OVERVIEW OF SUSTAINABLE ENERGY AND GEO-MODELING STUDIES FOR CO2

ACBSE-2010

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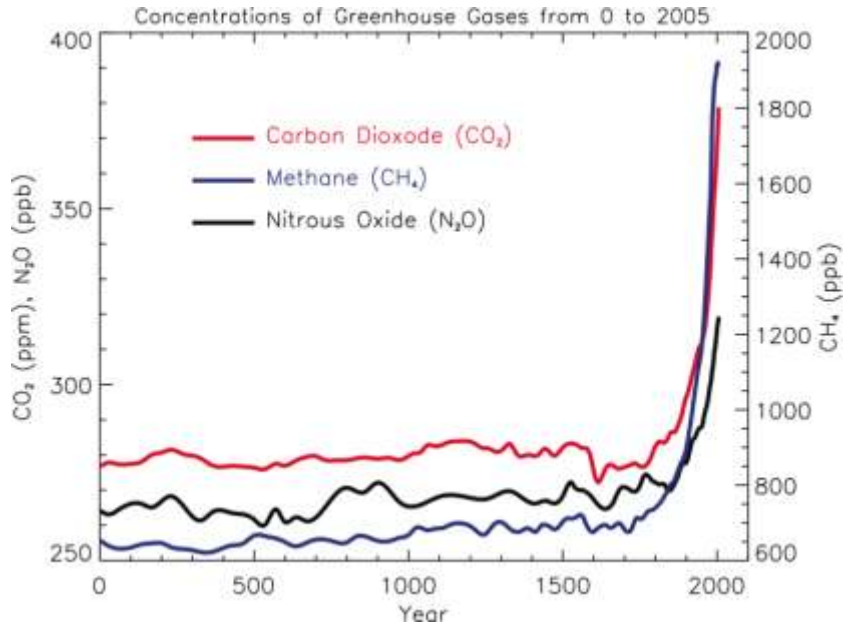
What is Sustainable Development?

- sustainable development is development that satisfies the need of the present generation without jeopardizing the abilities of future generation to satisfy their needs.

- World Commission on Environment and Development

Sustainable Energy Goals?

- Cost and Economics
- Materials and Resources
- Environment and Safety



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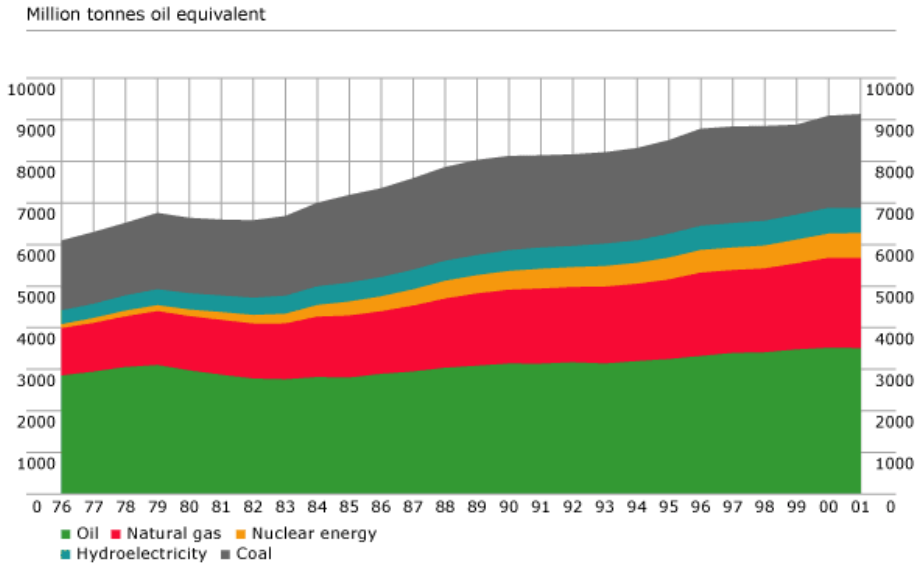
The Awareness and Capacity Building in Sustainable Energy (ACBSE – 2010)

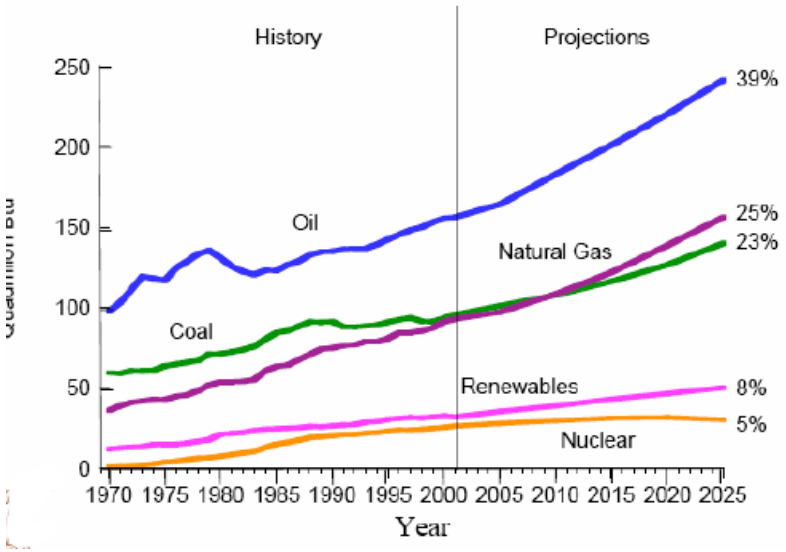
- One day Brainstorming Session organized in collaboration with **India International Centre** and **Center for Studies in Science Policy**
- Awareness on clean energy technology options and capacity building are targeted.
- Reduction of greenhouse gas emissions for mitigating and adopting to climate change impacts.

Energy Resource Base at a Place

- Renewables
  - Solar, Wind, Hydro, Ocean, Geothermal Bioenergy
- Non- renewables
  - Coal, Oil, Gas, Nuclear

World Energy is Dominated by Fossil Fuels





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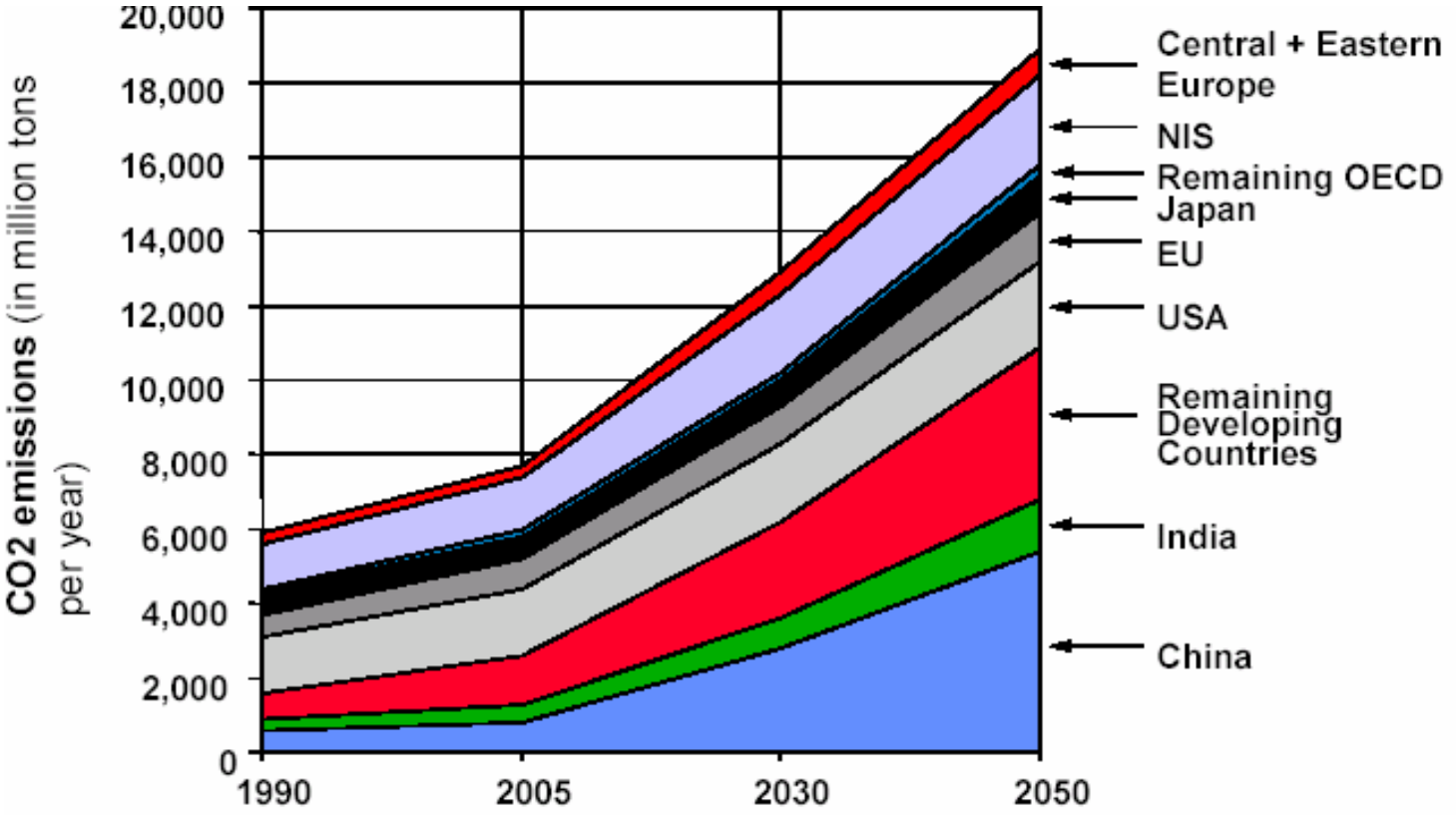
Technical Session I

Climate Change and Sustainability

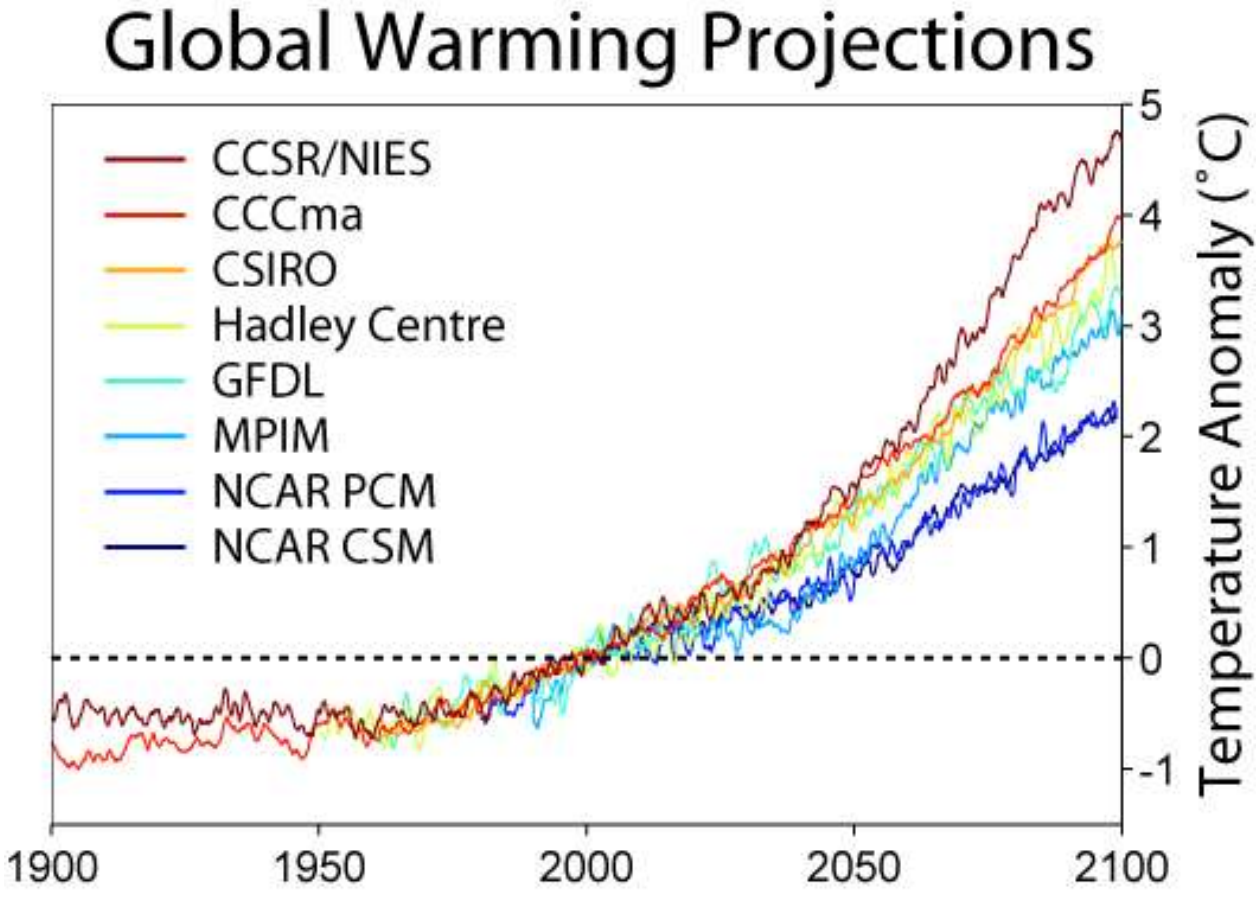
Focus on greenhouse gas emission scenario for India, the developments in renewable energy, nuclear energy & safety issues and recent developments including carbon capture for coal based power generation.

Global CO2 Emissions and Projections



Source- IPCC

Earth's Increasing Temperature



Source- IPCC

India's Energy - Solar Energy

- Jawaharlal Nehru National Solar Mission launched on 11th January 2010
- Three phases
  - First Phase 2009-2012 - 1000MW
  - Second Phase 2012-2017 – Developments in Solar thermal (15 million Sqm collector area)
  - Third Phase 2017-2022 – 20,000MW

Bio- energy

- Energy from Plants, which make use of solar chemical energy.
- Energy technologies include
  - Thermo-chemical Conversion of Biomass
  - Bio-chemical Conversion of Biomass
- Bio Energy share in 2031 for India is estimated to reach 500BkWh (2.5%)
- Competing demands from land for Agriculture

Nuclear Energy

- **Nuclear Fission**
  - Electricity generation from controlled nuclear reaction has become a target of many nations
  - 436 Nuclear plants are operational in 34 countries having over 350 GW capacity

Wind Energy

- Forecast for 2020 –World- 1,60,000 MW
  - India - 25,000 MW
- Wind Energy Potential in India 48,000MW
- Wind Energy installed capacity 10,904MW
- Indigenous capability in manufacturing of 3 MW and more

Fossil Fuels

- Nearly 40% of world's energy comes from coal
- Coal is dominant energy resource in India contributes almost 70 % of the generation
- Coal, Oil and Natural gas account for almost three fourth of total emissions

Clean Energy from Fossil Fuels

- Natural gas as replacement of coal and oil for reducing CO2 emissions
- Further reduction in CO2 emissions can be through carbon management such as carbon capture and storage

Technical Session II

Beyond Carbon Capture: Science of Geo-modeling Studies

In the context of global warming, CO_2 sequestration - carbon capture and storage (CCS) is widely acknowledged as an emerging technology to address the problem of increasing carbon dioxide (CO_2) in the atmosphere

Carbon Capture and Storage

The Carbon Capture and Storage (CCS) technologies are emerging for CO_2 mitigation. The CCS is characterized by three main technologies.

- **CO_2 Capture** - Capture from the flue (waste) gas of a large power plant or a heavy industry.
- **CO_2 Fixation** - Fixation of CO_2 in terrestrial environment using biological methods. It can also be converted into useful products.
- **CO_2 Transportation & Storage** - Safe transportation of captured CO_2 to a place of its disposal and its injections in suitable geo-environment for its removal from the atmosphere.

Where do you CO2 Store?

- Deep saline formations. These are porous and permeable reservoir rocks containing saline water in their pore spaces.
- Depleted or partially depleted oil fields – either as part of, or without, enhanced oil recovery (EOR) operations.
- Coal seams (= coal beds) – either with or without enhanced coal bed methane recovery (ECBM) operations

Super Critical CO2

- Dense gas
- Physico – chemical properties between those of liquid and gas.
- Solubility approaching liquid phase
- Diffusivity approaching gas phase

Trapping Mechanisms

- Solution trapping
- Residual gas trapping
- Mineralogical trapping
- Large-scale geometric trapping

Role of Geo-modeling

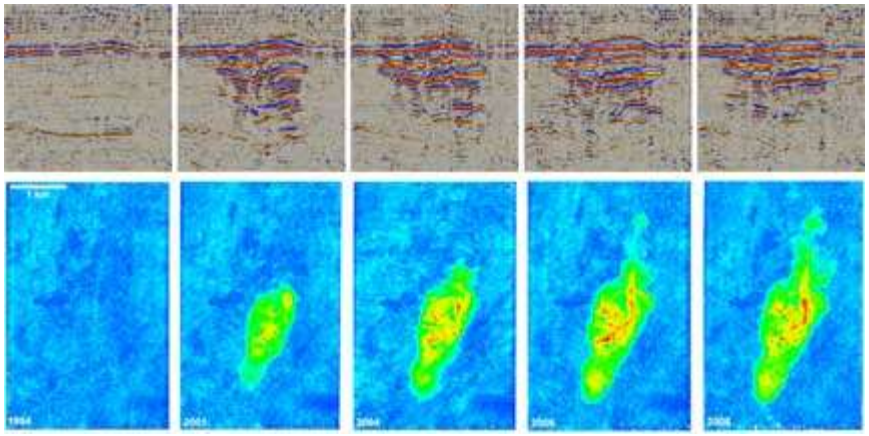
- Geo-modeling studies are needed to model the dynamics of reservoir in terms of its various parameters such as depths, size cap rock characteristics as well as CO2 behavior in the reservoir.
- Reactive transport modeling integrates the geochemical, hydrological, and mechanical processes that characterize dynamic geologic systems.

What Models can Do?

- A number of issues can be addressed in numerical modeling of CO2 sequestration
- A range of models have been developed to study CO2 geochemistry, leakage pathways and trapping mechanism, like STOMP, FEHM, PNLCARB and TOUGH.
- STOMP-CO2 is numerical multiphase CO2 flow and transport simulator for modeling behavior at CO2 of indifferent geo-environments.
- PNLCARB adopted a semi-analytical modeling framework to simulate deep-well injection of CO2 for geological sequestration.

CO2 Sequestration

- CO2 sequestration multi-national geo-modeling programme. It has two components
  - In situ Supercritical Suite [IS^3),
  - Geological sequestration software suit (GS^3).



IS3

- The In Situ Supercritical Suite or IS3 is a group of instruments to probe geochemical reactions inside the earth under supercritical pressures and temperatures.
- It uses advance optical spectroscopy, nuclear magnetic resonance, atomic force microscopy and high pressure XRD instruments to study supercritical CO2

GS3

- The Geologic Sequestration Software Suite, GS3, is designed for modeling of geological sites for sequestration using advance scientific programming
- It is an extensible, dynamic and integrated computing environment using data, scientific software, analytical tools, and computing resources.

Summing Up

Bridging the Gap between Science & Society

- A Renewable Energy Policy is needed for achieving the sustainability goals
- Understanding CO2 capture and geological storage is an important aspect of maintaining fossil fuel energy options