ENERGY-ENVIRONMENT NEWSLETTER

CENTRE FOR ENERGY STUDIES (CES)
INDIAN INSTITUTE OF TECHNOLOGY DELHI

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Office Bearers of Energy Forum 2009-10

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Faculty In-charge	Dr. S.N.Garg
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Office Bearers of Energy Forum 2008-09

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FOREWORD
Prof. S.C. Kaushik, Head, CES

Publication of Energy-Environment Newsletter is one of the major activities of the Energy Forum which is a joint venture of all students and faculty members of Centre for Energy Studies. Padmashree Prof. M. S. Sodha had established this centre in the year 1976. He is founder Head and an emeritus professor of this centre. The Energy Forum is actively involved in arranging invited lectures and seminars of eminent speakers from India and abroad. The faculty members take part in the seminars arranged by Energy Forum for the benefit and progress of students. The recent research and developments in the world gets known to both students and faculty members through such invited seminars by eminent speakers from all over the world and different recognized organizations in India.

The long due and desirable event was held on July 23, 2009 for revision of M.Tech. courses for Full-Time and Part-Time sessions. The centre has conducted many summer/winter QIP workshops from time to time on energy related topics for the benefit of faculty members from Engineering Colleges under the AICTE. The faculty members of this centre are recognized by PCRA and BEE as energy audit experts.

The centre has developed a National Test Facility for Ash Resistivity measurements desirable for pollution control studies in thermal power plants of the country. Also, the centre has developed well established I.C. Engine and Bio-fuels laboratory and lot of progress is being made in Solar Photovoltaic. The centre has demonstrated "Solar Energy Park" which is operating on renewable sources for past several years with progress in the field of solar energy utilization for various applications. The centre offers IREDA Chair Professorship in the Renewable Energy for energy experts since 2000 to senior faculty members of this centre.

Recently, Prof. G. N. Tiwari and Dr. K. Gadgil have been recognized for their contributions by National Awards. During the period 2007-09, faculty advisors to Energy Forum Dr. K. Gadgil and Dr. A. K. Sharma are superannuated from the Institute at the completion of 62 years age. Earlier, Prof. H. P. Garg and Prof. D. P. Kothari left after superannuating from Institute for joining private institutions as Director General and Vice-chancellor respectively to their credit. This centre has organized two international conferences SOLARIS-2007 and World Hydrogen Energy Conference-2009 in collaboration with other organizations at New Delhi.

This centre has produced about 50 doctorates in the field of energy during period 2007-2009. At present this centre is having several sponsored and consultancy projects in the field of Biofuels, Solar PV, Wind and Plasma Science and Technology. This newsletter is being published for providing information about this centre for the benefit of members of the forum in particular and public in general. The Energy Forum has been organizing technical industrial visits to Indian Oil Corporation Ltd., Solar Energy Centre, The Energy Research Institute's Retreat Centre, DRDO etc. and annual solar energy exhibitions at Pragati Maidan from time to time. I would like to encourage students to submit their short articles to this news letter regarding recent happenings in renewable energy sector. I hope that this news letter would create renewed interest among students and faculty members to update the events in future publications.

Prof. S.C. Kaushik, Head CES

Mudhouse at Solar Energy Park, IITD

Arvind Chel, G.N. Tiwari and Avinash Chandra

Vaulted or domed roof structures are frequently adopted by builders and architects throughout the Middle East and other hot dry areas. This article is based on practical case study of a vaulted roof adobe building located at "Solar Energy Park", IIT Delhi, New Delhi [29°35'N, 77°12'E, 216 m MSL]. The mud-house has six inter-connected rooms out of which three rooms with inverted U-shape roof and remaining three rooms with dome shape roof structures. The two dome shape roof rooms are identical and smaller as compared to the middle dome shape room. This mud house was constructed in 1988 (nearly 22 years back) to provide room for research work in solar energy and sustainable green building. The building is renovated in 2005 with wet mud layer of 1 cm and press fitted brick tile layer of 4 cm over the external curved roof surface. This renovation results in low annual maintenance cost for mud roof structure by prevention of water seepage and mud loss from exterior surface of roof during rainy season. Based on embodied energy analysis, the energy payback time for the mud-house was determined as 18 years. The embodied energy per unit floor area of R.C.C. building (3702.3 MJ/m^2) is quiet high as compared to the existing mud-house (2298.8 MJ/m^2).

This renovated building was integrated with an earth to air heat exchanger (EAHE) for space heating/cooling in winter and summer months respectively. The EAHE set-up consists of air blower, air ducts (made of polyvinyl chloride (PVC) pipes) and adobe house room. One of the three rooms located on north side of adobe house was integrated with EAHE air duct system. The air ducts are buried under the ground at depth of 1.5 m below the open field area (12 m × 7 m) behind the north room as shown in Fig.1.

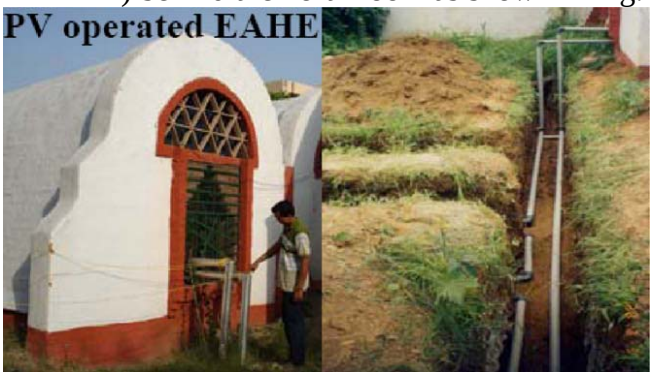

Figure 1. Space heating/cooling using EAHE

The air ducts consists of 78 m length of the PVC pipes of diameter 0.06 m. During the operation, the blower of EAHE system sucks room air and circulates it through the earth-air heat exchanger underground pipes. These underground pipes are at stable underground environment throughout the year maintained at constant temperature equal to annual average ambient air temperature of that location few meters below the ground surface (earth temperature 25 to 26 °C for 4 m below ground level for New Delhi). The room air is re-circulated back into the same room after the process of heat exchange between room air and the earth. There is convective heat transfer taking place between room air and underground PVC pipes and conductive heat transfer between the pipes and earth. The air passing through a tunnel or a buried pipe gets cooled and heated in summer and winter respectively. Thus, earth air pipe or tunnel system can be operated effectively in winter as well as summer for space heating and cooling respectively. The parameters such as surface area of pipe, length and depth of the tunnel below the ground, dampness of the earth, humidity of inlet air and its velocity affects the exchange of heat between air and the earth (or surrounding soil of pipes). This EAHE caters the need of heating/cooling for thermal comfort inside the room space through out the year. In summer months, the adobe house room air temperature was T_r = 30-33°C and improved due to EAHE, Tr= 26-28°C respectively. It is observed that, in the harsh winter months (ambient T_a= 3°C), the room air temperature (T_r) with and without EAHE was observed 18°C and 15°C respectively while in the harsh summer months (ambient T_a= 45°C) room air temperature was 28°C and 30°C respectively. Hence, the adobe house integrated with EAHE has large potential for building space heating and cooling during summer and winter respectively.

Figure 2. A 2.32 kW_P Stand-alone PV system

In addition to EAHE, this building is integrated with solar PV power supply unit which caters the daily need of electricity for air blower of EAHE and electrical equipments used in mudhouse such as electric fan, tube lights, submersible water pump, computer etc. This practical case study demonstrates a sustainable approach towards mitigating climate change using low embodied energy building materials and green source of power. This adobe building integrated with EAHE and PV power supply is suitable for remote Indian villages for community water pumping and space conditioning. The unit cost of electricity cost and capital cost of PV power supply was estimated for the existing stand alone PV power

system (Fig.2). The typical existing 2.32 kW_p stand-alone photovoltaic (SAPV) power generation system is integrated to the existing adobe house electrical loads. It caters the need of electricity throughout the year. The electrical load comprises of air blower, computer, fan, fluorescent tube lights, submersible water pump and CFL street lights in the park. The life cycle cost analysis is carried out for the given SAPV system to evaluate unit cost of electricity produced for 4 % interest rate as Rs.36.94/kWh which is nearly 7 times higher compared to grid electricity (Rs.5/kWh) from subsidized coal power plants. The system has 1120 W_P PV sub-array manufactured 20 years back and hence system efficiency is quiet low in the range of 3 to 6 %. Also, the energy payback time is calculated as 11 years and the total saving of CO_2 emissions in the lifespan of SAPV power system is estimated as 86 metric tons for the existing SAPV power system.

Figure 3. Skylight integrated with the Mudhouse

The illuminance level inside the mud-house with skylight (Fig.3) is found sufficient for office work inside the room from 10 am to 4 pm. The small dome room has maximum illuminance value (for h=0-1.5 m) in the range of 450 to 650 lux (in winter) and 800-1800 lux (in summer) while big dome room with maximum illuminance value (for h=0-1.5 m) 250-400 lux (in winter) and 400-900 lux (in summer) in New Delhi (India).

Role of Ultra Capacitor in an Electric Vehicle

Pawan Sharma and T. S. Bhatti

Two-wheelers are an integral part of life in developing countries like India, China, SE Asia, etc. The usage & function of two-wheeler is similar to car in developed countries. The traffic and road conditions, the short travel distances involved, moderate weather conditions, high fuel costs and the limitation of consumer spending power is the reason for the popularity of the Two- wheelers (Motorcycles, Scooters, Mopeds) in India. The production of Two-wheelers in India, in the year 2006 is 7.6 million and expected to grow at the rate of 16% in the coming decade. 75% of the two-wheelers manufactured in India are of 'Kick-Start' type, that is, they are with-out Starter Motor. They are fitted with 2.5 Ah batteries to meet the safety related loads, such as Horn, Direction Indicator, and Brake Lamp etc. Electric scooters require drive systems (motor, controller, transmission), and power sources (batteries/ultra-capacitors). Since the ultra-capacitor based electric scooter in this project essentially a battery powered electric vehicle with battery combined with ultra-capacitor, the basic electric scooter is described first. Components are chosen for the electric scooter on the basis of technical qualifications and economic considerations. The resulting electric battery-powered vehicle is used as a base platform to develop the ultra-capacitor scooter design. Despite the attraction they offer in the form of zero emissions, battery-powered electric vehicles have failed to capture significant market shares because they are inconvenient to recharge, and because they simply do not match the performance of existing alternatives. The important perfo-rmance criteria are vehicle range before refueling, power, cost, and to a lesser extent vehicle weight. Battery power electric vehicles have the limitations of low power density, low charge/discharge cycles temperature depen-dence, and more charging time. Ultra-capacitors don't have all these problems i.e. less charging time, high power density, can work in a wide range of temperatures in comparison to batteries, but they have low energy density than that of batteries.

Table 1. Comparison between Battery and Ultra-capacitor

	Parameters	Battery	Ultra-capacitor
1	Expected life in years	1 to 3	More than 20
2	Charge discharge cycles	1000	500,000
3	Power density (W/kg)	300	4000
4	Energy density (Wh/kg)	80 to 100	3 to 5
5	Ability to discharge completely	No	Yes
6	Self discharge rate	Low	High
7	Weight per watt	More	Less
8	Environmental friendly	No	Yes
9	Temperature dependence	Narrow	Wide

T-ray Source: Next Step to Airport Security and Cancer Detection

Anuraj Panwar, U.Verma and A.K. Sharma

T-rays are completely safe form of electro-magnetic radiation, may reshape not only airport screening procedures but also medical imaging practices. Scientists at the U.S. Department of Energy's Argonne National Laboratory, along with collaborators in Turkey and Japan, have created a compact device that could lead to portable, battery-operated sources of T-

rays, or terahertz radiation. Terahertz (THz) radiation, which lies in in the region of the electromagnetic spectrum between 300 gigahertz ($3x10^{11}$ Hz) and 3 terahertz ($3x10^{12}$ Hz), corresponding to submillimeter wavelength range between 1 millimeter (high-frequency edge of the microwave band) and 100 micrometer (long-wavelength edge of far-infrared light), is at the interface of electronics and photonics. While terahertz radiation is emitted as part of the black body radiation from anything with temperatures greater than about 10 kelvin, this thermal emission is very weak. As of 2004 the only effective stronger sources of narrow- band terahertz radiation were the gyrotron, the backward wave oscillator ("BWO"), the far infrared laser ("FIR laser"), quantum cascade laser, the free electron laser (*FEL*), synchrotron light sources, and fast diodes. Broad-band THz radiation can be produced by thermal sources and, more recently, by table-top laser-driven sources and by short electron bunches in accelerators, but so far only with low power.

In the fall of 2007, scientists at the U.S. Department of Energy's Argonne National Laboratory, along with collaborators in Turkey and Japan, announced the creation of a compact device that can lead to portable, battery-operated sources of T-rays, or terahertz radiation. The group was led by Ulrich Welp of Argonne's Materials Science Division. The new T-ray sources created at Argonne use high-temperature superconducting crystals grown at the University of Tsukuba in Japan. These crystals comprise stacks of so-called Josephson junctions that exhibit a unique electrical property: when an external voltage is applied, an alternating current will flow back and forth across the junctions at a frequency proportional to the strength of the voltage; this phenomenon is known as the Josephson effect.

These alternating currents then produce electromagnetic fields whose frequency is tuned by the applied voltage. Even a small voltage, around two milli volts per junction, can induce frequencies in the terahertz range. Since each of these junctions is tiny, a human hair is roughly 10,000 times as thick. The researchers were able to stack approximately 1,000 of them on top of each other in order to generate a more powerful signal. However, even though each junction would oscillate with the same frequency, the researchers needed to find a way to make them all radiate in phase.

In order to synchronize the signal, the stacks of Josephson junctions should be shaped into resonant cavities. When the width of the cavities was precisely tuned to the frequencies set by the voltage, the natural resonances of the structure synchronized the oscillations and thus amplified the T-ray output, in a method similar to the production of light in a laser. Once you apply the voltage, “some junctions will start to oscillate. If those have the proper frequency, an oscillating electric field will grow in the cavity, which will pull in more and more and more of the other junctions, until in the end we have the entire stack synchronized.” By keeping the length and thickness of the cavities constant while varying their width between 40 and 100 micrometers, the researchers were able to generate frequencies from 0.4 to 0.85 terahertz at a signal power of up to 0.5 microwatts. To expand the range of available frequencies and to increase the strength of the signal by making the Josephson cavities longer or by linking them in arrays. These alternating currents then produce electromagnetic fields whose frequency is tuned by the applied voltage. Even a small voltage– around two millivolts per junction– can induce frequencies in the terahertz range. THz radiations can pass through clothing, paper, cardboard, wood, masonry, plastic, ceramics, have many security and medical applications. They can also penetrate fog and clouds but cannot penetrate metal or water.

Security: Terahertz radiation can penetrate fabrics and plastics, so it can be used in surveillance, such as security screening, to uncover concealed weapons on a person, remotely. This is of particular interest because many materials of interest, such as plastic explosives, have unique spectral fingerprints in the terahertz range. This offers the possibility to combine spectral identification with imaging. Some controversy surrounds the privacy issues in using terahertz scanners for routine security checks due to the ability to produce detailed images of a subject's body through clothing, though this method is less invasive than a strip search.

Medical imaging: a) Terahertz radiation is non-ionizing, and thus is not expected to damage tissues and DNA, unlike X-rays. T-rays can also penetrate the human body by almost half a centimeter and they have already begun to enable doctors to better detect, and treat certain types of cancers, especially those of the skin and breast. Terahertz radiation can also detect differences in water content and density of a tissue. Such methods could allow effective detection of epithelial cancer with a safer and less invasive or painful system using imaging.

b) Some frequencies of terahertz radiation can be used for 3D imaging of teeth and may be more accurate and safer than conventional X-ray imaging in dentistry.

c) Dentists can also use T-rays to image their patient’s teeth cavity.

These qualities make terahertz devices one of the most promising new technologies for airport and national security. Unlike today’s metal or X-ray detectors, which can identify only a few obviously dangerous materials, checkpoints that look instead at T-ray absorption patterns could not only detect but also identify a much wider variety of hazardous or illegal substances.

Latest Technologies in Condition Monitoring of Power Transformers

Ashish Taneja

Transformers are the very essential voltage conversion components of Power Systems and the most expensive as well. The failure rate of Power Transformers is quite low and there is need to reduce it further which is a big responsibility on power engineers. It is found that most of the failures are due to Insulation failure, Bushing failure or OLTC failure. Some power sector companies have shown that this can be reduced by proper transportation, correct installation practices, good preventive maintenance practices, loading of transformer so that its temperature rise should be in limits and by use of some condition monitoring instruments. In olden times, the following conventional technologies for condition monitoring were used.

Once in a year or as per requirement/belief

1. Infrared Thermal Scanning
2. Dissolved Gas Analysis(DGA) of Oil of Main Tank and On Load Tap Changer
3. Insulation Resistance(IR)- Once in every 6 months or on every shutdown
4. Capacitance and Tan Delta
5. Vector Group

On an Everyday Basis

1. Oil Temperature Indicator and Winding Temperature Indicators
2. Visual, audibility test and hand sensation test for heating
3. Oil Level in Main Tank and On Load Tap Changer

Latest Techniques

1. **Frequency Response Analysis (FRA)** - This test is done for checking the mechanical integrity of Power Transformer. As a result of many Short Circuit faults or Transportation of transformers, there is a shift in winding which can be checked by FRA. The RLC (passive components) of the network has got some value due to its design at the time of its manufacturing as a function of particular frequency. These responses at different frequencies are measured at the time of manufacturing and can be compared with these at any time in future. If these signatures are not worth comparing after some time means that there is doubt in the mechanical integrity of the power transformer due to mechanical or electrical stresses.

- 2 KHz scan is sensitive to core deformation, open circuits, shorted turns and residual magnetism.
- 20 KHz scan is sensitive to mainly bulk movement of windings relative to each other.
- 200 KHz and 2 MHz scan are sensitive mainly to deformation within winding.
- The 10 MHz response is affected by the deposition of winding leads and test leads.

Complete isolation of transformer under test is required. All the jumpers have to be opened. The transformer should be oil filled for FRA test.

In the screen (Fig.4), it is shown the FRA of HV winding Y-Phase (Open Circuit condition) which is a comparison between the FRA done at the time of dispatch of a transformer from manufacturer's site and FRA at the time it reached to its desired destination.

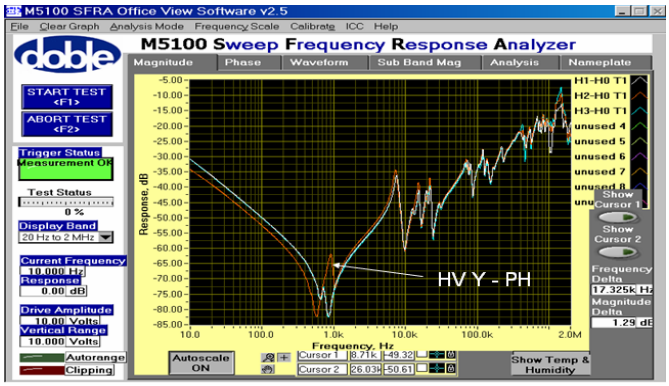

Figure 4. Sweep Frequency Response Output

2. **Partial Discharge Measurement (PD Measurement) –** Partial Discharge is nothing but Dielectric Breakdown of insulating material when it is subjected to high voltage stresses. This is a result of *bad manufacturing practices* like voids or bubbles remained during manufacturing, *damage during transportation* or *aging*. This discharge is sometimes visible and audible to the human eye and ear respectively specially in cables but not always, therefore some device is required which can detect the sound of the partial discharge. Today many a companies are manufacturing such units for power sector. These can be used without shutting down Power Transformer which is in itself a big advantage. In such devices, ultrasonic receptors are used which receive the sounds which are not audible to even human ears. Nowadays new generation automation compatible to partial discharge devices have come up in the market which give real-time monitoring of transformers at all times and are fitted during the erection and commissioning of the Transformers.

3. **Online Temperature Measurement of Oil and Winding –** Conventionally these are taken from pockets at the top of the transformer and mounted in the marshalling box and an operator has to take its reading every hour. Now automation and other advanced technologies are in place so that Oil Temperature and Winding Temperature within the transformer can be obtained on real time basis and are available in the control room itself. Secondly

there is storage of the last few entries depending on how much memory we opt for.

It can be obtained in two ways:

(i) By using *transducers* which can convert the conventional temperature readings (which are based on resistance measurement) into current in milli amperes and which can be made compatible with the numerical relays like Transformer Monitoring Units (TMU)

(ii) By the use of direct fiber optics technology which gives direct reading at all times in LCD display form to the operator in the control room. This needs to be fitted at the time of manufacturing of the Transformer.

4. Online Moisture and other gases determination – This comes in two forms. One is in portable form which can be transported and can be used for any other transformer and the other comes as dedicated to one transformer only.

The principle for measuring different gases and their concentrations can be different from manufacturer to manufacturer.

Gas Chromatography - In this method two steps are involved. Firstly, degassing the oil sample taken through vacuum extraction.

(i) Secondly Dissolved Gas Analysis by Gas Chromatography with TCD (Thermal Conductivity Detector), FID (Flame Ionization Detector) and Methanizer.

(ii) Photo Acoustic Spectroscopy - Photo-acoustic effect is caused by the ability of a gas to absorb electromagnetic radiations (Infra Red suppose). In absorbing the radiation, temperature of the gas is increased and if the gas is held in a sealed container, this temperature rise will produce proportional rise in pressure. If light source is pulsed the pressure of the gas fluctuates in sympathy and these pressure waves are detected by using sensitive Microphones.

Source: International Conference on Large Power Transformers organized by Central Board of Irrigation and Power (CBIP) at Hotel La Meridian on 12-13 Oct 2006, which was attended by the author of this article.

Energy from Plastic Wastes

Sanjoy Maji

During the last 50 years the proportion of population residing in urban areas has increased from 17% to 33%. The number of class I cities (population of one lakh and above) has increased from 212 to 300 during 1981 to 1991. There are now 23 metropolitan cities as compared to 12 such cities in 1981. These 23 cities account for roughly one-third of country's urban population and one-twelfth of country's total population. By 2050 half of Indian population will be concentrated on urban agglomerates as estimated by Government of India.

Waste generation rates are often affected by socio-economic development, degree of industrialization, and climatic conditions. Generally, greater the economic prosperity and higher the percentage of urban population, greater will be the amount of solid waste produced. Urbanization and rising incomes, which lead to more use of resources and hence more waste, are the two most important trends that factor into rising waste generation rates. The 20th century has seen the invasion of polymers especially plastics into almost all spheres of our daily life. Perhaps no other material has such wide applications as plastics because of their versatility. The advantages of plastics are many. Plastics are tough because of their molecular structure, which consists of very long chain of molecules. They can be moulded into any required shape and size and can take any colour. Plastics are also light, portable and above all resistant to the effects of water, chemicals, sunlight, termite, etc. Now a days plastic has become an integral part of our day to day life.

The growth of the Indian plastic industry has been phenomenal; the growth rate (17%) is higher than that for plastic industry elsewhere in the World (GOI, 1997). India has a population of over 1 billion and a plastic consumption of 4 million tones. Plastics continue to replace glass and paper in consumer products and packaging materials and carving their new markets. The use of plastics has infiltrated all sectors of the economy. Infrastructure, agriculture, building and construction, telecommunications, consumer goods and packaging are all high growth areas with a spiraling demand for plastics.

But, unlike other solid wastes, plastics have poor life span; they are disposed very frequently by the consumers other than the disposal caused during production of the same articles. The rising use of plastic has become a two sword problem of modern civilization. In one hand, due to its some desirable feature like light weight, easy to mould and easy to adapt to different user requirement, plastic is finding wide applications in different sectors. But the management of plastic wastes has become a matter of serious concern from the environment point of view. A huge amount of plastic in the waste is not only an aesthetic problem but due to its resistant nature it creates many environmental problems.

Since plastics are not attacked easily by micro-organisms they accumulate in the soil for a long time. Most of the plastic materials remain undegraded for about 400 years in soil. They obstruct the infiltration of water into the soil resulting in lowering of low groundwater table. Plastic waste is a real threat for ruminants, birds and marine animals. It has been observed that the ruminants grazing in the field

sometimes consume this plastic waste along with grass and then die. Fish and other marine species in the water ways, misunderstanding plastic garbage as food items swallow and die. Turtles are the most vulnerable to this illusion. Burning of plastic releases carcinogens such as dioxins (polychlorinated dibenzodioxins), furans (polychlorinated dibenzofurans) and poisonous gases, like phosgene. Dioxin (particularly, TCDD or 2,3,7,8 – tetrachlorodibenzo-p-dioxin) is considered to be the most potent chemical carcinogen ever evaluated by US Environmental Protection Agency (EPA). The pigments used to colour in plastic carry bags are cadmium based. Cadmium and its compounds are considered to be dangerous as they can cause bone abnormalities in child. Bags made of recycled polyethylene are even more dangerous. They are found to release toxic compounds of Cd, Pb, Cr and Hg. In a developing country like India, there is no separate mechanism to handle plastic waste. Either they are burnt to reduce the volume with municipal solid waste or find their way into landfill structure. Both practices are dangerous for environment. When plastics are burnt, they produce carcinogenic gases like dioxins, furans and phosgene. If plastic waste is used in landfill it hinders the percolation of rainwater to ground water. The effective management of plastic waste may be either to make it degradable in nature or to replace it. Both of which is not feasible right now. Both are cost intensive. Pyrolysis may be a viable procedure to solve the problem of plastic waste. When turpentine solution of plastic is passed through a catalyst (ZSM-5), the long chain of polymer breaks into smaller parts and gasoline is obtained as one of the products. In this way pyrolysis is not only a clean technology but through energy recovery it also fits with the principle of sustainable resource management.

Application of Phytoremediation in Environmental Management

Leela Kaur and Kasturi Gadgil

Heavy metal contamination of soils originating from agricultural or industrial activities is one of the major environmental problems. Heavy metals affect all groups of organisms and ecosystem processes and are critical in this regard. Some of the toxic heavy metals are Hg, Cu, As, Ni, Pb, Co, Cd, Ag, Be and Sn. Several approaches are currently used for treating soils contaminated with toxic metals like land filling, fixation, leaching, flocculation and phytoremediation. Most conventional remediation approaches do not provide acceptable solutions. Hence there is the need to develop and apply alternative, environmentally sound technologies (ESTs), taking into account the probable end use of the site once it has been remediated. Phytoremediation is one such innovative method which can be utilized as EST in today's technological era. It is the direct use of living green plants in situ, or in place, removal, degradation, or containment of contaminants in soils, sludges, sediments, surface water and groundwater. The mechanisms of phyoremedia-tion include rhizosphere biodegradation, phytoextraction, phytodegradation, phytostabilization and phytovolatilization. Some plants used are Alfalfa, Arabidopsis, Bladder campion, Brassica juncea, Tomato, alpine pennycress, Poplar, Bamboo family, Buxaceae, Euphorbeaceae, and Compositae family. To date there are approximately 400 known species metal hyperaccumulators in the world and the number is increasing. Brassica juncea is known to accumulate Zn and especially Pb and is considered to be one of the most promising species for phytoremediation. It has been used as a model system to investigate the physiology and biochemistry of metal accumulation in plants. Rhizofilteration is designed for the removal of metals in aquatic environment. Several aquatic species have the ability to remove heavy metals from water including water hyacinth, pennywort and duckweed. Some of the aquatic vascular plants have been used to treat Cr contaminated effluent and sludge from leather tanning industries. Hyper accumulation is a mechanism that allows sequestration of metals in tissues and in some cases, elimination of metals from the plant body by the shedding of those high metal tissues. Sequestration prevents the precipitation of the metals by capturing of metals in plants to keep metals out of the contaminant matrix (soil/water/air). The arbuscular mycorrhizal (AM) fungi are important rhizosphere microorganism which can increase plant uptake of nutrients especially relatively immobile elements such as P, Zn and Cu and consequently increase root and shoot biomass and improve the plant growth.

There are different effects of AM fungi on heavy metal uptake. In some cases, Am fungi reduces excess plant uptake of trace elements like Zn, Cd and Mn whereas in other cases they enhance or have no effect on the uptake. Compared to traditional remedial technologies, phytoremediation offers the following benefits: lower cost, applicability to a broad range of metals, potential for recycling the metal-rich biomass, minimal environmental disturbance, minimization of secondary wastes. Heavy metal accumulating plants can be incinerated and the ashes disposed, which is much easies than excavating and disposing the contaminated soil. Currently phytoremediation is being used to clear off various polluting elements such as heavy metals, insecticides, petroproducts, explosives, chlorinated solvents, and industrial by-products. It can be used in combination with other clean up approaches as a "finishing" step. Although phytoremediation is not

yet widely applied, momentum for its use is expected to build, particularly in application niches where other technologies are less suitable or do not exist. Many opportunities have been identified for research and development to improve the efficiency of phyto-remediation. Understanding some of the molecular mechanisms of phytoremediation, particularly phyto-extraction would enhance its utility and eventually it may become a new frontier of plant biology.

QIP Courses conducted during 2008-2009

December 2008: December 15-20, 2008

QIP Short Term Course on Emerging Potential of Biofuels & other Renewable Energy Sources

February 2009: February 06-12, 2009

QIP Short-Term Course on Applications of Solar Energy and Earned Carbon Credit

December 2009: December 03-10, 2009

QIP Short-Term Course on Energy Efficiency

February 2010: February 04-10, 2010 (Newly Announced)

QIP Short-Term Course on Alternative Sources of Energy

International Conferences held during 2007-2009

February, 2007: February 07-09, 2007

SOLARIS 2007: 3rd International Conference on Solar Radiation and Day Lighting, New Delhi

August, 2009: August 26-28, 2009

World Hydrogen Technologies Convention(WHTC), New Delhi

Workshops held during 2008-2009

January, 2008: January 22, 2008

One day seminar on Energy Scenario and Energy Security

June, 2008: June 12-13, 2008

Workshop On Developments in Biomass Derived Fuels and Other Renewable Energy Sources and Enhanced Energy Efficiencies in Power Generation and in Other Fuels

October, 2008: October 24, 2008

Workshop on Introduction to Nanotechnology and Its Emerging Role in Industries

February, 2009: February 28, 2009

Workshop at IIT Delhi on Bioinformatics and its Emerging Industrial Applications

July, 2009: July 23-24, 2009

Workshop on "Fuel Cell Technology and Hydrogen Energy"

Ph.D. Viva held during 2008-2009

Name	Date/Time	Title
Ms. Pragati Sharma	July 30, 2009, 15:00 P.M.	A study on Air Quality Modeling in Delhi City
Mr. S. Raj Kumar	July 28, 2009, 11:30 A.M.	A study of Thermal comfort and solar space conditioning in Building
Mr. Swapnil Dubey	July 23, 2009, 11:30 A.M.	Performance Evaluation of a Hybrid Photovoltaic/Thermal (PV/T) Solar Water Heating System
Mr. Mahesh Chand Singh	July 20, 2009, 11:00 A.M.	Energy Efficient Windows and Their Impact on Buildings
Mr. Vivek Raman	July 20, 2009, 15:00 P.M.	Energy, Exergy and Life Cycle Cost Analyses of Hybrid Photovoltaic Thermal Air Collectors
Mr. Baiju B.	July 8, 2009, 03:00 P.M.	Utilization of Biodiesel from High free fatty acid vegetable oils in compression ignition engines.
Mr. Vjay Kumar Dwivedi	March 27, 2009, 11:00 A.M.	Performance Study of Various Design of Solar Stills
Mr.Shiv Kumar Dubey	March 27, 2009, 14:00 P.M.	Performance analysis of Hybrid Photovoltaic/Thermal(PV/T) Active Solar Distillation System
P. P. Tripathy	January 20, 2009, 12 Noon	Determination of heat and mass transfer coefficients from drying kinetics of potato dried in mixed-mode solar dryer.
Mr.P. Barnwal	December 10, 2008, 11:00 A.M.	Design and Performance Evaluation of an Integrated Hybrid Photovoltaic Greenhouse Drying System.
Mr. Dilip Kumar Bora	November 21, 2008, 11:30 A.M.	Studies on Storage Stability of Bio-diesal and its Utilization in a Diesal Engine.
Mr Ajaya Kumar Dash	November 7, 2008, 11:30 A.M.	Life cycle analysis of Biodiesel production from Simarouba Glauca and its Application in C.I. Engine.
Mr. Najmur Rahman	September, 15 2008, 11:00 AM	Heat and Mass Transfer during Natural Convection Drying of Shrinking Bodies.

From All Energy Forum Members

WISH YOU ALL A VERY HAPPY AND PROSPEROUS NEW YEAR 2010