

IGCS BULLETIN

From the Editors' Desk



Dear Colleagues,

This is the first issue of the second volume of the IGCS Bulletin covering the activities of the IGCS in the Oct–Dec 2012 period, which has been a transition period of sorts. The first phase of the IGCS activities has been one of initiation, development, and consolidation of activities. It saw the Centre taking shape in terms of infrastructure and administrative support facilities, visiting German IGCS Professors and IGCS student scholars, the visit of an Indian Scientist–Professor to Germany, organization of two IGCS Indo–German Schools on Water, Waste Management, and Energy, and the launching of the IGCS Bulletin. IGCS Professors, Prof. Peter Fiener (Water) and Prof. Kristin Steger (Waste Management) participated very actively in the teaching of courses in the respective departments (Civil Engineering and Biotechnology respectively), collaborative research with IIT–M Professors, development of a course on sustainability as a minor stream, and also a proposal for a Master's Programme in

Sustainability. They also successfully coordinated the first IGCS Winter School on Water and Waste in IIT–M. They have returned to Germany after an eventful stay in IIT–M. As the very first IGCS Professors, Prof. Fiener and Steger have made a lasting contribution to the IGCS in its initial years and the IGCS wishes to extend a heartfelt 'Thank You' to them, and hopes that they will continue to associate with IGCS activities in the future. Another (designated) IGCS Visiting Professor, Dr. Christopher Martius, an international expert on Land Use, in his short stay in IIT–M, was actively involved in identifying 'Land Use' experts in India, and contributed substantially to the planning of the third IGCS Winter School in IIT–M. Prof. Pramod S. Mehta from IIT–M visited OWI, Aachen, as IGCS Scientist–Professor for interaction and collaborative research planning. The IGCS has gained tremendous experience and accomplished quite substantially in the first phase and it is entering the second phase with great expectations and confidence.

This issue contains news and other information as well as a long feature on



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the Role of Coal in the Indian Power Scenario. We hope you will enjoy reading it. The delay in publication of this issue is regretted. Thank you,

Prof. Ajit Kumar Kolar & Prof. Sibylle Petrak
Editors



Upcoming Meetings on Sustainability

13–18 May 2013, Bangkok (Krung Thep) Thailand

World Association of Soil and Water Conservation Conference

This conference, titled 'The Threats to Land and Water Resources in the 21st Century,' will address the following themes:

situations and evolution of land degradation; control measures to prevent land degradation and to restore degraded land; evaluation of the impact of land degradation on food production and the environment; effects of global climate change on land degradation and food security; law and policy to prevent and mitigate land degradation; and water resources management. The Second Council meeting of the World Association of Soil and Water Conservation (WASWAC) also will take place.

Details at

http://www.idd.go.th/web_waswac2/index.htm

email: waswac2@idd.mail.go.th

4–5 April 2013, Puducherry, India Green Campus Summit (GCS)-2013

This event will focus on strengthening relationships and knowledge exchange with those established or just starting on the campus sustainability journey. Join us for in-depth discussions and prime networking with leaders and visionaries from around the world. Further details on conference program and registration can be found in the conference website.

Topics include green campus, sustainability, biodiversity, pollution, greening, environment, education.

Contact: Mr. Nandhivarnan Muthu 23, Kamaraj Salai, Thattanchavady, Puducherry, India.

Phone: [+91-8870854633]

Email: info@greencampussummit.org

IGCS News

IGCS Lecture Series

Since our last bulletin we had two inspiring IGCS lectures:

- On October 8, 2012, Dr. Srikanth Mutnuri (Birla Institute of Technology and Science, Zuarinagar, Goa) gave a lecture on 'Biodegradation of Hydrocarbons by Enhancing Bioavailability using Cyclodextrins.'
- On the November 5, 2012, our designated IGCS Visiting Professor for Land Use, Dr. Christopher Martius, presented his previous research activities.

The first IGCS lecture in 2013 is on February 4.

Dr. M. Schneider from the University of Wuppertal will give a lecture on Biocatalysis for Bio-based Products.

IGCS lectures generally take place on the first Monday of each month during the IIT–M academic semesters at 4 p.m. in the Visvesvaraya Seminar Hall at the Civil Engineering Department of IIT–M. Further details and an invitation will be sent via the IIT–M 'Announce' mailing list. For those not on the IIT–M list but interested in more details and invitations please send an email to one of the editors.

IGCS Workshop

A students' symposium focused on 'Marine Conservation' was jointly organized by the Students' Sea Turtle Conservation Network (SSTCN) in association with the IGCS (October 28/29, 2012).

IGCS Seminar

A one-day seminar on 'Exploring the current issues in sustainability' was jointly organized by the Department of Civil Engineering, Department of Biotechnology and the Indo–German Center for Sustainability, on December 10, 2012. About 150 delegates from IIT–M, other academic institutions, non-governmental organizations and consulting organizations participated in the seminar. Prof. Bhaskar Ramamurthi, Director of IIT–M, inaugurated the seminar and delivered the inaugural address. The Chief Guest for the event was Dr. Ramachandra Guha, a well-known writer and social historian. He delivered the keynote address on 'Environmental Activism and Environmental Research: Towards an Interconnected History'. There were seven invited talks. Prof. Sudhir Chella Rajan, Coordinator of IGCS at IIT–M, made a presentation on sustainability in the context of climate change – challenges and opportunities for India. Mr. S. Raghupathy, Executive Director, CII–Godrej GBC, discussed approaches to greening the Indian industry, while Ms. Deepa Sathiam, Executive Director, En3 Sustainability Solutions Pvt. Ltd., discussed latest trends in sustainability of buildings. A presentation on sustainable solid waste management was made by Dr. Lucas Dengel, Executive, EcoPro, Auroville. Dr. Balaji Narasimhan, Department of Civil Engineering, talked about the current efforts being made by the consortium of IITs to prepare the Ganga River Basin environmental management plan. Prof. Peter Fiener, IGCS Visiting Professor in the Department of Civil Engineering, IIT–M, shared his views on sustainable water management, while Prof. Kristin Steger, IGCS Visiting Professor, Department of Biotechnology, IIT–M, presented her research findings from the project 'carbon fluxes in a rural catchment in Tamil Nadu', conducted by her and Prof. Fiener. All the four focal

areas of interest to IGCS namely sustainable management of water, waste, energy and land use were covered in the seminar. All the presentations were excellent, informative and led to lively discussions from the audience. The seminar ended with felicitations to Prof. Fiener and Prof. Steger, who have successfully completed their tenure as IGCS visiting professors at IIT-M.



*Prof. Ramachandra Guha
Chief Guest*



*Prof. Peter Fiener and Prof.
Kristin Steger*



Prof. B. Ramamuthy (Director, IIT-M), Prof. R. Guha and Prof. S. C. Rajan (IGCS Coordinator)



A section of the invited audience at the seminar



< *Prof. Steger receiving a memento from Dr. Lucas Dengel*



Prof. Fiener receiving a memento from Prof. Mukesh Dhoble >

Features

Role of Coal in the Indian Power Scenario

Prof. Ajit Kumar Kolar

Dept. of Mechanical Engineering, IIT-M (Energy Area Coordinator, IGCS, IIT-M)

Sreejus K.K.

M. Tech Student Dept. of Mechanical Engineering, IIT-M

Introduction

Energy in general, and electricity, the cleanest form of energy, in particular, is an essential infrastructural backbone of a country. It is the foundation on which the superstructure of the five sectors of a country's economic development, namely, agriculture, transport, industry, commercial and domestic, is built. The function of the power sector is to generate, transmit, distribute, and maintain assured electricity supply to other sectors to ensure sustainable economic development.

Energy security

Energy security, in terms of providing the practically needed energy to all energy sectors and all sections of the population on a continuous and assured basis is vital for the country. A near-term 'Apparent Energy Security' is possible using both indigenous and imported energy resources and technologies. However, a long term, 'True Energy Security' should aim at an ideal of completely 'indigenous energy source-technology mix'. With special reference to electricity (not including the thermal and motive energy forms) a True Power Security Index (TPSI) is a ratio of 'electricity produced by indigenous resources and technologies' to total electricity produced. The ideal 'True Power Security Index' is one, which should be pursued through prudent planning, enabling policy environment, and focused, goal-oriented implementation. The same logic can be extended to a long-term 'True Energy Security Index'.

Energy resources

The energy resources being presently used in our country for power generation are: fossil (coal, diesel oil, and natural gas), water (large, small, mini and micro hydro), renewable (on shore wind and biomass) and uranium. Only recently, solar power generation has started to make a contribution.

Coal resources

Coal is our most abundant fossil resource with about 118 billion tons proven. Most of the coal is high quality (less than half percent sulphur) with advantages in terms of low acid gas emission. However the coal is of low grade (high mineral

matter content resulting in up to 45 % ash production) creating challenges in obtaining high plant efficiency and ash handling. Substantial resources of lignite, a young form of coal, are also available in Tamilnadu, Rajasthan and Gujarat to the tune of about 40 billion tons (inferred). In 2011–12, 420 million tons were mined in India and 45 million tons were imported. The imported coal cost is about Rs. 5000 per ton compared to about Rs. 1500–2500 for indigenous coal. Presently the coal scenario is in a state of flux due to the lack of clear policies in coal pricing, a unilateral increase of imported coal price, and the practical need of coal blending for power generation

Environmental effects

During the year 2009–10 the estimated emissions from coal based power plants in India were as follows: CO₂: 498 Million Tons (0.94 kg/kWh); SO₂: 3.8 million tons, NO: 2.3 million tons, and about 160 million tons of ash. (Mittal et al, *Estimates of emissions from coal fired thermal power plants in India, 29th Emissions Inventory Conference, Aug 2012, Tampa, Florida*).

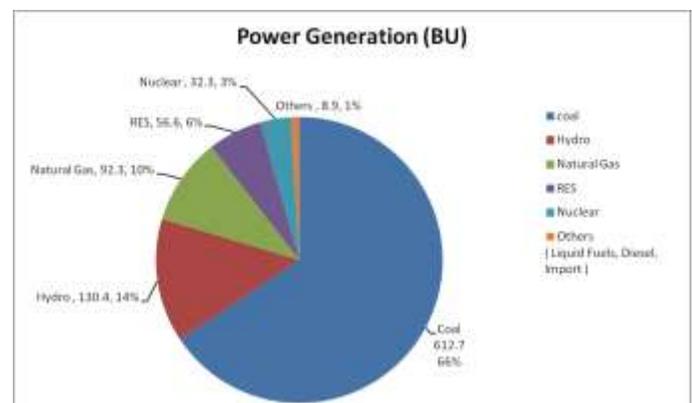


Fig. 1 Source-wise power generation 2011–12 (RES estimated by authors; others from CEA)

Advanced coal technologies

A prudent approach to use our precious, indigenous coal and lignite to boost national energy security is to identify, develop, and deploy ACT for their sustainable use, in terms of high efficiency, low emissions, and reasonable cost. A dream scenario in 2032 will be of zero coal import, by maximizing electricity generation from indigenous coal and lignite through indigenous ACT to meet a substantial share of electricity production, and create a robust enabling environment for other energy resource-technology mix to contribute the remainder of the electricity requirements.

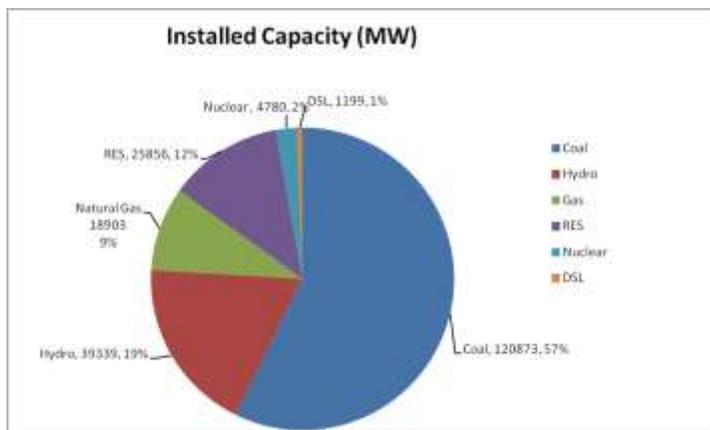


Fig. 2 Source-wise installed capacity Dec. 12 (source CEA)

Present power scenario

Figure 1 depicts the source-wise power generation during 2011–12 and Figure 2 the source-wise installed power capacity in the country at the end of 2012.

Coal-based thermal power generation contributes a major share of electricity produced, followed, in decreasing order, by large hydroelectric power generation, natural gas based combined cycle power generation, renewable (mainly wind power, small hydel and biomass power), and nuclear power generation. Both the public (Central and State) and private sector participates in the power generation. Diesel power generation is under private sector, primarily for decentralized, in-house purposes by industry and small commercial establishments.

By Dec 2012, the total power installed was 210951 MW and the electricity production from all sources, indigenous and imported, was 933 billion units (kWh) for 2011–2012, resulting in a per capita per year consumption of about 800 units as compared to the world average of about 2800 units. The estimated overall capacity factor of power

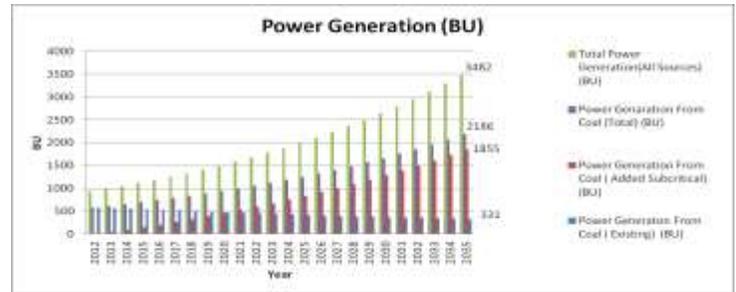


Fig. 3 Growth of power generation

generation was about 0.50. This low power generation scenario is adversely accentuated by the high technical loss of about 15 to 20 % in the transmission and distribution of power, leading to an effective per capita power consumption of about 700 units, one of the lowest in the world. It should also be noted that about 300 million people, mostly in the rural and remote areas, have no access to electricity. In many states, the power supply is erratic with several hours per day of scheduled and unscheduled power outages.

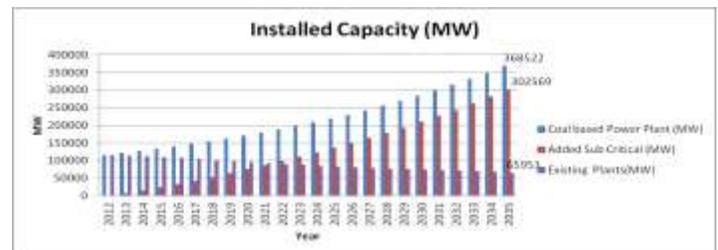


Fig. 4 Growth of coal-based installed power capacity

Projection

As a rapidly rising economy with a projected population of 1.5 billion people in 2032, India’s electricity requirements are also increasing exponentially. There are two ways of looking at the future electricity scenario for this huge population. Fix the per capita electricity consumption that is needed / desirable in 2032 and work backward to strategise the required growth of the installed capacity, the share of ‘energy source- technology’ mix, and the necessary funds, land, and human resources. The other option is to work forward from today’s installed capacity and per capita power consumption, assuming a practically feasible annual growth rate to arrive at an acceptable scenario in 2032. In either of the scenarios, the basic

reality is that a judicious ‘energy resource-technology’ mix is needed, utilizing all known and new energy resources.

Business as usual scenario

Only sub-critical plants will be used for capacity addition; yearly growth rate of power generation: 5.85% (average of 2007–2012)^[a]; share of coal electricity 62.8%; estimated per capita in 2035 is 2325 (kWh)

Dream scenario

Per capita in 2035 is fixed at 3000 kWh; **Coal Import is zero in 2035**; share of coal-based electricity is fixed at 40 %; from 2013 onwards capacity addition is super critical; 2020 onward capacity addition will be partially super critical and partially ultra super critical; By 2030, 50% of capacity addition is super critical and 50% is ultra super critical; 2030

onwards 40% capacity addition is from super critical and ultra super critical each and 20 % from PCFBC-SC-CC.

Road map

Technologies	Status		
	Short Term	Medium Term	Long term
PC SC	Induction	Diffusion & Standard	Standard
PC USC	R and D	Tech Dev & Diffusion	Standard
ACFBC	Induction	Induction & Diffusion	Large Scale Use
PCFBC SC CC	R and D	Demo & Induction	Diffusion
Coal gasification	Demo	Induction & Diffusion	Standard
IGCC	Demo	Induction	Diffusion
SOFC	R and D	Demo	Induction
IGFC	R and D	Demo	Induction
CG	R and D	Demo	Induction
CCS	R and D	Demo	Induction
Material development	R and D	Induction	Diffusion

PC SC: Pulverised Coal Super Critical, **PC USC:** Pulverised Coal Ultra Super Critical, **ACFBC:** Atmospheric Circulating Fluidised Bed Combustion, **PCFBC SC CC:** Pressurised Circulating Fluidised Bed Combustion Super Critical Combine Cycle **IGCC:** Integrated Gasifier Combined Cycle, **SOFC:** Solid Oxide Fuel Cell, **IGFC:** Integrated Gasifier Fuel Cell, **UCG:** Underground Coal Gasification, **CCS:** Carbon Capture and Sequestration. (Short Term: <2020; Medium Term: 2020–2030; Long Term: >2030)

Indian coal contains up to 45% of inorganic minerals leading to high ash production. Further the Indian ambient conditions are such that the design atmospheric temperature is about 30 to 33°C. These two features together, considering that coal is the only abundantly available fossil fuel in India, make it imperative to use coal for power production only, and not for production of coal liquids, hydrogen or other chemicals. These same features also limit the best efficiencies even under supercritical boiler conditions to about 43 to 44%. The much-publicised IGCC technology has not commercially established itself at the global level even for low ash coal, not having met the originally expected plant efficiency (greater than 50%), economic viability and reliability (greater than 85%). To cap it all, gasification technology for Indian high ash coal has not been demonstrated. Considering all this, it is prudent to develop and adopt the Combined Cycle mode of power generation with Pressurised Circulating Fluidised Bed Combustion of Indian coal under ultra-supercritical steam conditions

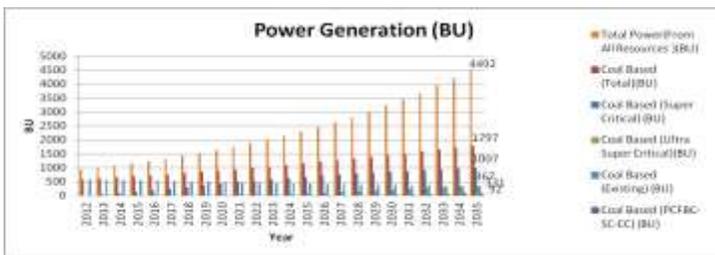


Fig. 5 Growth of power generation

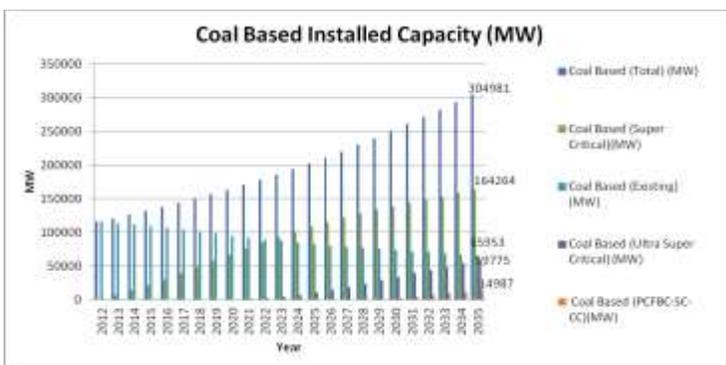


Fig. 6 Growth of coal-based installed power capacity

(PCFBC-SC-CC) and accept efficiencies of about 50–52%. It is also imperative that CO₂ capture technologies need to be developed and integrated with power generation to make coal use move towards environmental acceptability.

Final remarks

Coal will continue to be the main ‘workhorse’ of the Indian power scenario for several more decades to meet the ever-burgeoning power demand. The global coal scenario will be not much different. It is therefore prudent to develop technologies to make coal use more efficient, less environmentally damaging, and affordable. New technologies to increase coal plant efficiencies need to be developed and deployed, along with enabling technologies for emission reduction, and CO₂ capture and sequestration. The challenge of making coal an important part of a sustainable energy system must be pursued with a sense of urgency and inevitability.



Dr. Roy Hermanns and Prof. Pramod S Mehta with other researchers in OWI Aachen

IGCS Research News

IGCS Scientist Exchange

Prof. Pramod S. Mehta visits OWI, Aachen

The visit of Prof Mehta to Oel–Waerme–Institut (OWI), Aachen (7–27 December 2012) was organized under the auspices of the Energy Group Activities of the Indo–German Centre for Sustainability, IIT–M to facilitate discussions on his Bio-fuels related research and the developmental activities undertaken at OWI and explore possibilities of collaborative work in areas of common interests.

The ever-increasing interests in utilizing Bio-fuels from energy security and environmental considerations in different applications provide considerable scope of systematic investigations on the properties and processes for developing efficient systems where these fuels are employed. While the use of Bio-diesel in conjunction with mineral oil in the domestic/industrial stationary burners is a recommended practice in Germany, there is a growing interest in India to use straight and processed vegetable oils in agriculture/farm/road transport engines for augmenting energy security and the rural economy. The extensive visits of OWI facilities and detailed interactions/discussions of Prof Mehta with OWI researchers enabled identifying common interests with respect to testing, analysis and performance evaluation of Bio-fuels that can be pursued in independent and collaborative modes by the two groups.

During discussions, it is recognized that there are two Bio-fuels of interest viz., vegetable derived oils and alcohols, which have different characteristics. The behavior of Bio-diesel fuels is dependent on its fatty acid composition, which is known to differ based on base material source. Thus, the variations of Bio-diesel properties and performance are required to be tied up with their composition details. This aspect has been a main focus in Prof Mehta's research. Another important aspect of concern in use of Bio-fuels is their aging. The changes in behavior of Bio-fuels due to aging are extensively investigated at OWI using standard and novel techniques. The evaluation of flame speeds of volatile fuel like alcohols and the evaporation and burning rate characteristics of viscous Bio-diesel fuels are quite useful in investigating their combustion behavior in combustion systems like burners, engine etc. The heat flux method for flame velocity measurements used at OWI and the suspended droplet evaporation and porous sphere burn rate measurement techniques employed at IIT-M appear interesting for further development and measurements. The understanding of these behaviors, their accurate measurements and efficient use of the Bio-fuels and its blends in different systems are expected to enhance use of sustainable energy resources vis-à-vis mineral oils.

IGCS Research Possibilities

1. Put together a Bio-fuel property database on German and Indian fuels (fresh and aged) by testing important properties including compositions and validate the property correlations (IIT-M) to be incorporated in Bio-diesel models.
2. Establish heat flux technique at IIT-M for flame velocity measurements and porous sphere technique at OWI for Bio-diesel evaporation and burning rates. The measurement accuracy of these techniques could be further improved.
3. Conduct Bio-fuel performance studies on domestic/industrial stationary burners at OWI and engines at IIT-M
4. Build phenomenological and detailed kinetics modeling of ignition and combustion processes for Bio-fuels including evaporation modeling.

Student exchange programmes

Issues of graduate student exchange and continued interactions for sponsored funding from industries and local science bodies including European union were discussed.

Sustainability Conferences and Workshops

30 January 2013, Brussels, Belgium

Energy and Sustainability Summit at the European Parliament

Details at <http://www.agrion.prg/brussels>

5–7 February 2013, Addis Ababa, Ethiopia

Toward Sustainable Safe Drinking Water Supply in Developing Countries: The challenges of geo-genic contaminants and mitigation measures

Details at

www.eawag.ch/geogen2013

15–16 April 2013, New Delhi, India

B4E Global Summit 2013

Business for the Environment (B4E), is a leading international platform for dialogue and partnership solutions for the environment. The B4E summits bring together world leaders, CEOs, senior executives and industry experts to share ideas and commit to solutions, which address the most urgent environmental challenges facing the world today.

Topics include environment, sustainable development, business, energy, natural resource security, climate change, water management, biodiversity conservation, solutions and green economy.

Contact: Roshilah Atan;

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IGCS Courses and Faculty

IGCS Teaching

IGCS Professors taught the following courses in IIT–M during Aug–Nov 2012:

Sustainability and river basin management

Dr. P. Fiener; Civil Engineering Department

Sustainability in environmental biotechnology

Dr. K. Steger; Department of Biotechnology

Environmental and Resource Economics

Dr. S. Petrak; Department of Humanities and Social Sciences

Dr.S. Petrak also contributed towards teaching a part of a course on *Environment and Society* in the Department of Humanities and Social Sciences.

IGCS Winter School – February 25–March 10, 2013

Growth and Sustainability in a highly dynamic city - Exploring the urban development in Southern Chennai

End of February the IGCS will start its second Winter School in Chennai. The Winter School entitled "Growth and Sustainability in a highly dynamic city - Exploring the urban development in Southern Chennai" (February 25 - March 10, 2013) will be dedicated to exploring urban development in the city of Chennai, a bustling Indian metropolis with about 8 million inhabitants, a burgeoning car industry and an urban area rapidly expanding into the outskirts.

IGCS Staff & Scholars

End of October Katrin Premke (IGB, ZALF) visited us again as IGCS Fellow to carry out another field campaign at the Thimmapuram lake (Krishnagiri district).

Dr. Christopher Martius, an international expert on sustainability,

visited IIT–M from Aug – Nov 2012 as short-term Visiting Professor. He was actively involved in identifying Land Use experts in India and contributed substantially to planning the third IGCS Winter School in IIT–M.

IGCS recommended reading

BAYNES, T.M. and WIEDMANN, T. 2012. General approaches for assessing urban environmental sustainability. *Current Opinion in Environmental Sustainability*, 4(4), pp. 458–464.

DÖBERL, G., ORTMANN, M. and FRÜHWIRTH, W., 2013. Introducing a goal-oriented sustainability assessment method to support decision-making in contaminated site management. *Environmental Science and Policy*, 25, pp. 207–217.

JUWANA, I., MUTTIL, N. and PERERA, B.J.C. 2012. Indicator-based water sustainability assessment – A review. *Science of the Total Environment*, 438, pp. 357–371.

MAY, A.D., 2013. Urban Transport and Sustainability: The Key Challenges. *International Journal of Sustainable Transportation*, 7(3), pp. 170-185.



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