IGCS BULLETIN

From the Editors' Desk

Dear Readers,

The April issue of the IGCS Bulletin covering the IGCS activities of Jan – March 2013 is now in your hands. The highlights of this issue include an interesting article: Nuclear Energy - A Perspective; a report on the 2-week Winter School organized at IIT Madras and a summary of the project implemented by a group of students during the Winter School.

We are happy to note an important development at IGCS, namely, the sanction of a major financial grant by the Department of Science and Technology, Government of India that would give a fillip to the research collaboration between IIT Madras and German Universities. The preparations for the Summer School in Aachen, Germany in July 2013 have commenced. Also, the selection process for the next group of IGCS Visiting Professors is in progress. Dr. Sasidhar, an expert in Environmental aspects of Nuclear Energy (former senior officer of the Safety Research Institute, AERB, Kalpakkam) has joined the IGCS family as a Senior Consultant in IIT Madras. We hope this issue is informative and makes an interesting reading.

Thanking you,

Ajit Kolar and Sibylle Petrak

Editors

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Contents

Prof. Ajit Kumar Kolar

Prof. Sibylle Petrak

IGCS NEWS

IIT Madras and RWTH Aachen University sign MOU for IGCS Research Activities

Prof. Bhaskar Ramamurthi, Director, IIT-Madras and Prof. Ernst Schmachtenberg, Rector, RWTH Aachen University, signed a Memorandum of Understanding in the presence of the Indian Ministers for Human Resource Development, and Science, Technology and Earth Sciences, and the German Minister for Education and Research.

As per the new MoU signed, the objective of the Indo German Centre for Sustainability at IIT Madras is to enable collaborative research on sustainability topics between top German researchers and faculty of an outstanding Indian university with traditionally strong ties to the German scientific community. Indo-German research projects are planned in the core areas of energy, water, land use/rural development, and waste management. Also, Master's and doctoral programmes shall be set up at the IGCS with joint supervision and exchange of scholars between Germany and India.

In particular, this MoU is expected to give a fillip to the collaborative research between the two countries, through the recently sanctioned Department of Science and Technology (DST) project. The Rs. 5.33 crore (about 750000 Euros) project is titled 'Building an International Research Network on Sustainability to Enhance Strategic Knowledge for Climate Change'.

Over the next three years, IGCS will identify and carry out, with the collaboration of German partners, five research projects in energy, land use, waste and water around sustainability challenges that would be aggravated by climate change. The projects will focus on sustaining urban water bodies and improving public sanitation, ensuring local air quality, improving access to energy services, setting up a framework for sustainable urban and peri-urban land-use, and helping frame sustainable climate policy with emphasis on integrated solutions for climate adaptation.

Prof. Bhaskar Ramamurthi and Prof. Ernst Schmachtenberg signing the MoU (above) and exchanging the document (below)

Visit of representatives from MR, Germany

Dr. Uwe Kaltenborn and Dr.Martin Schmalfuss from Maschinenfabrik Reinhausen Gmbh, Regensburg, Germany, visited IIT Madras in the last week of February to explore the possibility of having a collaborative programme on aspects of High Voltage Engineering with the faculty of the Department of Electrical Engineering, IIT Madras. They also discussed the possibility of setting up a research laboratory jointly with IGCS.

IGCS Secretariat at IITM

Dr. P. Sasidhar joined IGCS on 21st January 2013 as a Senior Project Consultant to contribute to the activities of IGCS at IIT Madras. He retired as Head, Environmental and Fuel Chemistry Section, Safety Research Institute, Atomic Energy Regulatory Board, Kalpakkam in July 2012 after serving for 35 years. He was responsible to plan R&D programmes on the topics of Waste Management, Groundwater and Contaminant Transport, Environmental Safety, Environmental Impact Assessments and Remote Sensing and GIS in Land-use applications &Disaster management. He cherishes the goal to utilize his academic and professional background towards achieving a safe, healthy and sustainable environment.

IGCS Winter School (WS) held in IITM

IGCS Winter School, IIT Madras, 24 Feb to 10 Mar 2013

The two week Winter School on "Growth and Sustainability in a highly dynamic city – Exploring the urban development in South Chennai" was attended by 20 students, nine from Germany and the rest from India. Prof. Nagendran, Expert Member, National Green Tribunal (Chennai) inaugurated the WS with a technical lecture on Sustainability. The School consisted of sixteen interactive lectures on various topics of Sustainability including Water, Waste, Energy and Land Use by experts, a two day visit to Auroville to familiarize with various Renewable Energy and Water treatment projects, a visit to Waste Water Treatment plant in Chennai City, and one day guided tour of the IITM campus biodiversity scenario. Four student projects on Resource Efficiency in IITM Hospital, Water Conservation Awareness in Schools, Land Use and Mobility in IITM Campus, and Water Situation in a village near Chennai were organised. Seven experts from Germany and seven experts from India were the main Resource persons. All participants were presented with a CD containing all WS lectures and two booklets on IITM Flora and Fauna.

IGCS WS participants starting their field visit to Auroville

Prof.Kranert delivering a lecture on solid waste management

Prof. Elango delivering a lecture on water resources

Field visit to AuroVille

From the Top:

- Water treatment plant
- **S**olar dish in the solar kitchen
- **O**rganic farming

IGCS Research News

An ecological study pertaining to marine environment at Chennai was taken up at IGCS, as a collaborative effort between IGCS and AMM Murugappa Chettiar Research Centre (MCRC), Chennai. The post-doctoral research work carried out by Dr. R. Jayakumar was jointly guided by Prof. Dr. Kristin Steger (IGCS), Dr. Sundaram Seshadri, (MCRC) and Prof. T. S. Chandra, IITM, Chennai. The research results were published in the peer reviewed 'Journal of Marine Pollution Bulletin', Elsevier, Feb 2013 under the title: An assessment of temporal variations in physicochemical and microbiological properties of barmouths and lagoons in Chennai (Southeast coast of India),

(http://dx.doi.org/10.1016/j.marpolbul.2013.02.005). Two estuary and two coastal lagoon stations along Chennai, Southeast coast of India were monitored for one year to study both physicochemical and microbiological properties of water. Influence of the marine environment over the systems was evident by elevated salinity levels. Considerable concentrations of total heterotrophic bacterial count and fecal bacteria such as total coliforms, fecal coliforms and fecal streptococci were observed throughout the study period which evinced a pattern of anthropogenic activities. Principle component analysis was employed for assessing the overall pattern of variation within the data sets. Climatic variation was highly correlated with changes in water quality, i.e. the Northeast monsoon and Summer had influenced considerably the microbial occurrence as well as the physicochemical parameters such as total suspended solids, chloride, sulfate and salinity. However, the effect of the Southwest monsoon was less prominent than the Northeast monsoon with its heavy rains. As both estuaries revealed elevated concentrations of polluted water, these stations can be used as indicators or alerts for the water quality along the coastal zone of Chennai.

IGCS Steering Committee Meeting

The IGCS Steering committee meeting was held in IIT Madras on 1 March 2013. The Center Co –ordinators and the Area Co-ordinators from Germany and IIT Madras, and the representative of DAAD deliberated at length over the present status and the future activity of IGCS.

IGCS Summer School

The IGCS Summer School (the fourth in the series) on Sustainable Water and Waste Management will be held in RWTH Aachen, Germany from 02 July to 14 July 2013.The last date of application by potential student participants is May 15, 2013. For more details visit: www.igcs-chennai.org.

IGCS Professors

The process of identification of the second group of IGCS Professors in the areas of Water Resources and Waste Management is in progress. It is expected that the new IGCS Professors will begin their activities in IIT Madras by July 2013. The process of selection of IGCS professors in the areas of Energy and Land Use will be initiated shortly.

Environment News..

1. **Farmers complain about large-scale pollution of Cauvery by dyeing units**

The Hindu April 1 2013

Continuance of the large-scale pollution of the River Cauvery by dyeing, textile processing and tanneries on either side of the river (in Namakkal and Erode districts) was the most important issue that was raised by farmers dependent on water from the river to irrigate their fields, at the farmers' grievances meeting held at the Collectorate recently.

Farmers alleged that polluting units continue to discharge untreated effluents into the river at Pallipalayam, despite action initiated by authorities concerned. The farmers said that in addition to water from the river that is used for irrigation, about 10,000 families were using the highly contaminated water for drinking purposes.

State Secretary of Tamil Meetchi Eyakkam , C. Nandhagopalan alleged that close to 3,000 small and medium scale textile dyeing units, including illegal units, were functioning in and around Komarapalayam and Pallipalayam towns in Tiruchengode taluk. "These units do not have effluent treatment plants and directly discharge effluents into the river through open drains and hidden pipelines."

Talking to newsmen, District Collector D. Jagannathan said that the district administration and Tamil Nadu Pollution Control Board are taking regular action against the polluters through eviction drives. "However, we will once again monitor the present situation and take necessary action," he said.

The Collector said that the Pallipalayam and Komarapalayam municipalities that are located on the banks of the river have been instructed to treat the water twice in the peak summer when there is only meager flow of water in the river before distributing it to the people. "This is to help the people be safe from contamination of potable water," he added.
(http://www.thehindu.com/todays-paper/tp-national/tp-tamilnadu/farmers-complain-about-largescale-pollution-of-cauvery-by-dyeingnits/article4568487.ece)

2. **Fillip to Waste-to-Energy Projects**

Union Finance Minister P. Chidambaram proposed in his budget speech to support municipalities that will implement waste-to-energy projects through different instruments such as viability gap funding, repayable grant and low cost capital. He said: "India tosses out several thousand tonnes of garbage each day. We will evolve a scheme to encourage cities and municipalities to take up waste-to-energy projects in PPP mode."

It has come as a shot in the arm for the Coimbatore Corporation. The announcement has come at a time when the civic body has been planning a waste-to-energy plant at the waste management yard in Vellalore. Besides, the civic body is also planning another waste-to-energy project under 'Shunya,' the zero waste management project that is funded by international agencies.
(http://www.thehindu.com/news/cities/Coimbatore/support-for-wastetoenergy-project/article4465186.ece)

FEATURES

Nuclear Energy – A Perspective

P. Sasidhar

Senior Scientist, Indo-German Centre for Sustainability, IITM

Each country must make its own energy choices; one size does not fit all. But for those countries interested in making nuclear power part of their sustainable development strategies, it is important that the nuclear power option be kept open and accessible- **Mohamed ElBaradei**

Introduction

Sustainable development policies in the energy sector will rely on comparative assessment of alternative options taking into account their economics, health, environmental and social impacts, at local, regional and global levels.

In pursuit towards that objective, it is a crucial to integrate three key requirements: economic growth, environmental protection and social welfare in a balanced way and derive trade-offs. Many times, one is confronted with a conundrum: *whether to have the cake and eat it too!* Is this zero-sum approach really practical? It is well known that zero-sum competition is an opponent of sustainability. If one industry adopts ways to lower their costs often at the expense of either the environment and/or society, is far from the path of sustainability. Environmental and social impacts have to be lessened in order to achieve sustainable development goals.

The Fukushima incident has affected public and policy reactions to nuclear energy and that this response varies from country to country related to economic, technological and political factors. There are also lessons to be learnt for. (CEEPR,2012)

Nuclear power is mostly a component in the energy-mix in countries that are large energy consumers and have the necessary technological and financial resources. It is particularly appropriate from the sustainability considerations to apply their high-technology assets to put uranium resources to productive use, thereby conserving finite fossil resources for future generations. The endeavour in the article is to assess the extent to which nuclear energy is compatible in meeting goals of sustainable development.

Nuclear Renaissance

In the previous two decades, relatively few new nuclear plants were built around the world, except in countries like France, Japan, and South Korea. In the three largest producers of electricity from nuclear power (the U.S., France and Japan), the extension of licenses of most of the operating nuclear power plants was proceeding without much political opposition. Prior to Fukushima, 71 units had been re-licensed in the U.S. and 14 more are pending NRC decisions (NEI,2013). Re-licensing had begun in Japan prior to the Fukushima accident; France had begun evaluating its nuclear units for 10-year license extensions. Nuclear plants in Canada were being refurbished for continued operation. Several countries with strong anti-nuclear lobbies like Germany, Sweden, Italy, Spain and Belgium seemed to be moving away from earlier decisions to close existing nuclear plants, extending their operating lives, and in the case of Italy and Spain making it possible to build new plants.

China made a massive commitment to move the share of nuclear production from 1% of generation (11 GWe) to 6% of generation (about 100 GWe) by 2020, with 27 units already under construction at the time of the Fukushima accident (WNN, 2011). Through agreements with the U.S. and some other members of the nuclear suppliers' club, India, with rapidly growing electricity demand, expressed considerable interest in expanding its nuclear fleet with help from vendors in the U.S., France and Russia.

In the U.S., the events at Fukushima have not yet had any direct effects on the future of existing nuclear plants. License extensions continue and no plants have been closed due to safety concerns. In the EU, the member countries agreed that all nuclear plants are to be subject to inspections, a set of stress tests, and these stress tests have not led to any plants being closed for safety reasons so far. The German government permanently shut down the 8 oldest of its 17 nuclear units. In June 2011, the German Parliament passed a law to phase out the remaining plants by 2022. France recently completed a post-Fukushima safety audit, and recommends substantial investment to improve safety at existing sites, while it is committed to nuclear power and re-licensing existing plants.

Belgium had decided not to make any decisions until after the EU stress tests are completed. Japanese utilities and regulatory authorities are reviewing potential seismic and flooding design bases.

Thus, the post-Fukushima assessments have had little direct effect so far on plans to construct new nuclear units in the countries where significant nuclear programs were being planned prior to Fukushima. China, Russia, India, and most other non-OECD countries are continuing as planned, pending additional information from reactor safety.

Nuclear Industry – Sustainable or Stuck?

This competitive position is strong from a sustainable development perspective since most health and environmental costs of nuclear energy are already internalized (IAEA,2006). The electricity consumers are paying for nuclear safety and insurance against nuclear accidents, decommissioning of nuclear facilities, and radioactive waste disposal. Nuclear liability insurance regimes provide many guarantees to both the industry and potential victims of accidents, and the coverage of damages is increasingly taken on by nuclear operators.

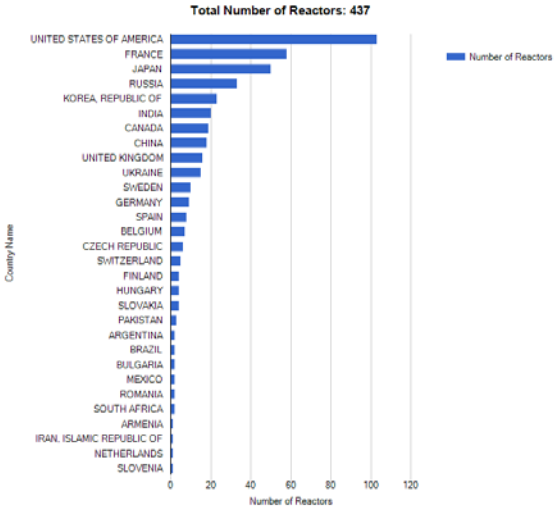

Fig.1 Operational Reactors as of April 2013
(http://www.iaea.org/PRIS/WorldStatistics/OperationalReactorsByCountry.aspx)

As on April 2013 there are 437 Nuclear reactors (Fig. 1) operating in the world with total Electrical Capacity of 372613 MW (~373 GW) contributing to about 16% world's electricity. USA tops the list with 103 reactors followed by France with 53. Sixty eight new plants are under construction with majority of them are planned in the developing countries. Current expansion, as well as near term and long term growth prospects, are centered in Asia.

Well run nuclear power plants are generally competitive and profitable source of electricity. One reason is that while these plants are relatively expensive to build they are relatively inexpensive to operate. Once a nuclear power plant's construction costs have been fully amortized, it is generally at its most profitable stage.

The total levelized cost of generating electricity with new nuclear units to be ordered in the coming years would range between 2.5 and 6 cents per kWh at a 5% discount rate and between 4 and 8 cents per kWh at 10% discount rate. The nuclear units compare well within a broad range of alternatives, including fossil fuels and renewables on the basis of full generation costs. Let us look at the resource constraints of nuclear fuels.

Nuclear Fuel Resources

Nuclear power plants of the present generation operated once-through extract more than 10000 times more energy per unit mass from uranium than other technologies do from fossil or renewable fuels.

Nuclear resources include uranium and thorium. Thorium is three times as abundant as uranium, but, as noted above, the reserves, or recoverable quantities, depend on market conditions and technology as well as the geology of different deposits. Currently, uranium is in much greater demand.

The sustainability of nuclear power option depends on the uranium availability and price. Identified conventional uranium resources are currently estimated at 4.7 million tonnes of uranium (Mt U). Additional conventional resources beyond those already identified are estimated to add another 10.1 Mt U. The Indian nuclear programme has been envisaged on modest uranium resources and vast reserves of thorium.

Table 1 summarizes how long conventional uranium resources would last at current burn-up rates. The top row of numbers assumes that future nuclear power reactors use the same technology as today's reactors, which can only use less than 2% of the energy in natural uranium. The bottom row assumes that, as uranium becomes expensive, used fuel is eventually recycled, using technologies available today, to extract more energy. Since all the numbers in the tables are based on current uranium consumption, they will all decrease in proportion to any expansion of nuclear power.

Reactor Fuel Cycle	Years of 2004 world nuclear electricity generation with identified conventional resources	Years of 2004 world nuclear electricity generation with total conventional resources
Current once-through fuel cycle with light water reactors	85	270
Pure fast reactor fuel cycle with recycling	5000–6000	16 000–19 000

Table 1. Years of Uranium Availability for Nuclear Power (OECD/NEA–IAEA 2006)

Nuclear energy has sufficient resource base. Current reserves are adequate to support nuclear fuel production for decades. Furthermore, the resource potential for nuclear energy can be extended through reprocessing of spent fuel and implementation of advanced fuel cycles that convert fertile uranium and thorium into fissile materials.

Environmental Characteristics

The principal environmental impacts associated with nuclear power are GHGs, air pollution, radiation and radioactive waste. The nuclear industry operates under regulations that impose stringent limits to atmospheric emissions and liquid effluents, and is committed to contain its waste and isolate it from the biosphere as long as it may be harmful for human health and the environment. Thus the industry has accepted the long-term responsibility for its emissions, effluents and waste and has internalized the corresponding costs. This internalization extends fully to waste management, waste disposal and plant decommissioning.

Greenhouse Gas Emissions

Among the alternatives for generating electricity, fossil fuelled technologies (coal, oil and natural gas) have the highest CO2 emission rates per kWh and create the majority of energy related GHG emissions.

The complete nuclear power chain, from resource extraction to waste disposal including reactor and facility construction, emits only 1–6 grams of carbon equivalent per kilowatt-hour (g C eq/kWh). This is about the same as wind and hydropower, including construction and component manufacturing. All three, together with solar power and biomass, are well below coal, oil and natural gas (60–460 g C eq/kWh) even taking account of carbon capture and storage. (IAEA, 2006)

Air Pollution

Nuclear power reactors emit virtually none of the traditional air pollutants associated with fossil fuel combustion, principally sulfur dioxide (SO2), nitrogen oxides (NOx) and suspended particulate matter (PM). Emission levels of these pollutants have been reduced in recent decades through technological improvements and by capturing emissions from stack gases.

Radiation

The US Environmental Protection Agency (EPA) estimates that someone living within 50 miles of a coal fired power plant receives an average dose of 0.3 µSv; someone living within 50 miles of a nuclear power plant receives 0.09 µSv. Both are more than one thousand times less than the average dose received by people from X rays and other medical procedures, and more than ten thousand times less than their average dose from natural background radiation.

Figure 2 presents a worldwide comparison, based on data from the United Nations Scientific Committee on the Effects of Atomic Radiation (UNSCEAR), showing, on a logarithmic scale, that the average radiation dose from nuclear power production is one ten-thousandth of the dose from natural background sources. The incremental dose from a home smoke detector is comparable to that from living within 50 miles of a nuclear power plant.

Adverse impacts from nuclear power plants arise mainly from major accidents that release radiation. The major accidents in nuclear industry in its wake brought about major changes, including the founding of a ‘safety culture’ of constant improvement, thorough analysis of experience and sharing of best practices.

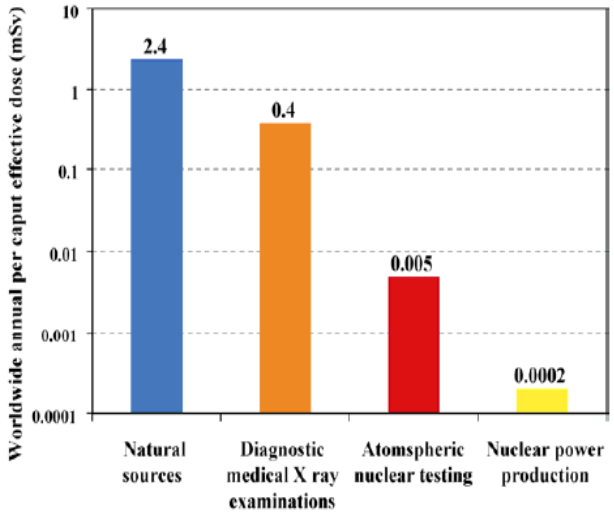

Fig.2 Worldwide average annual per capita dose from natural and anthropogenic radiation(adapted from UNSCEAR (2000)

Long Term Waste Disposal

The main challenge for nuclear energy is long-lived waste that remains hazardous in the very long term. However, this characteristic is not unique to radioactive waste. Other types of toxic waste, such as heavy metals, remains in the biosphere indefinitely, or cause enough impact in the near term to permanently influence the longer term. Waste arising from the use of nuclear energy represents small volumes, typically less than 1% of the overall toxic waste in countries with a nuclear energy industry, and they can be isolated from the biosphere at affordable costs using available technologies.

Repositories for low level radioactive waste from nuclear power plants and from medical, research, and other applications have been licensed and are in operation in many countries. There is no operating repository for the final disposal of high level waste (HLW) from civilian nuclear power plants, although the scientific and technical communities generally agree that such waste can be disposed of safely in stable geological formations. There is one operating geological repository, for the disposal of long lived transuranic waste generated by the weapon programme, the Waste Isolation Pilot Plant (WIPP) in New Mexico, USA. Fig.3 provides a comparison of annual waste generation from different energy options. It can be seen from Fig. 3 that quantum of wastes generated by nuclear power at the present generation levels are very low.

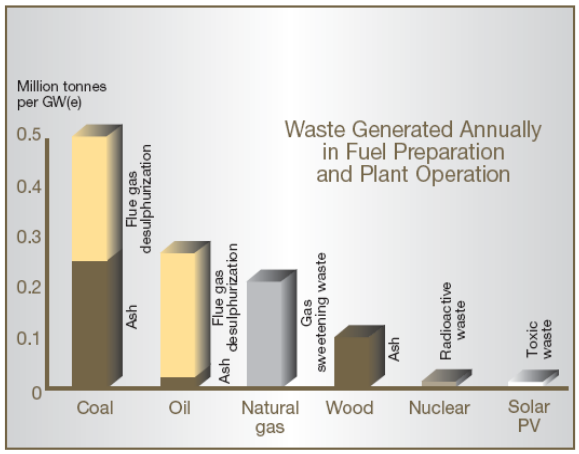

Fig. 3 Comparison of Annual Waste Generation (Source: Nuclear Power and Sustainable Development, International Atomic Energy Agency (IAEA) Information Series Division of Public Information 02-01574 / FS Series 3/01/E/Rev.1)

Currently, spent fuel generated by operating nuclear power plants is either reprocessed or stored. Reprocessing extracts usable uranium and plutonium from the spent fuel for use in new fuel. What remains is HLW that is currently stored pending final disposal. China, France, India, Japan and the Russian Federation reprocess most of their spent fuel.

Canada, Finland, Sweden and the USA have opted for the alternative of direct disposal of spent fuel as HLW.

For the long term, several options may be considered but geological disposal has been recognized as a strategy responsive to fundamental ethical and environmental considerations in several countries. The implementation of repositories, in ways discussed with and accepted by the public, will be a major step towards meeting sustainable development goals.

Safety and Sustainability

Severe accident in a nuclear power plant is a major concern that is continually addressed by nuclear safety regulations and measures. Nuclear safety is addressed based upon the precautionary design based accident (DBA) principle. They have been fortified progressively and the lessons learnt from the three severe accidents that have occurred with nuclear reactors – Three Mile Island in 1979 and Chernobyl in 1986 and Fukushima accident in 2011 – have led to significant improvements.

Addressing public concerns is essential to meet the social objectives of sustainable development. For this purpose and in the light of the widespread public concern about nuclear

risks, it is necessary to include the public in decision-making processes through which it gains confidence that its concerns are being heard and addressed. It is important to allow the public to put social, ethical and political issues related to nuclear energy into perspective with the issues raised by alternatives, including the different liabilities passed to future generations such as long-lived radioactive waste, climate change or resource exhaustion.

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Editors' Note:

The Supreme Court of India has recently delivered its judgement clearing the way for the commissioning of the latest 1000 MW Nuclear Power Plant at Koodankulam in Tamilnadu, near the southern tip of India. The plant houses the most advanced nuclear reactors supplied by Russia with passive reactor cooling system to protect the reactor under emergency conditions. However the Court has also imposed strict and periodic monitoring of the plant operation by the Atomic Energy Regulation Board and other related nuclear watchdogs. The Court's intervention was sought through a Public Interest petition by a large number of citizens who were not in favour of the Nuclear Power Plant on various technical and non-technical grounds. This judgement is expected to make it easier for the construction of another nuclear power plant in Jaitapur, Maharashtra, India, which is also being opposed by environmentalists and other concerned citizens.

Forthcoming Conferences

1. **ACSEE 2013 - The Third Asian Conference on Sustainability, Energy and the Environment**
6th to 9th June 2013, Osaka, Japan
Website: http://acsee.iafor.org
Contact person: Kiyoshi Mana
Organized by: The International Academic Forum (IAFOR), in affiliation with its global university partners

It is now recognized that the concept of sustainability is applicable to all areas of human society, for example in terms of social/economic justice, or responsible business practice. Issues such as poverty, hunger, education, health care, and access to markets should be a part of the evolution of any comprehensive sustainability paradigm as we work together to achieve a sustainable future. ACSEE 2013 will address these various dimensions of human sustainability as we invite scholars from around the world to address questions and search for synergies and solutions to the complex issues surrounding sustainability in a forum encouraging serious and thoughtful exchange between academics, members of the global business community, and practitioners in the fields of human endeavor that link these.

2. **Sustainable Development Conference: Green technology, renewable energy and environmental protection** 21st to 23rd June 2013, Bangkok, Thailand. Website: http://www.sdconference.org/Contact person: Dr. Jovana Savic; **Organized by:** Tomorrow People Organization; **Deadline for abstracts/proposals:** 21st May 2013

3. **2nd International Conference on Chemical, Ecology and Environmental Sciences (ICEES'2013)**
16th to 17th May 2013, Venice, Italy
Website: http://psrcentre.org/listing.php?subcid=217&mode=detail
Contact person: Prof. Dr. P. S. Sandhu
Organized by: Planetary Scientific Research Centre (PSRC)

Land use and Mobility at IIT Madras: Challenges for Sustainability and Bio-Diversity Conservation

KartikVenkataraman, Mehdi Javadi, Megha Sud, Nachiket Kulkarni
A brief project report from IGCS WS in IITM (Feb-March 2013)

The study aims to understand the impact of land-use planning on mobility, and how it impacts biodiversity in the IIT Madras campus ecosystem. This planning could be optimized, modified, and channelized toward a more sustainable and environmentally-friendly built-up fabrics, especially in areas of rich biodiversity ecosystems.

Mobility has been chosen as the focus from among other elements of land-use planning, as it proved to be one of the key challenges. By choosing IIT Madras as the case study, best practices as well as negative effects of development projects were explored in a small scale ecosystem.

The study encompassed four aspects of IITM campus: the IITM Landscape, Landscape Transformation and Campus Bio-Diversity, Biodiversity Conservation efforts, and mobility within the campus. This report is based on a combination of different methodologies identified as suitable for the purpose of the study. The research is both qualitative and quantitative, including personal interviews with IIT Madras faculty, administration and logistic departments, student council, nature club, environmental consultant, security personnel and others (11 interviewees). Also field assessment within the campus was conducted and questionnaires were sent to IIT students. An analysis of Campus Master Plan and Biodiversity Report and other documents was also used.

Following are some of the recommendations based on the study:

IIT Madras – Campus Scene

1) Make available adequate feeding spaces for animals so they do not have to feed on the roadsides
2) Enforce rule on no heavy vehicles at night
3) Noise levels in campus to be addressed
4) Ensure proper waste disposal to discourage feeding and gathering of animals in and around canteen and messes
5) Days of professional shows and concerts for Saarang (usually 5 days in January) witness vehicular traffic exceeding 20,000 vehicles per day. This is totally unacceptable, not only from a mobility or sustainability perspective, but also from a bio-diversity point of view. Added noise and air pollution due to increased traffic is an obvious hindrance to the animals on campus. Such shows could be shifted outside IIT, within bigger public venues in the Chennai City, which are capable of handling crowds of such levels. Mass Transit could be arranged from inside IIT to reach this venue, as the crowd from inside IIT is small in number compared to visitors from outside. At present, the difference between regular day transit traffic and festival day transit traffic is tenfold (ex: 1154 vehicles entering on regular day vs 13088 vehicles on festival day in 2011)
6) Bicycle only Zones near hostel, especially during peak times.
7) Since school traffic is a hassle, block incoming school traffic at gate and arrange increased internal bus service for kids. This can be facilitated by an intervention in the proposal of redesigning the entry gate in the master plan to accommodate an area for a public bus stop and pick up drop point outside the gate.
8) The bus stop created outside the main gate will encourage the use of public transport so that internal and external mobility of the campus can be easy and hassle free. People can take the IITM buses to the gate where a public transport option should be available.
9) Create disincentives for faculty/staff buying private vehicles, like high parking fees or expensive IIT pass.
10) Create incentives for faculty's use of mass transport/ cycles- Probably start a Green Prof award in every dept every month!

11) Car sharing system / car pooling, a facility to seek and find carpool options should be made on intranet of IITM.

12) Bicycle sharing system – monitoring energy saved by fitting tracking devices

13) Increasing bus frequency within the campus and more stops

14) The above measures will reduce to flow of traffic inside the campus and gives scope for modifying road to accommodate a dedicated cycle track without widening road

15) Specific solutions to address school timings, special occasions

16) There used to be electric buses on campus, but these have been abandoned due to the high maintenance costs and long charging periods required. There is a scope for considering buses that can run on other alternate fuels like CNG can be considered.

17) The above measures reduce noise levels and possibilities for accidents significantly. Most of these problems are known to the administration and are sought to be addressed by adding a new satellite campusat a reasonable distance of the mother campus; however it is not clear when such a plan is going to be finalized and realized as land is in short supply and the nearby districts like Velachery have developed rapidly in the last few years leading to a shooting up of real estate prices and increasing the land crunch in the area.

18) Stop further fragmentation of green areas. There can be another multi-level park at the main gate to further facilitate in the reduction of vehicular movement inside the campus

19) A dedicated week every year for activities to spread awareness about campus bio-diversity.

Conclusion

The IITM campus is now effectively an ecological island with little inflow and out flow .It was once connected to the Guindy National Park through a porous fence but now is separated by high walls effectively stopping any movement of terrestrial animals, making it a highly vulnerable area which is dealing with increasing pressures.The management is considerably sensitive to environmental issues but must balance the various demands on this small and complex system.

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