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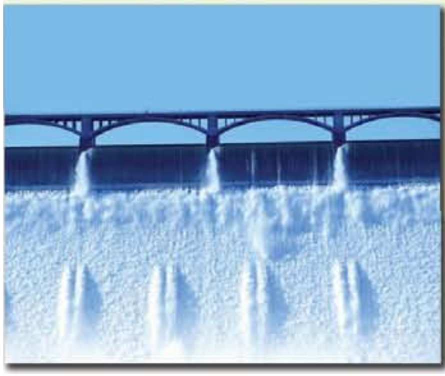

Karanja or jatropha: a better option for an alternative fuel in compression ignition engine

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Current research on renewable energy and development

A compilation of annotated bibliographies from different leading periodicals on current research on renewable energy and environment.

Technological developments

Some of the recent technological developments in the field of development are discussed.

Web updates

This section picks up some of the web resources available in the fields of renewable energy and environment.

India at a glance

This section focuses on recent energy efficiency and renewable energy statistics of India.

Forthcoming events

Covers some of the major forthcoming events in the field of environment, renewable energy, and sustainable development

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Karanja or jatropha: a better option for an alternative fuel in compression ignition engine

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Abstract

The high energy demand in the industrial world, as much in the domestic sector, and the derived problems of the widespread use of fossil fuels, make increasingly necessary the development of renewable energy sources. Recent development in gene segment transfer and modification techniques suggest an alternative route for the development of diesel fuel from plant sources, especially non-edible oil seeds. In this work the transformation process of jatropha and karanja oil in order to obtain biodiesel by means of transesterification, as prepared in the laboratory, will be discussed. In the laboratory experiment, jatropha and karanja methyl esters were characterized to test their properties as fuel in diesel engines, such as viscosity, density, flash point, and cetane number. The blends of varying proportions of the jatropha and karanja with diesel were prepared, analysed, and compared with diesel oil. The engine performance and emission characteristics were evaluated in a single cylinder CI engine and a comparison was made to suggest the better option among the biodiesel under study.

Introduction

During the last decade, India has maintained a high growth rate in accepting the improved technological challenges in the global scenario. India ranks sixth in the world in terms of energy demand, accounting for 3.5% of the world commercial energy demand in 2001. The diesel engines dominate in the field of technology because they can be easily operated and are more fuel efficient. The consumption of diesel is much higher than that of petrol. In India, the demand of HSD (high speed diesel) is projected to grow from 39.81 million metric tonnes in 2001/02 to 52.32 million metric tonnes in 2006/07 at the rate of 5.5% per annum. Also, due to gradual depletion of the world petroleum reserve, rising petroleum prices, increasing threat to the environment from exhaust emission, and global warming have generated an intense international interest in developing alternative, non-petroleum fuels for full or partial replacement. In recent years, systematic efforts have been undertaken by many researchers to determine the suitability of vegetable oil, animal fats and their derivatives as fuel or additives to diesel. Blending/dilution, microemulsification, thermal cracking, and transesterification are the common methods to convert oil as fuel in CI engines. In the recent years, biodiesel has received significant attention, both as a possible renewable alternative fuel and as an additive to petroleum-based fuels. Among these, vegetable oils are the most promising alternative fuels for CI engines as they are renewable, biodegradable, non toxic, environmental-friendly, and have a lower emission profile compared to diesel fuel and conventional petroleum diesel.

There are many tree species, bearing seeds available in India, which are rich in non-edible vegetable oils. But surprisingly, they are not used as per their potential. Therefore, in India the feasibility of producing biodiesel, as a diesel substitute, can be considered, along with the unutilization of the available potential of non-edible oil sources. There is a large junk of degraded forest land, unutilized public land, fallow lands of farmers, and lands in the rural areas, which will be beneficial for overall economic growth.

For the present study, the transformation process of jatropha and karanja oil, in order to obtain biodiesel by means of transesterification, was studied in the laboratory. The blends of varying proportions of jatropha and karanja with diesel were prepared, analysed, and compared with diesel oil. The engine performance and emission characteristics were evaluated in a single cylinder CI engine and a comparison was made to come up with the best alternative.

Experimental programme

The experimental investigations on karanja and jatropha oil are as follows.

Preparation of laboratory samples

Untreated vegetable oils, karanja and jatropha, under study were mixed with a mixture of anhydrous methanol and a catalyst, NaOH, in proper proportion. The mixtures were maintained at a temperature little below 65 °C (being the boiling point of methanol) and were continuously stirred for around three hours. After the stirring process, the mixture was allowed to settle down for 24 hours. The layer of glycerol, settled at the bottom, was carefully taken out and the upper layer, the ester of karanja oil, was tapped separately. The washing of the transesterified vegetable oils was done for the removal of additional ester, followed by the evaporation for the removal of water particles and alcohol.

Fuel property measurement

The improvement in the performance of the CI engines, over the past century, has resulted from the complimentary refinement of the engine design and fuel properties. Replacement of the existing fuels with new fuels call for an understanding of critical fuel properties to ensure that the new fuels can be used. Major problems encountered with vegetable oil, as bio diesel used in CI engine, is its low volatility and high viscosity due to its long-chain structure. The common problems faced are excessive pumping power, improper combustion, and poor atomization of fuel particles. Discussed in this section are some key fuel properties as well as a comparison with the standard diesel fuel.

Specific gravity

Specific gravity is the relative measure of the density of a substance. It is defined as the ratio of the density of the substance, ρ, to a reference density, ρεϕ. The specific gravity of conventional diesel fuel is about 0.835, while for transesterified karanja oil it is 0.882 and for transesterified jatropha the value is 0.876, which means that the biodiesel under study is denser than conventional diesel fuel.

Viscosity

The resistance to flow, exhibited by fuel blends, is expressed in various units of viscosity. It is a major factor of consequence in exhibiting their suitability for mass transfer and metering requirements of engine operation. High value of viscosity reduces volatility and gives poor atomization of oil during injection of the CI engine. This results in incomplete combustion and ultimately carbon deposits on the injector nozzle as well as in the combustion chamber. The viscosities of karanja, jatropha oil, and their derived biodiesel are measured by Red Wood Viscometer (ASTM D445). A comparative study of viscosity dependencies are made at different temperatures (Table 1) and plotted in Figure 1.

Table 1 Viscosity dependency on temperature variation

	Viscosity of Karanja oil (cSt)		*Viscosity of Jatropha oil (cSt)*	
Temp (°C)	*Raw*	*Derived biodiesel*	*Raw*	*Derived bio-diesel*
30	29.65	8.73	53.79	7.20
45	17.34	7.44	35.20	5.37
60	14.62	5.97	24.85	4.14
75	11.74	5.34	14.55	3.32
90	10.63	4.62	8.23	2.96

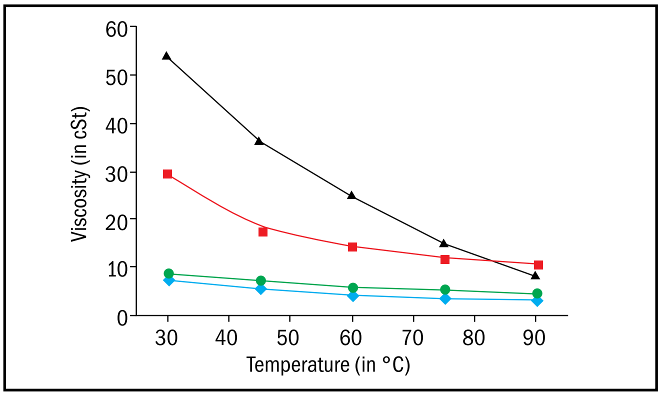

Figure 1 Viscosity Vs Temperature

Flash and Fire point

A key property, determining the flammability of a fuel, is the flash point. The flash point is the lowest temperature at which an applied ignition source causes the vapours of a sample to ignite.

The 'fire point' is sometimes used to designate the fuel temperature, producing sufficient vapour to maintain a continuous flame. These two parameters have great importance while determining the fire hazard (temperature at which fuel will give off inflammable vapour).

Table 2 Comparative studies of fuel properties of diesel and biodiesel

Properties	*Karanja oil*		*Jatropha oil*		*Diesel*
	Raw	*Derived biodiesel*	*Raw*	*Derived biodiesel*	
Viscosity (cST) at 30 °C	29.65	8.73	53.79	7.2	2.5
Calorific value (kj/kg)	–	35879	–	42640	43500
Flash point (°C)	241	217	261	248	52
Fire point (°C)	253	223	302	295	63
Cloud point (°C)	7	6	7	6	5
Pour point (°C)	3	3	4	4	4
Specific gravity (at 30 °C)	0.912	0.882	0.902	0.876	0.835

Cloud point and pour point

The cloud point is the temperature at which a cloud of wax crystals first appears in a fuel sample that is cooled under conditions described by ASTM D2500. The pour point is the lowest temperature at which movement of the fuel sample can be determined when the sample container is tilted under conditions described by ASTM D97. These two temperatures are of great importance in knowing the behaviour of fuels in cold weather.

Calorific value

The calorific value of a fuel is the thermal energy released per unit quantity of fuel when the fuel is burned completely and the products of combustion are cooled back to the initial temperature of the combustible mixture. It measures the energy content in a fuel. This is an important property of biodiesel that determines the suitability of the material as alternative to diesel fuels.

Cetane number

Perhaps the most important characteristic of the ignition of diesel and/or biodiesel fuels is the cetane number, since it directly pertains to ignition within compression ignition engines. The cetane number is the primary specification measurement used to match fuels and engines. The cetane number of a diesel fuel is related to the ID (ignition delay) time, that is, the time that passes between injection of the fuel into the cylinder and the onset of ignition. The shorter the ID time, the higher the cetane number and vice versa. A fuel of higher cetane number gives lower delay period and provides smoother engine operation. The API (American Petroleum Institute) and the NBS (National Bureau of Standards) have jointly devised an arbitrary scale, expressing the gravity or density of liquid petroleum product in terms of degree API. For karanja it is found to be 28.93 (degree API) and 47.79 (diesel index). The cetane number is calculated as 56.64. For jatropha, the corresponding values are 30.03, 50.15, and 57.12, respectively. These values prove the suitability of the fuel under study as a diesel fuel.

As shown in Table 2, the viscosity and specific gravity of biodiesel obtained are very high compared to the suitability in the CI engine, therefore, it is evident that dilution or blending of biodiesel with other fuels, like diesel, fuel would bring the viscosity and density close to a specification range. Therefore, biodiesel obtained from karanja and jatropha were blended with diesel oil, in varying proportions, to achieve the required viscosity and density, close to that of diesel fuel (Table 3).

Table 3 Variation of viscosity and density for different blends

Karanja blend with diesel		*B5*	*B10*	*B15*	*B20*	*B25*	*B100*
	Viscosity (cSt)	2.78	2.89	3.06	3.64	3.98	8.73
	Density (kg/m^3)	837	840	842	844	847	882
Jatropha Blend with diesel		B10	B20	B30	B40	B50	B60
	Viscosity (cSt)	2.99	3.5	3.81	4.31	4.51	5.34
	Density (kg/m^3)	839	843	847	851	855	859

Studies of different blends of biodiesel

To study engine performance and emission, the experiments were done in Kirloskar make vertical single cylinder, direct injected compression ignition diesel engine (Engine model-AVI). The power output of the engine was 5 HP (horsepower) at the rate of 1500 rpm (revolutions per minute), having a compression ratio 16.5:1. The emission as well as engine performance was studied at different engine loads (25, 50, 75, and 100% of the load corresponding to load at maximum power).

Brake thermal efficiency

The variation of brake thermal efficiency with load for different fuel blends are shown in Figure 2 and Figure 3. In all the cases, brake thermal efficiency was increased due to reduced heat loss with increase in load. The maximum efficiency for transesterified karanja oil, obtained in this experiment, was 33.74% (B25) and 33.54% (B20). However, considering the viscosity, B20 was the better option and this value is comparable with the maximum brake thermal efficiency for diesel (34.45%). For transesterified jatropha oil, considering the viscosity, B50 was the better option and the maximum brake thermal efficiency was 36.9%. From Figure 2 and Figure 3, it can seen that brake thermal efficiency for biodiesel, under investigations in comparison to diesel engine, is a better option for part load on which most engine runs.

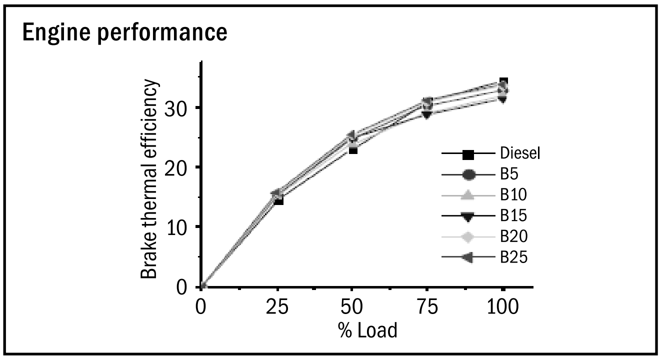

Figure 2 Variation of thermal efficiency for karanja blended with diesel

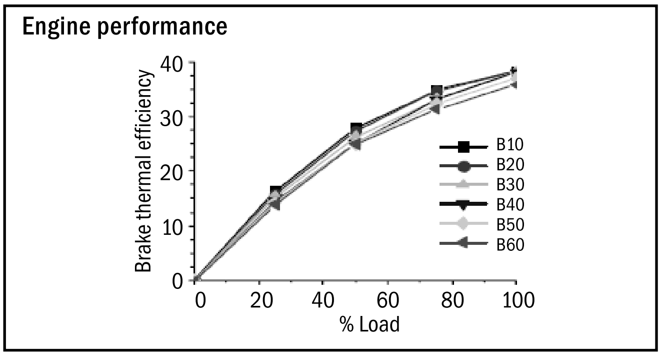

Figure 3 Variation of thermal efficiency for jatropha blended with diesel

Brake specific fuel consumption

The variation of BSFC (brake specific fuel consumption) at different load for jatropha and karanja, blended with diesel, is shown in Figure 4 and Figure 5. For all cases, BSFC reduces with increase in load. The reverse trend in the BSFC may be due to increase in biodiesel percentage, ensuring lower calorific value of fuel. Another reason for the change in BSFC in biodiesel in comparison to petro-diesel may be due to a change in the combustion timing caused by the biodiesel's higher cetane number as well as injection timing.

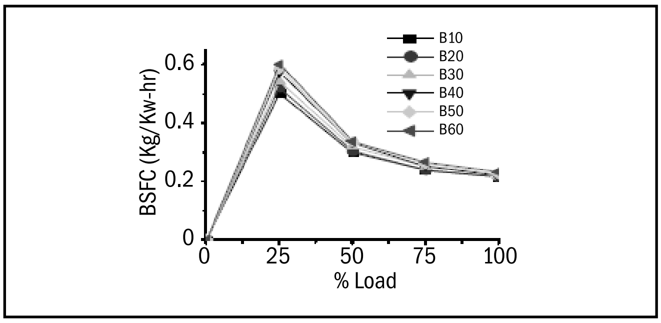

Figure 4 Variation of BSFC for jatropha blended with diesel

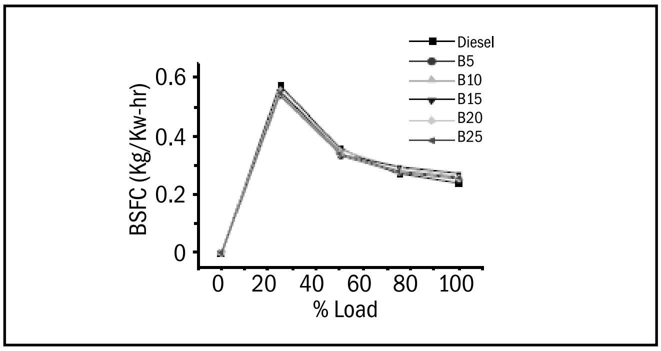

Figure 5 Variation of BSFC for karanja blended with diesel

Carbon monoxide emission

The variation of CO (carbon monoxide), produced with diesel and diesel blends (karanja and jatropha), are presented in Figure 6 and Figure 7. The amount of CO produced, whether for a B20 karanja blend or a B50 jatropha blend, is much less than the CO produced from the diesel that indicates the complete combustion of the biodiesel being an oxygenated fuel. For B20 karanja blend, at maximum load, the amount of CO produced is 1.42 gm/kW-hr and for jatropha B50, it is 0.756 gm/Kw-hr, which are less than that mentioned in EURO-IV norms (max 1.5 gm/Kw-hr).

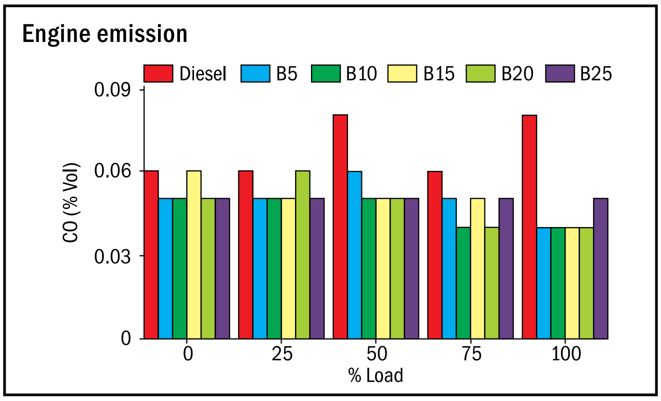

Figure 6 Variation of CO for karanja blends

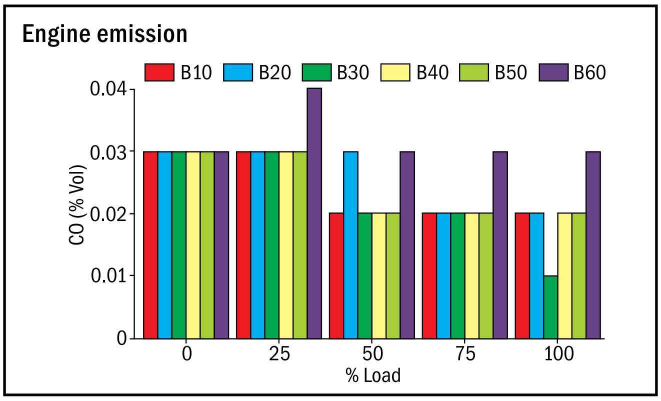

Figure 7 Variation of CO for jatropha blends

Nitrogen oxide emission

The variations of NO_x (oxides of nitrogen), at different engine load for the fuel under study, is presented in Figure 8 and Figure 9. The cetane numbers of the biodiesel obtained are generally higher than that of diesel fuel associated with lower NO_x emissions. For B20 karanja blend, the maximum and minimum NO_x produced is 0.12 gm/Kw-hr and 0.06 gm/Kw-hr, whereas the value for jatropha (B50) is 0.11 gm/Kw-hr and 0.04 gm/Kw-hr, which is much less than that mentioned in EURO-IV norms (max 3.5 gm/Kw-hr).

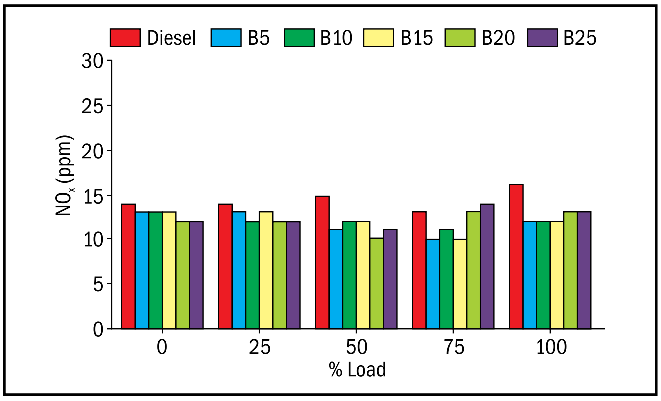

Figure 8 Variation of NO_x for karanja blends

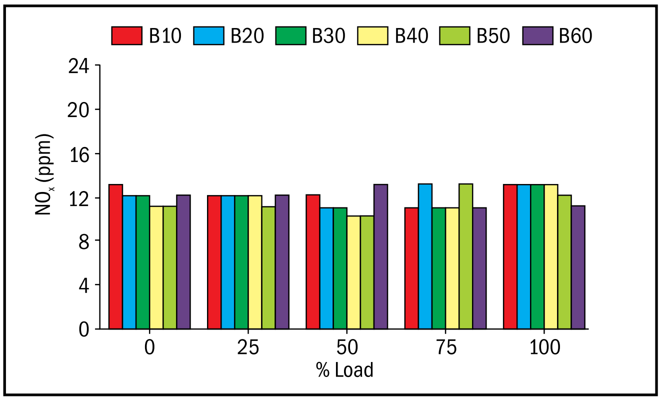

Figure 9 Variation of NO_x for jatropha blends

The variations of un-burnt hydrocarbon, at different engine load for different diesel blends with karanja and jatropha, are shown in Figure 10 and Figure 11. The shorter ignition delay, associated with biodiesel higher cetane number, could also reduce the over mixed fuel, which is the primary source of un-burnt hydrocarbons. For B20 karanja blend, the maximum and minimum hydrocarbon produced is 0.35 gm/Kw-hr and 0.18 gm/Kw-hr, whereas for the B50 jatropha blend, it is 0.09 gm/Kw-hr and 0.07 gm/Kw-hr, which are much less than the HC produced from diesel emission.

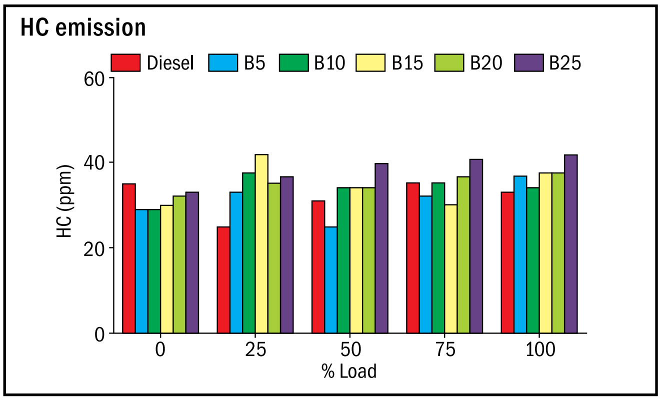

Figure 10 Variation of NO_x for karanja blends

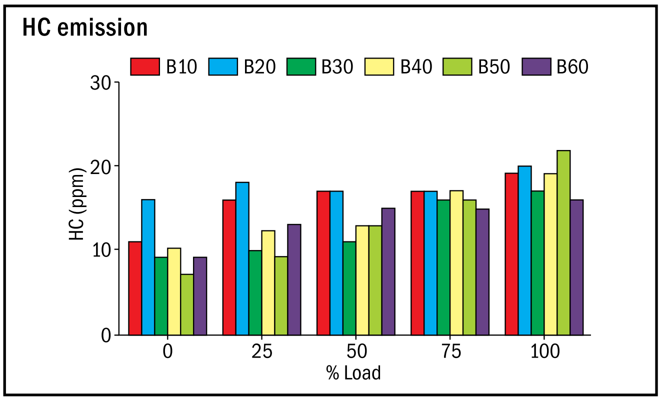

Figure 11 Variation of NO_x for jatropha blends

Conclusion

Based on the result of this study, that is, the physical and chemical properties of karanja or jatropha oil, it can be suggested that fuel produced from these plants cannot be used directly as CI engine fuel due to higher viscosity and density as this will result in low volatility and poor atomization of oil during oil injection in the combustion chamber, causing incomplete combustion and carbon deposits in the combustion chamber.

Based on engine emission studies, that is, CO, NO_X and hydrocarbon, it can be said that all the parameters are within the maximum limits that conclude safer use as an alternate fuel.

The physical and chemical properties results of all blends show that blends of upto 20% straight karanja and upto 50% straight jatropha have a value of viscosity and density equivalent to specified range for CI engine fuel, therefore, it can be concluded that upto 20% blend for karanja and 50% blend for jatropha can be used to run the stationary CI engine on a short-term basis. In overall perspective, the B50 jatropha is a better choice as it can partially replace more amounts of diesel in comparison to karanja.

The combustion process essentially results in deposition inside the cylinder walls and more importantly on the cylinder head. With continued use of the engine, these depositions may eventually lead to hotspots, creating possibilities of untimely ignition. While the last aspects have been investigated in detail in CI engines using diesel, the same is wanting in the proposed biodiesel under investigation for long-term purposes.

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Rooftop solar power

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The SPV (solar photovoltaic power) system is the simplest form of converting solar energy to electricity. However, its high capital cost makes it one of the costliest resources of energy, ostensibly with implications of high fixed charges. Despite its high cost, over the last 40 years, the price of the module, which is the main ingredient of SPV, has fallen from $99.61 per watt in 1975 to $3.84 in 2007. The cost of energy from SPV plants is still five times higher than conventional sources such as coal-based thermal power. It may not be fair to compare the price of SPV or other renewable or nuclear source with GHG (greenhouse gas)-emitting thermal power as they are completely different entities. While the former is clean and environment friendly and does not get any credit other than the remotely available CDM (Clean Development Mechanism) benefit, the latter is not subjected to imposition of carb
on tax.

Looking at the power scenario in the country, which requires 800 000 MW (megawatt) of installations by 2031, at best 50% of the total requirement can be catered to by coal-based sources. These sources also have their constraints as far as quality and economic feasibility of mining areas is concerned. The high cost of importing good quality coal and other infrastructural necessities is also a matter of concern. The remaining 50% of the energy demand has to be met from hydro, wind, biomass, bio-energy, nuclear, and solar power. Excluding solar and nuclear, others put together will add up to about 250 000 MW, based on assessed potential. The burden of meeting the shortage will fall upon nuclear and solar power. Solar power potential is as high as 600 000 MW. Thus, it is imperative to find a methodology to make solar power competitive for installations on a large- scale, both for encountering the harmful effects of GHG and remedying the shortfall between demand and supply. Nuclear power also has the potential to grow if the issue of fuel supply and harnessing higher technology is sorted out with the Nuclear Supply Group and through recent agreements with USA and other countries.

Continuous R&D (research and development) backed by wide-scale application has resulted in the fall of SPV prices. However, there is a long way to go as far as the price of SPV is concerned. According to forecasts, the price will be halved in another seven to eight years. To overcome the effect of high price, innovative financial packages are being worked out along with loans on easy terms. One such encouraging stimulus is the FTT (feed-in tariff), which will fix the sale price of solar energy for supply to the grid at a special higher rate. This factor has given a big boost to SPV, so much so that world installation is experiencing a growth rate of more than 30%. Germany, Japan, USA, and Spain, in particular, are progressing at a fast rate to add more than 1500 MW annually. China is following them, as evident from applications of solar power displayed during last Olympic Games. World installations of SPV have exceeded 8000 MW against only about 2 MW of grid-connected type in India. This implies that the country is yet to launch its movement in a proactive manner. The Prime Minister's National Solar Mission, the first amongst eight programmes under climate change initiatives undertaken by the government, is likely to address the issue of advancing solar power.

India has declared FIT at the national and also at some of the state levels. Unfortunately, this tariff structure is not attractive from the profitability point of view, considering the long payback period for the investment. Nevertheless, a beginning has been made. There are caps on overall annual and five-year capacity addition to be eligible for FIT as preferential tariff. Only 50 MW has been targeted in place of 5000 MW. Solar SPV power of 5000 MW grid-connected installations will deliver annual energy to the tune of 6 billion units. Utilities are likely to buy solar energy at FIT rate from entrepreneurs and realize the cost from overall distribution to ultimate consumers. Such a small quantity from SPV, even at five times the price of conventional energy, would hardly have any impact on the overall tariff structure chargeable to the consumers. Enhancement of FIT from Rs 15 to Rs 20 per unit, as incentive to investors, will invite investment from India and abroad for a rising industry, besides opening up windows of opportunity for growth of the economy by providing employment opportunities, increase in manufacturing goods, marketing, installations, operations, and maintenance. At Rs 15 per unit, profitability is unattractive and payback period of investment is very long, as can be seen in a set of calculations below. Unless both removal of caps as well as increased FIT are set right, it is unlikely that the purpose of boosting solar power will be served. In order to fulfil the agenda for clean power in adequate quantity, and to make good shortfall in demand in the long-run, SPV is bound to play a vital role in the power scenario. The limitation of resources and the affect of GHG emissions have created an urgent need for the introduction of innovative measures in SPV to deter fast growth.

SPV power is supplied in different forms. One such is the battery operated domestic lighting system, the capacity of which is termed in watts. This system is mainly useful for un-electrified areas. Other types are off-grid or on-grid, generally termed in KWs (kilowatts) or MWs, where power generated in central units are distributed locally in case of off-grid type or supplied to grid in on-grid type. On-grid type rooftop solar power units are common features in countries, which are advanced in SPV where power in KWs, generated in solar panels placed on the roof-top owned by an individual, is supplied to the grid with or without deduction of captive consumption. These schemes are oriented to be mutually beneficial to the entrepreneur and the grid authorities for which encouraging financial packages are made available other than FIT. This is being replicated in West Bengal as a unique scheme, which will go a long way in demand management, generate green power, and reduce consumption of fossil fuel. Rooftop SPV units operate on net-metering (import–export) for supply of power to the grid. In West Bengal, the entrepreneur will receive

Table 1 SPV rooftop 250 kW

Project Cost: 55 million rupees	**Loan:** 38.5 million rupees **Equity:** 16.5 million rupees	
Tariff rate:	Rs 11 from WBSEDCL and Rs 4 from Government of India + Depren benefit Rs 15 for 19 years and Rs 11 for next 10 years	
O and M rate: Firs two years 0.20% and third year onward $2.00% + 3% escalation (loan repayment for third year in eight equal installments)		
Interest rate: 12% (Mat rate – 11.33%; IT – 33.99%)		
Generation: 0.35 million kWh (–1% each year de-rating after five years)		
Depreciation rate:	80%	20%
Depreciation amount:	44	11
Tax saving:	14.96	3.74

COST

Year	*O and M*	*Interest*	*Depreciation benefit*	*Income*	*MAT/IT*	*Cash*	*Cum surplus deficit*	*Loan repayment*	*Outstanding loan*	*Loan repayment installment*
									38.500	
1	0.110	5.005	14.956	5.250	0.594	–0.459	–0.459	14.96	23.544	14.96
2	0.110	2.825	3.739	5.250	0.594	1.721	1.262	3.74	19.810	3.74
3	0.113	2.377		5.250	0.594	2.166	0.949	2.48	17.330	2.48
4	0.117	2.080		5.250	0.594	2.460	0.933	2.48	14.850	2.48
5	0.120	1.931		5.250	0.594	2.605	1.062	2.48	12.378	2.48
6	0.124	1.609		5.198	0.594	2.870	1.456	2.48	9.903	2.48
7	0.128	1.287		5.146	0.594	3.137	2.117	2.48	7.427	2.48
8	0.131	0.966		5.094	0.594	3.403	3.044	2.48	4.951	2.48
9	0.135	0.644		5.043	0.594	3.670	4.238	2.48	2.476	2.48
10	0.139	0.322		4.993	0.594	3.938	8.176	2.48	0.000	
11	0.144			3.812	1.247	2.421	10.597			
12	0.148			3.773	1.232	2.393	12.990			
13	0.152			3.736	1.218	2.365	15.356			
14	0.157			3.698	1.204	2.338	17.693			
15	0.162			3.661	1.190	2.310	20.003			
16	0.166			3.625	1.175	2.283	22.286			
17	0.171			3.588	1.161	2.256	24.542			
18	0.177			3.553	1.148	2.229	26.770			
19	0.182			3.517	1.134	2.202	28.972			
20	0.187			3.482	1.120	2.175	31.147			

WBSEDCL – West Bengal State Electricity Distribution Company Ltd

FIT at Rs 15 for 10 years (Rs 11 from utility and balance from MNRE [Ministry of New and Renewable Energy], Government of India) and also at Rs 11 per unit for the next 10 years. Results emanating out of the present FIT, as shown in the calculations, are good for profit-making industry houses like ITC, Tata, and so on. However, this deserves to be improved to bring down the payback period to six-seven years and make the programme exciting and alluring so that it can be implemented in cities. Economic analysis indicates that a 2.5 KW rooftop SPV in a commercial house will save conventional energy and the bill, thereof, will reflect a payback period of five years only in Kolkata. Four leading countries have progressed in this manner, despite having price differences with conventional power as high as that in India. However, the fact remains that investment being high, bank finances would be an inevitable necessity and for this purpose, both soft interest rates and further rise in FIT are the only possible options because India is under a high interest regime.

Current research on renewable energy and development

Liming H. 2009. **Financing rural renewable energy: a comparison between China and India**. *Renewable and Sustainable Energy Reviews* **13** (5): 1096–1103

Institute of South Asian Studies, National University of Singapore, 469A Bukit Timah Road, #07-01 Tower Block, 259770 Singapore, Singapore

This paper analyses the current status of RRE (rural renewable energy) in China and India, develops and employs an analysis framework to study the environment, channels, instruments, and innovative mechanisms of financing RRE in China and India, and makes a primary comparison. (1 tables, 41 references)

Purohit P. 2009. **CO_2 emissions mitigation potential of solar home systems under clean development mechanism in India**. *Energy* **34** (8): 1014–1023

IIASA (International Institute for Applied Systems Analysis), Schlossplatz 1, A-2361 Laxenburg, Austria

The Government of India has taken several initiatives for promotion of solar energy systems in the country during the last two decades. A variety of policy measures have been adopted, which include provision of financial and fiscal incentives to the potential users of solar energy systems, however, only 0.4 million SHSs (solar home systems) have been installed so far, which is far below their respective potential. One of the major barriers is the high costs of investments in these systems. The CDM (Clean Development Mechanism) of the Kyoto Protocol provides industrialized (Annex-I) countries with an incentive to invest in emission reduction projects in the developing (non-Annex-I) countries to achieve a reduction in CO_2 (carbon dioxide) emissions at lowest cost that also promotes sustainable development in the host country. SHSs could be of interest under the CDM because they directly displace GHG (greenhouse gas) emissions while contributing to sustainable rural development, if developed correctly. In this study, an attempt has been made to estimate the CO_2 mitigation potential of SHSs under CDM in India. (10 figures, 8 tables, 45 references)

Purohit P. 2009. **Economic potential of biomass gasification projects under Clean Development Mechanism in India**. *Journal of Cleaner Production* **17** (2): 181–193

IIASA (International Institute for Applied Systems Analysis), Schlossplatz 1, A-2361 Laxenburg, Austria

Biomass gasification projects could be of interest under the CDM because they directly displace GHG emissions while contributing to sustainable rural development. In this study, an attempt has been made to assess the economic potential of biomass gasifier-based projects under CDM in India. The preliminary estimates, based on this study, indicate that there is a vast theoretical potential of CO_2 mitigation by the use of biomass gasification projects in India. The study results indicate that in India around 74 MT (million tonne) of agricultural residues, as a biomass feedstock, can be used for energy applications on an annual basis. In terms of the plant capacity, the potential of biomass gasification projects could reach 31 GW (gigawatt) that can generate more than 67 TWh (terawatt-hour) electricity annually. The annual CER (certified emission reduction) potential of biomass gasification projects in India could theoretically reach 58 MT. Under more realistic assumptions about diffusion of biomass gasification projects, based on past experiences with government-run programmes, annual CER volumes by 2012 could reach 0.4–1.0 million and 1.0–3.0 million by 2020. The projections based on the past diffusion trend indicate that in India, even with highly favourable assumptions, the dissemination of biomass gasification projects is not likely to reach its maximum estimated potential in another 50 years. CDM could help to achieve the maximum utilization potential more rapidly as compared to the current diffusion trend if supportive policies are introduced. (8 figures, 10 tables, 62 references)

Agoramoorthy G, Hsu M J, Chaudhary S, Shieh P C. 2009. **Can biofuel crops alleviate tribal poverty in India's drylands?** *Applied Energy* **86** (1): 118–124
Sadguru Foundation, Dahod, Gujarat State, India

The on-going climate change concerns have stimulated heavy interest in biofuels and supporters of biofuels hail that they are considered naturally carbon neutral. Critiques on the other hand cry that the large-scale production of biofuels strain agricultural resources and also threaten future food security. People who live in the drylands of India are often faced with challenges and constraints of poverty. Foremost among the challenges are the marginal environmental conditions for agriculture, often influenced by low and erratic rainfall; frequent droughts; poor soil condition; unreliable irrigation water supply; and rural migration to urban areas in search of work. In this paper, the authors have analysed a case study of community lift irrigation, practiced in India, and its impact in boosting agricultural productivity and enhancing local food security. The lift-irrigation model practiced in the drylands of India, to grow food crops, can be adopted for the expansion of biofuel crops. It has the potential to eradicate poverty among farming communities if appropriate sustainable development measures are carefully implemented. (2 figures, 4 tables, 41 references)

Pillai I R, Banerjee R. 2009. **Renewable energy in India: status and potential** *Energy* **34** (8): 970–980
Department of Energy Science and Engineering, Indian Institute of Technology Bombay, Powai, Mumbai– 400 076, India

A majority of the Indian population does not have access to convenient energy services (LPG [liquefied petroleum gas] and electricity). Though India has made significant progress in renewable energy, the share of modern renewables in the energy mix is marginal. This paper reviews the status and potential of different renewables (except biomass) in India. This paper documents the trends in the growth of renewables in India and establishes diffusion model as a basis for setting targets. The diffusion model is fitted to the past trends for wind, small hydro, solar water heating, and is used to establish future targets. The economic viability and GHG saving potential is estimated for each option. Several renewables have high growth rates, for example wind, PV (photovoltaic) module manufacture, and solar water heaters. New technologies like tidal, OTEC (ocean thermal energy conservation), solar thermal power plants, and geothermal power plants are at the demonstration stage and future dissemination will depend on the experience of these projects. (18 figures, 9 tables, 43 references)

Basha S A, Gopal K R, Jebaraj S. 2009. **A review on biodiesel production, combustion, emissions, and performance.** *Renewable and Sustainable Energy Reviews* **13** (6–7): 1628–1634
H-No: 9-280, Gurrala Chavidy, Chilakaluripet, Guntur district – 522 616, Andhra Pradesh, India

This article is a literature review on biodiesel production, combustion, performance, and emissions. This study is based on the reports of about 130 scientists who published their results between 1980 and 2008. As fossil fuels are depleting day by day, there is a need to find out an alternative fuel to fulfil the energy demand of the world. Biodiesel is one of the best available sources to fulfil the energy demand of the world. More than 350 oil-bearing crops have been identified, among which only some are considered as potential alternative fuels for diesel engines. The scientists and researchers conducted tests by using different oils and their blends with diesel. A vast majority of the scientists reported that short-term engine tests, using vegetable oils as fuels,

were very promising but the long-term test results showed higher carbon built up and lubricating oil contamination resulting in engine failure. They concluded that vegetable oils, either chemically altered or blended, can be used with diesel to prevent engine failure. It was reported that the combustion characteristics of biodiesel are similar as diesel and blends were found to have shorter ignition delay, higher ignition temperature, higher ignition pressure, and peak heat release. The engine power output was found to be equivalent to that of diesel fuel. In addition, it was observed that the base catalysts are more effective than acid catalysts and enzymes. (129 references)

Bhattacharya S C and Jana C. 2009. **Renewable energy in India: historical developments and prospects**. *Energy* **34** (8): 981–991

Indian Institute of Social Welfare and Business Management, Management House, College Square West, Kolkata – 700 073

Promoting renewable energy in India has assumed great importance in recent years in view of high growth rate of energy consumption, high share of coal in domestic energy demand, heavy dependence on imports for meeting demands for petroleum fuels, and volatility of the world oil market. A number of RETs (renewable energy technologies) are now well established in the country. The technology that has achieved the most dramatic growth rate and success is wind energy; India ranks fourth in the world in terms of total installed capacity. India hosts the world's largest small gasifier programme and second largest biogas programme. After many years of slow growth, demand for solar water heaters appears to be gaining momentum. Small hydro has been growing in India at a slow but steady pace. Installation of some of the technologies appears to have slowed down in recent years; these include ICSs (improved cooking stoves) and solar PV systems. In spite of many successes, the overall growth of renewable energy in India has remained rather slow. A number of factors are likely to boost the future prospects of renewable energy in the country; these include global pressure and voluntary targets for GHG emission reduction, a possible future oil crisis, intensification of rural electrification programme, and import of hydropower from neighbouring countries. (10 tables, 4 figures, 42 references)

Singh A. 2009. **A market for renewable energy credits in the Indian power sector**. *Renewable and Sustainable Energy Reviews* **13** (3): 643–652

Department of Industrial and Management Engineering, Indian Institute of Technology Kanpur, Kanpur – 208 016, India

Electricity generation from renewable energy sources in India has been promoted through a host of fiscal policies and preferential tariff for electricity produced from the same. The fiscal policies include tax incentives and purchase of electricity generated through renewable energy sources. The enactment of the Electricity Act 2003 has lent further support to renewable energy by stipulating purchase of a certain percentage of the power procurement by distribution utilities from renewable energy sources. The RPO (renewable portfolio obligation) as well as the FIT (feed-in tariff) for power procurement has been specified by a number of SERCs (state electricity regulatory commissions) for the respective state under their jurisdiction. A FIT, determined through a cost-plus approach under a rate of return framework, lacks incentive for cost minimization and does not encourage optimal utilization of renewable energy resources in the country. Such regulatory provisions differ across states. The prevalent practice of fixing a RPO along with cost-based FITs disregards economic efficiency. The paper proposes nationally tradable renewable energy credits scheme for achieving the targets set by the respective SERCs as RPO. This would reduce the cost of compliance to a RPO and would encourage efficient resource utilization and investment in appropriate technologies. The paper highlights its advantages and implementation issues. The paper discusses regulatory developments for promotion of renewable energy in various Indian states and also identifies a number of issues related to regulations concerning renewable portfolio obligation. (27 references, 1 figure, 1 table)

Varun, Prakash R, and Bhat I K. 2009. **Energy, economics, and environmental impacts of renewable energy systems.** *Renewable and Sustainable Energy Reviews* **13** (9): 2716–2721

National Institute of Technology, Hamirpur – 177 005, HP, India
Motilal Nehru National Institute of Technology, Allahabad– 211004, UP, India

The renewable-based electricity generation technologies were assessed against a range of sustainability indicators using data obtained from the literature. These indicators are the cost of electricity generation, GHG emissions, and energy pay-back time. All the three parameters were found to have a very wide range for each technology. For grading different renewable energy sources, a new figure of merit has been proposed, linking GHG emissions, energy pay-back time, the and cost of electricity generated by these renewable energy sources. It has been found out that wind and small hydro are the most sustainable source for the electricity generation. (44 references, 6 tables)

Goyal M and Jha R. 2009. **Introduction of renewable energy certificate in the Indian scenario.** *Renewable and Sustainable Energy Reviews* **13** (6–7): 1395–1405

Department of Electrical Engineering, Indian Institute of Technology, Delhi, New Delhi – 110 016, India

Generation deficit in India is in the range of 9% and the scenario is expected to get grimmer in the context of high growth rate of the country. With peak power shortage as high as 15.2% (Ministry of Power Annual Report 2008), the nation needs to harness all forms of generation including renewable, which currently has a meagre share of 8% of the total generation in the country. Shooting price of crude oil, reaching up to $135 (May 2008) per barrel, along with increasing awareness and concerns about the environment, the stage seems to be set for an increased mix of renewable energy into the overall energy requirement in the country. Keeping the concern for environment and energy security for the country in mind, the Government of India has been emphasizing on the promotion of renewable energy sources. Central and state government policies have always been instrumental in the propagation of capacity additions in renewable energy power. One of the main aims of these policies has been to increase private sector participation in this sector. In the pre-reform period, the state governments took policy decisions regarding financial incentives, buy-back tariff, and other measures, targeting investment in renewable energy. However, the SERCs are now responsible for many of these tasks. The SERCs have come up with a host of initiatives, inline with their functions laid down in the Electricity Act 2003, to increase the share of renewable energy inside their respective states. Despite the efforts of the SERCs, large potential of renewable energy generation remains untapped. There is lack of clarity on how to promote renewable energy generation inside states, which are not having significant renewable energy generation potential. This paper explores the way in which SERCs can introduce measures to further promote renewable energy generation inside the country. The authors discuss, in detail, the framework to promote renewable energy, which puts into place the RPO mechanism.
The framework includes setting of RPO targets, provisions for a surcharge levied upon non-compliance of RPO targets, and a mechanism to meet RPO through trading of certificates.
(23 references, 12 figures, 3 tables)

Akella A K, Saini R P, Sharma M P. 2009. **Social, economical, and environmental impacts of renewable energy systems.** *Renewable Energy* **34** (2): 390–396

Electrical Engineering Department, National Institute of Technology, Jamshedpur – 831 014, India

Conventional energy sources based on oil, coal, and natural gas have proven to be highly effective drivers of economic progress, but at the same time damaging to the environment and human health. Keeping in mind this factor, the social, economical, and environmental effects of renewable energy system have been discussed in this paper. The uses of renewable energy system, instead of

conventional energy system, to control the social, economical, and environmental problems have been discussed. The results show that the trends of total emission reduction in different years is exponentially increasing after the installation of renewable energy system in remote areas. (7 references, 8 tables, 1 figure)

Hiremath R B, Kumar B, Balachandra P, Ravindranath N H, Raghunandan B N. 2009. **Decentralised renewable energy: Scope, relevance and applications in the Indian context.** *Energy for Sustainable Development* **13** (1): 4–10
AE and CST (Centre for Science and Technology), IISc (Indian Institute of Science), Bangalore – 560 012, India

Presently used centralized energy planning model ignores energy needs of rural areas and poor and has also led to environmental degradation, whereas decentralized energy planning model is in the interest of efficient utilization of resources. Energy planning at the village level is the bottom limit of the application of the decentralized planning principle. The individual villages are the smallest social units where energy consumption takes place. Renewable energy is the energy derived from sources that are being replaced by nature such as water, wind, solar or biomass. Renewable sources are essentially non-polluting if applied correctly. The paper presents a review of the important decentralized renewable energy options, related case studies of successful deployment of renewable energy technologies in India, and the resulting lessons learnt. Case studies discussed in the present work show the feasibility of decentralized energy options for the residential and small-scale applications in a village or a cluster of villages. The paper also details the different initiatives taken by the government of India to promote decentralized energy production in the country. It is found that the small-scale power generation systems, based on renewable energy sources, are more efficient and cost effective. Thus, the focus should be on the small-scale RETs that can be implemented locally by communities and small- scale producers, but can make a significant overall contribution towards the national energy supply. (12 references, 6 tables)

Urban F, Benders R M J, and Moll H C. 2009. **Energy for rural India.** *Applied Energy* **86** (supplement 1): 47–57
IDS (Institute of Development Studies), University of Sussex, Brighton BN1 9RE, UK

About 72 million households in rural India do not have access to electricity and rely primarily on traditional biofuels. This research investigates how rural electrification can be achieved in India using different energy sources and the effects for climate change mitigation could be. The authors use the REM (Regional Energy Model) to develop scenarios for rural electrification for the period 2005–2030, and to assess the effects on GHG emissions, primary energy use and costs. The authors compare the BAU (business-as-usual) scenario with different electrification scenarios based on electricity from renewable energy, diesel, and the grid. The results indicate that diesel systems tend to have the highest CO_2 emissions, followed by grid systems. Rural electrification, with primarily renewable energy-based end-uses, could save up to 99% of the total CO_2 emissions and 35% of primary energy use in 2030 compared to BAU. The research done by the authors indicate that electrification with decentralized diesel systems is likely to be the most expensive option. Rural electrification with renewable energy tends to be the most cost-effective option when end-uses are predominantly based on renewable energy, but turns out to be more costly than grid extensions when electric end-use devices are predominantly used. This research, therefore, elaborates whether renewable energy is a viable option for rural electrification and climate change mitigation in rural India and gives policy recommendations. (50 references, 5 tables, 5 figures)

Rao P S C, Miller J B, Wang Y D, Byrne J B. 2009. **Energy microfinance intervention for below poverty line households in India.** *Energy Policy* **37** (5): 1694–1712
278 Graham Hall, Centre for Energy and Environmental Policy, University of Delaware, Newark, DE19716, USA

More than 72% of India's population resides in rural India, and it also has a high concentration of people living under abject poverty. Out of the total rural population 27.1%–28.3% can be categorized as BPL (below poverty line). A lack of energy-finance options is hampering the 'quality of life' of the BPL community. The members of this disadvantaged group, which forms 27.1% and 23.6% of the India's rural and urban population, has no ready access to mainstream finance or know-how of sustainable energy products, nor do they have access to energy service providing agency. This lack of energy-finance options has provided the marginalized population little means to break the conventional energy paradigm and the corresponding poverty cycle. Considering the aforementioned problem, the authors propose a energy-microfinance intervention or a model that encompasses two independent entities. One has an energy expertise and the other possesses finance management skills. Alternatively, the authors also propose a special purpose entity that comprises of these two entities. This entity fosters different institutional, technical, and financial engineering approaches to the provision of energy, finance, and infrastructure services necessary for poverty alleviation. (21 references, 3 tables, 21 figures).

Technological developments

MCD plan to get fuel from waste

The MCD (Municipal Corporation of Delhi) has embarked upon schemes to derive fuel and power from municipal solid waste. The two upcoming projects will process 3200 tonnes of solid waste per day. The total generation of electricity will be about 32 MW (megawatt) of energy per day. It will fetch carbon credit and royalty by sale of energy. The MCD, with the help of UNDP (United Nations Development Programme), has got a study conducted recently. The findings of the study indicate that deriving fuel from refuse is a good option for management of solid waste in Delhi.

The Tribune, 6 June 2009

Samsung unveils solar-powered phone

Electronics major, Samsung, have launched the world's first solar-powered mobile phone, priced at Rs 2799 in the Indian market. The handset, 'Solar Guru' (Guru E1107) enables users to charge the battery using solar energy. 'The Solar Guru has been developed keeping in mind the needs of Indian consumers, especially customers residing in areas where the electric supply is unstable,' Samsung Country Head (mobile division), Mr Sunil Dutt, said. The handset has the capacity to provide around 5–10 minutes of talk time with one hour of solar charging. This is apart from the normal electric charging. It has other features like FM radio, MP3 ring tones, embedded games, and torch light.

The Tribune, 11 June 2009

BEE to assign labels to 21 products by 2012

The BEE (Bureau of Energy Efficiency) has proposed to establish systems and procedures to measure, monitor, and verify energy-efficiency results in individual sectors and make them mandatory. About 21 consumer products will have to go through mandatory labelling processes, which also include passenger cars, by 2012. From 2010, manufacturers of ACs, refrigerators, power distribution transformers, and tubelights must carry the star label for energy efficiency, giving the consumption details. With the new labelling norms in place, which attribute to the energy efficiency, there is a proposal in the government to reduce taxes as well. The government was contemplating to give incentives in the tax rates for those companies which adhere to star ratings. At present, appliances including air conditioners, refrigerators, tubelights, and transformers are given a star rating on a scale of 1 to 5. The government has a proposal to collect 0, 4, 8, and 12% on the appliances which are rated with 5, 4, 3, and 2 stars respectively.

The Financial Express, 22 June 2009

Solar passive features made mandatory

In a major initiative to pave way for energy-efficient buildings, the government has decided to make solar passive features mandatory for all structures in the areas where the Town and Country Planning Act is in force. While certain minimum features will have to be incorporated in the design of common residential structures, institutional buildings like schools, hostels, hospitals, government offices and commercial establishments like hotels will be required to have double glazing, solar water heaters and other features. In case of residential buildings, cross- ventilation, adequate windows to allow natural light and sun rays and some other provisions as per the energy conservation building code will be essential.

The Tribune, 29 June 2009

New hybrid vehicle concept for recreational vehicle travellers developed

While the cost of fuel has put a damper on the travel plans of many Americans, one father-son engineering duo with a passion for RV (recreational vehicle) travel has decided to combat the problem by creating a concept for an electric-hybrid passenger vehicle with the ability to improve fuel economy and increase the acceleration of the motor home towing it. In this concept, the dinghy consists of a hybrid SUV (sport utility vehicle) towed by the RV. When driven as a standard automobile, the SUV operates as a fully functional hybrid vehicle. When towed behind a RV, the SUV switches into the HDP (hybrid dinghy pusher) mode, where only the electrical portion of the hybrid-SUV is utilized. The HDP works by going into generator mode and storing energy when going downhill, and energy previously stored in the batteries is used to help push the motor home up-hill. The previously stored electrical energy in the HDP can also be used to help accelerate the motor home more quickly from a stop or while just driving down the road.

Science Daily, 18 September 2009

Toward the design of greener consumer products

So you are a manufacturer about to introduce a new consumer product to the marketplace. Will that product or the manufacture of the product contribute to global warming through the greenhouse effect? Until now, there was no clear way to answer that question. Scientists are reporting development of a new method for screening molecules and predicting how certain materials, ranging from chemicals used in carpeting to electronics, will contribute to global warming. The scientists analysed more than a dozen molecules, involved in global warming, to find out which chemical and physical properties are most important in determining their inherent radiative efficiency and, thus, possess the largest potential to contribute to global warming. They found that molecules containing several fluorine atoms tend to be strong greenhouse gases, compared to molecules containing chlorine and/or hydrogen. They found for the first time that molecules containing several fluorine atoms bonded to the same carbon increase their radiative efficiency in a non-linear fashion.

Science Daily, 18 September 2009

Achieving energy efficiency by eliminating waste

Japan's premium Voltage Optimization Technology is now available in South Africa. Optimizing the supply voltage can yield a significant reduction in energy consumption by eliminating waste and bringing the benefits of increased equipment life and reduced maintenance. The energy losses, derived from excess voltage, have been well documented, but not until recently has the means to monitor and control incoming voltages in a reliable and efficient manner been available. Power Optimisa is proud to launch the patented E-four Japanese Voltage Optimization Technology in South Africa. This technology has literally become the standard in the UK and testament to its effectiveness is a newly formed partnership with British Energy as the only energy saving solution offered to their commercial and industrial clients.

Energy Management News **15**(2), *June 2009*

New process may convert toxic computer waste into safe products

Discarded computer parts could one day wind up fuelling cars. That is because researchers in Romania and Turkey have developed a simple, efficient method for recycling printed circuit boards into environment-friendly raw materials for use in fuel, plastic, and other useful consumer products. In the new study, Cornelia Vasile and colleagues collected printed circuit boards from discarded computers and processed the boards with a combination of high temperatures, catalysts, and chemical filtration. The processing method removed almost all of the toxic substances from the scraps, resulting in oils that can be safely used as fuel or raw materials called feedstocks for a wide variety of consumer products, the researchers say.

ScienceDaily, 12 May 2008

American Superconductor Corporation India to serve the country's wind energy market with superconductor-based solutions

AMSC (American Superconductor Corporation) India will operate from offices in Delhi and Pune where it will provide local applications – engineering, sales, business development, and field service support – for the Indian wind energy industry. According to the Global Wind Energy Council, India ranks fifth in the world in terms of installed wind power capacity, which grew to 9600 MW last year, a rise of 22%. The Indian Wind Energy Association is anticipating the wind energy industry to continue increasing, estimating that the country has 65 000MW of wind power potential.

Greg Yurek, Founder and CEO of AMSC, said, 'India is beginning to tap into its renewable energy resources and is making significant investments to vastly improve the throughput and reliability of its power grid. Our advanced power electronics and superconductor solutions are well positioned to address these needs both in the near and long term. AMSC India has been formed to provide high-quality local technical support for our new wind power customers and build a strong foundation for future sales into India's broader renewable energy and power grid markets'.

http://www.newenergyworldnetwork.com, 17 September 2009

Renewables Global Status Report 2009 Update

The year 2008 was the best yet for renewables. Even though the global economic downturn affected renewables in many ways starting in late 2008, the year was still one to remember. As shown in the report, in just one year, the capacity of utility-scale solar photovoltaic (PV) plants (larger than 200 kW) tripled to 3 GW. All forms of grid-tied solar PV grew by 70%. Wind power grew by 29% and solar hot water increased by 15%. Annual ethanol and biodiesel production both expanded by 34%. Heat and power from biomass and geothermal sources continued to grow, and small hydro increased by 8%.

The year 2008 also marked four years of dramatic gains across all technologies. Looking back, many can remember the milestone 'Bonn Renewables 2004' conference, which brought together delegates from over 145 countries around the world to accelerate global action. That year was also the genesis of the REN21 Renewables Global Status Report. Since then, the four-year period 2005–2008 saw gains unprecedented in the history of renewables: grid-connected solar PV capacity increased six-fold to 13 GW; wind power capacity increased 250% to 121 GW, and total power capacity from new renewables increased 75% to 280 GW, including significant gains in small hydro, geothermal, and biomass power generation. Meanwhile, solar heating capacity doubled to 145 GWth; biodiesel production increased six-fold to 12 billion litres per year; ethanol production doubled to 67 billion litres per year; and annual renewable energy investment in new capacity increased four-fold, to reach $120 billion.

http://www.renewableenergyworld.com 9 September 2009

Web updates

Renewable Energy Project Kit

http://re-energy.ca/

Re-Energy.ca is a renewable energy project kit that can be downloaded and printed from the World Wide Web for free. Re-Energy.ca explores wind energy, water energy, solar energy, biomass energy, and more. The website helps in developing ones own working models from one of five easy-to-follow construction plans, including a wind turbine, biogas generator, solar car, and more. Re-Energy.ca provides educators with background information, exciting hands-on learning activities, resources and links on renewable energy, and sustainable energy technologies.

Re-Energy.ca is a hands-on renewable energy learning experience. Building working models of renewable energy technologies allows students to discover the fundamental principles of biology, chemistry, and physics, and to explore the application of science and technology to social and environmental issues.

Renewable Energy Policy Project

http://www.repp.org/aboutus.html

The REPP (Renewable Energy Policy Project) supports the advancement of renewable energy technology through policy research. The REPP seeks to define growth strategies for renewables that respond to competitive energy markets and environmental needs. Since its inception in 1995, REPP has investigated the relationship among policy, markets, and public demand in accelerating the deployment of renewable energy, which include biomass, hydropower, geothermal, photovoltaic, solar thermal, wind, and renewable hydrogen. The organization offers a platform from which experts in the field can examine issues of medium- to long-term importance to policy-makers, green energy entrepreneurs, and environmental advocates.

Renewable Energy Corporation

http://www.recgroup.com/en

The REC (Renewable Energy Corporation) is a leading manufacturer of high- quality multicrystalline solar modules for the global PV (photovoltaic) market. The website focuses on quality, continuous improvement, and the lean production of the website has made it a significant and growing module supplier. Its customers are among the world's leading installers, wholesalers, and project developers across Europe, North America, and Asia. The high-performance solar modules, available on the website, have consistently and reliably delivered power all over the world, from major metropolitan areas to the most remote urban regions. The A-Series modules are the perfect choice for building solar systems that combine long-lasting product quality with reliable power output. The REC combines high quality design and manufacturing standards to produce high-performance solar modules with uncompromising quality.

European Renewable Energy Council

http://www.erec.org/organisation.html

The EREC (European Renewable Energy Council) is the umbrella organization of the European renewable energy industry, trade, and research associations active in the sectors of bioenergy, geothermal, ocean, small hydropower, solar electricity, solar thermal, and wind energy. The EREC, thus, represents a turnover of 45 billion euros and the sector provides jobs to over 450 000 people.

Sardar Patel Renewable Energy Institute

http://www.spreri.org/index.htm

The SPRERI (Sardar Patel Renewable Energy Institute) is a non-profit autonomous organization registered as a Society under the Societies Registration Act 21 of 1860 and also as a Public Trust under the Bombay Public Trust Act 1950. It has been approved as a research association for the purpose of clause (ii) of subsection (1) of Section 35 of the Income Tax Act 1961 and is recognized as a SIRO (Scientific and Industrial Research Organization) by the Department of Science and Technology, Government of India. It is recognized by SP University, Vallabh Vidyanagar as a Centre for Ph.D. research.

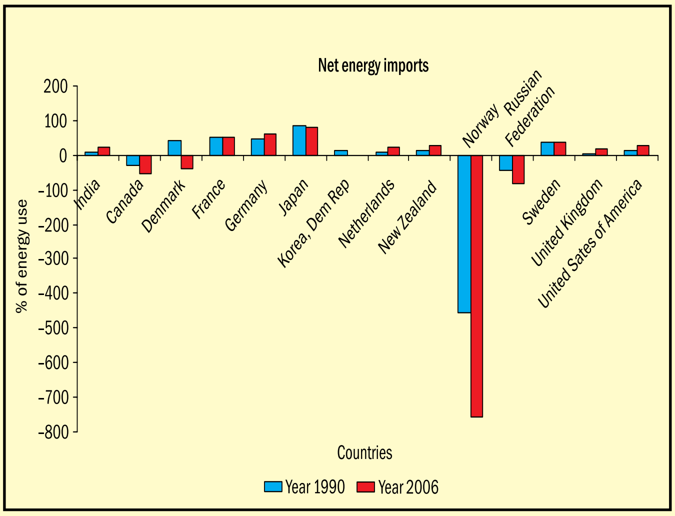
Karnataka Renewable Energy Development Ltd

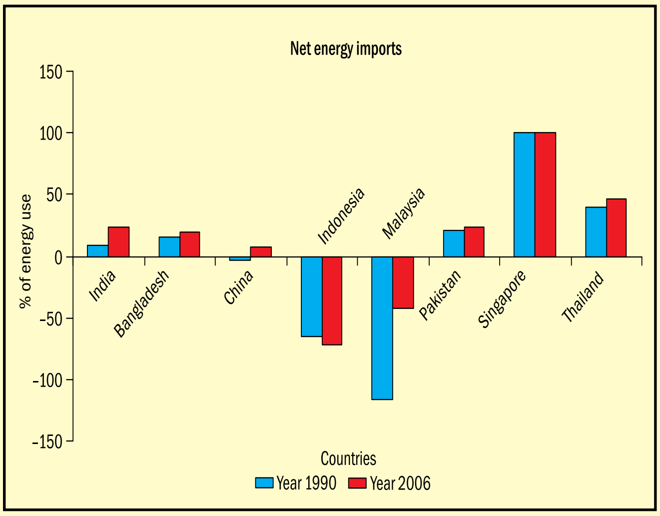
http://kredl.kar.nic.in/Index.asp

The KREDL (Karnataka Renewable Energy Development Ltd) is an organization devoted entirely to the promotion of non-conventional energy sources in Karnataka. The aim of KREDL is to promote projects for harnessing energy from wind, small-hydro, biomass, solar energy, and energy recovery from wastes through private investment. The company advises the Government of Karnataka on policies to be adopted for ensuring a systematic and balanced growth of projects for harnessing renewable energy sources.

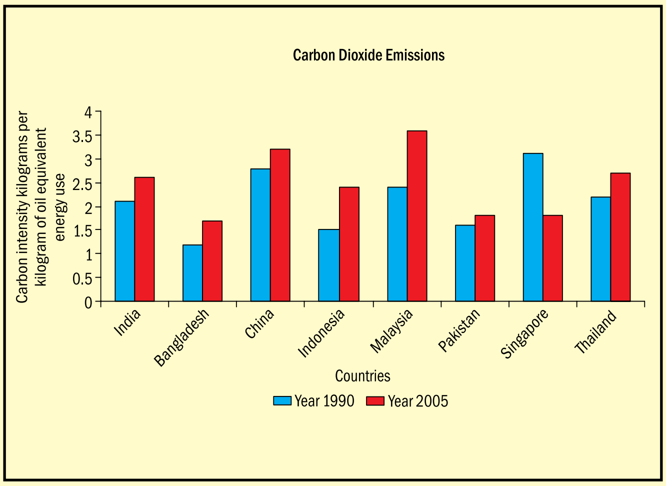
India at a glance

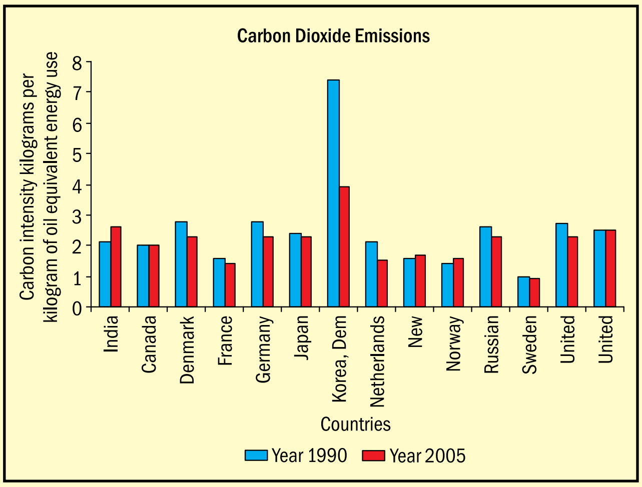
A comparative chart between Indian and other countries





Source World Development Indicators, 2009





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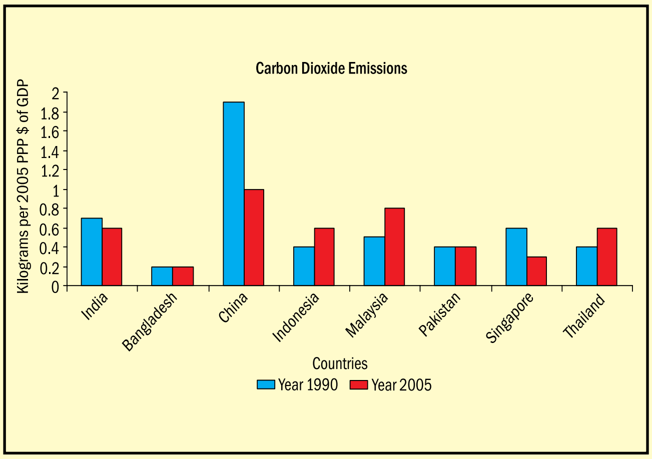

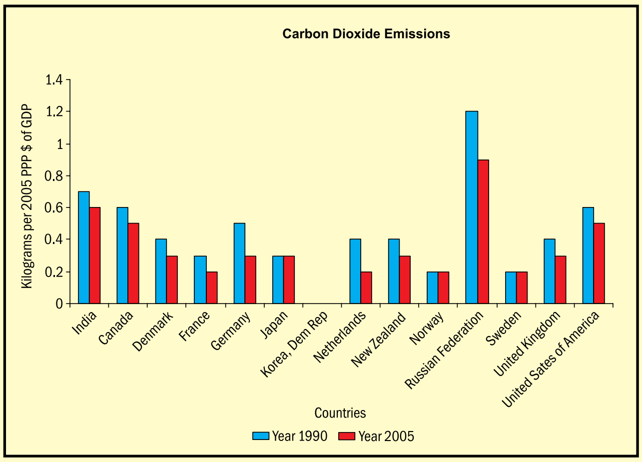

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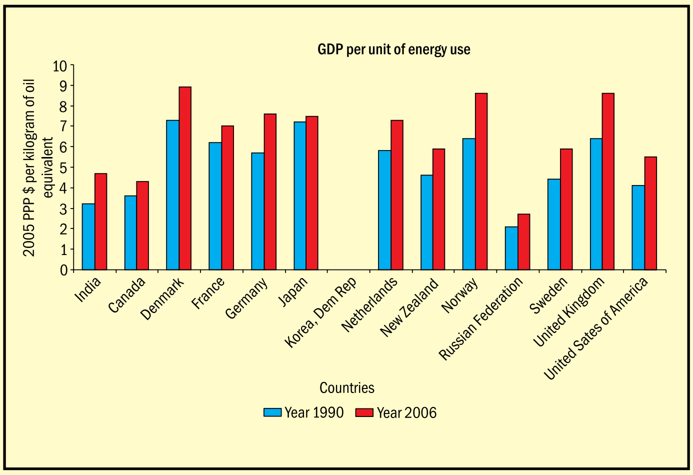

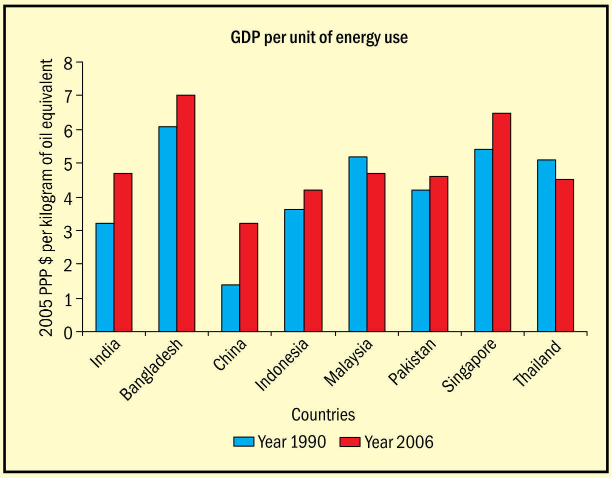

Source World Development Indicators, 2009

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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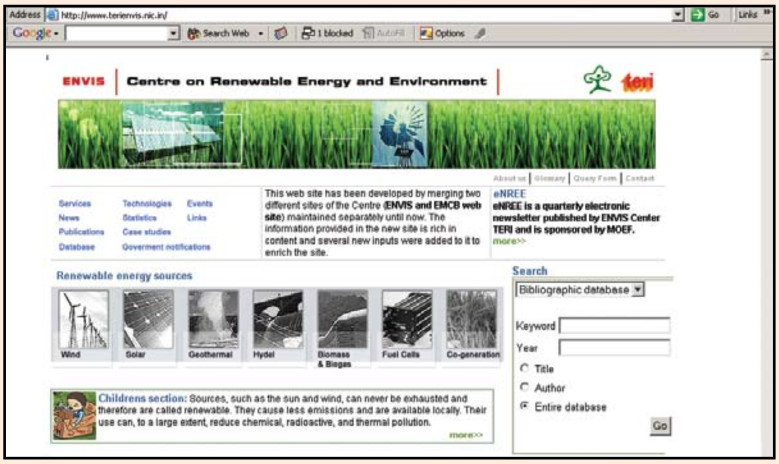
Forthcoming events

7-8 December 2009 Toronto, Canada	**Solar Conference 2009** Tel: 1 613 736 9077 Fax: 1 613 736 8938 E-mail: info@cansia.ca Website: www.cansia.ca
16–17 November 2009 Brussels, Belgium	**3rd European Renewable Energy Policy Conference** Tel: 332 2 546 19 33 Fax: 32 2 546 19 34 E-mail: erec@erec.org Web site: www.erec.org
12–13 November 2009 San Francisco, California	**2nd Solar Energy Investment and Finance Summit** Tinu Ademosu, Conference Director, New Solar Today 7-9 Fashion Street, London, E1 6PX, UK Tel: +44 (0)207 375 7166 Fax: 1 800 814 3459 ext 225 E-mail: tinu@newsolartoday.com Web site: http://www.newsolartoday.com/usafinance
9–11 November 2009 Hyderabad, India	**Solarcon India** Tel: 91 80 4050 9200, Fax: 91 80 4040 711 E-mail: msuresh@semi.org Web site: www.solarconindia.org
5–7 November 2009 Jodhpur, Rajasthan.	**NaCORE 2009** Dr U S Mirdha, Associate Professor, Department of Physics Vyas Institute of Engineering and Technology, Kuri Haud, Near Pali Road, NH-65, Jodhpur – 342 001 Tel:0291 - 2721011-14 Fax:0291 - 2720 784 E-mail:usmirdha@gmail.com, vietjodhpur@gmail.com, Web site:www.nacore2009.vyaseducation.org
27–29 October 2009, Anaheim, California, USA	**Solar Power International 2009** Tel: 1 202 857 0898 Fax: 1 202 682 0559 E-mail: ebrown@solarelectricpower.org Web site: www.solarpowerconference.com
11–14 October, Johannesburg, South Africa	**ISES Solar World Congress 2009** ISES Solar World Congress 2009 Secretariat Tel: +27 12 816 9127 Fax: +27 12 807 7191/7153 Email: kateg@foundation.co.za Web site: http://www.solarworldcongress2009.com/contact.html

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'.

■ **Editors** Shantanu Ganguly and P K Bhattacharya ■ **Assistant Editor** Chandni Sengupta

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