Greenhouse Gases Emission

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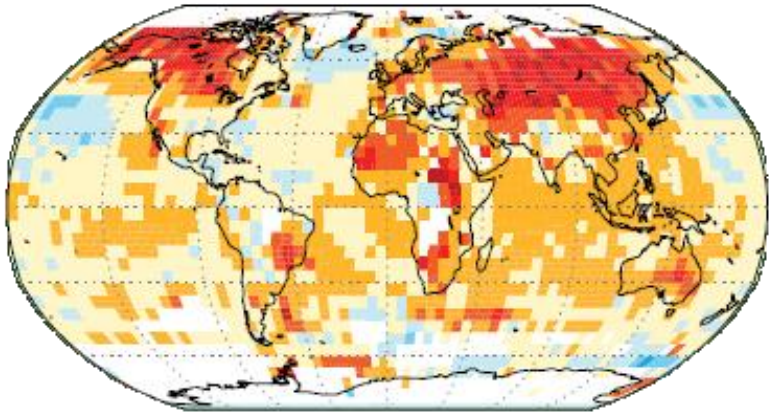
Global Warming

- Earth's surface temperature has risen by about 1 degree in the past century, with accelerated warming during the past two decades.
- There is stronger evidence that most of the warming over the last 50 years is attributable to human activities.
- Human activities have altered the chemical composition of the atmosphere through the buildup of greenhouse gases – primarily carbon dioxide, methane, and nitrous oxide. The heat-trapping property of these gases is undisputed

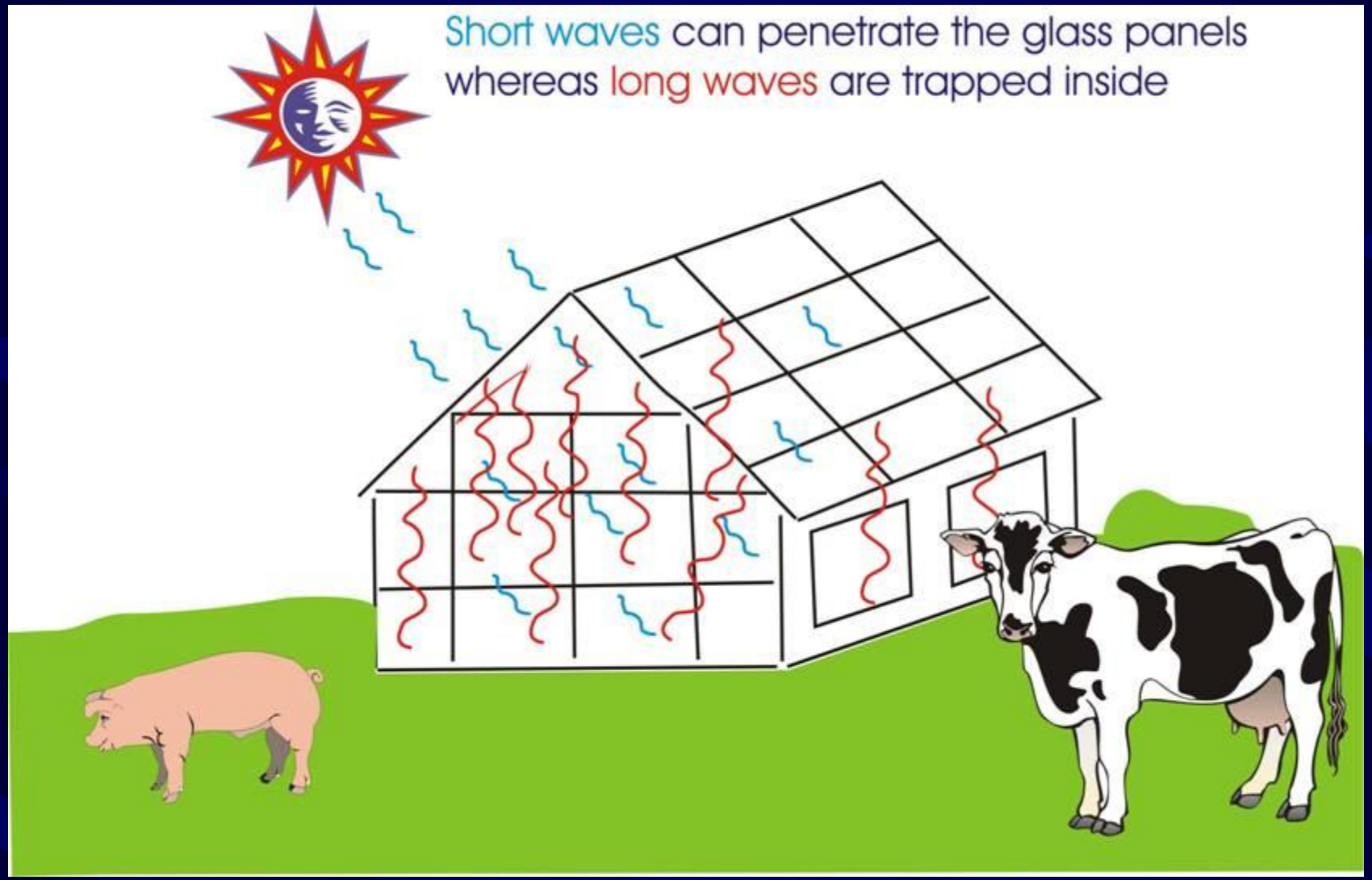
The Climate is Changing

- Temperatures are rising
- Sea levels are rising
- The ocean is acidifying
- Climate change is reflected in water cycle changes and in extreme weather

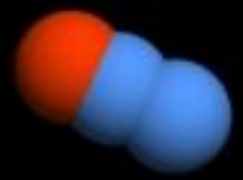


Temperature rise, indicated by color (red=higher rate of increase). Earth's surface temperature has risen ~1.3˚ F since 1850.

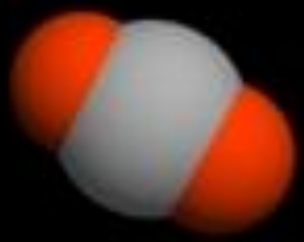
The real greenhouse



Greenhouse gases



Nitrous oxide



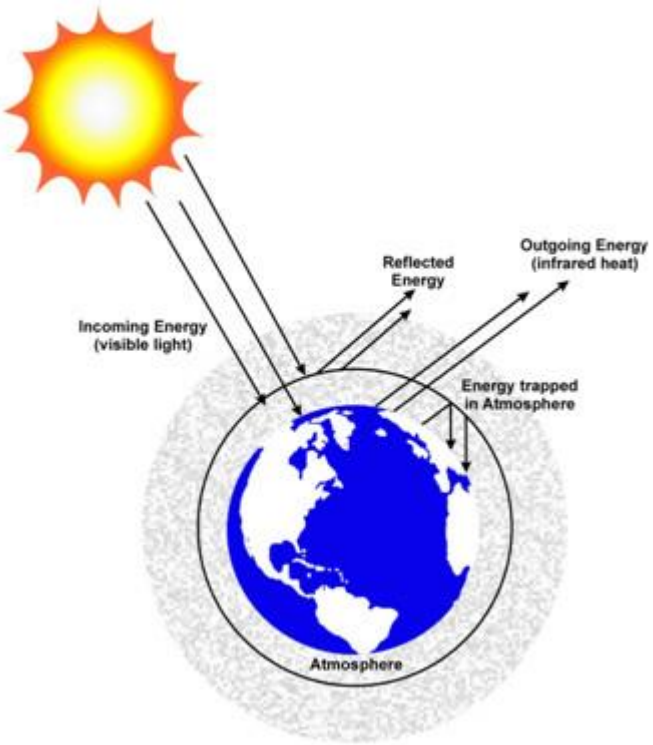
Carbon dioxide

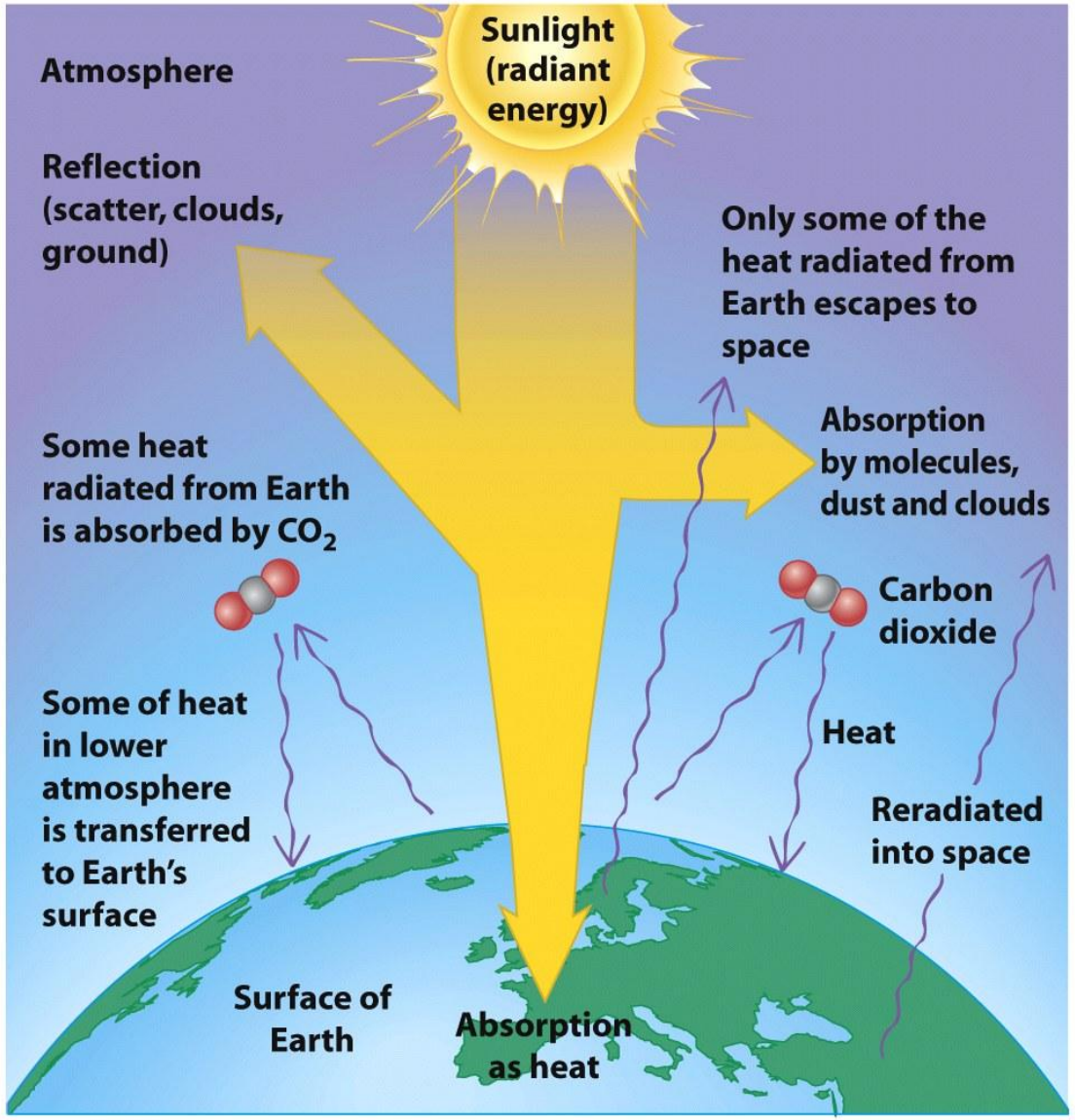
Methane

Water

Sulfur hexafluoride

GREENHOUSE EFFECT



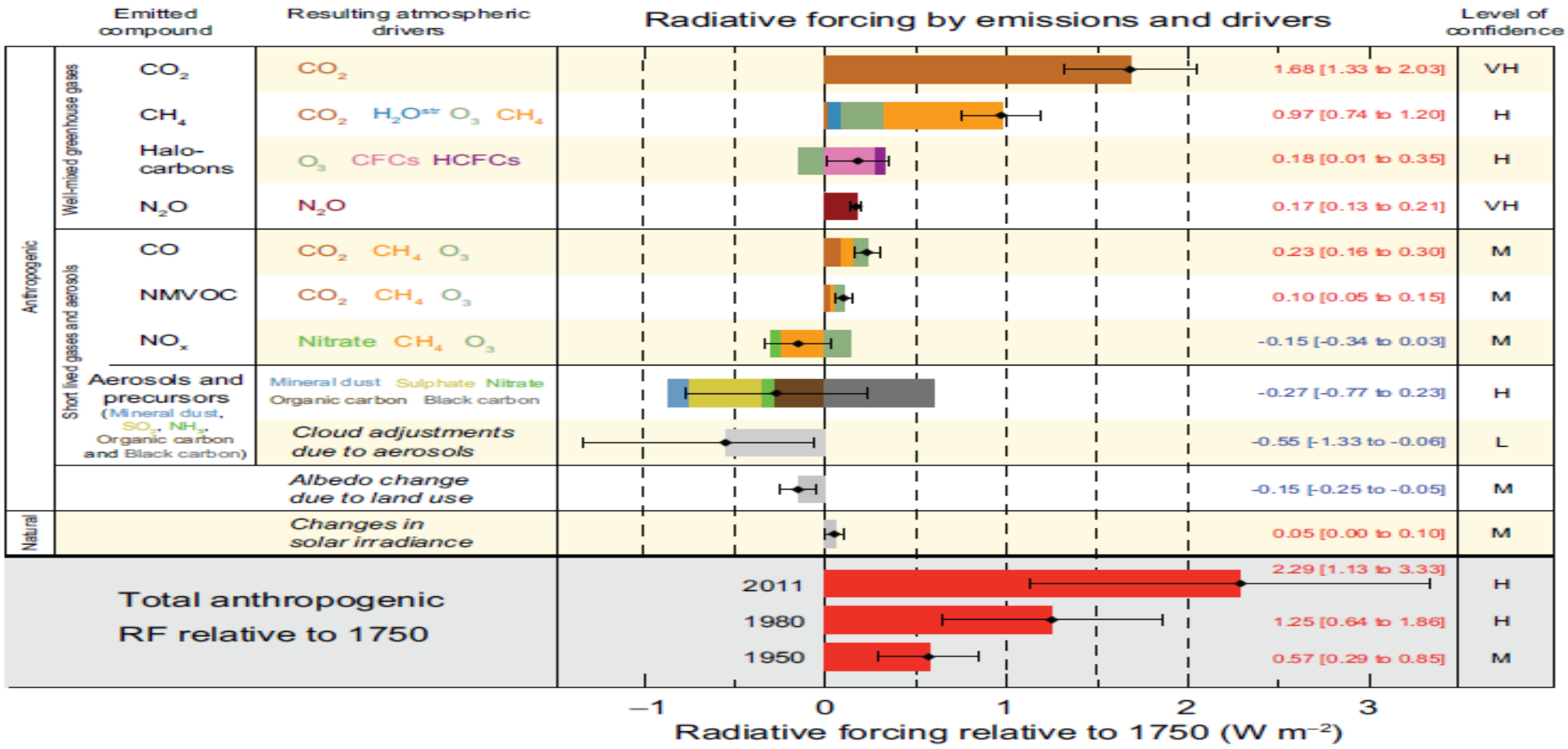


SOURCES

Major sectors in India-

- Energy
- Industry
- Agriculture
- Land use change
- Waste

BEST ESTIMATE OF GLOBAL RADIATIVE FORCING

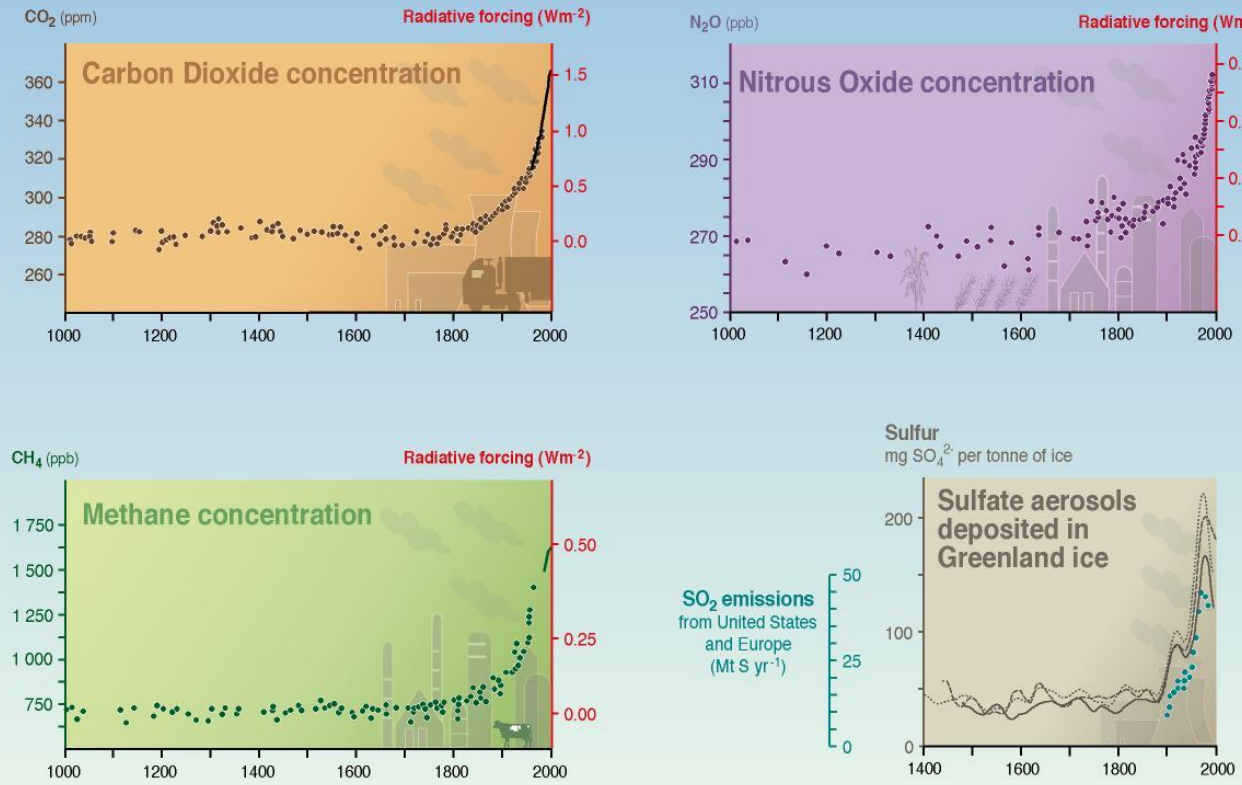


Radiative forcing at an average rate of 1.6 $W \cdot m^{-2}$ would imply that the earth is gaining energy at a rate 57 times greater than the rate associated with total global commercial consumption of energy !

Global warming potential (GWP) values relative to CO_2

Industrial designation or common name	Chemical formula	GWP values for 100-year time horizon		
		Second Assessment Report (SAR)	Fourth Assessment Report (AR4)	Fifth Assessment Report (AR5)
Carbon dioxide	CO_2	1	1	1
Methane	CH_4	21	25	28
Nitrous oxide	N_2O	310	298	265
Substances controlled by the Montreal Protocol				
CFC-11	CCl_3F	3,800	4,750	4,660
CFC-12	CCl_2F_2	8,100	10,900	10,200
CFC-13	$CClF_3$		14,400	13,900
CFC-113	CCl_2FCClF_2	4,800	6,130	5,820
CFC-114	$CClF_2CClF_2$		10,000	8,590
CFC-115	$CClF_2CF_3$		7,370	7,670
Halon-1301	$CBrF_3$	5,400	7,140	6,290
Halon-1211	$CBrClF_2$		1,890	1,750
Halon-2402	$CBrF_2CBrF_2$		1,640	1,470
Carbon tetrachloride	CCl_4	1,400	1,400	1,730
Methyl bromide	CH_3Br		5	2
Methyl chloroform	CH_3CCl_3	100	146	160

Indicators of the human influence on the atmosphere during the Industrial era

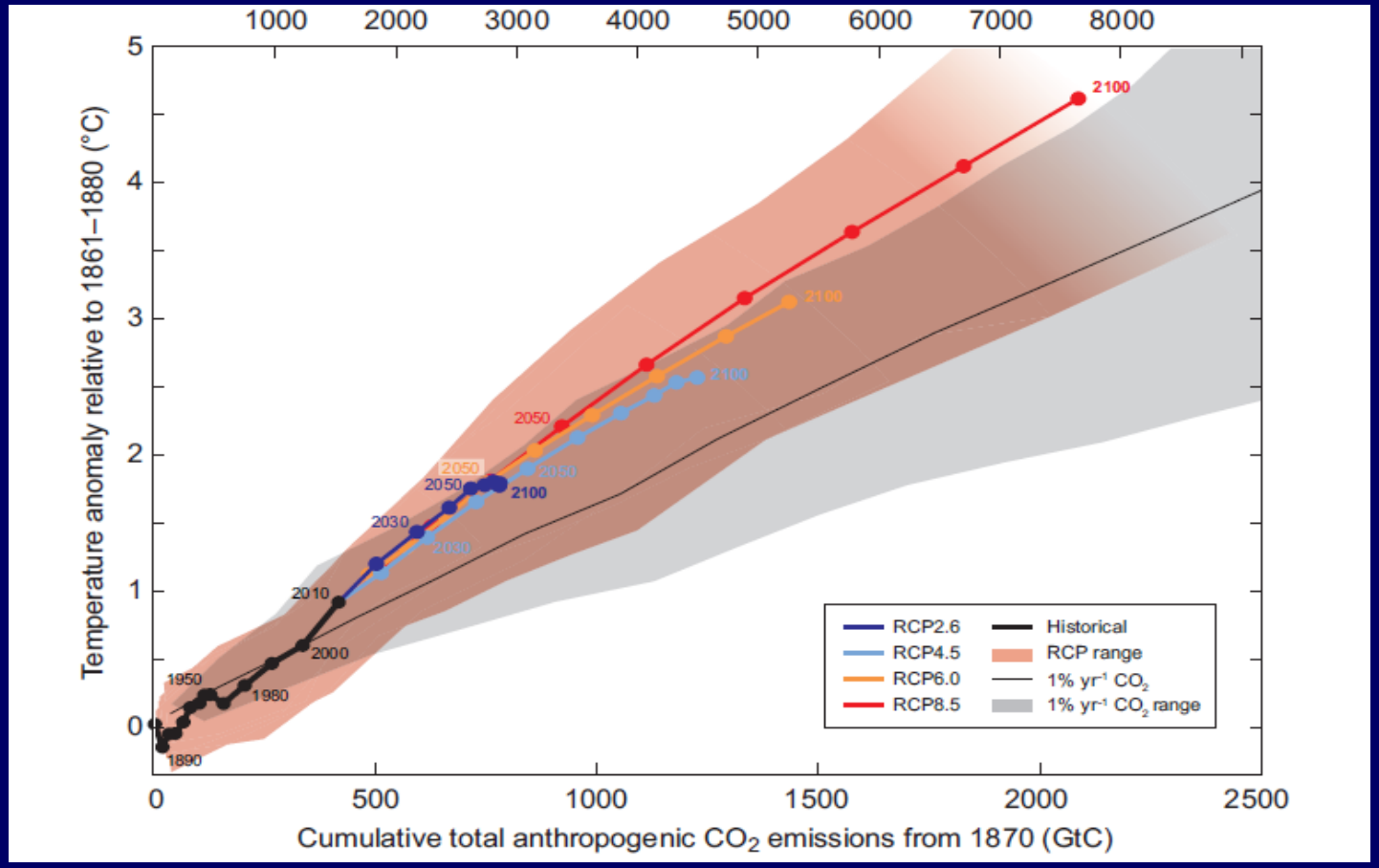


SYR - FIGURE 2-1
WG1 FIGURE SPM-2

Scenario	Cumulative CO_2 Emissions 2012 to 2100[a]			
	GtC		$GtCO_2$	
	Mean	Range	Mean	Range
RCP2.6	270	140 to 410	990	510 to 1505
RCP4.5	780	595 to 1005	2860	2180 to 3690
RCP6.0	1060	840 to 1250	3885	3080 to 4585
RCP8.5	1685	1415 to 1910	6180	5185 to 7005

Notes:

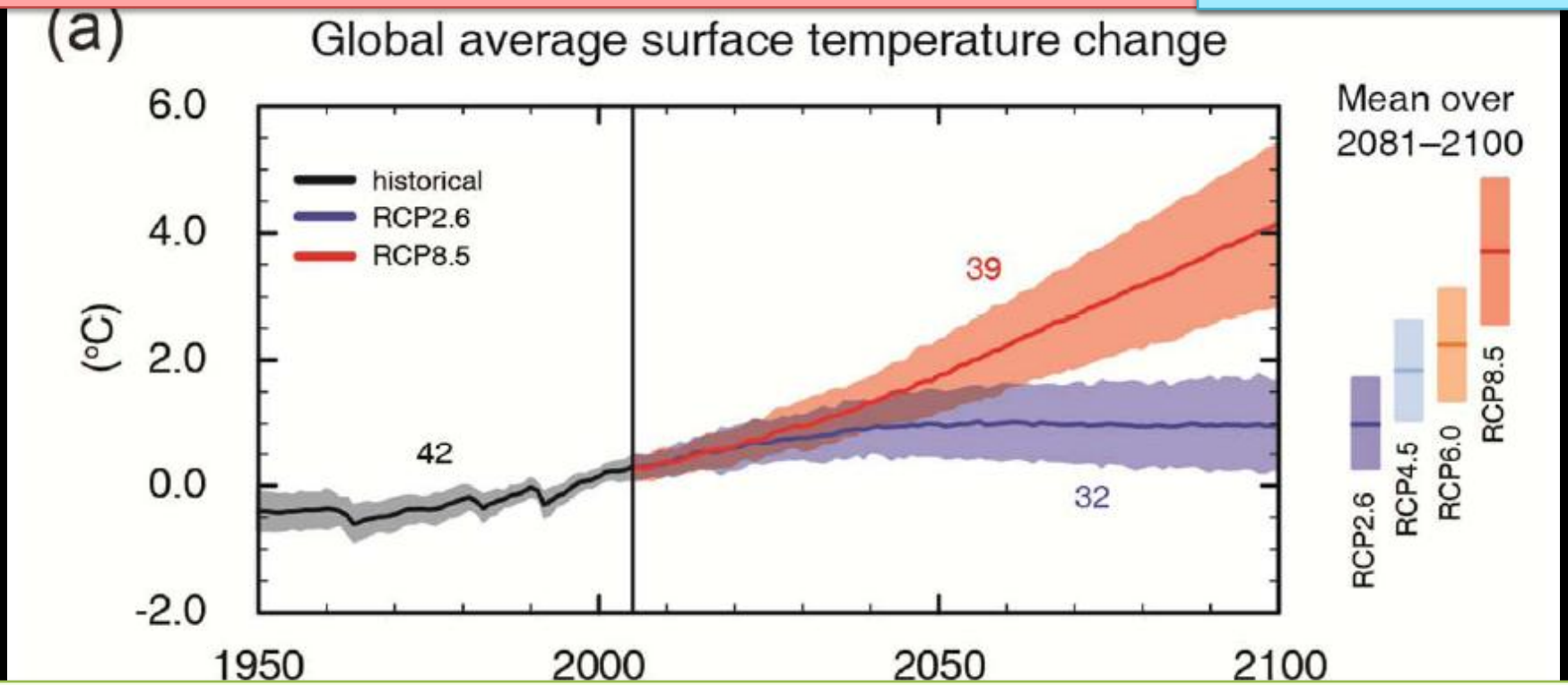
[a] 1 Gigatonne of carbon = 1 GtC = 10^{15} grams of carbon. This corresponds to 3.667 $GtCO_2$.



Representative Concentration Pathways (RCPs)
approximate total radiative forcing in year 2100 relative to 1750:

RCP2.6 (2.6 W m-2, CO_2 eq conc. 475 ppm)
RCP4.5 (4.5 W m-2, CO_2 eq conc. 630 ppm)
RCP6.0 (6.0 W m-2, CO_2 eq conc. 800 ppm)
RCP8.5 (8.5 W m-2, CO_2 eq conc. 1313 ppm)

Representative Concentration Pathways (RCPs), was used for the new climate model simulations



Global surface temperature change for the end of the 21st century is projected to be likely to exceed 1.5°C relative to 1850 -1900 in all but the lowest scenario considered, and likely to exceed 2°C for the two high scenarios

Earth System Model simulations were performed with prescribed CO_2 concentrations reaching

- 421 ppm (RCP2.6)
- 538 ppm (RCP4.5),
- 670 ppm (RCP6.0),
- and 936 ppm (RCP 8.5) by the year 2100

Including also the prescribed concentrations of CH_4 and N_2O, the combined CO_2-equivalent concentrations are

- 475 ppm (RCP2.6),
- 630 ppm (RCP4.5),
- 800 ppm (RCP6.0),
- and 1313 ppm (RCP8.5).

Climate Change History

- Historical Emissions since 1880 has resulted in rise in global temperature by 0.85° Celsius

- **Historical carbon space occupied by various countries** in 2009 (1850 as base year):
  - **USA: 29%**
  - **Other Developed countries: 45%**
  - **China: 10%**
  - **Other Emerging Economies: 9%**
  - **India: 3%**

- **India, even though not part of problem, wants to be part of solution.**

India's INDC

- Ambitious target for renewable & electricity to all:
  - **175 GW** Renewable energy target by 2022
  - 100 GW of Solar, 60 GW of Wind, 10 GW of biomass and 5 GW of small hydel

- ***Swachh Bharat Mission, Zero Effect Zero Defect, Make in India, Smart Cities Mission, Housing for all***

- Laid emphasis on: **Sustainable Development**

  Climate Justice

  Lifestyles

Reduce Emission Intensity of GDP

- Goal: ***To Reduce the emissions intensity of its GDP***

  By 33 - 35% by 2030 from 2005 level.

  75% jump in ambition over 2020

- **Avoided emissions:**

  3.59 billion tonne of CO_2 equivalent

- Our national plans ambitious and purposeful:
  - Thrust on Renewable Energy and Promotion of Clean Energy; Enhancing Energy Efficiency
  - Climate Resilient Urban Centres and Sustainable Green transportation Network
  - Swachh Bharat Mission, Cleaning of rivers, Zero Effect Zero Defect, Make in India

Enhancing Forests Carbon Sink

- Goal:

  To Create additional carbon sink of 2.5 -3 billion tonnes of CO_2 equivalent through additional forest and tree cover (increase of about 680 - 817 million tonne of carbon stock)

- Emphasis on India's Plans to enhance its carbon sink:
  - Full implementation of Green India Mission
  - Launched Green Highways Policy: 140,000 km long "tree-line" along both sides of national highways. 1% of project cost to be earmarked for plantation
  - Plantation along Rivers: part of the Namami Gange Mission

High Economic growth possible with low per capita emissions

India's Per capita emissions in 2030:

remain lower than

the current global average of Developed Nations -

8.98 metric tonnes of CO_2 equivalent

CO_2: Carbon dioxide

- A naturally occurring gas that is also a byproduct of the combustion of fossil fuels, biomass, other industrial processes, and land-use changes

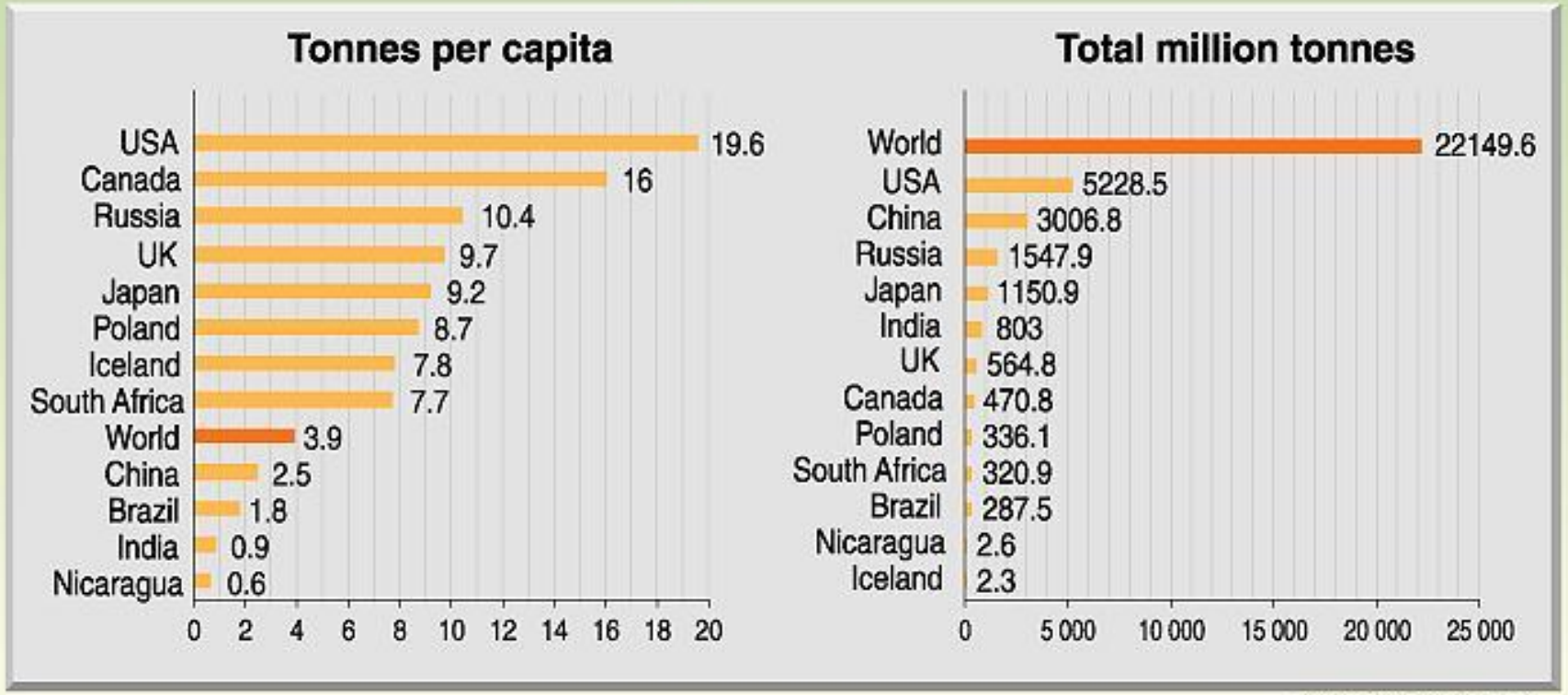
- CO_2 is the principal anthropogenic greenhouse gas (~ 60%)responsible for global warming

- It is the reference gas against which other greenhouse gases are measured; therefore, it has a global warming potential of 1
- US EPA limit is 25,000 tpy as CO_2 equivalent

Profile by process or industrial activity of worldwide large stationary CO_2 sources with emissions of more than 0.1 Mt CO_2 per year

Process	Number of sources	Emissions ($MtCO_2$ yr^{-1})
Fossil fuels		
Power	4,942	10,539
Cement production	1,175	932
Refineries	638	798
Iron and steel industry	269	646
Petrochemical industry	470	379
Oil and gas processing	N/A	50
Other sources	90	33
Biomass		
Bioethanol and bioenergy	303	91
Total	**7,887**	**13,466**

Emissions of CO_2 - selected countries (1995)



GRAPHIC DESIGN : PHILIPPE REKACEWICZ

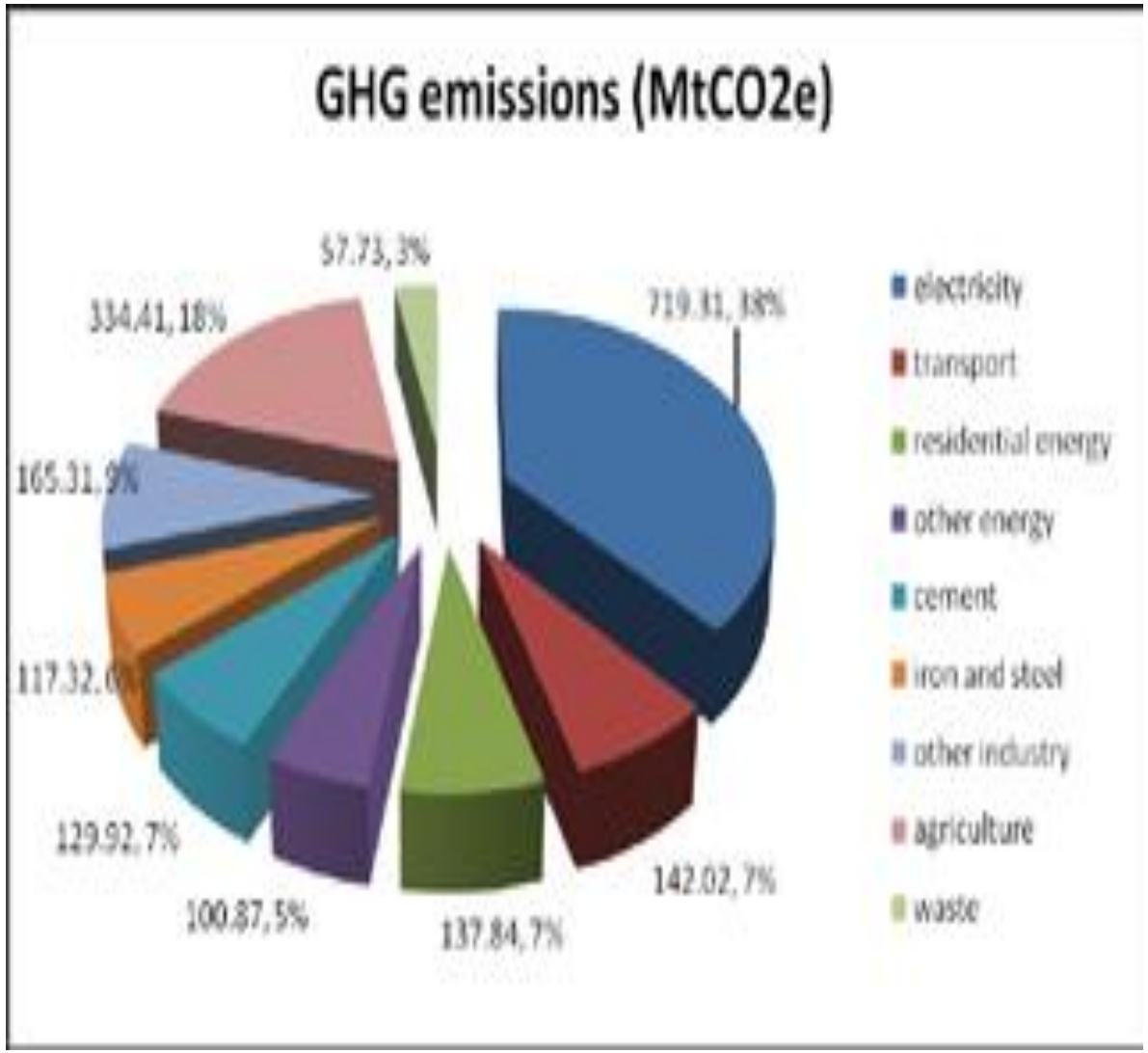
GRID Arendal UNEP

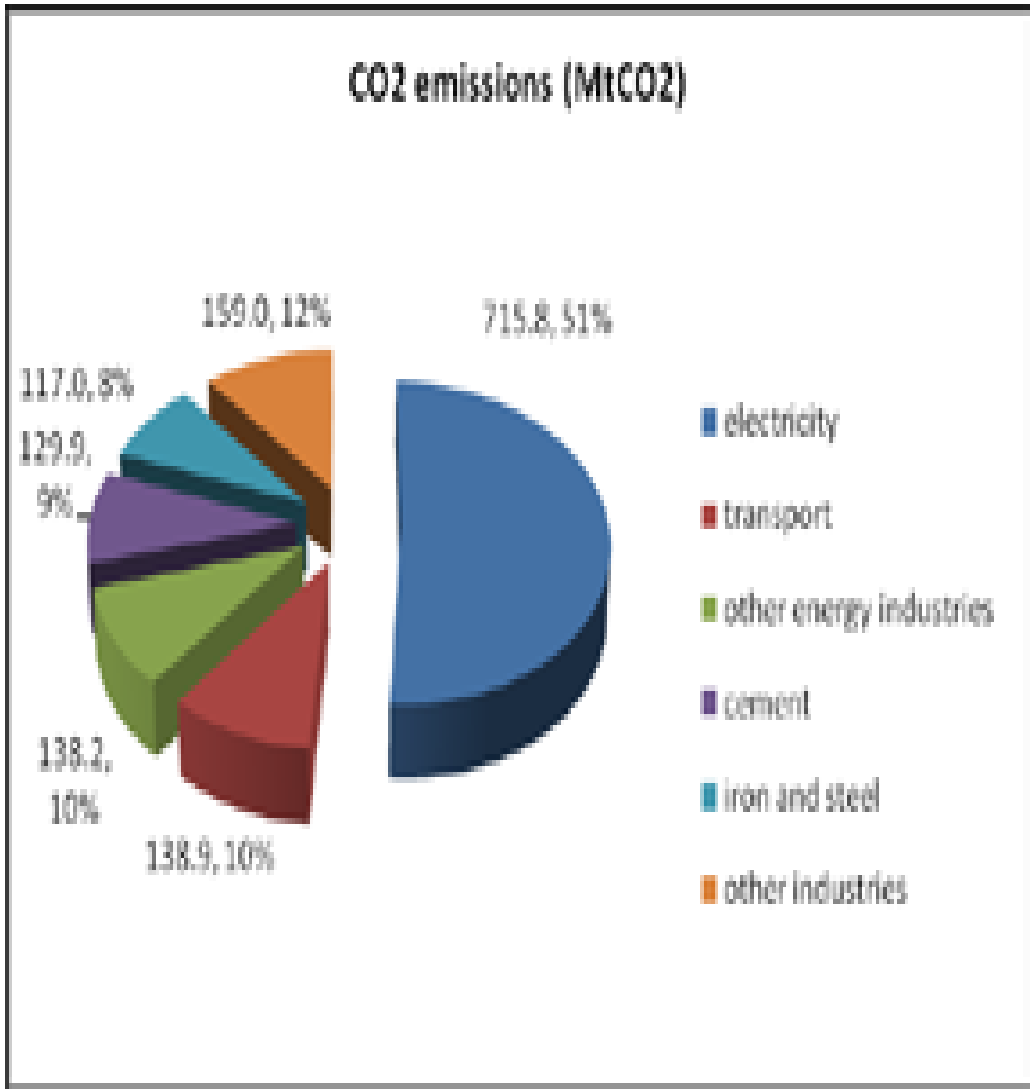
Source : International Energy Agency, 1998.

Emissions by Countries (2012)

Country	CO_2 Emissions per year (billion tons)	%age Share in Global Annual Emissions	CO_2 Emissions per capita (tons/person)
World	34.5	100%	4.9
China	9.86	28.6%	7.1
United States	5.19	15.1%	16.4
European Union	3.74	10.9%	7.4
India	1.97	5.7%	1.6
Russia	1.77	5.1%	12.4
Japan	1.32	3.8%	10.4

India's GHG emissions inventory and India's carbon emissions in 2007 (INCCA)





GHG EMISSIONS

GHGs-

- Carbon dioxide (CO_2)
- Methane (CH_4)
- Nitrous oxide (N_2O)
- Ozone (O_3)
- Water vapour (H_2O)
- Choloroflurocarbons (CFCs)

GHG Emissions

Country	Annual GHG Emissions in 2005 including LULUCF				
	$MtCO_2e^2$	global ranking	% of global total	per capita	per capita ranking
Brazil	2,840.5	4	6.6%	15.3	19
China	7,194.8	1	16.7%	5.5	94
India	1,865.0	7	4.3%	1.7	152
Indonesia	2,035.5	5	4.7%	9	58
Mexico	671.0	11	1.6%	6.3	82
South Africa*	422.6	23	0.98%	9	59
Russia	1,997.6	6	4.6%	14	23

Future emissions

- Existing coal-fired power plants present over the world emit about 2 billion tons of CO_2 per year
- Global CO_2 emissions range from 29 to 44 GtCO2 (8–12 GtC) per year in 2020
- 23 to 84 $GtCO_2$ (6–23 GtC) per year in 2050
- **Opportunities and challenges for converting this waste gas into a resource**

Typical flue gas composition from power plants

Gas	Pulv. coal combustion flue gas	Waste incinerat flue gas	Coal gasification fuel gas §	Coal-fired IGCC flue gas	Natural gas Groningen	Gas-fired CC flue gas
O_2 %v	~ 6	7 - 14		~ 12		~14
N_2	~ 76	balance	~4 / ~1	~ 66	~14	~76
CO_2	~11	6 - 12	~4 / ~13	~ 7	~1	~ 3
H_2O	~ 6	10 - 18	~4 / ~1	~ 14		~ 6
CO		0.001-0.06	~58/~40			
H_2			~30/~29			
Ar	~ 1	~ 1	~ 1	~ 1	~1	
SO_2 ppm w		200 -1500		10 - 200		
H_2S			1000-4000			
NOx	500 - 800	200 - 500		10 - 100		10 - 300
NH_3			300 - 800			
HCN			40 - 150			
HCl		400 - 3000	500 - 600			
HF		2 - 100	150 - 250			
CH_4					~ 81	
HC		< 0.002			~ 4	

Conversion factor used for CO2 emission

Category	Conversion Factor	Source
Electricity (per kW)	0.87	http://www.mnes.nic.in/baselinepdfs/chapter2.pdf
Coal (per kg)	2.06	www.branz.co.nz
LPG (per kg)	2.78	IEMA (Institute of Environmental Management & Assessment
Kerosene (per litre)	2.41	Clients reference
CNG (per kg)	2.67	IEMA (Institute of Environmental Management & Assessment
Diesel (per litre)	2.46	www.branz.co.nz
Petrol (per litre)	2.14	www.branz.co.nz
Air (per person)	0.26	www.branz.co.nz
Train-Diesel (per person)	0.13	www.branz.co.nz
Train-Electric (per person)	0.17	www.branz.co.nz
Firewood (per kg)	1.07	**Considered Renewable**
Gober (per kg)	1.07	
Gober Gas (per kg)	2.67	

CO_2 emissions ($MtCO_2$).

	2005	2020				2030			
		Frozen[a]	$20[b]	$50[b]	$100[b]	Frozen[a]	$20[b]	$50[b]	$100[b]
Total	9442	16,664	15,233	14,423	13,895	24,549	21,792	20,069	19,288
by industries									
Steel	2297	3486	3148	3106	2975	4410	3787	3699	3555
Cement	1652	2381	2287	2281	2248	2812	2670	2657	2635
Other industries	5493	10,796	9798	9035	8672	17,328	15,336	13,713	13,099
by regions									
Japan	477	511	488	479	469	520	491	483	463
USA	1057	1350	1297	1207	1196	1538	1468	1330	1315
EU15 in Western Europe	957	1127	1103	1094	1063	1219	1184	1172	1118
EU10 in Eastern Europe	157	231	214	206	200	288	254	248	242
Russia	441	759	704	630	600	1075	985	820	777
China	3085	6290	5742	5289	5104	9969	8992	7934	7623
India	615	1779	1387	1367	1261	3564	2607	2536	2456
Brazil	123	212	202	200	197	278	261	257	255
Other OECD regions	596	875	823	783	770	1085	1001	926	910
Other non-OECD regions	1932	3529	3272	3167	3034	5013	4548	4363	4129

[a] Assumes diffusion rate and energy efficiency of the technologies are fixed at the same level as in 2005.

[b] Assumes introduction of emissions reduction technologies under $20/$tCO_2$, $50/$tCO_2$ and $100/$tCO_2$, respectivily.

Climate Change Impacts

The IPCC and other groups have predicted future ***impacts of climate change****.*

- Temperature will rise 3–5°C
- Droughts, floods, snowpack decline, and water shortages will create diverse problems.
- Temperature extremes will cause health problems; tropical diseases will move north into the U.S.
- Sea level rise will flood coastal wetlands, real estate.
- Ecosystems will be altered; some will disappear.
- Agriculture and forestry may have mixed results.

Responding

- Mitigation- refers to efforts to cut or prevent the emission of greenhouse gases - limiting the magnitude of future warming. It may also encompass attempts to remove greenhouse gases from the atmosphere.

Globally by all countries- low carbon society AVOIDING THE UNMANAGEABLE

- Adaptation-refers to the actions taken to manage the unavoidable impacts of climate change

Regional- climate resilient society MANAGING THE UNAVOIDABLE

Emissions reduction: More efficient generation and usage

Electricity generation is the biggest source of greenhouse gas emissions in the U.S.

So solutions include:

- Improved technology at plants
- Cleaner-burning coal
- Energy conservation by consumers

Emissions reduction: Renewable energy

Another solution is to switch to renewable energy sources:

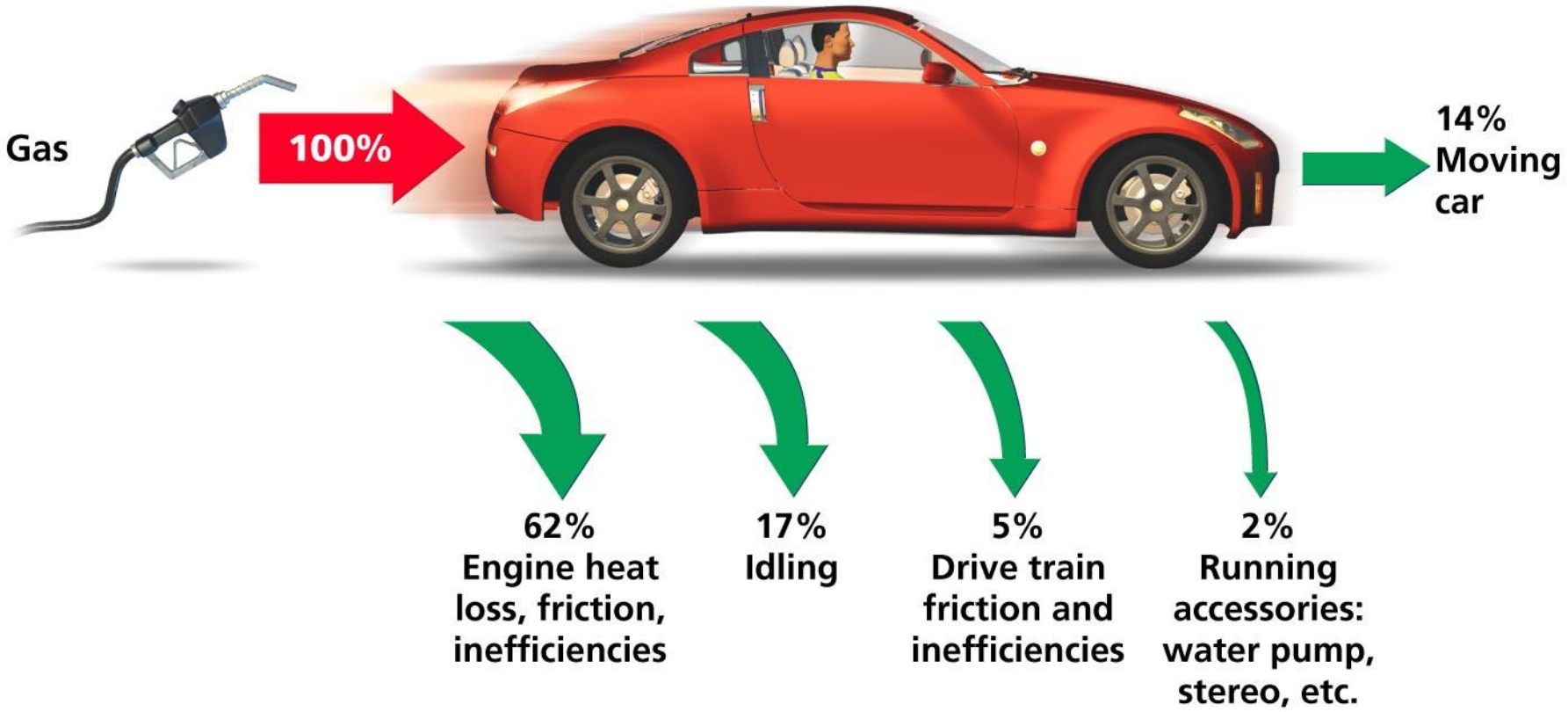
- Hydroelectric power
- Geothermal energy
- Photovoltaic cells
- Wind power

ENERGY EFFICIENCY, RENEWABLE ENERGY AND SOLAR MISSION

Emissions reduction: Inefficient autos

Transportation: the 2nd largest source of greenhouse gases.

Cars use energy very inefficiently. We could do better.



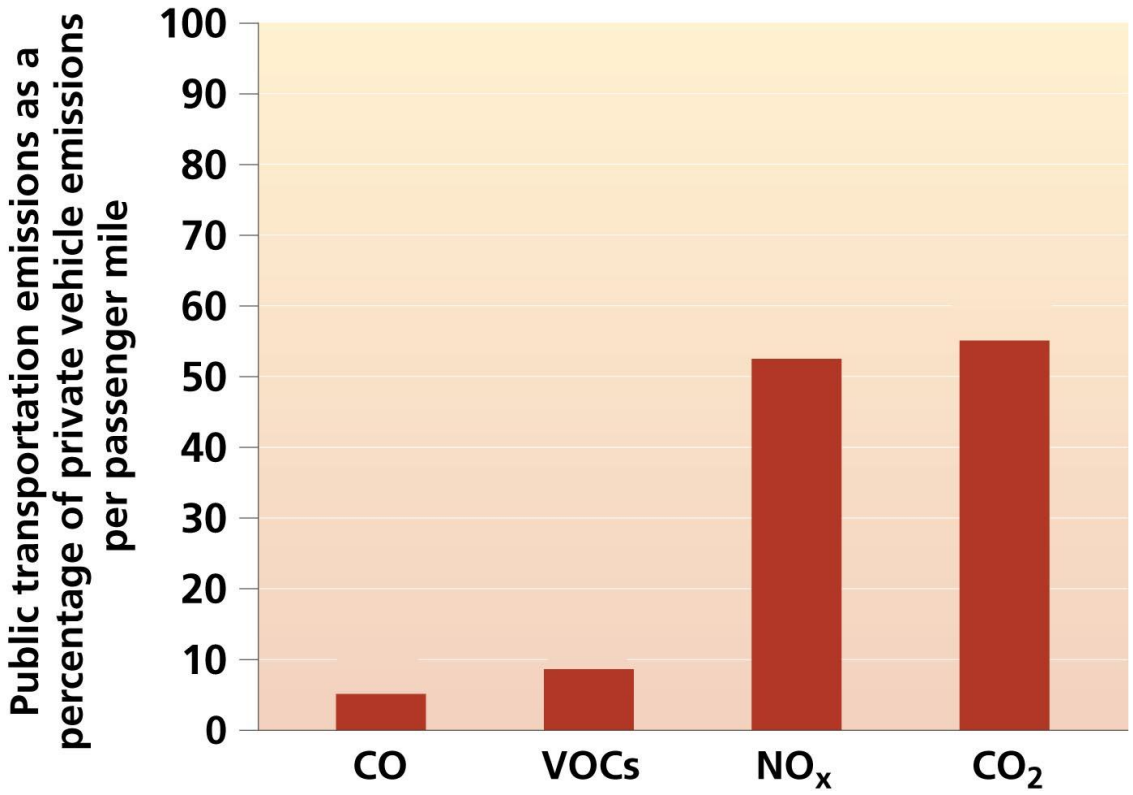
Emissions reductions: Biking and walking

Reducing automobile usage would also lower emissions.

- *More and more people are choosing to live closer in and bike or walk to work.*

- *If we use public transportation at the rate Singaporeans do, Indians would no longer need Saudi Arabian oil.*

Emissions reductions: Public transportation



Using **public transportation** like buses and trains lowers emissions of many pollutants … which has a public health benefit as well.

Clean Energy

- Energy-Societies dependent on fossil fuels- Change to a system of sustainable and **renewable energy-**must devote ourselves to enabling and accelerating that transition—by developing the **technologies**, policies and practices that would make it possible.
- New technologies for energy storage, to solar to reduce pollution
- Strategies and initiatives that reduce energy consumption and GHG emissions in the ways we live and work
- Create effective solutions- Ideas, innovation and discovery will serve as indispensable elements in combating the climate threat

WHAT ARE PEOPLE DOING NOW TO MANAGE CO2?

- A combined portfolio of carbon management options is being implemented to reduce current emission levels associated with energy production while maintaining energy security and building the technologies and knowledge base needed to mitigate carbon emissions.
- Use fuels with reduced carbon intensity – renewables, nuclear, and natural gas
- Adopt more efficient technologies on both the energy demand and supply sides
- Develop and implement carbon capture and storage (CCS) technology.

SINKS

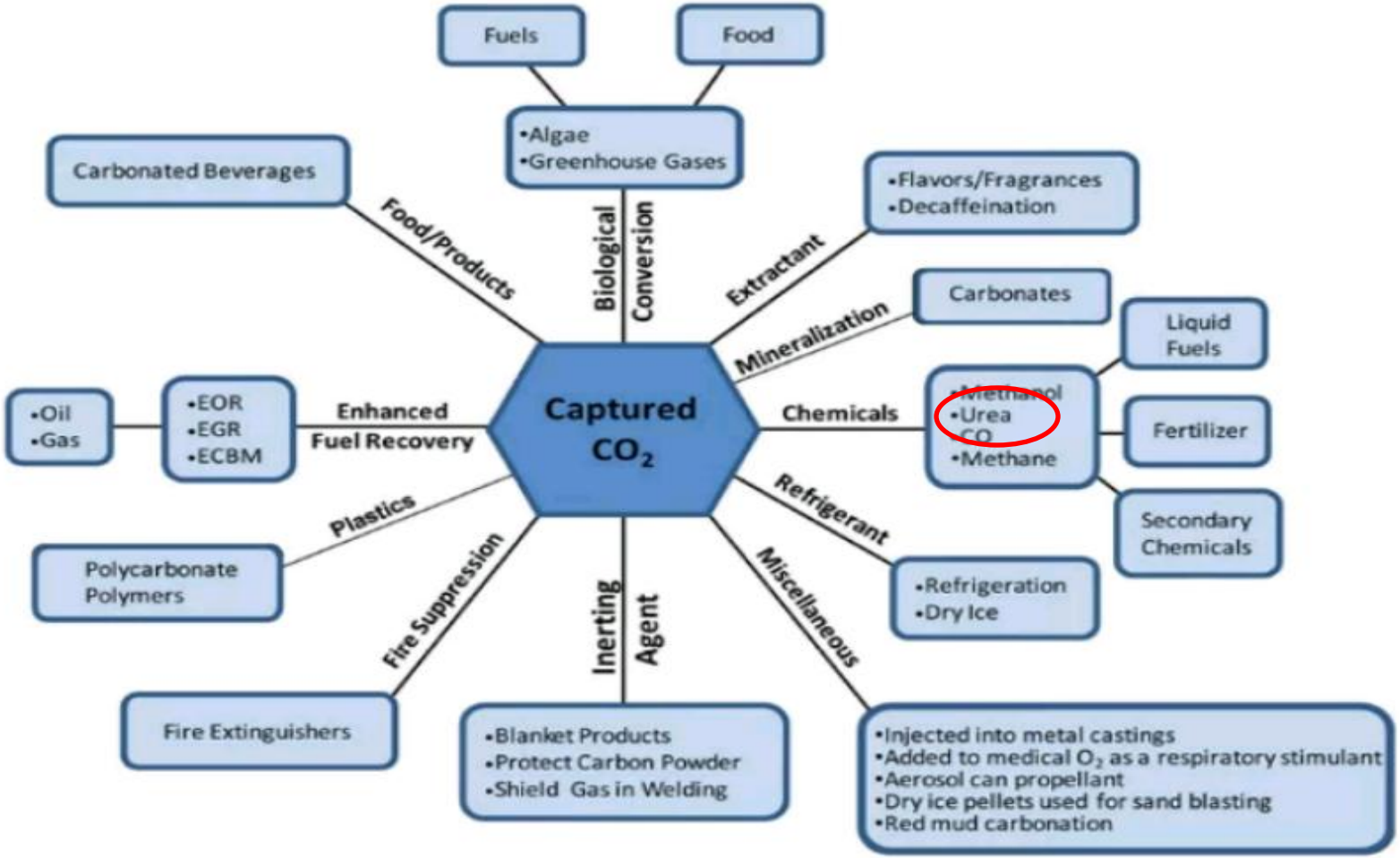
Major sectors in India-

- Forest land
- Wet land
- Crop land

CO_2 Capture and Storage

- **CCS refers to the separation of CO_2 from the other components in the flue gas or process stream of a power plant or an industrial facility**
- The process of capturing carbon dioxide from an emission source, converting it to a supercritical state, transporting it to an injection site, and injecting it into deep subsurface rock formations for long-term storage
- CCS is sometimes referred to in the literature as carbon dioxide capture and sequestration
- The process of increasing the carbon content of a *reservoir*/pool other than the *atmosphere*

CARBON CONVERSION-CCU



CARBON CONVERSION IS KEY TO SOLVING CLIMATE CHANGE PROBLEMS

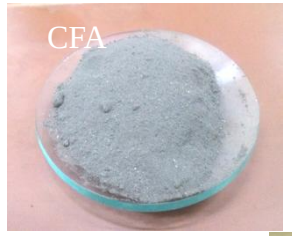
Source: NETL, CO_2 utilization focus area

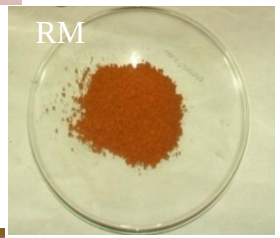
ALKALINE SOLID WASTES

CO_2 CAPTURE AND STORAGE OR SEQUESTRATION (CCS)

MINERAL CARBONATION

- Environmentally benign
- Permanent storage
- Reduced energy and cost
- No post monitoring
- Single step
- Ex-situ carbonation- directly applicable





ALKALINE SOLID WASTES

- **Maximum sequestration capacity achieved was in aqueous carbonation route**
  - 35 g of CO_2/kg of Red mud
  - 89 g of CO_2/kg of Coal fly ash
  - 362 g of CO_2/kg of Steelmaking slag

PUBLICATIONS

1. Tamilselvi Danajayan, RR, Kandasamy, P & Andimuthu, R, 2015, 'Direct mineral carbonation of coal fly ash for CO_2 sequestration', **Journal of Cleaner Production**, vol. 112. Part 5, pp. 4173-4182. IF- 4.2.
2. Rushendra Revathy, TD, Palanivelu, K & Ramachandran, A, 2015, 'Direct mineral carbonation of steelmaking slag for CO_2 sequestration at room temperature', **Environmental Science and Pollution Research**,IF- 2.8. Available online at: http://link.springer.com/article/10.1007/s11356-015-5893-5.
3. Rushendra Revathy, T.D, Palanivelu, K, Ramachandran. A, 2015, 'Sequestration of carbon dioxide by red mud through direct mineral carbonation at room temperature", **International journal of Global Warming**, IF- 0.77 (In press).
4. Rushendra Revathy, T.D**,** Pavithra, E, Palanivelu, K, Ramachandran. A, 2014, 'CO_2 sequestration by lime mud through direct mineral carbonation', **Journal of Chemical and Pharmaceutical Sciences**, special issue 4, pp no. 15-17.

* INDIA'S ACTION PLAN TO REDUCE CO_2 EMISSIONS

1. Reduce emission intensity by 33 to 35 per cent by 2030 compared to 2005 levels

HOW:

- Introduce new, more efficient, cleaner technologies in thermal power generation
- Reduce emissions from transport sector
- Promote energy efficiency, mainly in industry, transport, buildings, appliances
- Develop climate resilient infrastructure
- Pursue Zero Effect, Zero Defect policy under Make in India programme

2. Produce 40 per cent of electricity from non-fossil fuel based energy resources by 2030

HOW:

- Install 175 GW of solar, wind and biomass electricity by 2022, scale it up in following years
- Aggressively pursue hydropower development
- Achieve target of 63 GW of installed nuclear power capacity by 2032

3. Create additional carbon sink of 2.5 to 3 billion tonnes of carbon dioxide equivalent by 2030 through additional forest and tree cover

HOW:

- Full implementation of Green India Mission, other afforestation programmes
- Develop 140,000 km long tree line on both sides of national highways

Recent Initiatives of the Government

- Revisiting national missions, creation of new missions and enhancing of targets etc.

Mitigation Initiatives

- Renewable Energy target 175 GW & National Solar Mission from 20 to 100 GW
- Kochi Airport worlds' first airport powered by solar energy
- Solar powered toll plazas
- National Smart Grid Mission & Green Energy Corridor for efficient transmission & distribution network
- Swachh Bharat Mission

Conclusion

- Many factors shape global climate – Main GHGs
- Scientists and policymakers are beginning to understand anthropogenic climate change and its impacts more fully.
- Many scientists and policymakers are deeply concerned.
- As time passes, fewer experts are arguing that the changes will be minor.
- Sea-level rise will affect developed and developing countries alike.

Mother Earth -- Our Home

It is has water, oxygen and a hospitable climate

Let us preserve and sustain it

Thank you !