

# Carbon dioxide Capture & Storage in Emerging Economies

(Session II)

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# Global Climate Change is not a Myth but Truth

Evidences are:

- Rise in Atmospheric CO<sub>2</sub> & Temperature ; Shrinking of Glaciers; Breaking of Arctic Shelf and Sea Level Rise

Are we concerned about it?  
Yes

Are we serious about it?  
To some extent...



## Carbon dioxide emissions – 2002

**Description** : Carbon dioxide emissions: Anthropogenic carbon dioxide emissions stemming out from the burning of fossil fuels, gas flaring and the production of cement

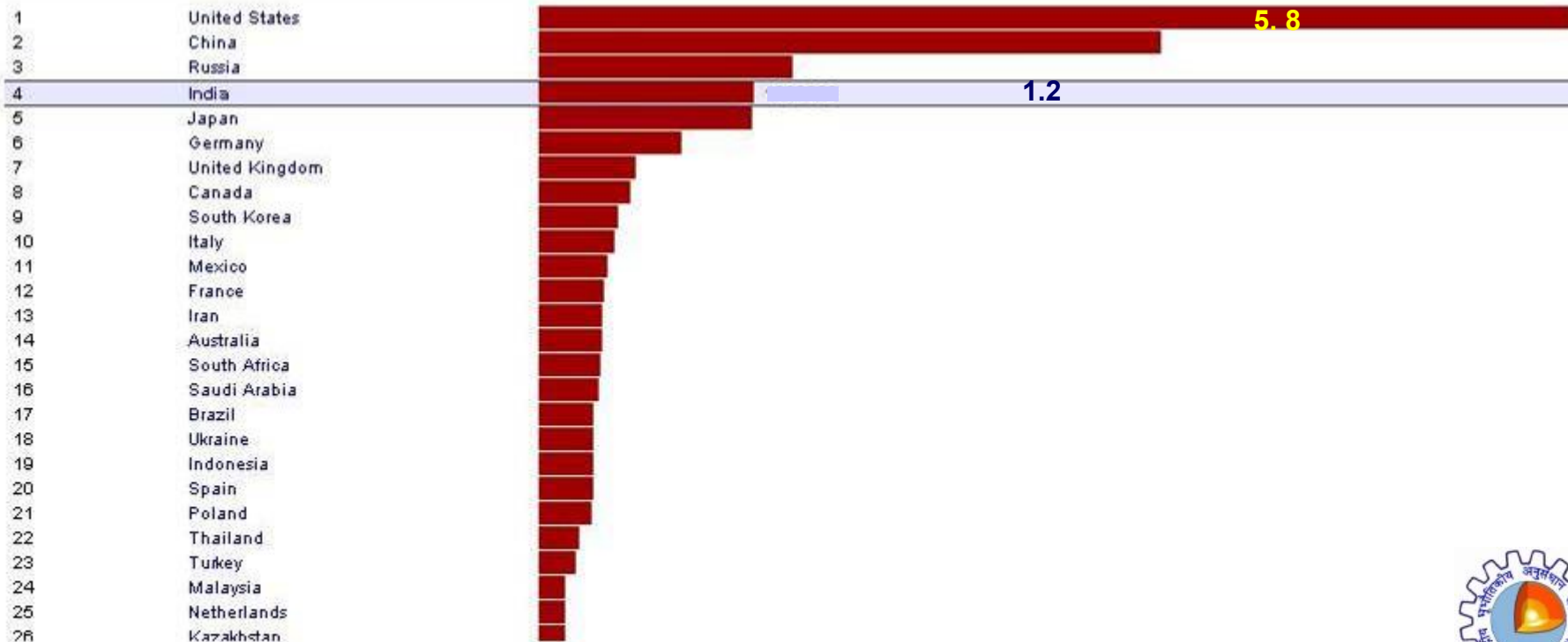
**Source** : UN Common Database (CDIAC)

**Category** : Environment

**Year** : 2002

**Units** : Giga Metric Tons

### Bar chart



## Carbon dioxide emissions per capita

**Description :** Carbon dioxide emissions per capita Anthropogenic carbon dioxide emissions stemming from the burning of fossil fuels, gas flaring and the production of cement.

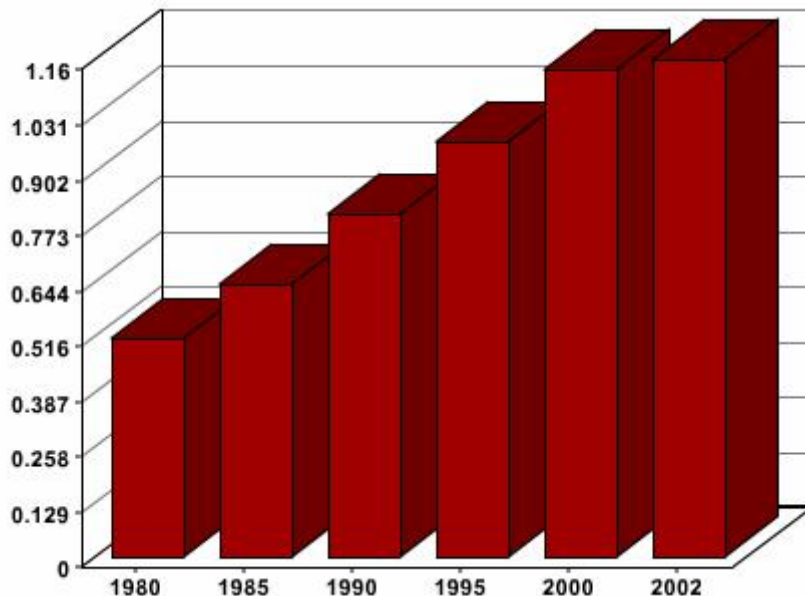
**Source :** UN Common Database (CDIAC)

**Category :** Environment

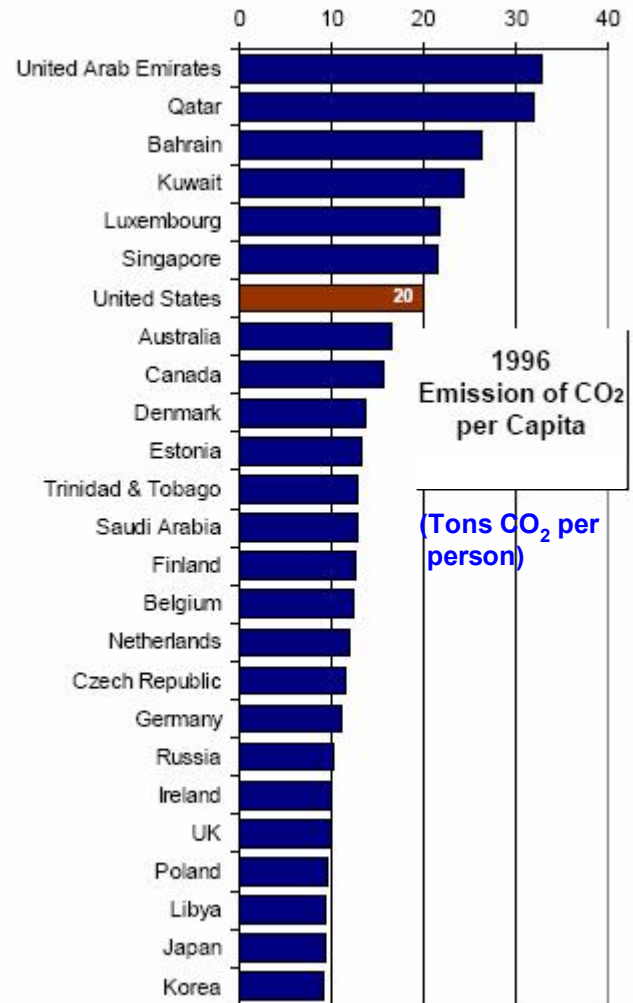
**Ranking :** 54 (2002)

**Unit of measurement:** Metric tons per capita

*India signed and ratified the Kyoto Protocol in 2003 but is not obliged to cut emissions up to 2012*



**INDIA**



# International Incentives or Mechanisms for CCS in Energy System

- Acceptance amongst scientists, technologists, policymakers regarding Global Warming and its consequences
- Initiatives by International Co-operative Forums (CSLF, IEA, UNFCCC, European Commission, Asia Pacific Partnership on Clean Development Environment etc.)
- Clean Development Mechanism (CDM)
- Development of R&D technologies for Carbon Capture & Transport
- Advancement in research on Geological CO<sub>2</sub> storage, Clean & Green Electrical Energy & Renewable Energy Sources



# International Incentives or Mechanisms for CCS in Energy System (Not Worked?)

- **Economic benefits for CO<sub>2</sub> capture and storage**
  - The cost of CCS for power generation is > US \$ 80 / Ton as compared to US \$ 20 / Ton which is approximately the value of carbon credit in the emerging trading market. If the CCS has to be viable then the \$ 60 gap must close
- **Liabilities and International Claim**
- **Emission Trading Schemes**
- **Funding Mechanism to ensure an effective international framework for supporting CCS**
- **IPR**
- **Public Awareness**



# Areas of Early Opportunities for CCS

(Middle East, Africa, India)

- Enhanced Oil & Gas Recovery
- Enhanced Coal Bed Methane Recovery
- CO<sub>2</sub> storage in geological formations
- CO<sub>2</sub> EOR and Clean Electricity

## Other challenging options

- Molecular replacement of Methane from hydrated reservoir using CO<sub>2</sub> replacement technology
- Bio-sequestration



# CO<sub>2</sub> Sequestration in Methane Hydrates

- Methane Hydrates are class of solids in which methane molecules occupy cages made up of hydrogen-bonded water molecules.
- CO<sub>2</sub> can also be stored as hydrates with simultaneous conversion of in situ methane hydrates into natural gas.
- At temperatures below 10°C, there is a pressure range in which methane hydrate is unstable while CO<sub>2</sub> hydrate is stable.
- The heat released from the formation of CO<sub>2</sub> gas hydrate is greater than that needed for CH<sub>4</sub> hydrate dissociation:  
 $\text{CH}_4(\text{H}_2\text{O})_n \Rightarrow \text{CH}_4 + n\text{H}_2\text{O}$ ;  $H_f = 54.49 \text{ KJ/mole}$   
 $\text{CO}_2(\text{H}_2\text{O})_n \Rightarrow \text{CO}_2 + n\text{H}_2\text{O}$  ;  $H_f = 57.98 \text{ KJ/mole}$   
where  $n$  is the hydration number for CH<sub>4</sub> hydrate and CO<sub>2</sub> hydrate
- $n$  is dependent on pressure, temperature and the composition of the gas in the gas phase which implies that under certain pressure and temperature conditions, the replacement of CH<sub>4</sub> in the hydrate with CO<sub>2</sub> is thermodynamically possible.

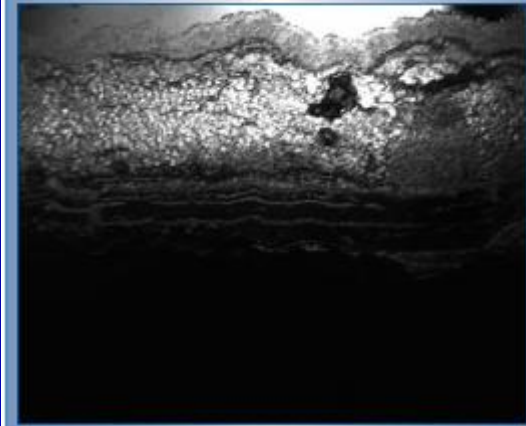


Figure 4. This laser image shows methane hydrate embedded in the sediment at the start of CO<sub>2</sub> injection.

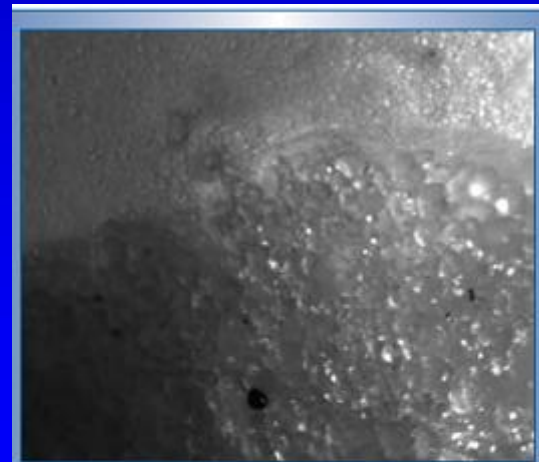
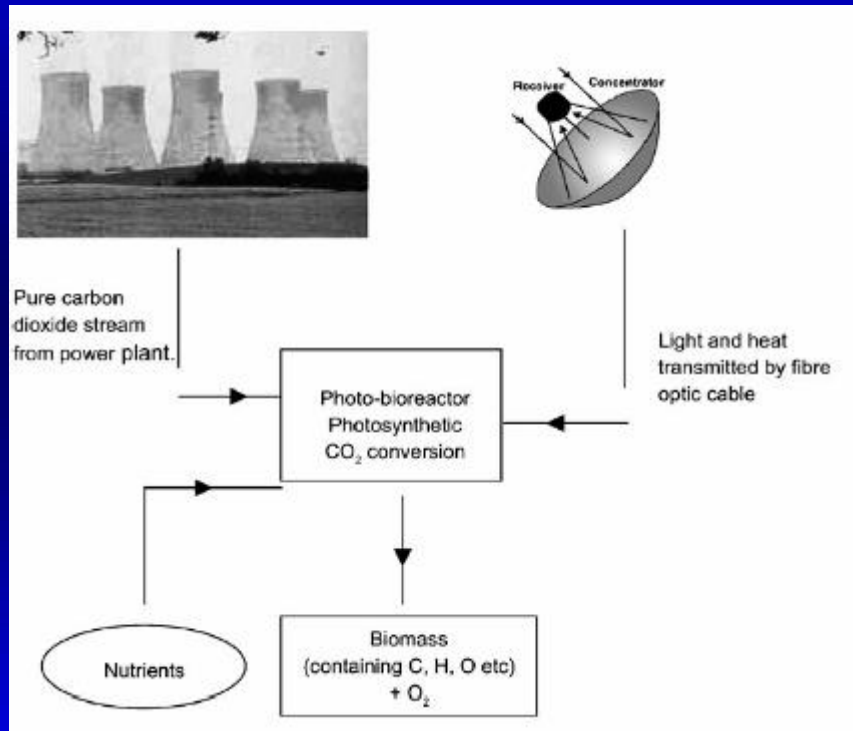


Figure 5. This laser image shows hydrates embedded in the sediment after 92 hours.



## Bio-sequestration :

The concept of photosynthetic conversion to fix carbon dioxide using bacteria or micro-algae under a controlled environment.

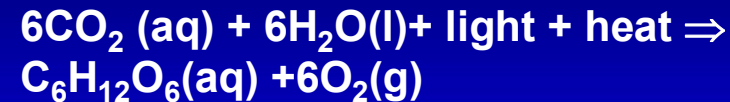


Conceptual diagram of Photosynthetic conversion of carbon dioxide to biomass.

- The solar energy is collected using Fresnel lens devices/parabolic concentrator and a fibre optic light delivery system is used to stimulate biological organisms like cyanobacteria or micro-algae in a bio-generator to produce useful by-products from carbon dioxide.

- For uniform growth of the organisms, the distribution of photosynthetic photon flux light in the wavelength range of 400–700 nm needs to be delivered to the bioreactor.

- The photo-bioreactor system makes use of the natural process 'photosynthesis' to convert light, heat and carbon dioxide to useful products, such as carbohydrates, hydrogen and oxygen.



- Assuming that the carbon uptake rate of 1.5 g/day for the particular micro-organism *Synechocystis aquatilis* up to 2.2 ktonne C/year could be sequestered from the environment.

(After Energy Conv. and Manag.46 (2005))



## Additional Investments in CCS

- Making CCS economically viable
- Developing international funding mechanism including funding from World bank to support CCS projects
- Building of an International framework for the prioritization, selection and funding of CCS R&D projects
- Facilitating Public and Private Partnership
- Sharing R&D benefits of CCS amongst global partners/users



Glacier AX010, Nepal  
1978



# Thank You

Glacier AX010, Nepal  
2004

