Renewable Energy Sources and Concept of Sustainability (With Special Reference to India)

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Energy is the prime mover of economic growth, and is vital to sustaining a modern economy and society. Future economic growth significantly depends on the long term availability of energy from sources that are affordable, accessible and secure. Although 80 percent of the world's population lies in the developing countries (a fourfold population increase in the past 25 years), their energy consumption amounts to only 40 percent of the world total energy consumption. The high standards of living in the developed countries are attributable to high-energy consumption levels. Also, the rapid population growth in the developing countries has kept the per capita energy consumption low compared with that of highly industrialized developed countries. The world average energy consumption per person is equivalent to 2.2 tons of coal. In industrialized countries, people use four to five times more than the world average and nine times more that the average for the developing countries. An American uses 32 times more commercial energy than an Indian.

There is a large potential for renewable energy in India, an estimated aggregate of over 100,000 MW. As against the estimated 84776 MW renewable energy based grid connected power generation potential in the country, so far only about 9372.5 MW installed capacity has been achieved. The renewable energy based power generation capacity presently constitutes 7% of the total installed capacity in the country for power generation from all sources. The country is aiming to achieve up to 10% of additional installed capacity to be set up till 2012 to come from renewable energy sources.

Over the last three decades, the renewable energy Programme in India has evolved in three distinctive stages.

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STAGES	DURATION	FIELD
First stage	late '70s to the early '80s	Capacity building and R&D, largely in national laboratories and educational institutions.
Second stage	from early '80s to the end of the decade	Witnessed a major expansion with accent on large-scale demonstration and subsidy driven extension activities mainly in the field of biogas, improved cook stoves and solar energy.
Third and current stage	90's till today	Application of matured technologies for power generation, based on wind, small hydro, biogas cogeneration and other biomass systems, as well as for industrial applications of solar and other forms of energy.

In the first stage, from about the late '70s to the early '80s, the thrust of the national effort in this field was directed towards capacity building and R&D, largely in national laboratories and educational institutions. The second stage, from early '80s to the end of the decade, witnessed a major expansion with accent on large-scale demonstration and subsidy driven extension activities mainly in the field of biogas, improved cook stoves and solar energy. These Programme created awareness and also generated field experience. The extension Programme, particularly in the areas of biogas and improved woodstoves (chulhas), generated a vast network of institutions and non-government organizations, right down to the level of self-employed workers and organizations at the grassroots levels. In the third and current stage, extending from the beginning of the last decade, the emphasis has been more on application of matured technologies for power generation, based on wind, small hydro, biogas cogeneration and other biomass systems, as well as for industrial applications of solar and other forms of energy. There is also a gradual shift from the subsidy driven mode to commercially driven activity in the area.

Ministry of Non-Conventional Energy Sources (MNES) is the nodal Ministry of the Government of India for all matters relating to new and renewable energy. This is the administrative ministry for policies

and Programme in this area. The ministry itself is organized into several divisions dealing with a set of technologies and applications. For the development and deployment of new and renewable energy in India many Banking and Non-Banking Financial institute come in this sector. Indian Renewable Energy Development Agency Ltd. (IREDA) was established in 1987 as Non-Banking Financial Company under the administrative control of the Ministry of Non-Conventional Energy Sources (MNES) to provide term loans for renewable energy projects. A comprehensive Renewable Energy Policy for all round development of the Renewable sector, encompassing all the key aspects, has been formulated by MNES. Through this Energy policy statement, it is proposed to send appropriate signals to industry, scientific and technical community, business and investors to indigenously develop new and renewable energy technologies, products & services, at par with international standards, specifications, and performance parameters for deployment in a manner so as to arrive at an optimal fuel-mix that most effectively meets the overall concerns of the country. Besides the National level policy, many states also have announced policy packages including wheeling, banking, third party sale and buy back.

Today, India has one of the world's largest programmes for renewable energy. The activities cover all major renewable energy sources of interest to India, such as biogas, biomass, solar energy, wind energy, small hydropower and other emerging technologies. In each of these areas, the Ministry of Non-Conventional Energy Sources has been supporting R&D for technology and manpower development in renewable energy. Present emphasis is on reduction in cost and increase in efficiency. For sustained development of this sector, efforts are being made so that the market and the consumer drive renewable energy to a large extent. The Ministry is involved in the implementation of the programme for development, demonstration and utilization of various renewable energy based technologies, such as solar thermal, solar photovoltaic, wind power generation and water pumping, biomass combustion/cogeneration, small, mini, & micro-hydro power, solar power, utilization of biomass - gasifiers, briquetting, biogas, improved chulha (cook-stove), geothermal for heat applications and power generation/ energy recovery from urban, municipal and industrial wastes, and tidal power generation.

The RE (Renewable Energy) technologies have been categorized as following :

- Power generation technologies
- Rural energy technologies
- Solar energy technologies
- Energy from waste
- New technologies

Power Generation Technologies: In India, there is huge potential for power generation from renewable energy sources, such as, wind, small hydro, biomass and solar energy. Special emphasis has, therefore, been given to the generation of grid-quality power from renewable sources of energy. The Renewable Energy Power sector includes:

- Wind energy
- Small hydro power
- Biomass energy
- Biomass Gasifier
- Solar energy

Table : Power from Renewable- cumulative achievements as on 31/01/2007

Source/System	**Cumulative achievements (MW)**
Wind Power	6315
Small hydro Power	1905
Cogeneration Bagasse	602
Waste to Energy	40.95
Bio Power (Agro residues)	510
Total	**9372.95**

Source: www.mnes.nic.in

Wind Energy : India's wind power potential has been assessed at around 45,000 MW assuming 1% land availability for wind farms requiring @12 ha/MW in sites having wind power density in excess of 200W/ sq.m. at 50 m hub-height. The potential for grid interactive wind power would be less (around 15,000 MW) if sites having wind power density in excess of 300 W/ sq.m. at50 m hub-height are considered in keeping with international practice. India is one of the countries with highest

total installed wind power capacity. Wind power installed up to 31.12.2006 was 6270.40 MW. During 2006-07 888 MW have been installed up to 31.12.2006 & as per trend it is likely that a total of 1700 MW would be added during the year. India has overtaken Denmark as the fourth largest wind market in the world. Capacity installed in 2005 is 1430 MW.

Trend of increase in installed wind power in India (MW)

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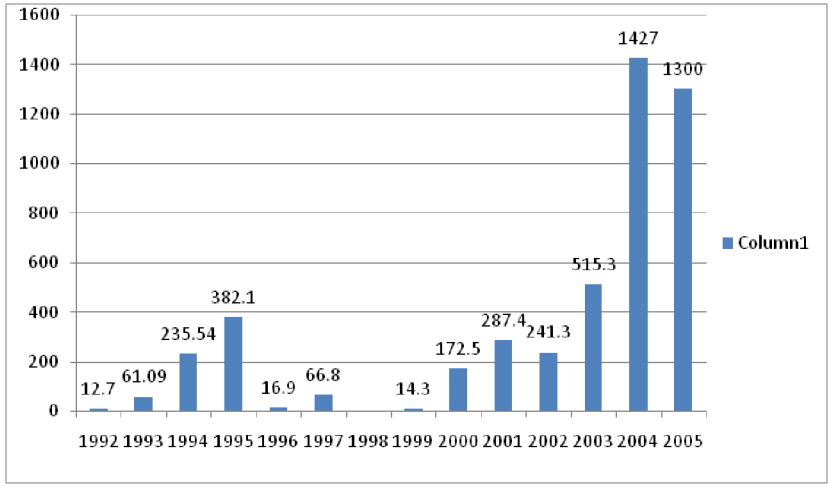

Data Source: MNRE

Small Hydro Power : Ministry of Non-Conventional Energy Sources is assigned the business of small hydro power (SHP) up to 25 MW station capacities. The Ministry's aim is that out of the total grid interactive power generation capacity that is being installed, 2% should come from small hydro. The SHP Programme is essentially private investment driven. Electricity generation from small hydro is becoming increasingly competitive with preferential tariffs and some other concessions. The challenge is to improve reliability, quality and costs. There is need to lower the cost of equipment, increase its reliability and set up projects in areas that give the maximum advantage in terms of capacity utilization. Of the estimated potential of 15,000 MWe of small hydro in the country, 4,400 sites with an aggregate capacity of 10,500 MW have been identified. The cumulative installed capacity of grid interactive small hydropower projects up to 31.3.2006 is 1826 MW.

Comparison of identified SHP potential with capacity of projects installed

S.NO.	STATE	TOTAL CAPACITY OF INSTALLED SHP(MW)
1	ANDHRA PRADESH	255
2	ARUNACHAL PRADESH	1059
3	ASSOM	149
4	BIHAR	194
5	CHHATISGARH	180
6	GOA	03
7	GUJRAT	157
8	HARYANA	30
9	HIMACHAL PRADESH	1625
10	JAMMU&KASHMIR	1207
11	JHARKHAND	170
12	KARNATAKA	653
13	KERALA	467
14	MADHYA PRADESH	336
15	MAHARASTRA	599
16	MANIPUR	106
17	MEGHALAYA	181
18	MIZORAM	190
19	NAGALAND	181
20	ORISSA	157
21	PUNJAB	65
22	RAJASTHAN	27
23	SIKKIM	203
24	TAMIL NADU	339
25	TRIPURA	10
26	UTTAR PRADESH	267
27	UTTARANCHAL	1478
28	WEST BENGAL	183
29	A&N ISLAND	06

Source: MNRE Annual Report 2005-06

Biomass and cogeneration: Currently, biomass contributes about 14 percent of the total energy supply worldwide and 38 per cent of this energy is consumed in developing countries, predominantly in the rural and traditional sectors of the economy.

The various applications of biomass energy include:

- Thermal or heat
- Mechanical water pumping for irrigation.

- Power generation (stand-alone or grid connected) including village electrification and industrial applications.
- India is the largest producer of cane sugar and the Ministry is implementing the world's largest co-generation Programme in the sugar mills.
- Biomass power generation from surplus agricultural residues is also being actively promoted.

The current availability of biomass in India is estimated at about 120-150 million MT/annum covering agricultural and forestry residues corresponding to a potential of 16,000 MW.

State -wise Grid interactive Biomass Power Installed Capacity

S.NO.	STATE	CUMULATIVE INSTALLED CAPACITY (MW)
1	ANDHRA PRADESH	301.25
2	CHHATTISGARH	88.50
3	GUJRAT	0.50
4	HARYANA	6.00
5	KARNATAKA	254.28
6	MAHARASTRA	62.00
7	PUNJAB	28.00
8	RAJASTHAN	23.30
9	TAMIL NADU	215.50
10	UTTAR PRADESH	121.50

Source: MNRE Annual report (2006-07)

Biomass Gasifiers : Biomass gasification is the thermo chemical conversion of solid materials into a gaseous fuel known as producer gas. It can be used for replacing diesel oil in engines for mechanical and electrical applications or for replacing other forms of conventional energy in heating applications. The Ministry has been supporting development of biomass gasification technology for almost two decades and as a result of these efforts, India today ranks among the technology leaders in the world. In the area of small-scale biomass gasification, significant technology development work has made India a world leader.

Biomass Gasifiers are now being exported not only to developing countries of Asia and Latin America, but also to Europe and USA. A large number of installations for providing power to small-scale industries and for electrification of a village or group of villages have been undertaken.

Potential from available Biomass is 16000 MW. Four biomass gasifier each of 100 kW capacities has been set up in villages Tora, Ukhurul Distt. And Songatal, Chorachandpur Distt. In Manipur for meeting the electricity needs.

Solar Energy : Solar energy can be utilized for various applications such as cooking, water heating, drying, desalination and space heating. India has a high level of solar radiation, and receives solar energy equivalent to more than 5,000 trillion kWh per year, which is far more than its total annual consumption. The daily global radiation is around 5kWh per sq.m per day with the sunshine ranging between 2300 and 3200 hours per year. Though the energy density is low and the availability is not continuous, it has now become possible to harness this abundantly available energy very reliably for many purposes, by converting it to usable heat or through direct generation of electricity.

A 140 MW Integrated Solar Combined Cycle (ISCC) Power Project is being given final shape for setting up at Mathania near Jodhpur in Rajasthan. Government of India has accorded approval of the project as a centrally assisted project to be implemented by Rajasthan Renewable Energy Corporation Limited (RRECL), Jaipur.

Rural Energy Technologies:

Biogas : Biogas is an alternate source of fuel derived mainly from organic wastes available abundantly in various forms. The technology, based primarily on cow dung, has been promoted in the country for more than three decades. Standardized models of biogas plants suitable both for individual households as well as for institutions or communities are available. Over the years, a large pool of skilled manpower has been developed for taking up construction and maintenance of the plants.

The Ministry of New and Renewable Energy Sources has been promoting family type biogas plants since 1981-82. The models being promoted under the programme include:

- Floating gasholder type, popularly called "Indian or KVIC (Khadi and Village Industries Commission) Model".
- Fixed dome type, commonly known as "Deenbandhu Model".
- Bag type portable digester made of rubberised nylon fabric.

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Solar water heaters are generally viable in areas where hot water requirement is there for at least six months in a year. A domestic solar water heater of 100 liters per day capacity has the potential to save electricity upto 1500 KWh/ annum and pays back its cost in 3-4 years through conservation of electricity. It is now recognized that reliable products exist that can save substantial amounts of electricity or other conventional fuels, can be used to support peak load reduction and reduces the emission of carbon dioxide, a major GHG. Solar water heaters are fast catching up in urban centers such as Bangalore, Pune, Hyderabad and Mysore.

Solar air heating technology can effectively be used for drying and curing of agricultural products, space heating for comfort, regeneration of dehumidifying agents, seasoning of timber, curing of industrial products, tanning of leather and many more industrial and agro processing\activities.

The heat from the sun can be effectively used for cooking, through the use of a **solar cooker**. One solar steam cooking system consisting of 20 dishes of 12.6-m2 areas each has been installed at Global Hospital & Research Centre, Mount Abu during the year. The system produces 1200 Kg. of steam, which is used for the purpose of cooking, sterilization and laundry purposes. A solar steam cooking system for cooking food for around 5000 people per day is under installation at Sringeri Math in Karnataka. Three solar steam-cooking systems for 500 people each are under installation in Gujarat.

Solar photovoltaic (PV) systems convert sunlight into electricity. The electricity thus produced can directly be used or can be stored in a battery. The technology has a desirable set of attributes that make it suitable for a variety of applications based on decentralized power generation.

An **SLS (solar street lighting system)** is an outdoor lighting unit used to illuminate a street or an open area usually in villages. A CFL is fixed inside a luminaries, which is mounted on a pole. The PV module is placed at the top of the pole, and a battery is placed in a box at the base. The module is mounted facing the south, so that it receives solar radiation throughout the day, without any shadow falling on it. A typical SLS consists of a PV module of 74-kWp capacity, a flooded lead-acid battery of 12 V, 75 AH capacity, and a CFL of 11-W rating. This system is designed to operate from dusk to dawn. The CFL automatically lights up when the surroundings become dark.

Source: Akshaya Urja, July-August 2006, Volume 2 Issue 4 (MNRE publication)

Energy from Waste : The enormous increase in the quantum and diversity of waste materials generated by human activity has led to an increasing awareness, world-wide, about an urgent need to adopt efficient, scientific and safe methods for the treatment, processing and disposal of wastes. The technologies for recovery of energy from wastes not only reduce the quantity but also improve the quality of waste to meet the required pollution control standards, besides generating a substantial quantity of energy According to a recent estimate, about 42 million tones of solid waste (1.15 lakh tones per day) and 6000 million cubic meters of liquid waste are generated every year in urban areas. This translates into a potential for generation of over 1700 MW of power.

The following recent developments regarding municipal solid waste management and energy recovery from urban wastes are expected to facilitate promotion and installation of such projects:

1- Notification of Municipal Solid Wastes (Management and Handling) Rules – 2000 necessitates all Class-I cities to provide proper treatment and disposal facilities for MSW.

2- Twelfth Finance Commission has recommended that at least 50% of the grants provided to States for the Bulbs should be utilized to support the cost of collection, segregation and transportation. Segregated wastes require relatively simpler and less expensive equipment and devices for conversion into energy, and initiative being taken under National Urban Renewal Mission is expected to give a major boost to the efforts for improving waste management in 60 large cities.

Some State Governments, namely Uttar Pradesh, Madhya Pradesh, Tamilnadu, Andhra Pradesh, Rajasthan, Maharashtra, Haryana & Karnataka have announced policy guidelines measures pertaining to allotment of land, supply of garbage and facilities for evacuation, sale and purchase of power to encourage setting up of waste to- energy Projects.

New Technologies :

1. Hydrogen Energy and Fuel Cells
2. Geothermal Energy
3. Tidal Energy
4. Alternative Fuels for Surface Transportation
5. Bio fuel

Hydrogen Energy and Fuel Cells : In recent years hydrogen has been receiving worldwide attention as a clean and efficient energy carrier with a potential to replace liquid fossil fuels. Significant progress has been reported by several countries, including India, in the development of hydrogen energy as an energy carrier and an alternative to fossil fuels. Serious concerns relating to energy security, depleting fossil fuel reserves, GHG emissions and air quality are driving this global transformation effort towards a hydrogen-based economy. Hydrogen has high energy content. When burnt, it produces only water as a by-product and is, therefore, environmentally benign. At present, hydrogen is available as a byproduct from several chemical processes, plants or industries.

Geothermal Energy : Geothermal energy can be harnessed for power generation, space heating and other thermal applications. Preliminary data of resource assessment has been generated for 340 hot springs in the country. Magneto telluric investigations for assessing the suitability of sites and other studies have been taken up at a few sites through National Geophysical Research Institute (NGRI), Hyderabad. NGRI has been conducting magneto-telluric (MT) studies in Satluj-Spiti, Beas and Parbati valley in Himachal Pradesh, Badrinath-Tapovan in Uttaranchal and Surajkund in Jharkhand. A total of 36 stations were set up in Badrinath-Tapovan region to collect the data, which is being analyzed through computer modeling and quantitative interpretation. Currently, harnessing geothermal energy is not regarded as being commercially viable in India.

Tidal Energy : Power generation through tidal energy has been found to be a technically viable option when considering the sea as a resource. In India, Gulf of Kutchh and Gulf of Cambay in Gujarat and delta of

Ganga inm Sunderbans, 24 Parganas district, West Bengal are potential sites for generating tidal power. The Ministry sponsored a detailed project report and environmental impact assessment study for setting up of a 3.6 MW capacity tidal power plant at Durgaduani Creek, in Sunderbans area of West Bengal.

Bio fuel : Petroleum resources are finite and, therefore, the search for an alternative is continuing around the world. Moreover gases emitted by petrol and diesel driven vehicles have an adverse effect on the environment and on human health. There is universal acceptance of the need to reduce such emissions. In India, domestic supply of crude oil meets only about 22% of the demand and the rest is being met from imported crude. Bio fuel has been considered as one of the most preferred alternative fuel for petrol and diesel, particularly in the transport sector. Most bio fuels are fuels generated from biomass, which are renewable energy sources (some synthetic fuels). There are different routes to use biomass as energy source such as directly burning it, controlled combustion to generate producer gas, anaerobic digestion to generate methane and fermentation process to produce alcohol.

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