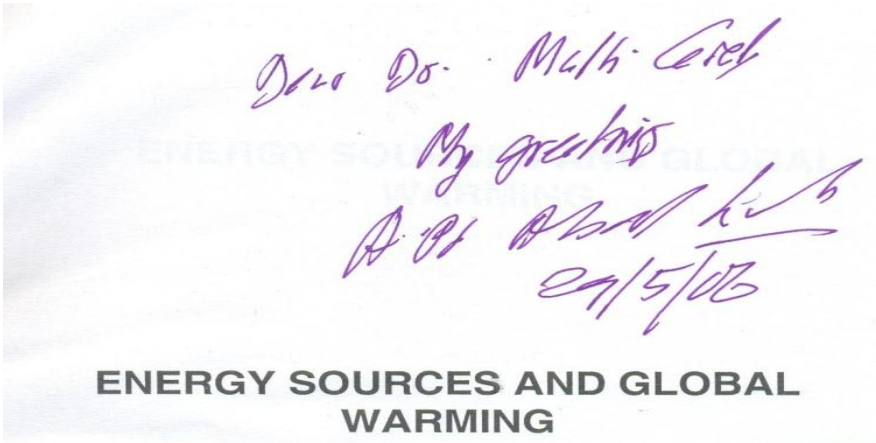
An Assessment of CO_2 Reduction Potential from Carbon Capture v/s Renewable Energy Targets in India

ACBCCU-2018

Awareness and Capacity Building in Carbon Capture and Utilization

India International Centre , 29th August to 1st September 2018


Global Warming

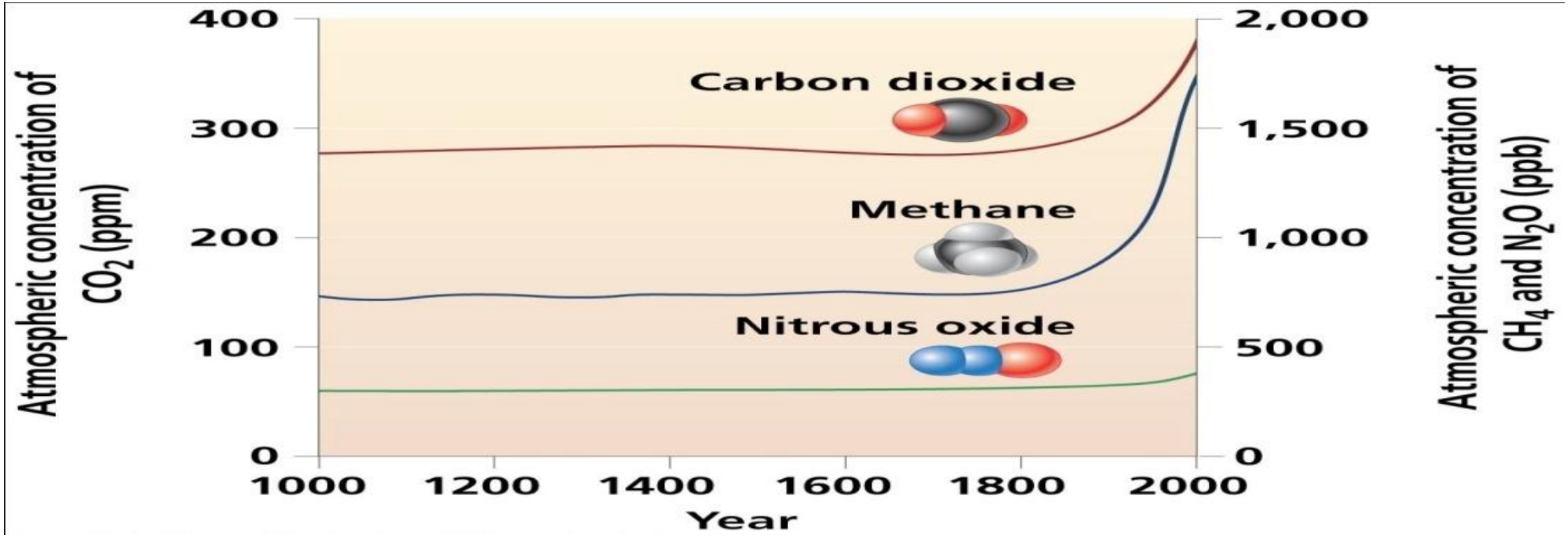

ENERGY SOURCES AND GLOBAL
WARMING

Introduction

- Current population of India is more than 1.22 billion and increasing at annual rate of 1.58 %, accounts 17.31% of world population
- 70% of GHG emissions are related to electricity generation and remaining from Industry and Agriculture Sectors

A. Key Country Indicators			
	Global Rank	**Global share**	
CO_2 emissions from fuel combustion[1] (2012)	3	6.16%	1954 Mt CO_2 Eq.
Population[2] (2013)	2	17.58%	1252.14 Million
CO_2 emissions / Pop.[1] (2012)	99		1.58 tCO_2 per capita
GDP Size[2] (2013)	3	6.65%	Based on PPP
GDP Size[2] (2013)	10	2.51%	Based on exchange rates
UNDP human development index[3] (2012)	136		
GDP Structure[2], % (2013)	Agriculture: 18, Industry: 25, Services: 57		
Share of GDP[2], % (2013)	Imports: 28, Exports: 25		

Greenhouse gases in the Atmosphere are increasing



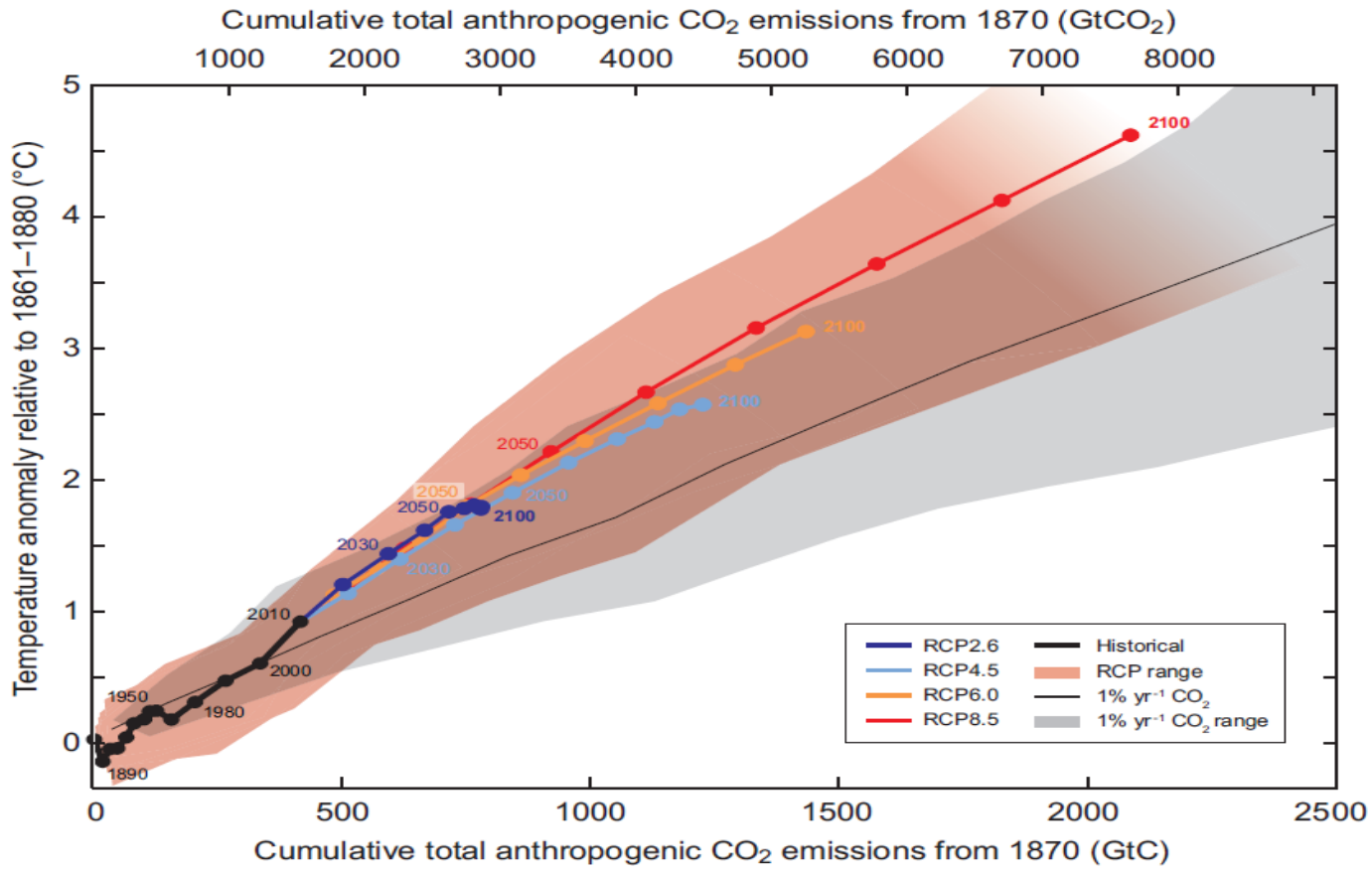
Carbon Dioxide

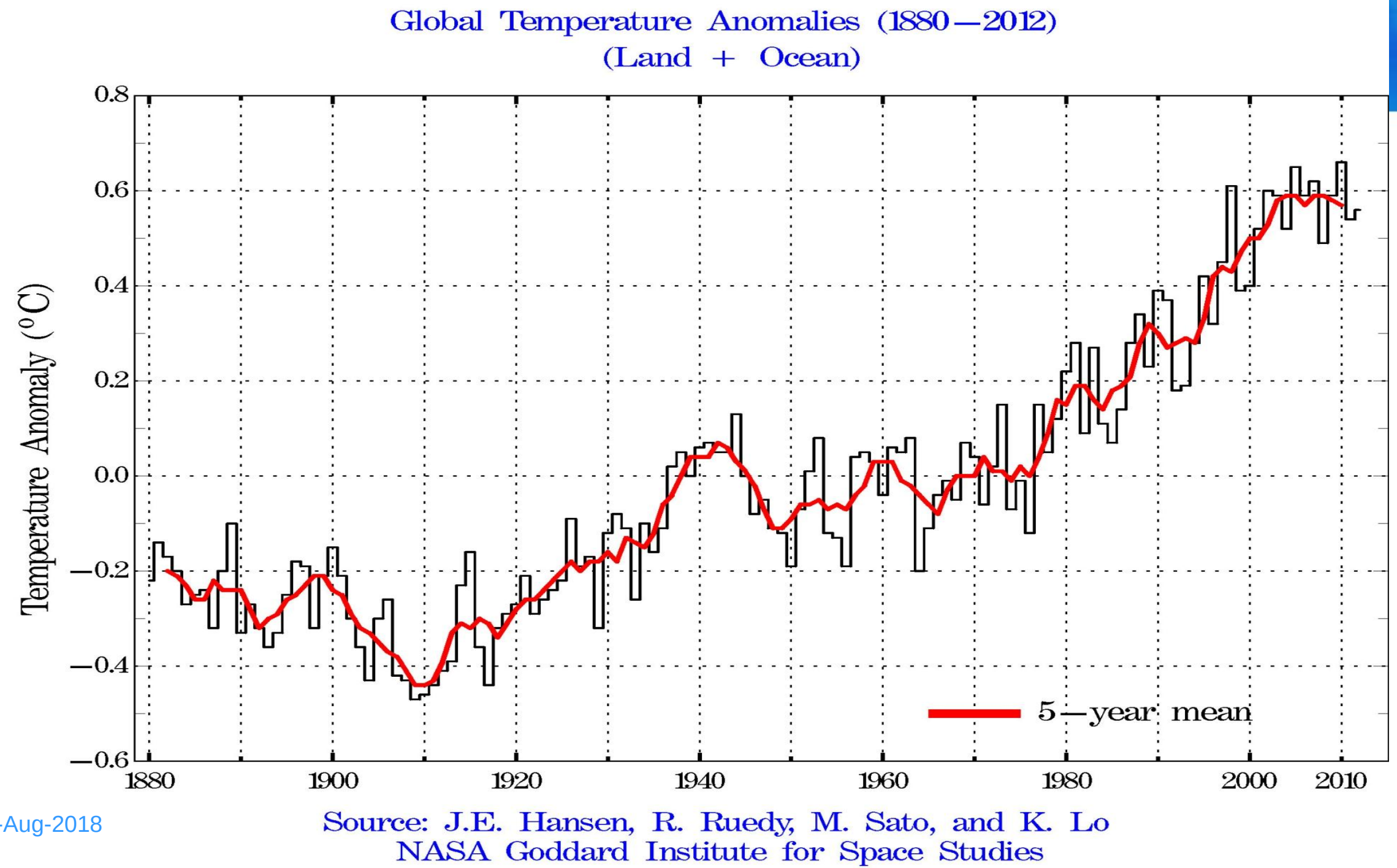
- **Burning of fossil fuels**: Combustion of carbon-rich fuels from the ground where they have been stored for millions of years, sending CO_2 into the atmosphere.

- CO_2 is the principal anthropogenic greenhouse gas (~ 60%) responsible for global warming

- It is the reference gas against which other greenhouse gases are measured; therefore, it has a global warming potential of 1

Increasing CO_2




Global Temperature Anomalies (1880—2012)
(Land + Ocean)
Temperature Anomaly (°C)
0.8
0.6
0.4
0.2
0.0
−0.2
−0.4
−0.6
1880
1900
1920
1940
1960
1980
2000
2010
5—year mean
Source: J.E. Hansen, R. Ruedy, M. Sato, and K. Lo
NASA Goddard Institute for Space Studies

Current and Future emissions

- Existing coal-fired power plants are emitting about 2 billion tons of CO_2 per year
- CO_2 concentration has increased 33% in the past 200 years.
- It is now at its highest level in 400,000 years, and is Close to 400 ppm
- Global CO_2. emissions may range from 29 to 44 $GtCO_2$ (8–12 GtC) per year in 2020
- 23 to 84 $GtCO_2$ (6–23 GtC) per year in 2050

International Initiatives

- In 1988 World Meteorological Organization and the United Nations Environment Programme established, the Intergovernmental Panel on Climate Change (IPCC)
- The **role** of the **IPCC** is to provide summary of model predictions to policy makers as basic scientific, technical and socio-economic information relevant to understanding the risk of human-induced climate change, its potential impacts and options for adaptation and mitigation.
- The IPCC does not conduct any research nor does it monitor climate related data or parameters to assess the latest scientific and technical information about global warming

Climate Change and International Protocols

- **Predictions of Climate Change and Its Impacts**

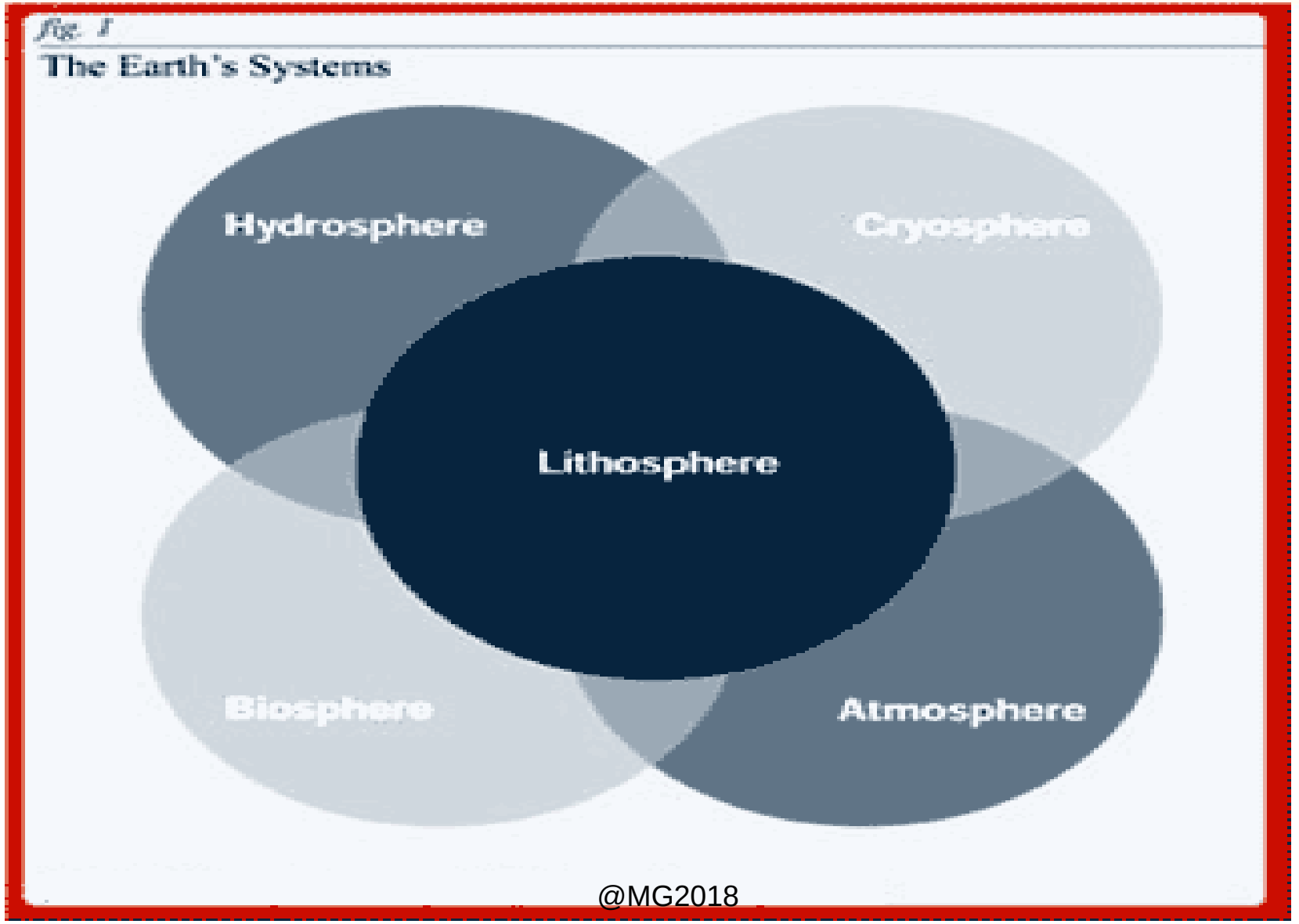
  General Circulation Model (GCM), is developed as a set of equations of motion for the fluid, equations for conservation of energy (including radiative transfer), mass and water vapour

- **Climate Change Actions & Global Binding Treatise**
  - Montreal Protocol
  - Kyoto Protocol
  - Convention on Biodiversity
  - Paris Agreement

Carbon Cycle

- The ***Carbon Cycle***. Carbon dioxide is present in living and non living as a part of the ocean, air, and even rocks.
- The ***carbon cycle*** is the circulation and transformation of ***carbon dioxide*** back and forth between living things and the environment.
- It is the biogeochemical ***cycle*** by which ***carbon*** is exchanged among the biosphere, lithosphere, geosphere, hydrosphere, and atmosphere of the Earth.

Earth System of five Major Interactive Spaces



Lithosphere and Hydrosphere

Lithosphere

- Lithosphere is hard solid land mass on earth, comprising of Crust. Mantle, Core
- Soil degradation, land use changes and water shortages, are some of the concerns in Lithosphere

Hydrosphere

- Hydrosphere is water sphere on the earth, which constantly interacts with atmosphere and biosphere
- It comprises of Runoffs, Lakes, Ponds, Rivers and other water bodies, ground water and Sea water.
- Hydrological cycle play very important role in the environment. Evaporation – leads to cloud formation and rainfall. Transpiration – the water released from plant/ trees and Evapotranspiration – when transpired water evaporates, are very important elements of hydrological cycle

Biosphere and Cryosphere

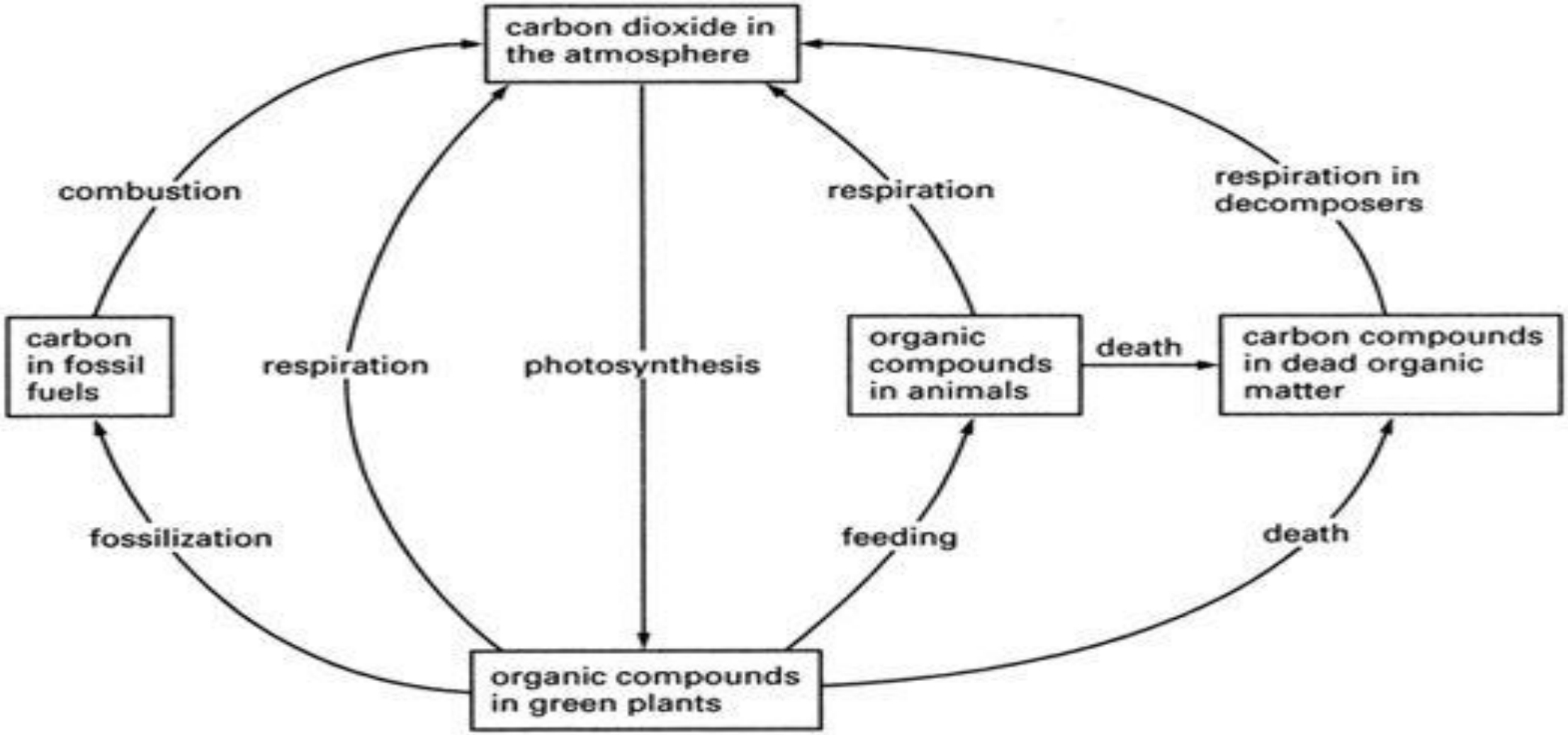
Biosphere

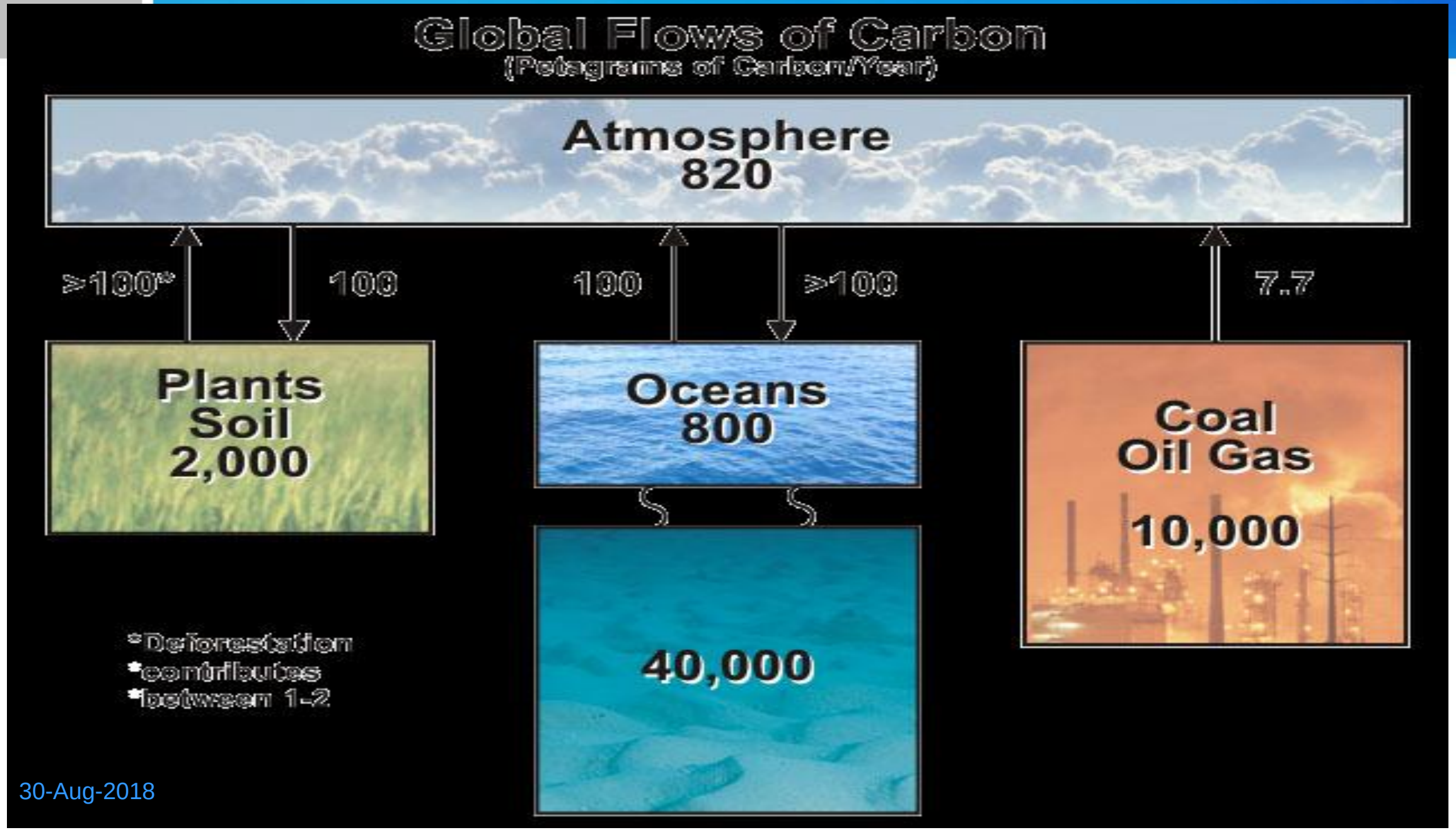
- Biosphere covers all living organisms on earth, macro and micro including plants and vegetation
- Life on earth exists and extends from 6000m above the sea level and 10,000m below the sea level in the sea
- Mutual exchange of energy from plants and atmospheric constituents constantly takes place in the biosphere

Cryosphere

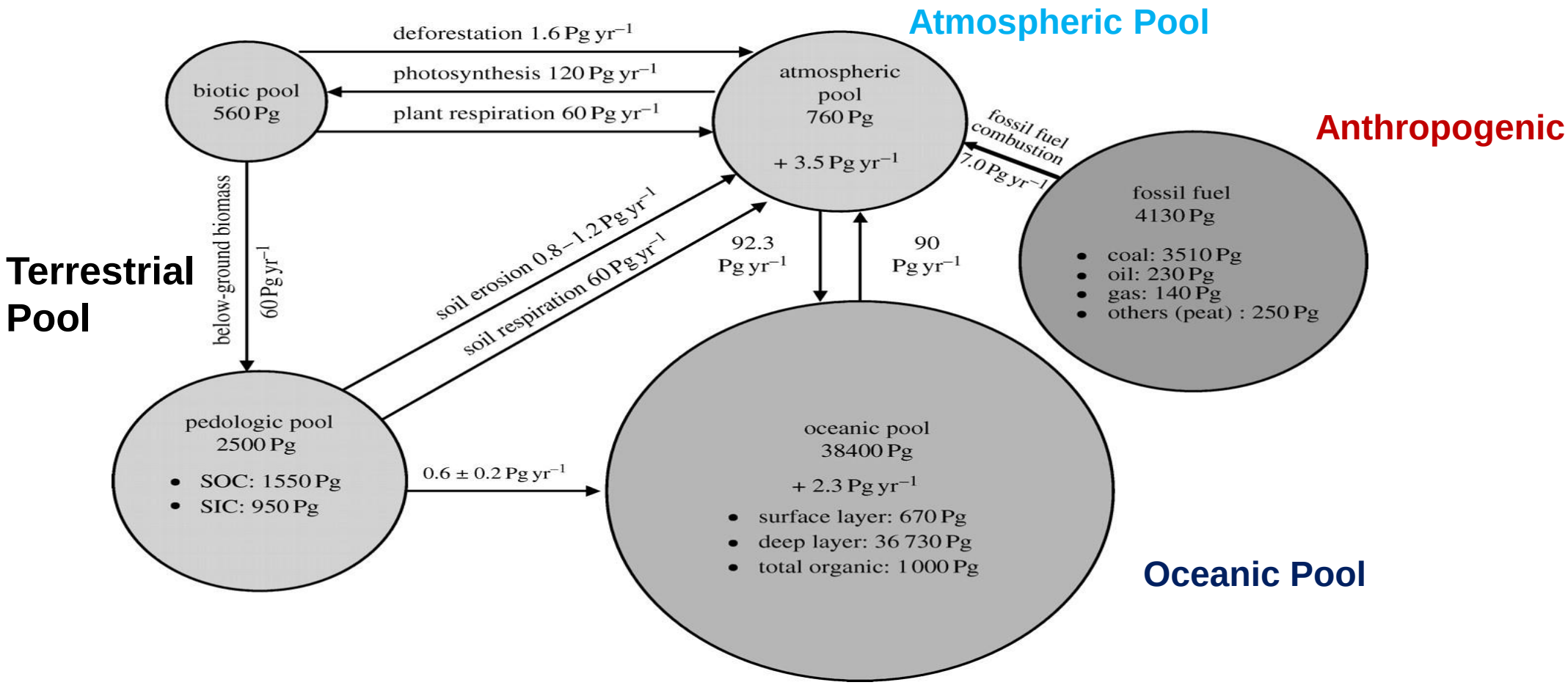
- Cryosphere is that portions of the Earth surface where water is in solid form, including sea ice, glaciers, polar caps.
- It forms essential linkages with atmosphere, river flows and ocean circulations

Carbon Cycle Exchanges in Atmosphere



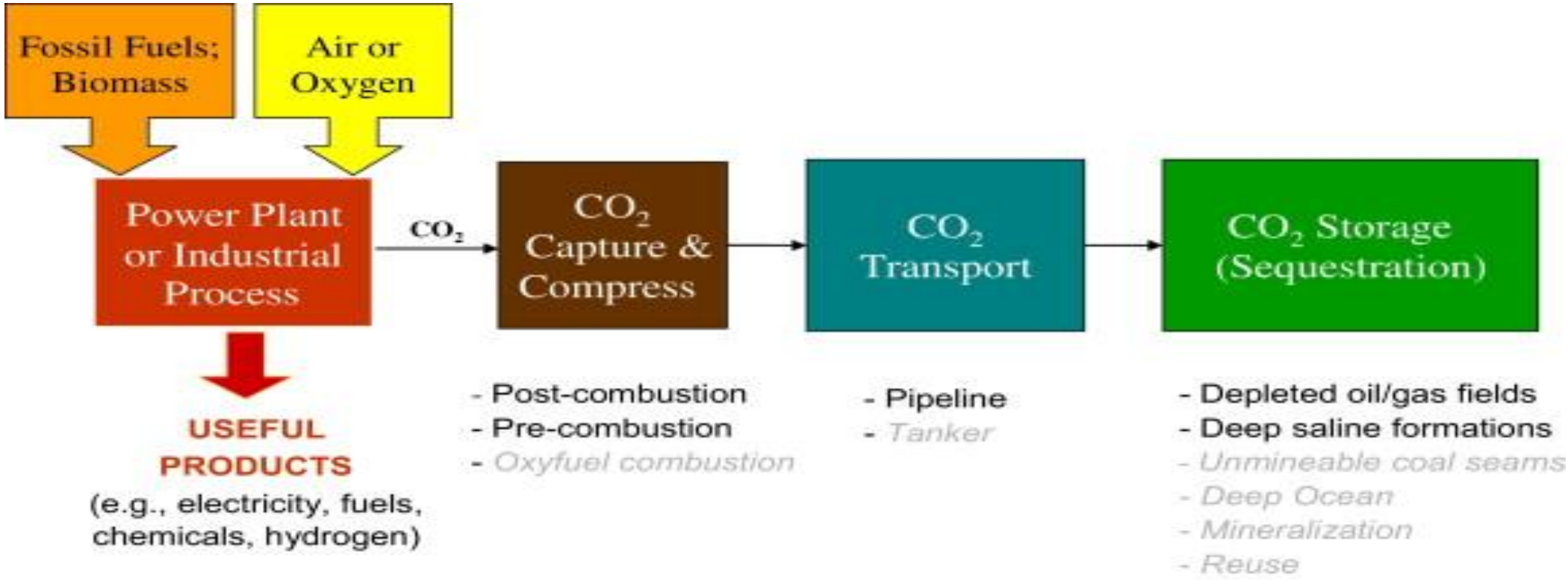

Global Flows of Carbon
(Petagrams of Carbon/Year)
Atmosphere
820
>100*
100
100
>100
7.7
Plants
Soil
2,000
Oceans
800
40,000
Coal
Oil Gas
10,000
*Deforestation
*contributes
*between 1-2

Perturbations



Rattan Lal Phil. Trans. R. Soc. B 2008;363:815-830

Carbon Sequestration



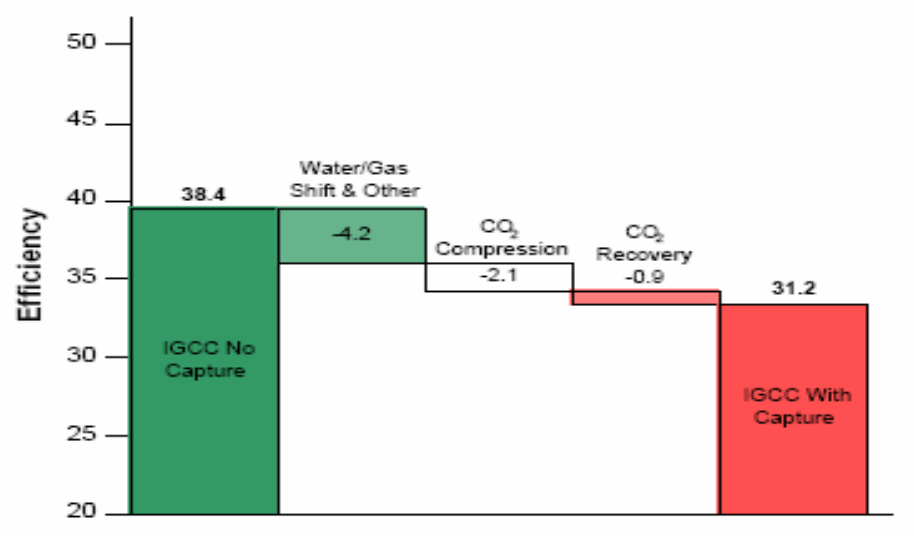
Capture of carbon dioxide

- Chemical absorption
- Physical adsorption
- Pressure swing adsorption
- Temperature swing adsorption
- Cryogenic distillation

CO2 Capture Challenges

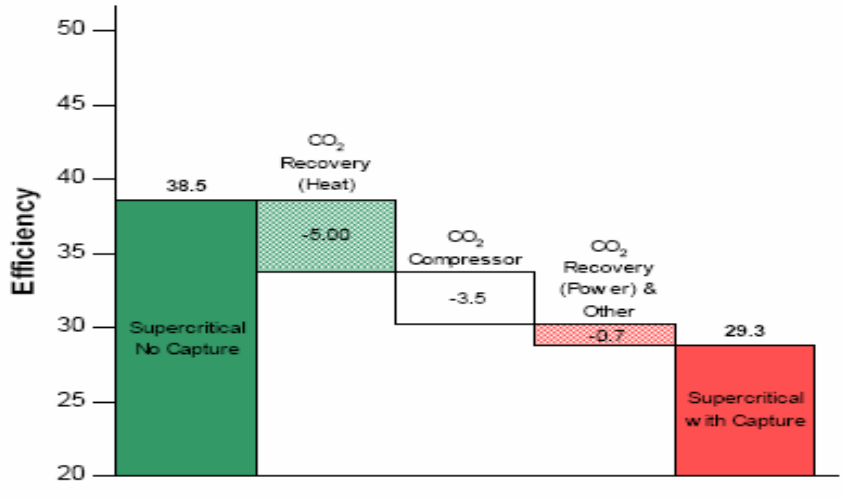
High energy penalty – High cost – Scaling up

PRE-COMBUSTION



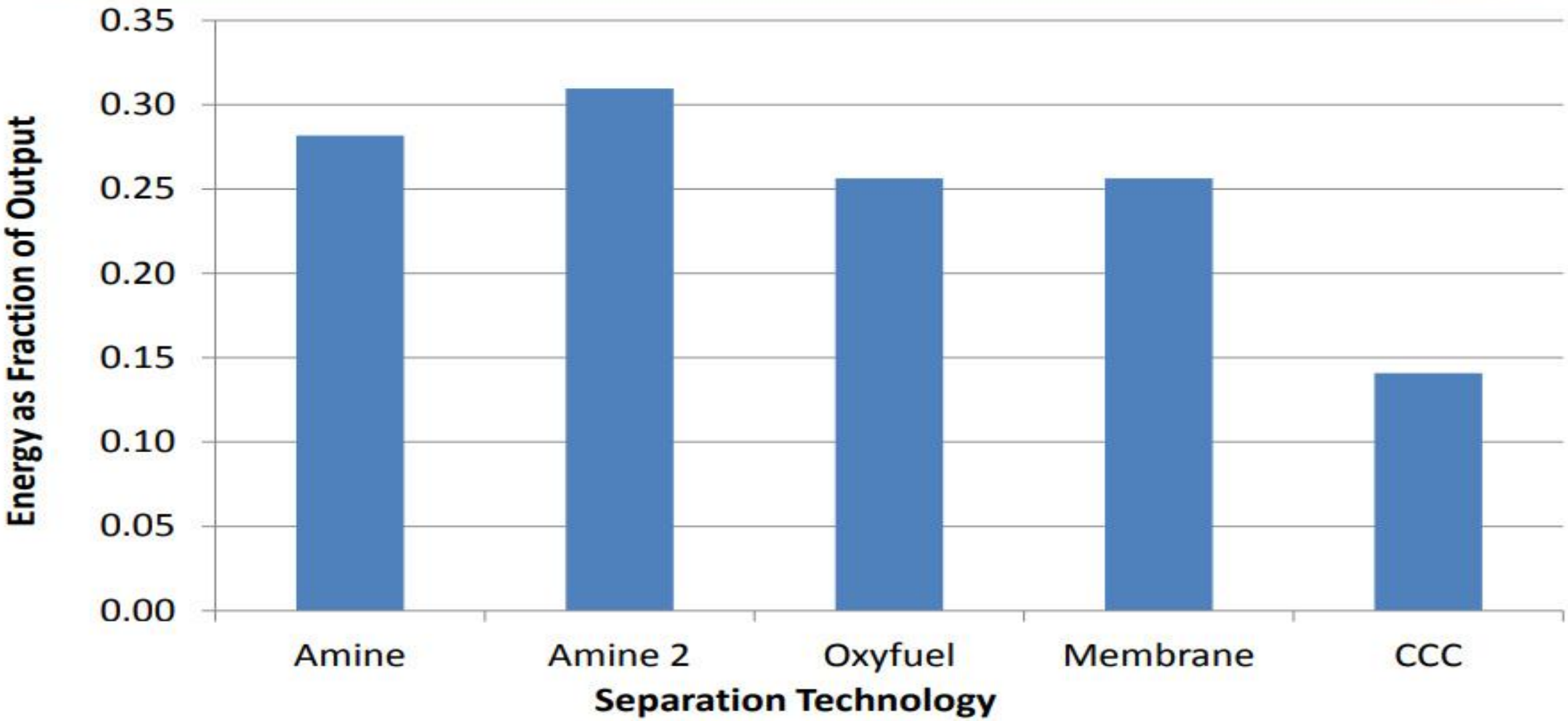
Net efficiency penalty 7.2 %

POST COMBUSTION



Net efficiency penalty 9.3 %

CCS Energy Demand



Carbon Storage and Utilization Options

- Non Biotic Engineered systems
- Biotic- Photosynthesis-Plants -Algae

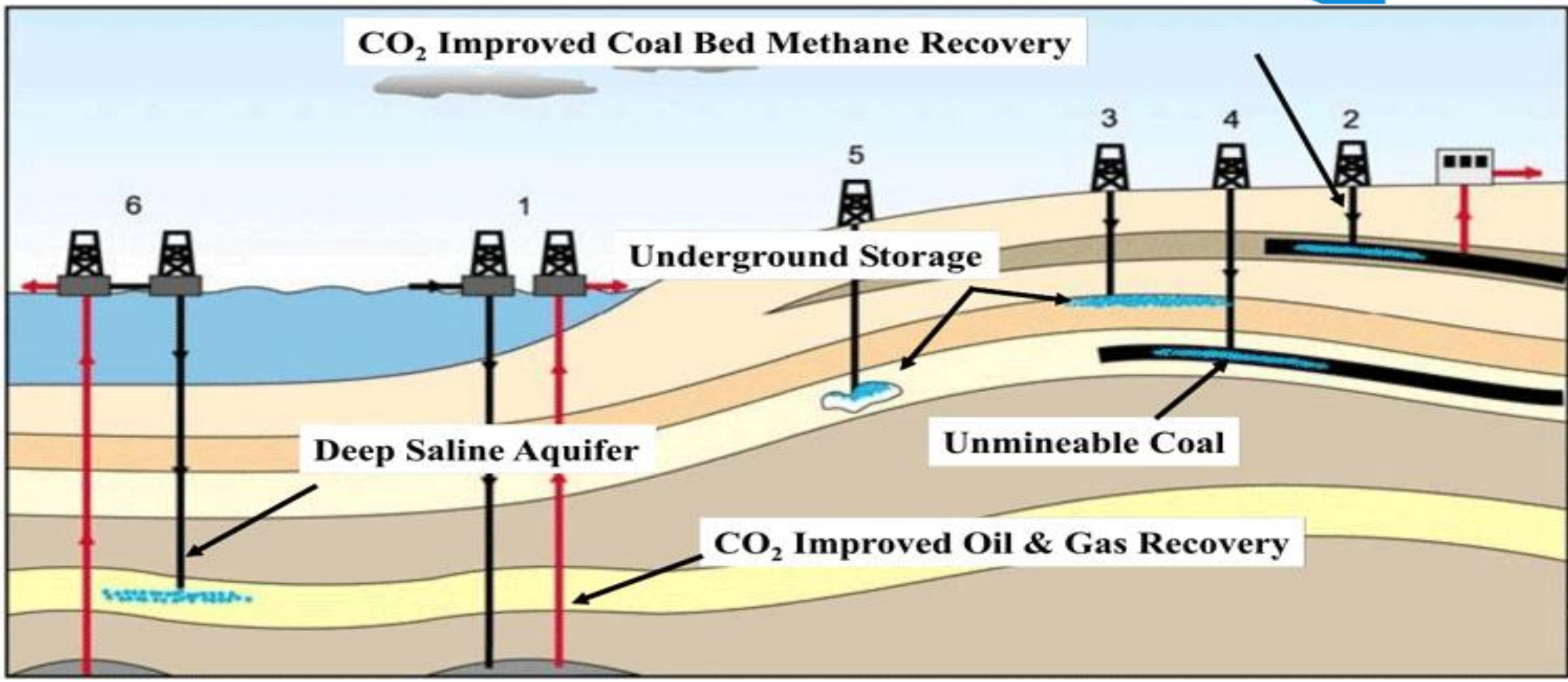
Non Biotic or Engineering Processes

- **Carbon Capture and Storage**
- **Underground Injection**
- **Enhanced Oil Recovery**
- **Oceanic Storage**

Geological Injection of Captured CO2

- Saline aquifers located below fresh water reservoirs separated by a permeable layer are porous sediments filled with water.
- CO2 is sequestered hydro-dynamically and by reacting with other dissolved salt to form carbonates.
- It form gas like phase and also aqueous phase in dissolve from, creating multi-component environment
- CO2 injection in oil & gas fields to extract more oils
- CO2 can be injected into unmineable coal seams where it is absorbed to produce methane

Engineering Storage Options



Challenges in Engineering Processes

- Capturing of CO2 from flue gases is expensive
- Technology of deep injection over land and in oceans is developing
- It is expensive & Energy Intensive
- Risk of leakage & safety
- Need to be monitored for a long time
- Measurement & monitoring guidelines are needed

Carbon Dioxide Removal – Biotic Processes

- Terrestrial Sequestration
- Carbonate Formation
- Ocean Fertilization
- Biofuels Production

Biotic (Terrestrial) Processes

CO2 Fertilization

- Enhanced Photosynthesis by increased atmospheric *carbon dioxide* concentration in plants that produce a three-carbon compound (C3)—including most trees and agricultural crops like rice, wheat, soybeans, potatoes, and vegetables
- Show a larger response than in plants that produce a four-carbon compound (C4) including grasses and the agriculturally important crops maize, sugar cane, millet, and sorghum.

Biotic (Oceanic) Processes

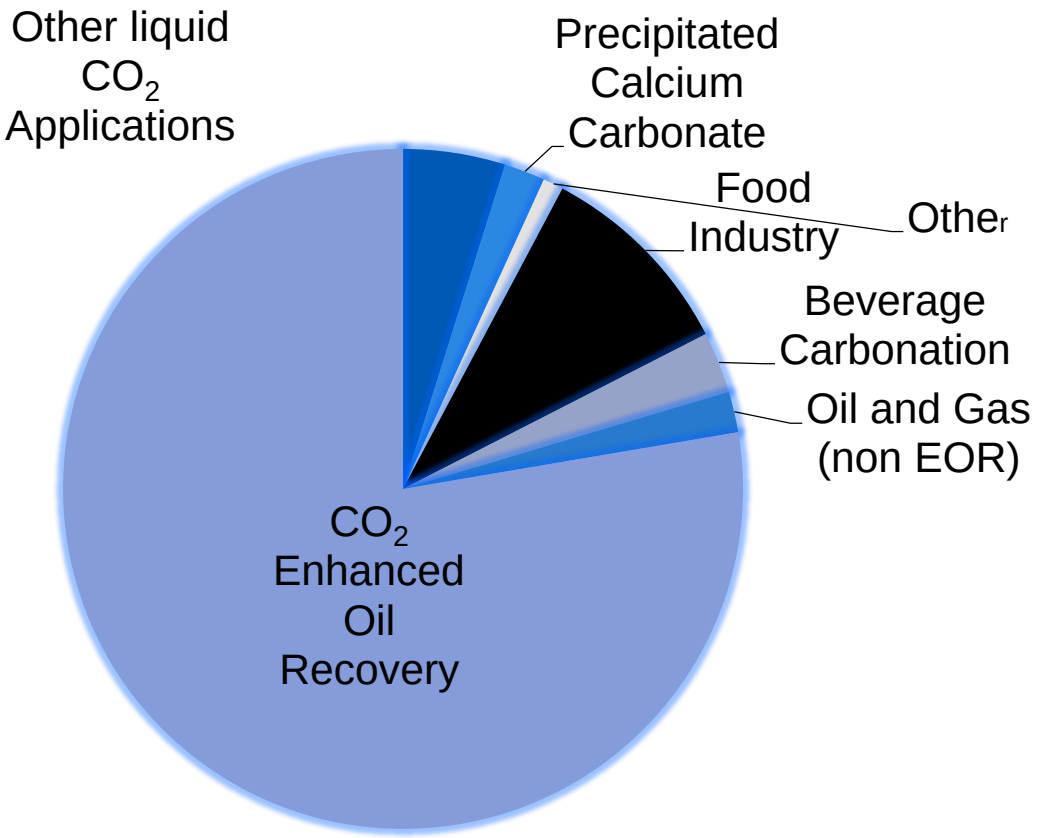
Seaweed Production

- Seaweed production holds great promise not only in acting as a significant sink, but also in meeting to some extent global food, fodder, fuel and pharmaceutical requirements.
- A number of Biological products can be derived from them, such as agars, alginates, have and will continue to have diverse applications in the food, chemical, pharmaceutical and other industries.
- Ocean Fertilization by Iron Filling Phytoplanktoon Generation

Benefits in Biotic Processes

- Improved quality of soil & water conservation
- Decreased nutrients loss
- Cost effectiveness
- A number of chemicals and biofuels can be produced

Carbon Utilization Options



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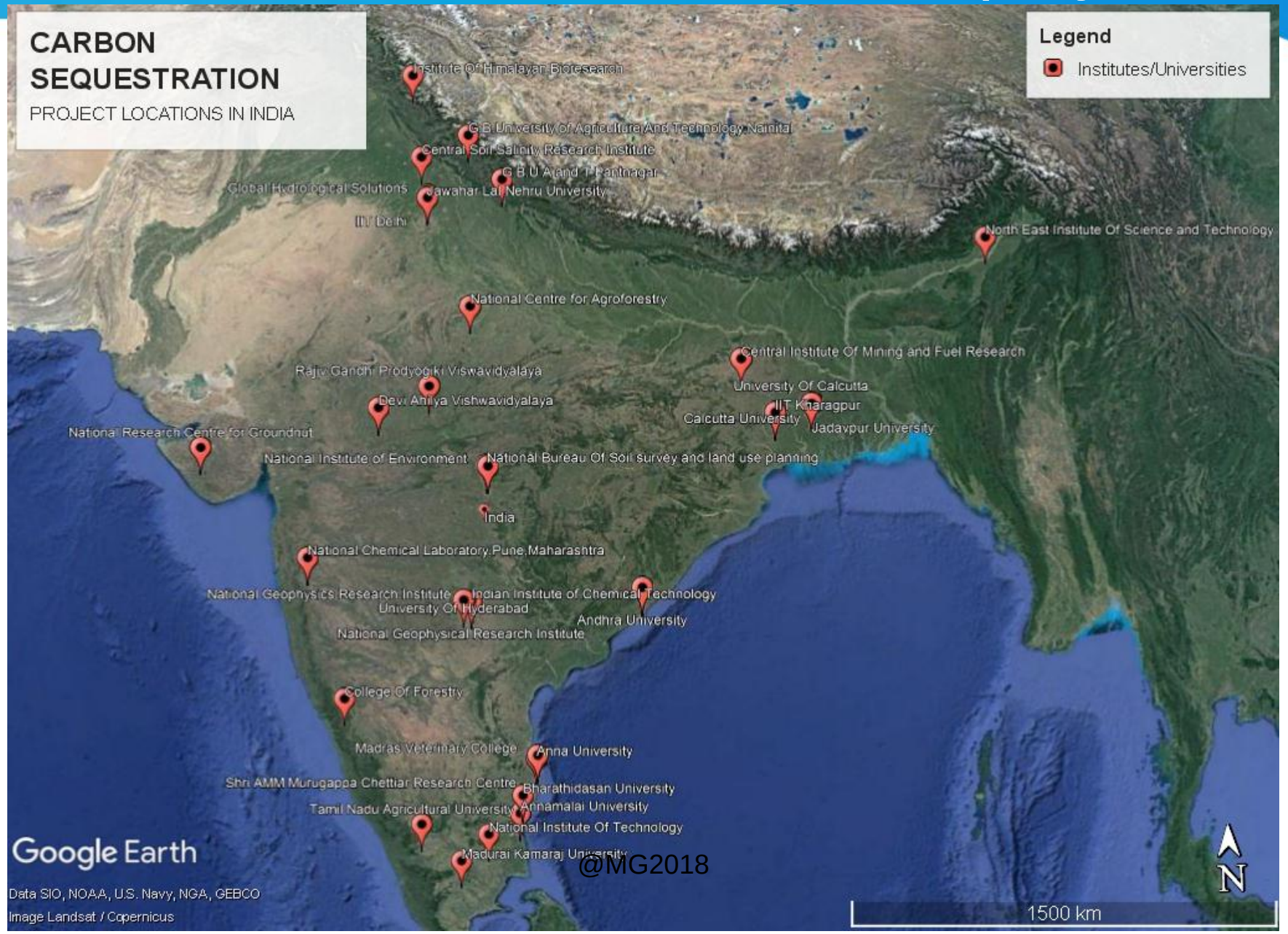
- Mitigation of Climate Change
- Energy transition
- Increasing innovation capacity
- Technology maturity
- Broad Application Range
- Increase in Raw material base

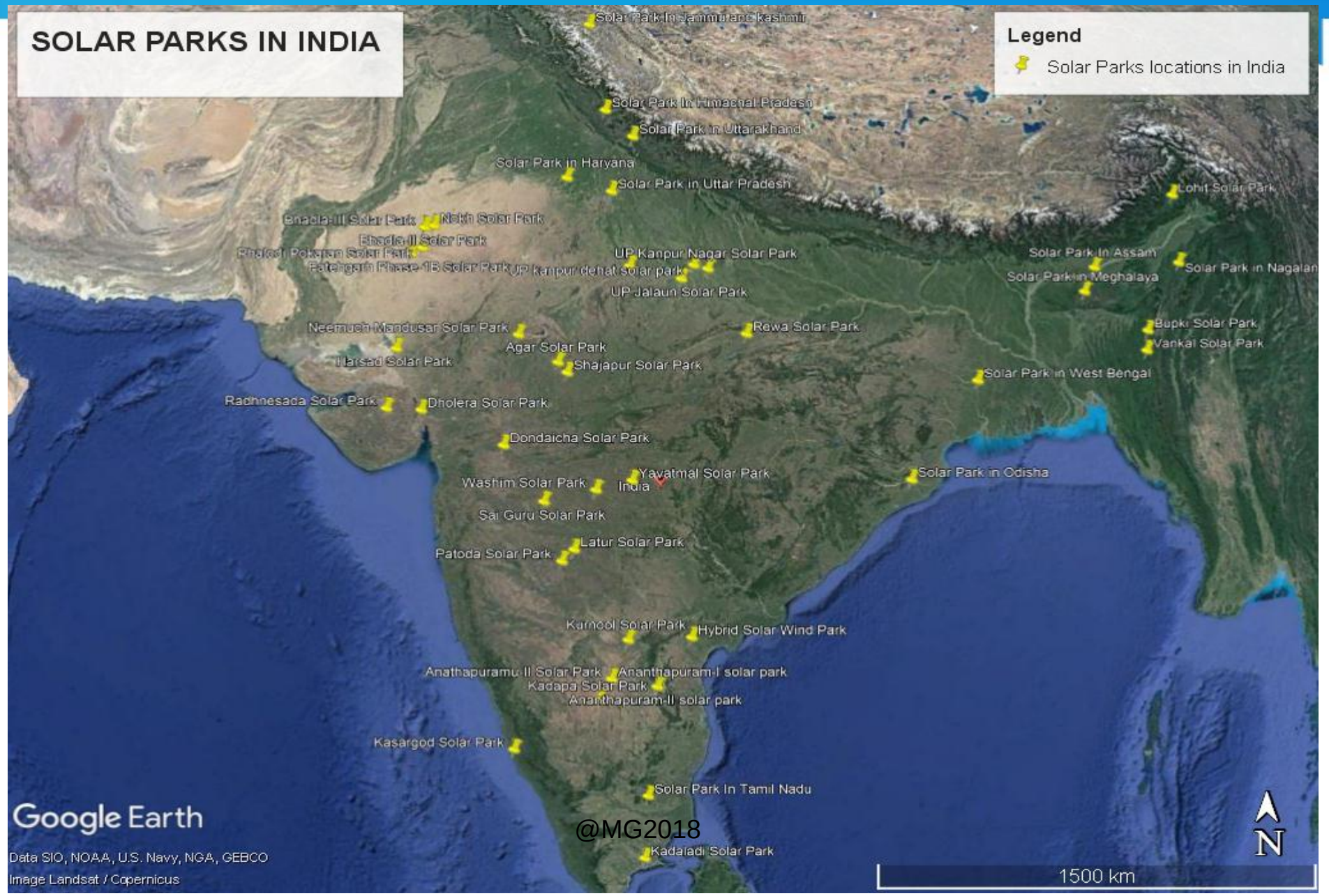
Intensification of R&D projects in India



Free Air Carbon dioxide enrichment (FACE) facility aseembled in the campus of Jawaharlal Nehru University in a DST sponsored project by Professor B. C. Tripathy. Mustard (Brassica) plants are grown inside two FACE Rings maintained at elevated CO_2 (600 ppm)

Renewable Energy Growth In India

- India is fast becoming world's second most attractive market for renewable energy investments
- Jawaharlal Nehru National Solar Mission(2010)
- Renewable Purchase Obligation(2011)
- Renewable Energy Certificates (2011)
- New Targets to achieve 175 GW by 2022 (2014)

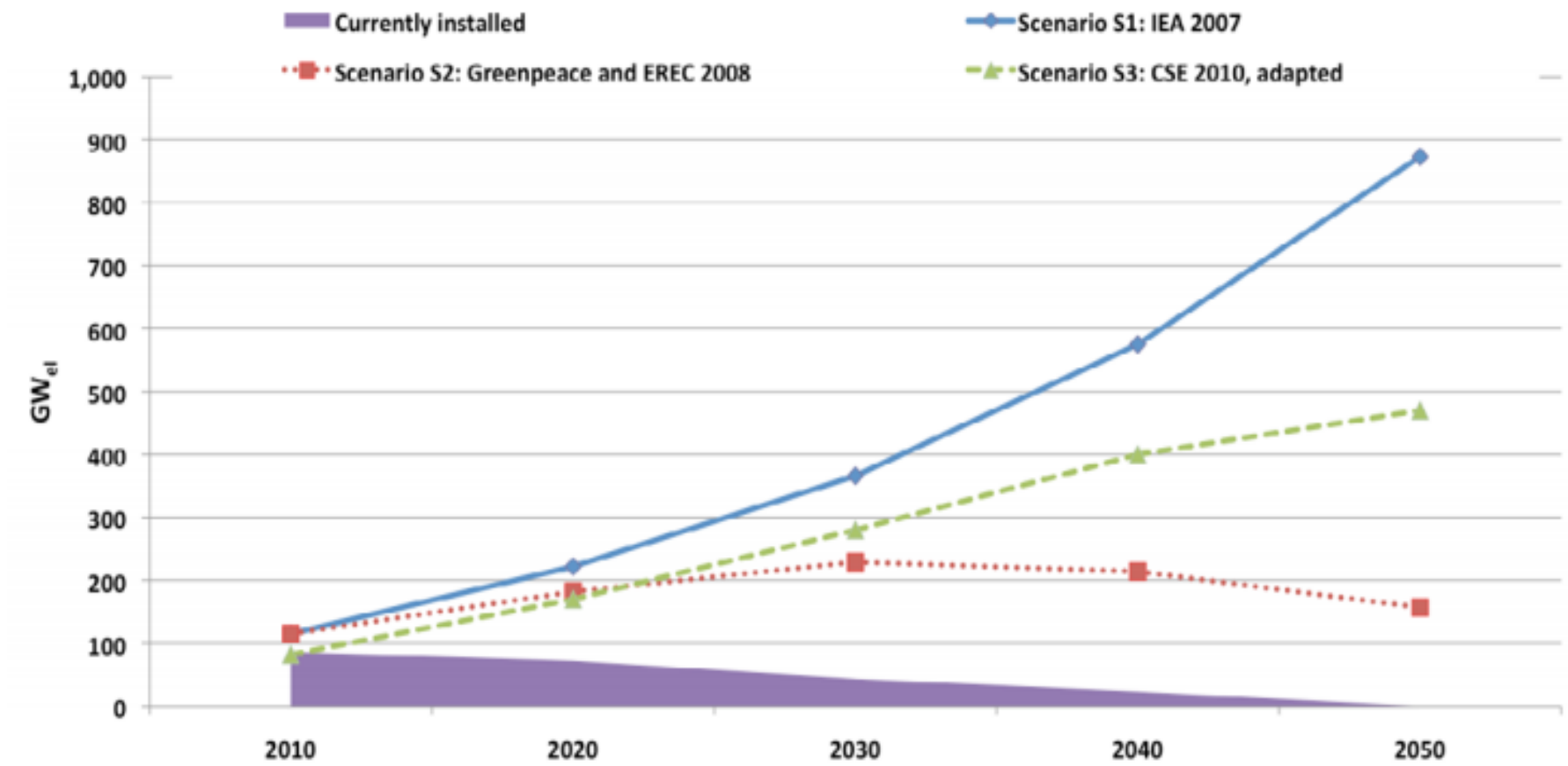

SOLAR PARKS IN INDIA
Legend
Solar Parks locations in India
Solar Park In Jammu and Kashmir
Solar Park In Himachal Pradesh
Solar Park in Uttarakhand
Solar Park in Haryana
Solar Park in Uttar Pradesh
Lohit Solar Park
Bhadla-III Solar Park
Nokh Solar Park
Bhadla-II Solar Park
Phalodi Pokaran Solar Park
Fatehgarh Phase-1B Solar Park
UP Kanpur Nagar Solar Park
UP Kanpur dehat Solar park
UP Jalaun Solar Park
Solar Park in Assam
Solar Park in Meghalaya
Solar Park in Nagalan
Neemuch Mandusar Solar Park
Rewa Solar Park
Agar Solar Park
Banaskantha Solar Park
Shajapur Solar Park
Bapki Solar Park
Vankal Solar Park
Solar Park in West Bengal
Radhnesada Solar Park
Dholera Solar Park
Dondaicha Solar Park
Yavatmal Solar Park
Washim Solar Park
India
Solar Park in Odisha
Sai Guru Solar Park
Latur Solar Park
Patoda Solar Park
Karnool Solar Park
Hybrid Solar Wind Park
Anathapuramu-II Solar Park
Ananthapuram-I solar park
Kadapa Solar Park
Ananthapuram-II solar park
Kasargod Solar Park
Solar Park In Tamil Nadu
Kadaladi Solar Park
Google Earth
Data SIO, NOAA, U.S. Navy, NGA, GEBCO
Image Landsat / Copernicus
1500 km
N

Renewable Energy Growth and CO2 Mitigation Potential

Year	Installed capacity (MW)	Installed capacity (TWh)	Baseline CO_2 (kg/kWh)	Mitigation potential million tonnes of CO_2
1992	32	0.28032	0.86	0.27
1997	902	7.90152	0.86	7.49
2002	1658	14.52408	0.86	13.77
2007	7761	67.98636	0.86	64.45
2012	24,503	214.6463	0.86	203.48
2017	54,503[a]	477.4463	0.86	452.61[a]

[a] Targeted mitigation potential.

Assessment of CO2 Reduction Potential



Coal fuelled power plant capacity, currently installed and envisaged according to three long-term energy scenarios (own illustration)

Source: *Peter Viebhan,Samuel Holler,Daniel Vallentin, Holger Liptow,Andreas Villar, Future CCS Implementation in India: a systematic and long term analysis,Energy Procedia 4(2011)2708-2715*

CCSU International

- International Energy Agency future outlook study has predicted that CCS may have a share up to 17% by 2050 in reduction of concentrations.
- According to Global CCS Institute 85 CCS demonstrations are currently in pipeline.
- CCU technologies are being demonstrated as promising business models.
- Mission Innovation has 23 Countries as its members with India as a partner country.
- Worldwide number of programmes have been held supported by World Bank, ADB and other multi-lateral organizations

ACBCCS Workshops

- Awareness and Capacity Building in Carbon Capture and Storage – 27-31 July 2009
- Awareness and Capacity Building in Carbon Capture and Storage: Earth Processes – 15-19 Jan 2013
- Awareness and Capacity Building in Carbon Capture, Storage and Utilization: Towards a low Carbon Growth Strategy – 27-31 July 2015.

Massive Capacity Building efforts needs to be taken for the encouragement of massive scale-up of renewable technology

Thank You

A presentation by Dr. (Mrs.) Malti Goel
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