Office of the Renewable Regulator

http://www.orer.gov.au/about/index.html

The ORER (Office of the Renewable Energy Regulator) was established to administers the Renewable Energy (Electricity) Act 2000 (the Act), Renewable Energy (Electricity) Charge 2000, and the Renewable Energy (Electricity) Regulations 2001 (the regulations) to increase renewable electricity generation. The site hosts REC registry, legislations, forms, publications, news, renewable power stations, RE certificates, and much more useful information.

The Source for Renewable Energy

http://energy.sourceguides.com/

The *Source for Renewable Energy* is a comprehensive online buyer's guide and business directory to more than 14 000 renewable energy businesses and organizations worldwide. The searchable directory is categorized by locations, business types, company names, and product types.

American Coalition for Ethanol

http://www.ethanol.org/

A non-profit membership association devoted to promoting the increased production and use of ethanol in USA. The ACE website hosts news, events, publications, market information, and policy matters.

AGORES

http://www.agores.org/

A global overview of renewable energy sources from the official European Commission website for renewable energy sources. The website is a rich source of renewable energy information including policy, publications, links, who's who, news, and events. The site also covers sectoral information of RE sources, community programmes, and information on related research areas.

Northeast Sustainable Energy Association

http://www.nesea.org/

The Northeast Sustainable Energy Association fosters the use of renewable and sustainable energy, the responsible use of non-renewable forms of energy, and conveys the value of these practices for the preservation of the environment. The site brings together interesting web resources including open forums, educators list, resource library, events, links, news, and many other types of information.

Natural Gas Vehicle Coalition

http://www.ngvc.org/

The NGVC (Natural Gas Vehicle Coalition) represents more than 180 natural gas companies; engine, vehicle, and equipment manufacturers; and service providers, as well as environmental groups and government organizations interested in the promotion and use of natural gas as a transportation fuel. The site is rich information source for market information, news, technology, directory, government policies, other resources, and publications.

India at a glance

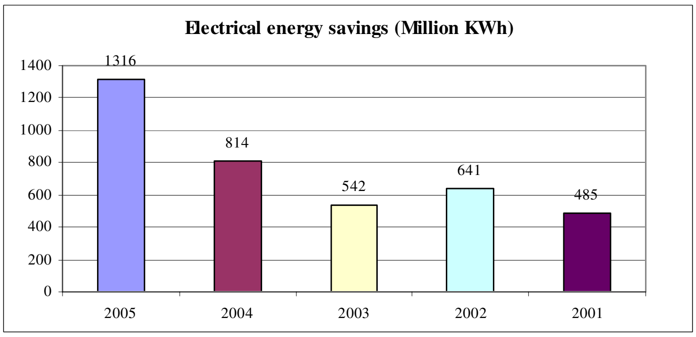
Power from renewables

Grid-interactive renewable power

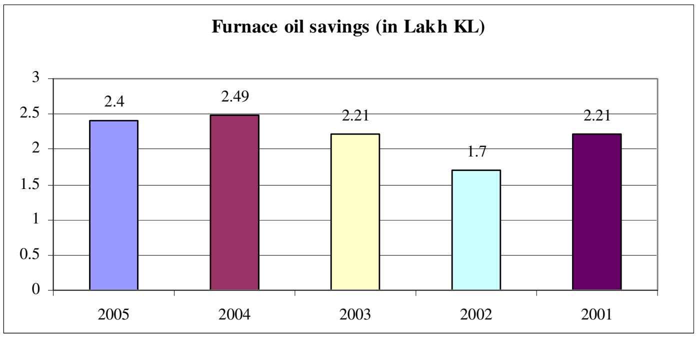
Power source	*Estimated potential* (MW)	*Achievements as on 31 January 2009* (MW)
Wind power	45 195	9755.85
Biopower (agro residues and plantations)	16 881	683.30
Bagasse cogeneration	5000	1033.73
Small hydropower (up to 25 MW)	15 000	2344.67
Energy recovery from waste	2700	58.91
Solar photovoltaic power	—	2.12
Sub total	**84 776**	**13 878.58**
Captive/combined heat and power/distributed renewable power		
Biomass/cogeneration (non-bagasse)	—	150.92
Biomass gasifier	—	160.31
Energy recovery from waste	—	31.07
Sub total	**—**	**342.30**
Total	**—**	**14 220.88**
Decentralized energy systems		
Family-type biogas plants	120 lakh	40.90 lakh
Solar photovoltaic systems	50 MW/km^2	120 MWp
Solar street lighting systems	-	70 474
Home lighting systems	-	434 692
Solar lantern	-	697 419
Solar power plants	-	8.01 MWp
Solar photovoltaic pumps	-	7148
Solar thermal systems		
Solar water heating systems collector area	140 million m^2 collector area	2.60 million m^2
Solar cookers		6.37 lakh
Wind pumps		1347
Aero generator/hybrid systems		0.89 MW_{eq}

Source Ministry of New and Renewable Energy (2009)

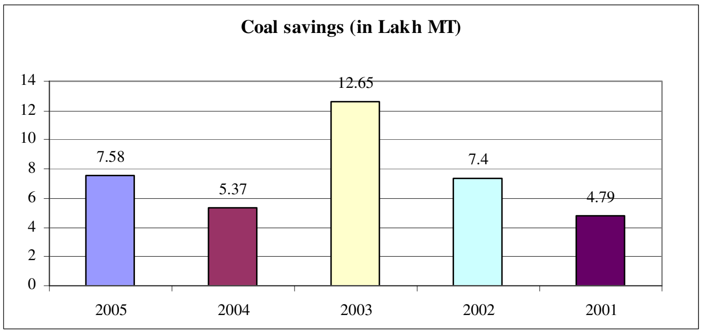
Energy savings by industrial units



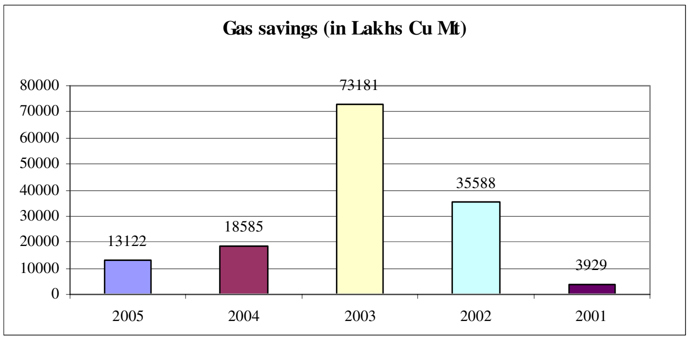
Source Ministry of Power (2006)



Source Ministry of Power (2006)



Source Ministry of Power (2006)



Source Ministry of Power (2006)

Forthcoming events

11–16 May 2009, Buffalo, New York, **USA**

SOLAR 2009
Kate Hotchkiss
American Solar Energy Society, 2400 Central Ave, Suite A, Boulder, Colorado 80301
Tel. 303 443 3130 • *Fax* 303 443 3212
E-mail ases@ases.org
Web http://www.solar2009.org

7–12 June 2009, Philadelphia, **USA**

34th IEEE Photovoltaic Specialists Conference
Robert J Walters
Program Chair, U S Naval Research Laboratory
Bldg 208, Rm. 135, 4555 Overlook Ave., SW
Washington, DC 20375
Tel. 202 767 2533
E-mail Robert.Walters@nrl.navy.mil
Web http://www.34pvsc.org/index.php

Forthcoming events

15–17 June 2009, Amman, **Jordan**

International Conference and Exihibion on Green Energy and Sustainability
Mohammed Al Ta'ani
Coordinator, Hashemite University
Zarqa, Amman, Jordan
Tel. +962 777 418 782, 962 799 055 314 • *Fax* +962 538 266 13
E-mail mtaaninq@gmail.com • *Web* http://www.greenenergy-jo.com

17–18 June 2009, Paldi, Gujarat, **India**

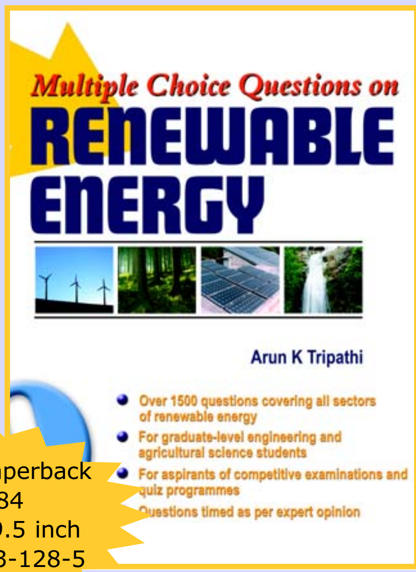
Fifth National Conference on Indian Energy Sector
Mr Manoj Patel
Saket Projects Ltd, Saket House, Panchsheel
Usmanpura, Ahmedabad – 380 013, Gujarat
Tel. 91 79 2755 1931/1817/2873 • *Fax* 91 79 2755 0452
E-mail Saketprojects@gmail.com
Web http://www.synergy4energy.net

24–26 June 2009, Tokyo, **Japan**

PV Japan 2009
Tetsuya Ono
SEMI Japan, 4-7-15 Kudan-minami, Chiyoda-ku, Tokyo
Tel. 81 3 3222 5776 • *Fax* 81 3 3222 5757
E-mail pvj@semi.org
Web www.pvjapan.org/PVJAPAN.var

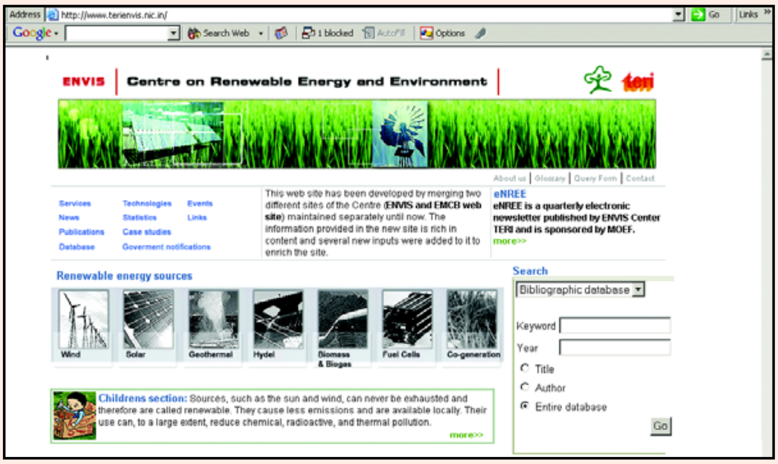
30 June–2 July 2009, Rome, **Italy**

Photovoltaics Summit Europe 2009
Paul Squires
Crowne Plaza Rome St Peter's
Via Aurelia Antica 415, Rome 00165, Italy
Tel. +44 (0)1372 802051 • *Fax* +44 (0)1372 802243
E-mail paul.squires@pira-international.com
Web www.pvsummiteu.com



ENVIS Centre on Renewable Energy and Environment

A knowledge gateway



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

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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