

**KEYNOTE ADDRESS ON
ECO-FRIENDLY CHEMICAL TECHNOLOGIES
IN NEW MILLENIUM**

UDCT, Amravati University, February 7, 2002

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ABSTRACT

The Eco-Friendly Technologies (EFTs) for the rapidly developing Chemical Industries are the need of the hour. The known EFTs are classified based on technologies as: Power generation; Solar Energy; Rural Energy and Emerging Areas. The first three technologies are being practiced from a limited to a moderate extent in India. The EFTs based on Emerging areas has a lot of promise for a rapid development of Chemical Industries. Fuel Cells, Hydrogen Energy, Geothermal Energy and Alternate Fuels for transportation are classified under emerging areas where research is still under progress to bring out an economically feasible technology with less pollution loads. Fuel Cells, for example, are ideally suited for decentralized power generation due to their modular nature. The focus is presently on technology development and applications for generating electricity, water and heat. Similarly, Hydrogen is another clean fuel, good energy carrier and is a possible substitute to fossil fuels and can be used as a fuel for vehicular transport. It has a wide range of applications. Geothermal energy is an enormous, underused heat and power resource that is clean, reliable and homegrown. The tidal energy is also one of the emerging EFTs but only the tides can be harnessed to produce power with the presently known technology. The search for an Alternate fuel for surface transportation is presently at its primitive stage and a wide range of thrust areas of research is in progress.

The present talk addresses the various in-roads into EFTs and their adaptability to the present scenario of the Chemical Industries in general, and emphasizes the tremendous scope and potential the Fuel cells and Hydrogen energy possess in particular. Few details of the several practices being followed at BITS, Pilani with regard to the Solar thermal systems are also discussed as a case study.

Key words: Eco-Friendly Technologies, Emerging Technologies, Fuel Cells, Hydrogen Energy, Geothermal Energy, Tidal Energy, Alternate Fuel for Surface Transportation.

BACKGROUND

The Chemical Industries are currently undergoing sea change to meet the new challenges imparted due to liberalization, privatization, and globalization. The Environmental compatibility of new technologies has gained importance under the above circumstances offering edge to the technology. In order to gain the additional advantage and overcome the above-mentioned challenges faced by the chemical industries, the eco-friendly technologies have become the need of the hour. The Eco-Friendly Technologies (EFTs) that are aimed for deliberations in this seminar are Waste treatment, Recovery & recycling, Impact assessment, Techno-environmental & Economically feasible methods, and Pollution Control & Regulations.

The applications of EFTs identified by the Organizers for discussion in this seminar are (1) Treatment of bulky waste from Industries such as Paper, Food, Oil and Paint, Petrochemical & Chemical Industries etc. (2) Membrane Technology for recovery and recycling of products along with energy conservation. (3) Recycling of waste to create eco-friendly and clean environment with value added products. (4) Waste minimization. Several options are available to address the above-mentioned application areas. Few of them are discussed below:

Adsorption is one of the significant EFTs employed for the removal and/or recovery of bulky waste from Industries such as Paper, Food, Oil and Paint, Petrochemical & Chemical Industries etc. Adsorption finds its successful application in the removal and/or recovery of pollutants such as color, toxic metal ions, organic chemicals, etc.

Waste Minimization approach is one of the novel ideas to identify the several possible options to reduce the waste emissions into the environment. The Waste minimization can be achieved either by process modification or by effecting changes in raw material. Information pertaining to two aspects covered under Waste Minimization approaches are briefly discussed below:

1. Life Cycle Analysis (LCA): The LCA methodologies are based on material and energy balances for a particular process. The LCA consists of four steps: (1) Goal definition and Scoping (2) Inventory Analysis (3) Impact Assessment (4) Improvement Assessment. The LCA methodologies can be used to identify the process options for which fewer emissions are possible. Two types of methodologies are available: (1) Pollution Prevention (P2) Factors and (2) Pollution Prevention Progress (P2P)

2. Co-generation using Agricultural wastes: It reduces particulate and gaseous emissions compared to fossil fuels due to their low ash and sulphur contents. It thus increases the life of Fossil fuels (natural resources). For co-generation purposes, the Calorific Value (CV) of fuel is an important parameter. The agricultural wastes will normally have a low CV. A number of combinations can be tried to improve the CV of agricultural wastes. For example, the CV of Bagasse can be improved by mixing with fuel oil and is considerably more effective than that of firing Bagasse alone. Bagasse proved to be a valuable and effective fuel source for co-generation. A number of bagasse

based co-generation projects are implemented and many more are under implementation in several States in India.

3. Energy recovery options: A number of Energy recovery options are available in literature. They are categorized as (1) Biogas (2) Electricity (3) Waste Heat Recovery (4) Energy Integration (Heat Exchanger Network Synthesis). Out of the four options listed above, only the biogas is presently being tapped as an energy recovery option. Biogas is recovered from anaerobic digestion of organic matter and converted to electricity for supply to nearby users. The last two options viz., Waste heat recovery and Energy Integration are yet to be tapped in a large scale. The attractive options are energy recovery and/or generation and the related sources are Waste products/streams and Non-conventional energy resources. Many Funding schemes and Institutions are available in India for Energy recovery and/or generation.

The present talk is focused on:

- Available Eco-Friendly Technologies (EFTs) for energy recovery and/or generation
- Case study with an emphasis on utilization of Solar Energy
- Exploring the Potential of certain Emerging Technologies such as Fuel Cells and Hydrogen Energy

AVAILABLE ECO-FRIENDLY TECHNOLOGIES

The available EFTs are classified based on Technologies such as:

- Power Generation
- Solar Energy
- Rural Energy
- Emerging Areas

The details of each of the above EFTs are discussed briefly below:

POWER GENERATION TECHNOLOGIES

They are further classified as:

- Wind Power
- Small Hydro Power
- Biomass Power
 - Cogeneration
 - Gasifiers
- Industrial/Municipal Wastes

Wind power

The Wind Energy Potential in India is 45,000 MW. The Tamil Nadu, Gujarat, Andhra Pradesh, Karnataka, Kerala, Madhya Pradesh, and Maharashtra are having high Wind Power Potential. A total of 6.5 Billion units (kWh) of electricity fed to the respective

State Grids. The capital cost of Wind Power plant is ranging from Rs. 4.0 to 4.5 crore/MW and the cost of power generation is ranging from Rs. 2.0 to 2.5 per kWh. The costs are expected to decline and profitability to increase with:

- Technology improvements
- Increase in turbine size
- Optimal planning and site selection.

Out of the total power generated, 80% is used for captive consumption while 20% is sold to the grid or to a third party. A total of 26 Project Sites developed in the above States resulting in a capacity of 57 MW.

Small Hydro Power (SHP)

The estimated potential of SHP in India is 15,000 MW out of which, the total installed capacity of SHPs up to 3 MW is 63 MW (1989 status). However, there is a drastic increase to 226 MW in just 10 years (4-fold). Around 387 units totaling to 1341.05 MW of SHPs up to 25 MW capacity are established. They are predominantly located in hilly regions & canal drops. Most SHPs are grid connected. Some of them are de-centralized and managed by NGOs or local communities. A well-established manufacturing base is available in India for a full range and type of SHP equipment.

Biomass Power

The biomass power generation is 14% of total energy supplies worldwide and 38% of the above energy is consumed in developing countries in rural & traditional sectors. The major applications are: Direct & Indirect heating, Water pumping for irrigation, Power generation (stand-alone or grid connected), Village electrification and Industrial uses. The Prime Power Generation Technologies are: Gasification, Co-generation and Direct combustion. A total of 34 units aggregating 210 MW capacity co-generation plants are commissioned while 26 units aggregating 237 MW capacity are under implementation.

Energy from Wastes

The primary focus is on reducing the quantity of wastes. This will improve the quality of the wastes to meet the required pollution control standards and subsequently generates substantial quantity of energy. The technologies available for energy recovery from Urban and Industrial Wastes are Anaerobic Digestion/Bio-methanation, Landfill Gas Recovery, Incineration and Densification/Pelletisation. In addition to the above technologies, pyrolysis, gasification, alcohol fermentation, slurry Carb process and plasma arc technology are also available for energy recovery from urban and industrial wastes.

SOLAR ENERGY TECHNOLOGIES

- Solar Photo Voltaics
- Solar Thermal Systems
- Hybrid Systems
- Stand-alone Systems

Solar Photo Voltaics

The solar energy received in India (5000 trillion kWh/year) is far more than the total energy consumption. The daily average solar energy incident over India is in the range of 4-7 kWh/m² (location dependent). The reduction in the cost of SPV is more than 10 times in the last twenty years and is expected to reduce further. The sector-wise applications are: Household, Agriculture, Telecommunications, Defence, Railways, etc.

The Range of products include Solar lanterns, home lighting systems, Solar home systems, Street lighting systems, Stand-alone power plants, Solar water pumping systems, Commercial energy source (Refrigerator etc.)

Solar Thermal Systems

The Non-grid Solar Thermal Technologies include Solar Water Heating, Solar Cookers, Solar Air Heating, Solar Thermal Building Design (Passive Solar Architecture).

Case study: BITS, Pilani

- Status in 12 Hostels (Boys & Girls)
 - Total Number of Existing Systems: 101
 - Total Existing Capacity: 67600 LPD
- Status in student messes & other places
 - Total Existing Systems: 13
 - Total Existing Capacity: 9000 LPD
- Solar Cookers
- Dish Cookers
- Distilled Water Plant
- Solar Lighting System at Met Station
- Passive Solar Architecture Seminar
- Active Research in Renewable Energy
- CREED (Center for Renewable Energy & Environment Development)
- Fuel Cells

Hybrid & Stand-alone Systems

Hybrid systems combine the advantages of two different Energy technologies. An Integrated system would ensure that Power supply can be maintained at an optimum level during cloudy days (for SPV systems) and low wind conditions (Wind electric generators).

Stand-alone Wind Technologies include wind water pumps, wind battery chargers and chemical storage (Exothermic and Endothermic reactions).

RURAL ENERGY TECHNOLOGIES

Biogas: The potential number of plants is 12 million and out of which 3.1 million plants are installed. The two types of gas collection adopted are: Fixed drum and Floating drum.

The necessary biogas equipments such as stoves, burners and lamp mantles are indigenously available.

The Energy-efficient Cook stoves (Improved Chulhas): They are scientifically designed for both optimal regulation of heat flow and better fuel utilization. They also conserve fuel wood, reduce indoor air pollution, check on deforestation, reduce health hazards and cooking time, provide employment opportunities to rural people and upgrade the environment.

EMERGING TECHNOLOGIES

Fuel Cells

Hydrogen is the primary fuel in Fuel cells. Other fuels can also be used to produce hydrogen with the aid of reformers. They are ideally suited for decentralized power generation due to modular nature. The focus is on technology development and applications for generating electricity, water and heat.

The Potential Applications of Fuel Cells include: Production of electricity, water and heat, Industrial and Residential uses, Surface transportation, Electrification of remote locations and villages and Power supplies for PCs, hospitals, health clinics, etc.

Hydrogen Energy

Hydrogen is the simplest and most common element found on earth. It has highest energy content per unit of weight of around 52,000 Btu/lb (or 120.7 kJ/g) of any known fuel. When cooled to a liquid state, this low-weight fuel takes up 1/700 as much space as it does in its gaseous state. It is used as a fuel for rocket and spacecraft propulsion, which requires fuel that has low-weight, compactness and high energy content.

Hydrogen is a clean fuel and good energy carrier. It is a possible substitute to fossil fuels and can be used as a fuel for vehicular transport. It is useful in a broad range of applications. A hydrogen fuel cell vehicle may be able to travel for 5,000 km between re-fuelling stops.

The exciting advances are on their way in the field of Carbon Nano-fibre Technology (CNF). CNF has a capacity to store up to 70% of hydrogen by weight (A metal hydride can store between 2% and 4% by weight - in a heavy structure).

Geothermal Energy

Geo (Earth) thermal (heat) energy is an enormous, underused heat and power resource that is **Clean** (emits little or no greenhouse gases), **Reliable** (average system availability of 95%) and **Homegrown** (making us less dependent on foreign oil).

Geothermal resources vary from shallow ground to hot water and rock several miles below Earth's surface and even farther down to the extremely high temperatures of molten rock called magma. The Earth's energy can be converted into heat and electricity.

The Technology categories include Geothermal heat pumps, Direct-use applications and Power plants. The Geothermal heat pumps consist of pipes buried in the shallow ground near the building, a heat exchanger and ductwork in the building. In the direct-use applications of Geothermal energy, the hot water near Earth's surface can be piped directly into facilities and used to heat buildings, dehydrate onions and garlic, heat water for fish farming and pasteurize milk. Three types of power plants can be operated using Geothermal energy: Dry steam plants (Directly use geothermal steam to turn turbines), Flash steam plants (Pull deep, high-pressure hot water into lower-pressure tanks and use the resulting flashed steam to drive turbines), Binary-cycle plants (Pass moderately hot geothermal water by a secondary fluid with a much lower boiling point than water and Causes the secondary fluid to flash to steam, which then drives the turbines).

There are more than 300 potential sites available throughout India out of which, the Tattapani Geothermal fields, Chattisgarh (300 kW power plant is planned by MNES) and Puga Geothermal fields, Ladakh (J&K) have been earmarked for tapping.

Tidal Energy

The different forms of Ocean Energy are: Tides, Ocean thermal energy conversion, Ocean waves, and Ocean currents. However, only the tides can be harnessed to produce power with the presently known technology. The potential sites identified in India are: Gulf of Kutch and Gulf of Khambat (Cambay) in Gujarat (Western Coast); and Durgaduani creek and a delta of Ganga (Sunderbans area) in West Bengal (Eastern Coast).

Alternate Fuel for Surface Transportation

It is presently at a primitive stage of research. The thrust areas of research include, Material technology development, Performance improvement, Cost reduction, Eco-friendly electric and alternate energy/hydrogen energy vehicles and Advanced high energy density batteries for electric vehicles.

CONCLUSIONS:

- There are numerous technologies available having huge potential in terms of Energy supply (see Table-1 & Table-2 given below).
- India ranks among the top 5 in most of the technologies and ranks first in Biomass based power generation (see Table-3 given below).
- Adsorption (with novel adsorbents) and Life cycle analysis can be used to minimize the waste generated.
- Bagasse-based cogeneration and making useful products from Bagasse are some of the options available.
- Power generation, Solar Energy, Rural Energy and Emerging Areas are classified under Eco-Friendly Technologies.
- Fuel Cells and Hydrogen Energy are among the foremost emerging areas having a very good scope for research to tap the tremendous potential they possess.

Table-1: Potential for Bagasse based Co-generation in Major Sugar Producing States in India

State	Potential (MW)	Commissioned till Dec 2000 (MW)
Maharashtra	1,000	9.0
Uttar Pradesh	1,000	46.5
Karnataka	300	61.6
Andhra Pradesh	200	36.2
Gujarat	200	0.5
Punjab	150	12
Others	300	9
Total	3,500	272.80

Source: MNES, GOI Report, 2001.

Table-2: Potential and current achievements in India

Sources / Technologies	Units	Approximate Potential	Achievements
Wind Power	MW	45,000	1,267
Small Hydro Power (up to 25 MW)	MW	15,000	1,341
Biomass Power	MW	19,500	308
Biomass Gasifiers	MW	16,000	35
Biomass Co-generation	MW/sq. km	3,500	273
Urban & Industrial Waste-based Power	Million square meter collector area	1,700	15.20
Solar Photo Voltaics	Million	20	47 MW
Solar Water Heating	Million	140	0.55

Source: MNES, GOI Report, 2001.

Table-3: India's ranking in the world in cumulative achievements

Source / Technologies	Units	Cumulative Achievements	India's Position in The World
Power Generation			
Wind Power	MW	1,267	Fifth
Small Hydro Power (up to 25 MW)	MW	1,341	Tenth
Biomass based Power	MW	273	Fourth
Biomass Gasifiers	MW	35	First
Solar Photo Voltaics	MW	47	Fourth
Energy from Urban & Industrial Wastes	MW	15.20	---

Source: MNES, GOI Report, 2001.