

**DEPARTMENT**  
**OF**  
**ENERGY SCIENCE AND ENGINEERING**  
**IIT BOMBAY**



***To develop sustainable energy  
systems and solutions for the  
future***

**BRICS Network University meeting**  
**Yekaterinburg, April 2016**

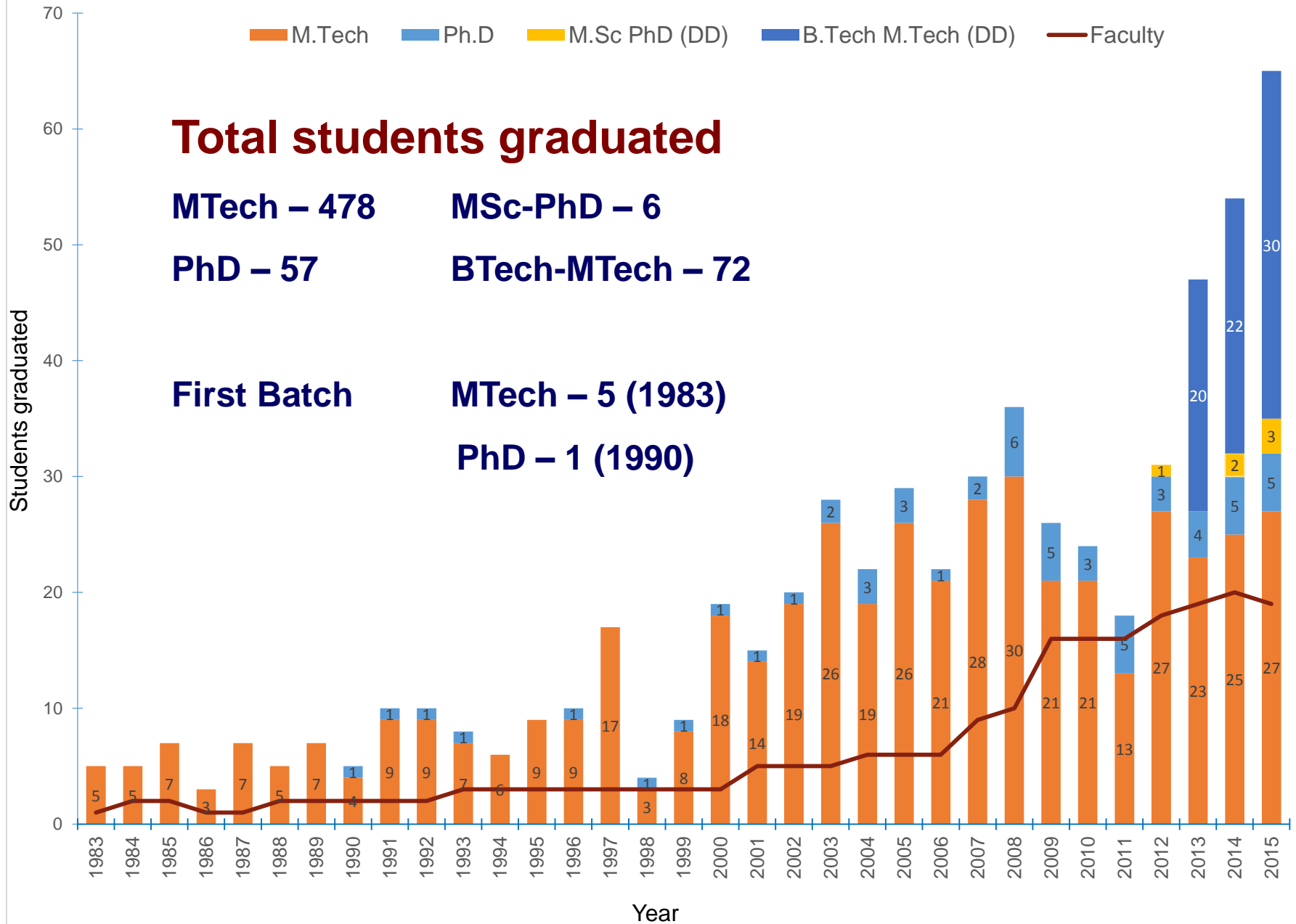
# DESE (BY NUMBERS)

- Core Faculty: 20
- Associated Faculty: 30
- Students: ~ 400
- Staff – 8, Project Staff ~ 80
- Degrees granted (in 2015): 94
- Research funding (annual 2014) ~ Rs 175 Million
- International Journal Publications (2014) 101
- DESE Patents ~ 16 (last 5 years)

## Academic Programmes

- MTech
- PhD
- BTech-MTech (5 year programme)
- MSc-PhD
- Minor in Energy Engineering

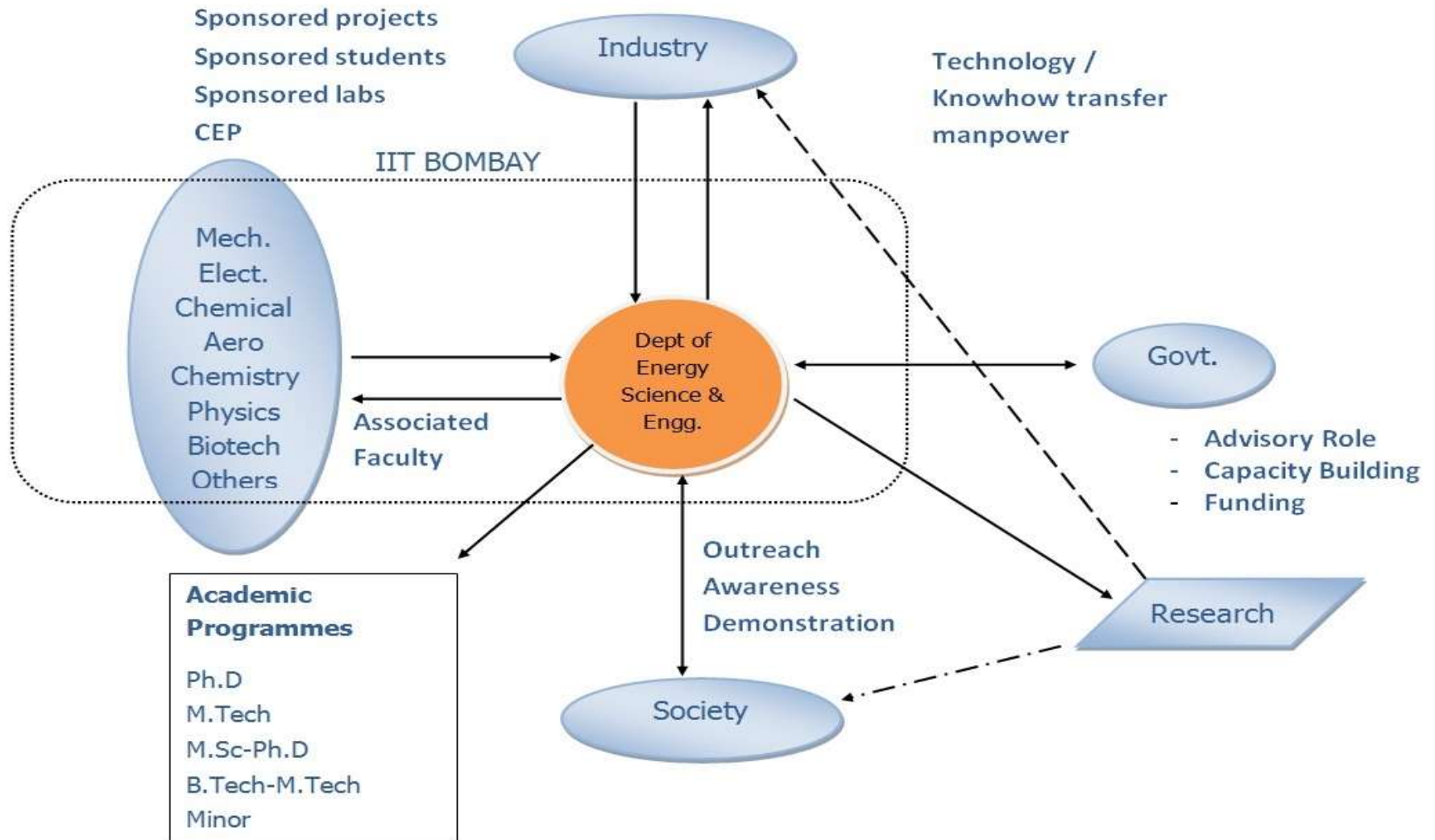
# GRADUATE OUTPUT



# DESE FACULTY



# DEPARTMENT OF ENERGY SCIENCE AND ENGINEERING



# UNDERGRADUATE PROGRAMME (5 YEARS)

Courses including Laboratories + MTech thesis

## Core Courses

- Energy Engineering Fundamentals
- Basic Electrical Engineering
- Thermodynamics and Energy Conversion
- Electronics
- Materials Science for Energy Applications
- Power electronics and machines
- Introduction to renewable energy technologies (M)
- Heat and mass transfer
- Fluid mechanics
- Equipment design and control
- Power generation and systems planning
- Electrical energy systems
- Combustion engineering

- Energy Resources, Economics & Environment (M)
- Energy System Modelling and Analysis
- Energy Management (M)
- Electrochemistry

## Other core

Institute core courses on basic science and engineering  
Energy design project  
Nine Laboratory courses (including Energy Innovation Lab)  
Seminar and Project

## Electives Courses

11 electives + 2 Minor electives

## LABORATORIES (TEACHING AND RESEARCH)

- Biomass Lab
- Cummins Engine Lab
- ONGC Lab
- Gasifier lab
- Bio-diesel lab
- Energy Materials Lab
- Solar Lab
- Forbes Marshall lab
- Wet chemistry lab
- Urja Computational Lab
- Fuel Cell Lab
- Hydrogen Storage Lab
- PV Characterization and Simulation lab
- Power Engineering Lab
- SEM lab
- Thermography lab
- Electrochemical energy lab

# RESEARCH

## Energy Conversion and Storage

Novel Batteries – Li and Na, Hydrogen  
Generation and Storage,  
Microgrids, Fuel Cells

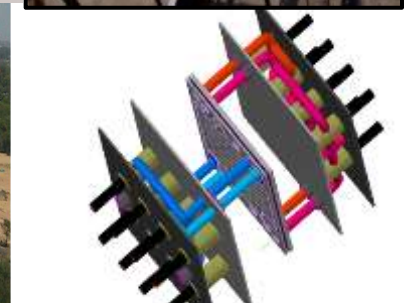
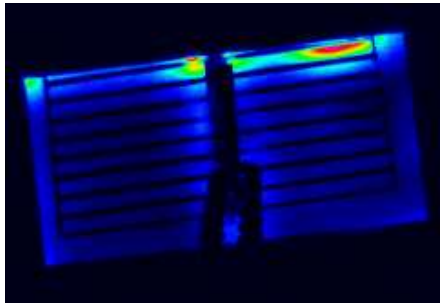
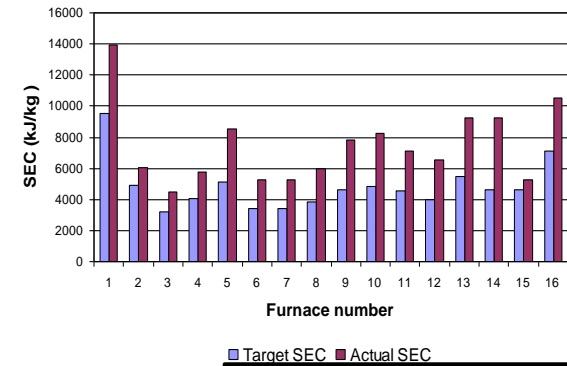
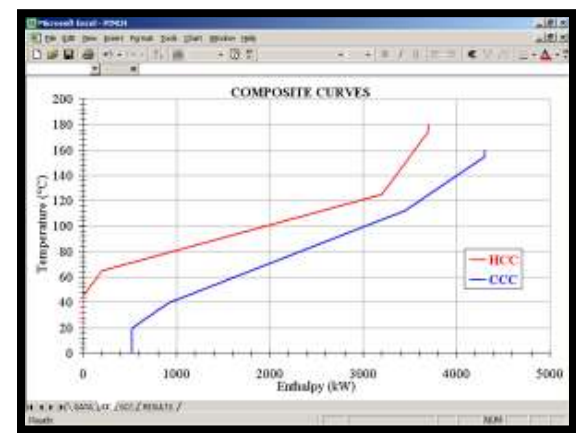


## Renewable Energy

Solar PV, Solar Thermal,  
Biofuels

## Energy Systems Analysis

Energy Policy and Energy Management,  
Energy Efficiency,  
Integration and Optimization





# INTERNATIONAL COLLABORATIONS

- Joint Research Centres (SERIIUS)
- Joint Research Projects (STAPP, BIRD, IMASE)
- Joint PhD Programmes (Monash, U Alberta)
- Faculty level collaborations
- Graduate Student exchanges
- Academic Exchanges
- Joint Workshops
- Joint Courses

# INTERNATIONAL COLLABORATIONS

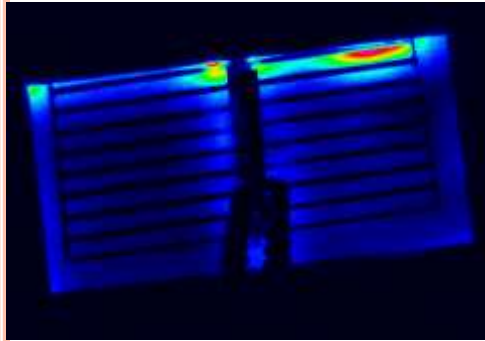


# INDUSTRY COLLABORATIONS

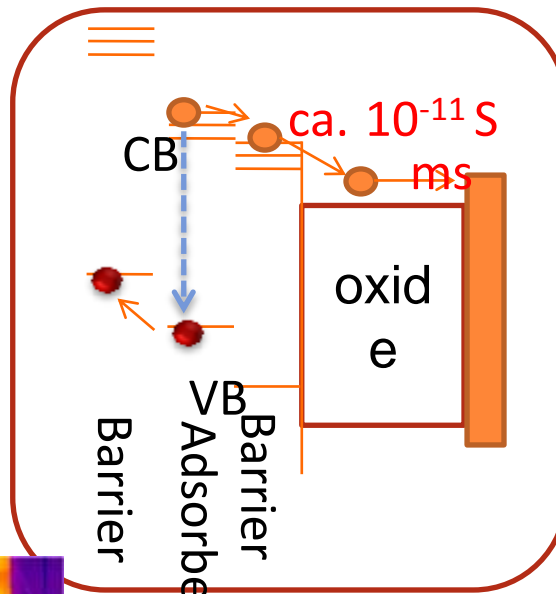
- Sponsored Projects
- Consultancy Projects
- External (Industry) students
- Sponsored Laboratories (FM, Cummins)
- Chair Professorships (FM, Praj)
- Membership in Consortia
- Internships
- Course Project support
- Joint workshops (ABB)

**Industry Partnership Scheme**

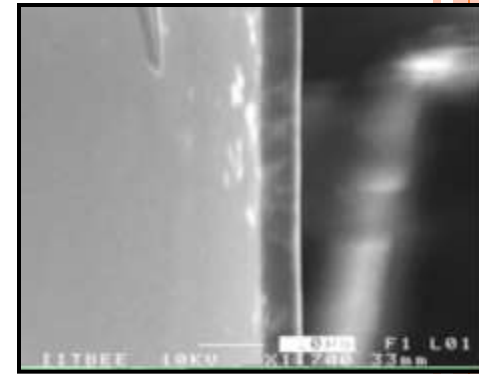
# SOLAR PHOTOVOLTAIC



Lock-in Infrared Thermography



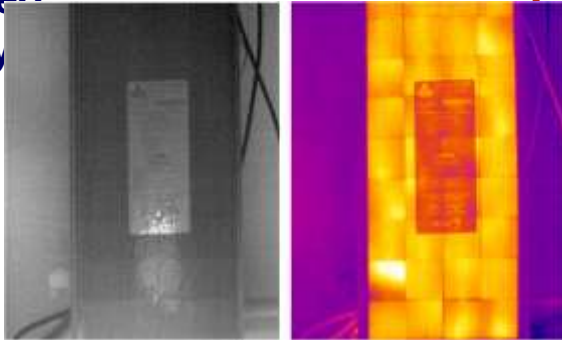
Nanocrystalline Solar Cell



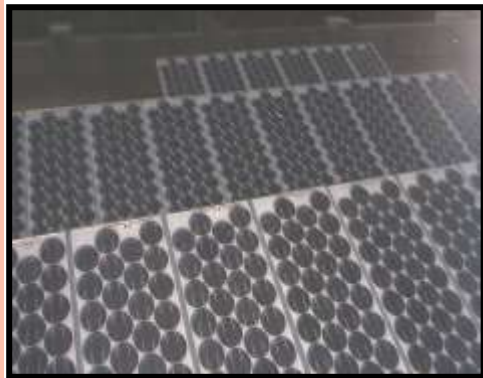
Porous Si films



Si nanoparticles



Characterization of defects in solar modules



Grid connected PV

Hot-Wire CVD



Conc. V-trough module

# NATIONAL CENTRE FOR PHOTOVOLTAIC RESEARCH & EDUCATION – SILICON FAB



*Diffusion Furnace*



*PECVD & Edge Isolation*



*Screen Printer*



*Rapid Thermal Processing*

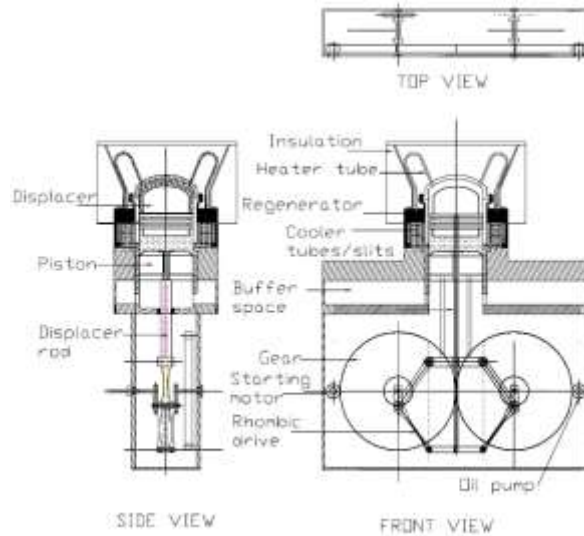
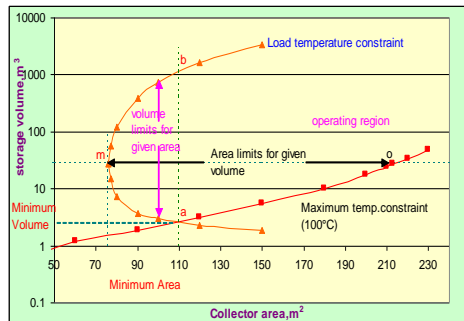


*Electron Beam Evaporator System*

# SOLAR THERMAL



**ARUN160 at Mahananda Dairy, Latur**



**Solar Stirling Engine**



**Test Facility for thermosyphon systems**



**Evacuated glass tube solar air heater**



**South facing Trombe Wall**

**Design of Solar thermal Systems**



**Day light retrofit**

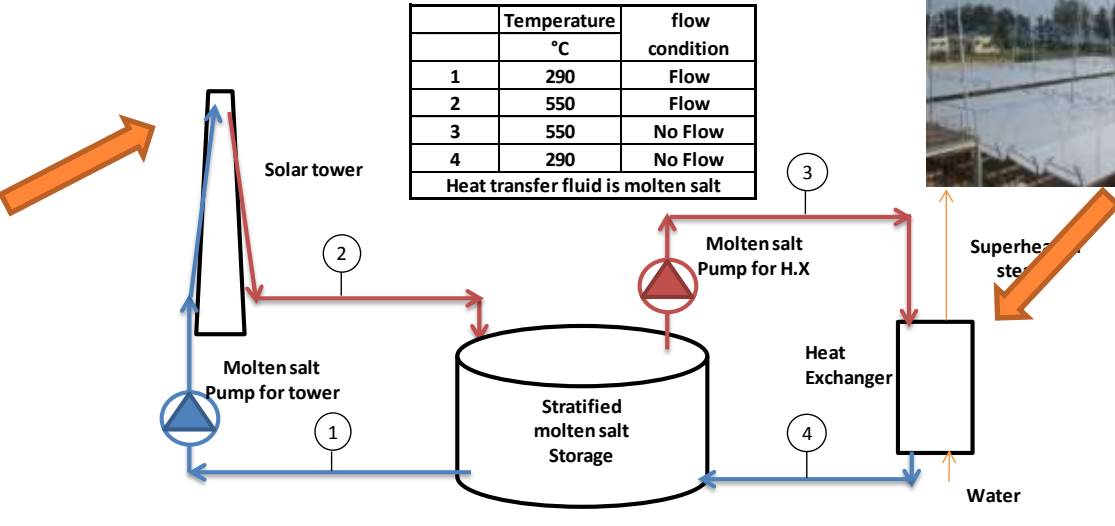
# ARIAL VIEW OF 1 MWE SOLAR THERMAL POWER PLANT AND TEST FACILITY BY IIT BOMBAY



# PROTOTYPE FOR 24 X 7 SOLAR THERMAL POWER

1. Development of indigenous heliostat
2. Development of improved LFR with steam storage using PCM
3. Development of molten salt loop and stratified storage

*DESE- IIT Bombay*  
*Partners: Clique Consultants, Mumbai*  
*KGDS Renewable Energy, Coimbatore*  
*Sponsored by NETRA – NTPC Ltd*





# BIOMASS



**Updraft gasifier with catalytic cracker**



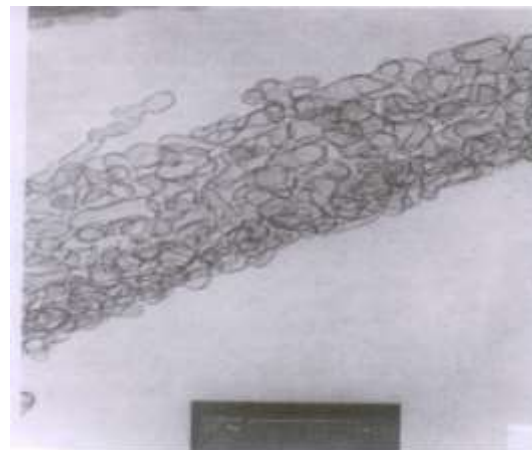
**SVO fuelled engine**



**Updraft Gasifier  
Steel re-rolling  
Raipur**



**Bio diesel Plant**

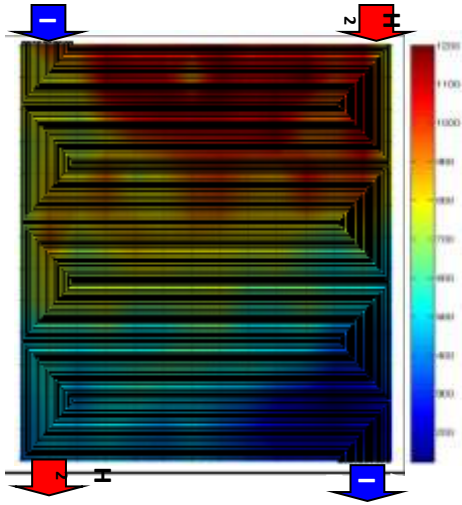


**Carbon nanotubes**

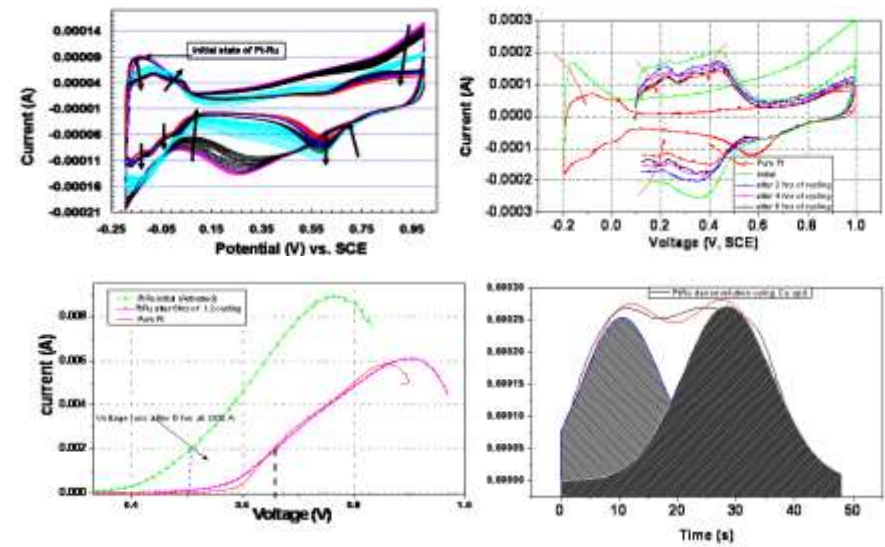


**Bio-char unit**

# FUEL CELLS/HYDROGEN/BATTERIES



Current distributions



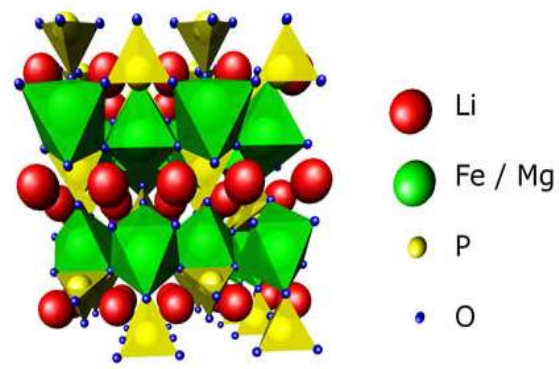
Catalyst Degradation



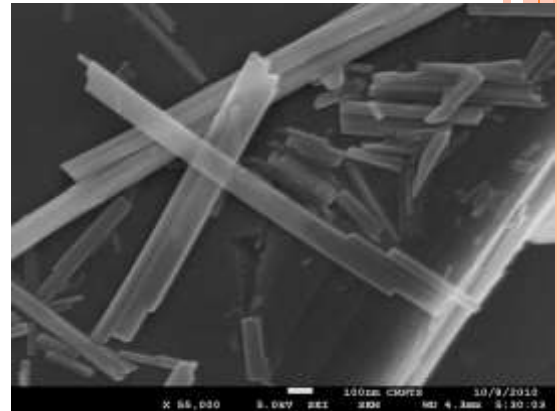
Fuel cell test station



P C Isotherm: For H<sub>2</sub> storage behavior of material



Li-ion Battery

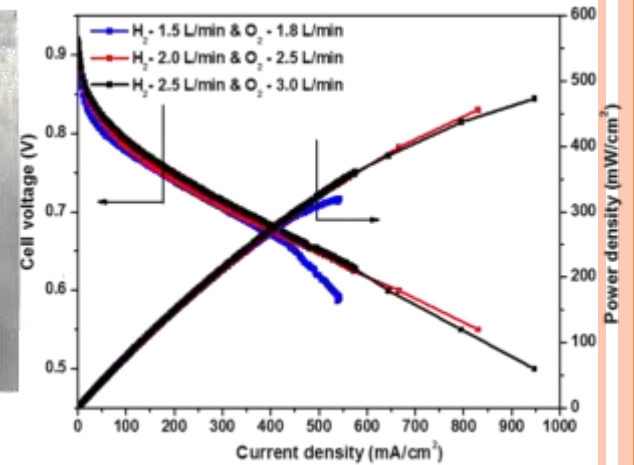
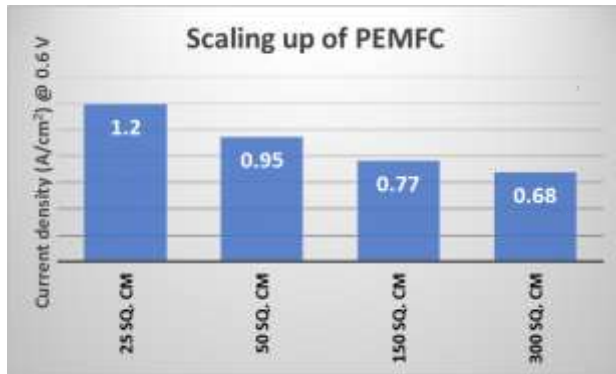


Cathode Materials of Mg-ion Battery

# FUEL CELLS

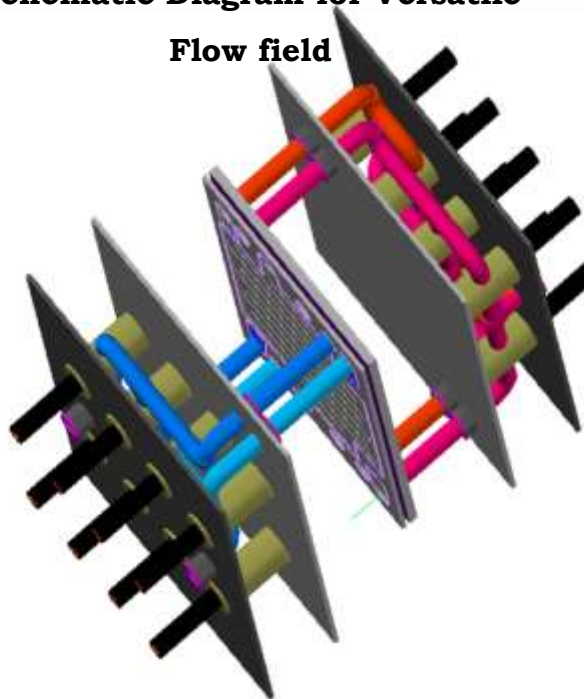
## Flowfield Design (300 cm<sup>2</sup>) suitable for commercial application

## PEFC Performance for 300 cm<sup>2</sup> under Ambient conditions

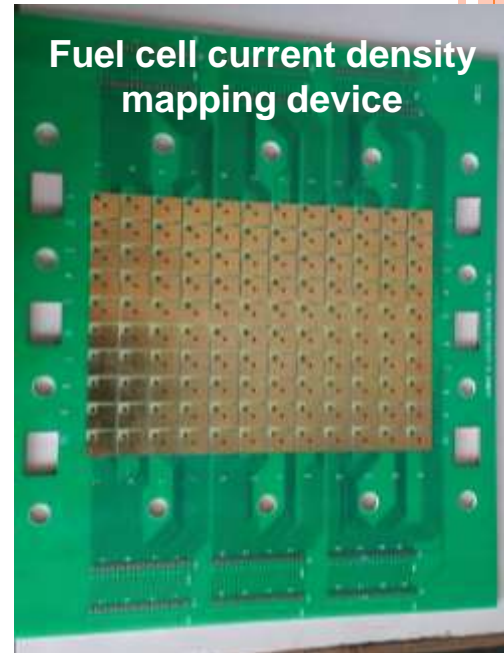


## Schematic Diagram for Versatile Flow field

## Possible Mode of Operation Using Versatile Flowfield and at performance 60 °C (at 0.6 V)

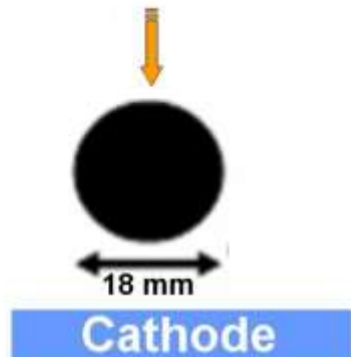
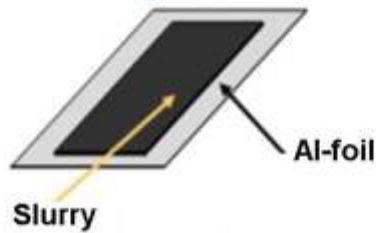


- ❖ Multi-channel serpentine: 0.78 A/cm<sup>2</sup>
- ❖ Counter flow field: 0.56 A/cm<sup>2</sup>
- ❖ Interdigitated: 0.76 A/cm<sup>2</sup>
- ❖ Serpentine-interdigitated hybrid: 0.68 A/cm<sup>2</sup>



# Lithium Battery Fabrication Facility

## Tape Casting Process



## Doctor Blade



## Hole Puncher



## Configuration of Cell



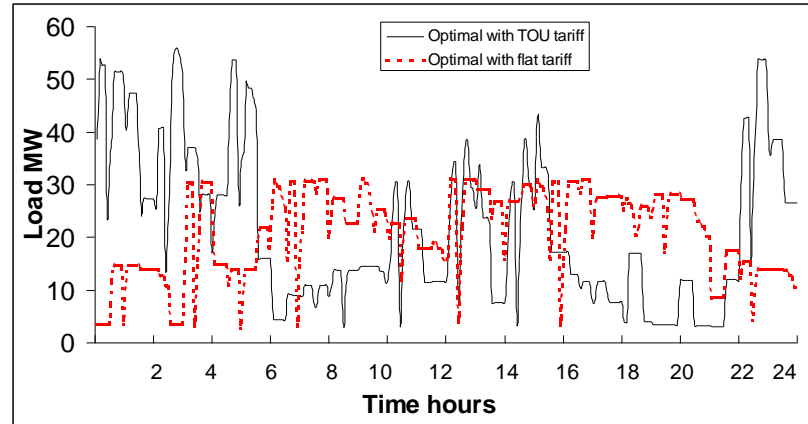
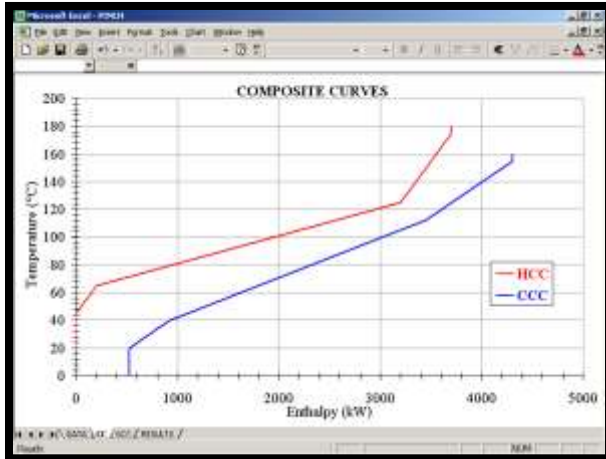
Two Electrode System for High Precision Experiment



# ENERGY EFFICIENCY

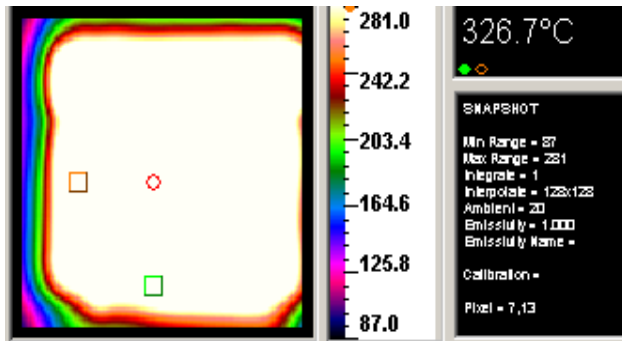


## Energy Audit of IIT Bombay Campus

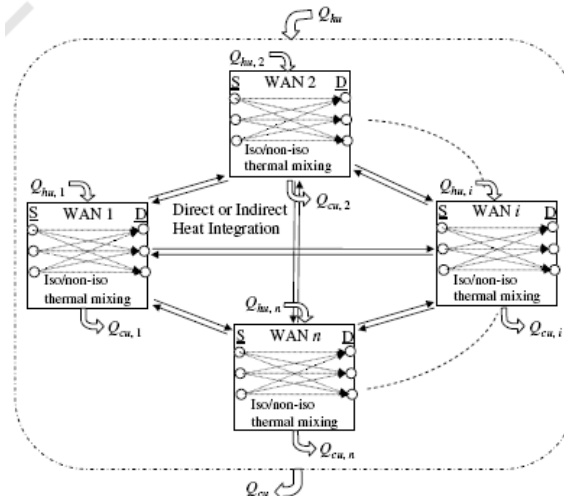


**Steel Plant  
Optimal  
Response to  
TOU tariff**

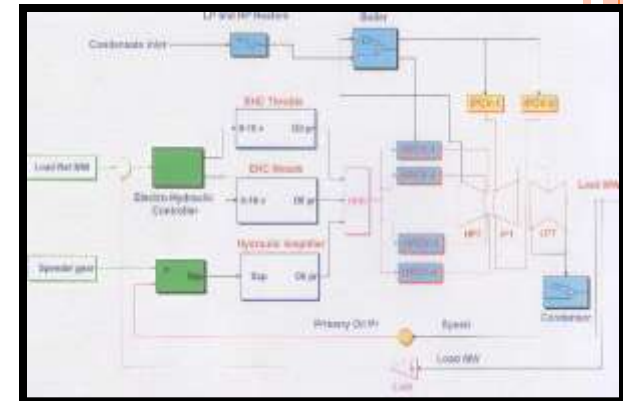
## Process Integration



## Thermal image of furnace



## Water & Energy Conservation

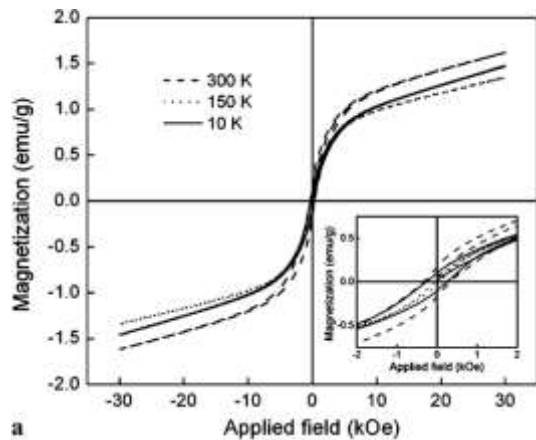


## Simulator transferred to Reliance Energy

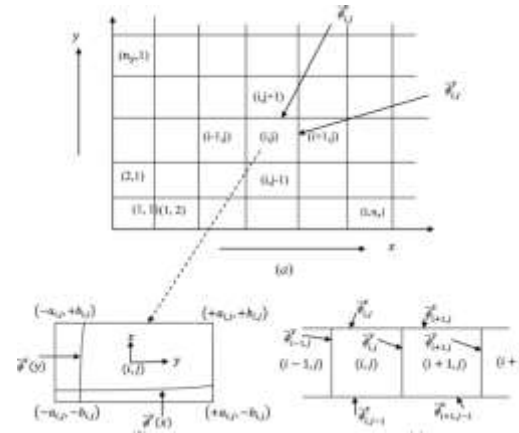
# OTHERS



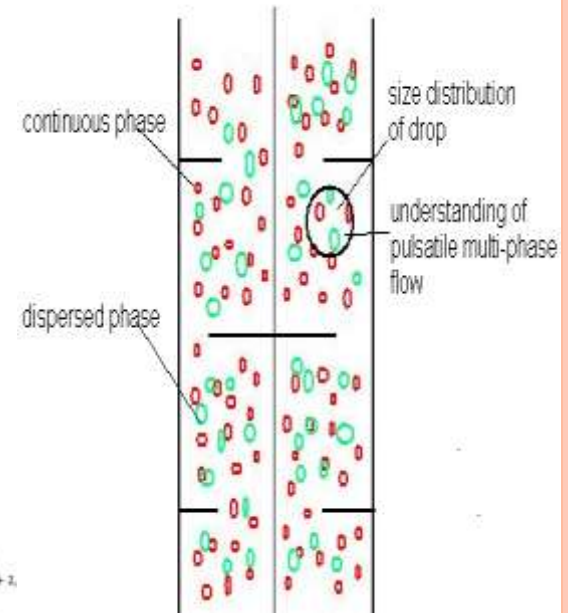
**Fixed Bed Reactor for Study of Underground Coal Gasification**



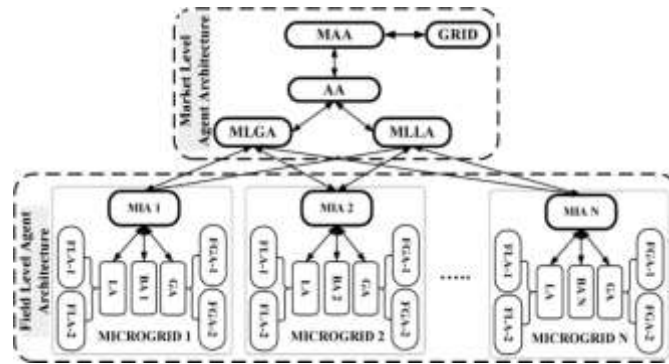
**Magnetic properties of iron oxide nanoparticles**



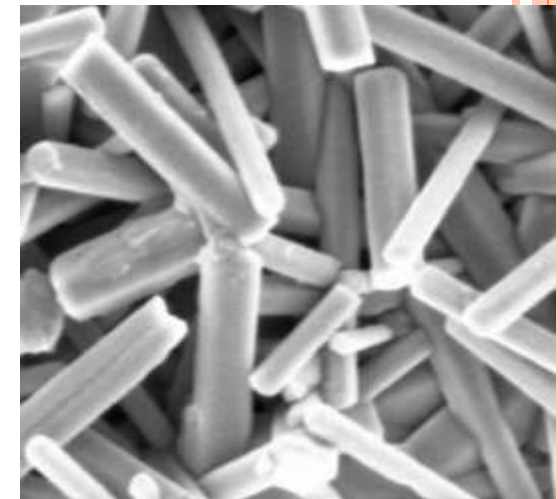
**Solving Navier-Stokes Equations**



**Investigation of pulsating flow**



**Intelligent Microgrids**



**ALD Coated ZnO Nanorods**

# ETVISION2035



Orientation April, 2012



ETV Facebook page



Youtube video



ETVision2035 website  
<http://www.etvision2035.in/>



# TEAM SHUNYA

Building a sustainable future

## SOLAR DECATHLON EUROPE 2014





# HOUSE IN VERSAILLES – 26TH JUNE, 2014



Team Shunya



**70 students 13 disciplines 12 faculty**





**1000 Teacher's Training Program on Solar PV**

***National Award for Excellence in Energy Management 2010, CII***



**Village electrification project developed by Cummins Engine Research Facility, IITB**



**1 Million Solar Urja Lamps (SoUL)**

# INDUSTRY COLLABORATIONS



# PLACEMENTS

**Schlumberger**

**ABENGOA**

**ABENER**

**SONY**  
make.believe



**BOSCH**

McKinsey & Company

MP **EN**SYSTEMS  
Advisory Pvt. Ltd.

**iCICI Lombard**  
GENERAL INSURANCE



पावरग्रिड

**ARUP**

**HOUSING**<sup>BETA</sup>  
Housing.co.in

indusinsights

**Abbott**  
A Promise for Life

**altius**  
CONSULTING

**AMAT**  
ENGINEERING



Cognizant

**ATKearney**

**BAIN**  
& COMPANY

**OLA**

**snapdeal**.com

**JPMorganChase**

CONSULTANT

**Rakuten**

**TRANSPARENT**<sup>TM</sup>  
ENERGY SYSTEMS PRIVATE LIMITED  
LOYAL TO RESOURCE CONSERVATION



# DEPARTMENT SEMINARS (RECENT)



Urban energy systems -Towards more sustainable city and neighborhood design" by Prof. Christoph Reinhart  
**Prof. Christoph Reinhart, MIT, USA** December 4, 2015



"Selected Power Electronic Interfaces for Stand Alone and Grid Connected Applications by **Dr. Dipankar De**  
Aug 14, 2015



"How to write for and get published in international scientific journals" by  
**Ms. Swati Meherishi,** October 28, 2015



"Towards sustainable energy processes: From materials design to system integration and control" by **Prof. Milana Trifkovic**  
Aug 4, 2015



"The energy question for India? Clean energy or energy access?"  
by **Dr. Sunita Narain** October 9, 2015



"Importance and Developmental Challenges of Advanced Lithium Batteries for Mankind"  
by **Dr. Joykumar Thokchom,** July 10, 2015



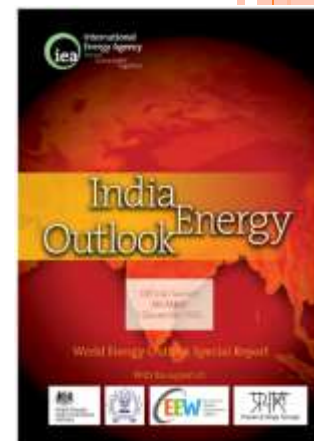
"Rational Buildings - Beyond IoT"  
by **Dr. M T Arvind** September 30, 2015

## IEA – INDIA ENERGY OUTLOOK REPORT (OFFICIAL LAUNCH)

World Energy Outlook Special Report-INDIA ENERGY OUTLOOK IEA with support of the British Deputy High Commission, IIT BOMBAY, Council of Energy, Environment and Water, Prayas (Energy Group) on 1 December, 2015 at IIT Bombay.



"Sustainability Goals 2020: Striving towards Sustainable Snacking"  
by **Mr. Arjun Bhowmik** September 30, 2015



"Energy access - persistent inequalities"  
by **Dr. Satish B Agnihotri,** September 24, 2015

Helios

# DEPARTMENTAL ACTIVITIES

Energy Day



10<sup>th</sup> ANNUAL HELIOS 2013  
 Indian Institute Of Technology Bombay  
 Department of Energy Science and Engineering  
 www.heliosiitb.org

**LECTURE**  
 Solar Energy in India - The near and distant future. Limits and challenges in harnessing Solar Energy, their implications, and what needs to be done to overcome these.  
 Dr. ANIL KAKODKAR  
 VENUE: VMCC 22  
 DATE: 20/09/13

**WORKSHOPS**  
**SOLAPP**  
 Solar Photo-Voltaic Design Simulation and hardware workshop  
 VENUE: VMCC 22  
 DATE: 20/09/13  
**SOLAR COOKING**  
 VENUE: MB ROADS  
 DATE: 20/09/13  
**LAB VISITS**  
 VENUE: SOLAR LAB  
 DATE: 20/09/13  
**SOLAR IOD DISPLAY**  
 VENUE: VMCC FOYER  
 DATE: 20/09/13

**COMPETITIONS**  
**ENERGY LIVE!**  
 A 30-minute, 30-second game in which participants trade in various sources of energy. Participants will be tested on their ability to make dynamic decisions based on changing conditions.  
 PRIZES: WORTH INR 12000  
 VENUE: VMCC 22  
 DATE: 20/09/13

**SOLAR BUILDING**  
 Give some presentations of a house/structure, being prepared and participants are expected to come up with novel ideas on making a sustainable living space taking cost & energy consumption into account.  
 PRIZES: WORTH INR 8000  
 VENUE: VMCC 22  
 DATE: 20/09/13

**WASTE TO ENERGY**  
 How do you convert waste into energy? Waste-to-energy technology and you may to present innovatively about the converting waste into energy.  
 PRIZES: WORTH INR 8000  
 VENUE: VMCC 22  
 DATE: 20/09/13

**TOTAL PRIZES WORTH INR 40000**

join us @  
[www.facebook.com/heliosiitb](http://www.facebook.com/heliosiitb)



Department of Energy Science and Engineering



**Dr. Harish Hande**  
 MD and Co-founder, SELCO-India  
 B.Tech in Energy Engineering, IIT-KGP  
 Ph.D, University of Massachusetts

**Interactive Session on  
 'Future of an Energy Engineer'**  
 Wednesday, 18<sup>th</sup> September  
 Venue: ME 201  
 Timing: 3:00-4:15pm



Energy Club



# ESA COUNCIL (ENERGY STUDENT ASSOCIATION)



Energy Club organizes event with NITI  
AAYOG



Fun filled Dept. Trek to Bhimashankar



5<sup>th</sup> ICAER Dec 15-17, 2015



Dec. 10-12, 2013  
245 papers



3<sup>rd</sup> ICAER Dec. 9-11, 2011



2<sup>nd</sup> ICAER Dec. 9-11, 2009



1<sup>st</sup> International Conference on Advances in Energy Research (ICAER), Dec. 12-14, 2007  
130 papers



Advances in Energy Research  
Dec. 4-5, 2006 , 89 papers



Thank you