

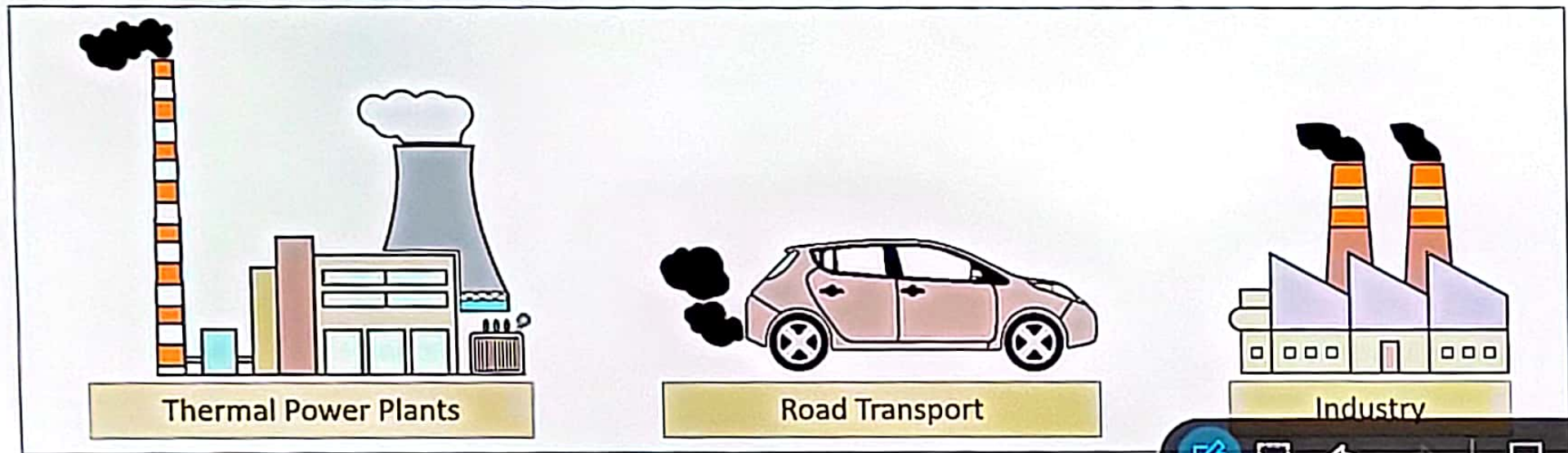
1. What is the difference between HEV, PHEV, BEV and FCEV?
2. Is the electric vehicle (EV) the answer to our transportation needs in the future?
3. Will EVs help to solve climate change-related problems?
4. What is the average efficiency of an EV as compared to an IC engine car?
5. How long does it take to charge an EV battery?
6. What is the drive range of an EV with full charge?
7. Are electric cars expensive to run?
8. Do electric cars breakdown more?
9. Can we drive and charge an electric car in the rain?
10. Is there a standard for an electric Vehicle charger (on-board, off-board)?
11. Other than LFP, NMC, and LTO, what are the other upcoming battery technologies ?
12. What kind of Ancillary Services the Electric Vehicles can provide to the TSO and DSO?
13. What are the impacts of the Electric Vehicles on the TSO & DSO networks?
14. Is disposal/recycling of EV battery a serious challenge for the EV manufacturers?
15. Is there any comparison between BEVs and Fuel Cell EVs?



# CO<sub>2</sub> EMISSIONS FROM FUEL COMBUSTION

In the year 2022,

humans dumped **36,400,000,000,000** kg of CO<sub>2</sub> in the atmosphere.



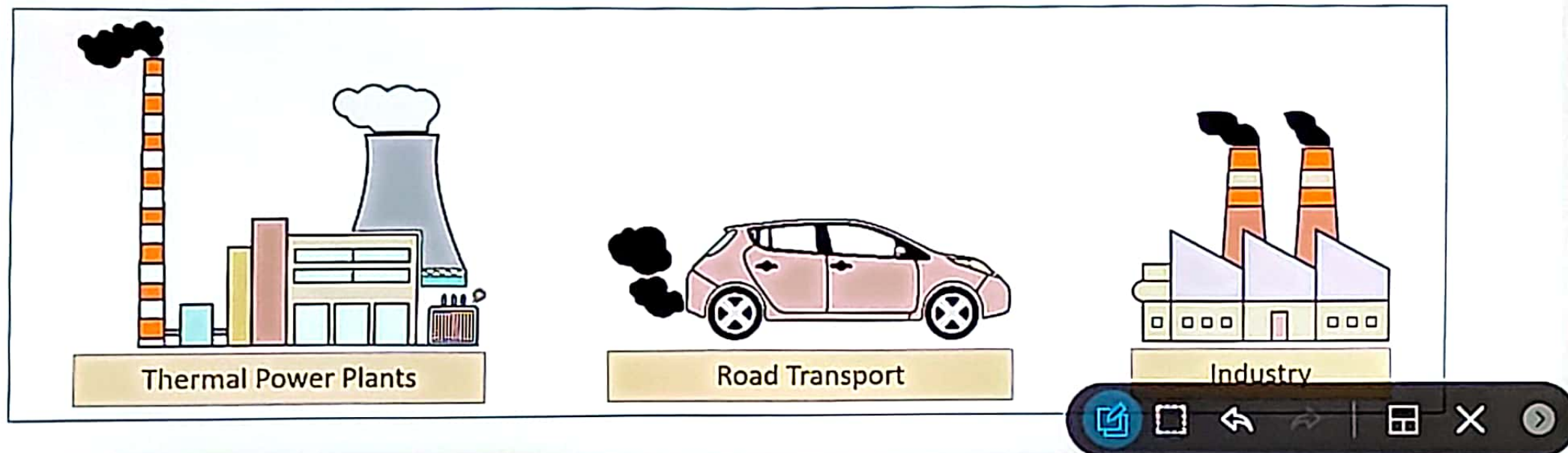


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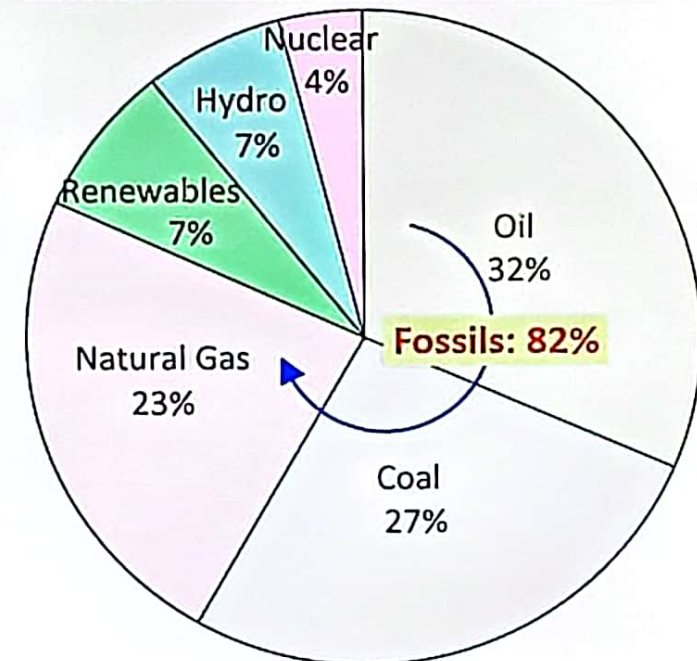
- ❖ World population by the end of 2022 → 8.005 billion.
- ❖ The per capita CO<sub>2</sub> emission was **4,547 kg** (~4.6 metric ton).



# SIGNIFICANCE OF FOSSIL HYDRO CARBONS

Growth in World Total Energy Consumption

Year: 2022



Energy Institute (2022) = 604.04 exajoule = 167.8 PWh

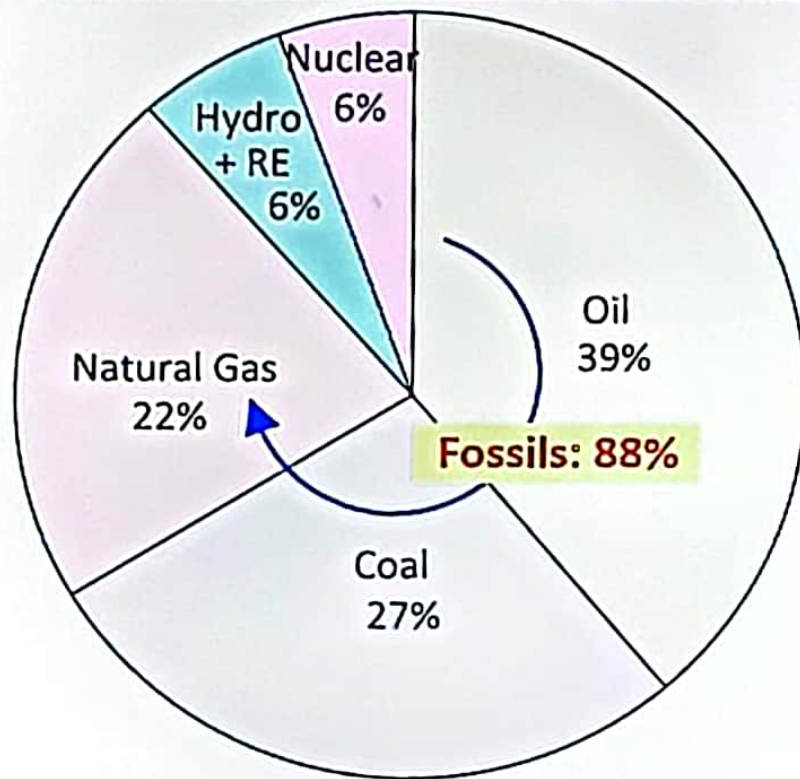




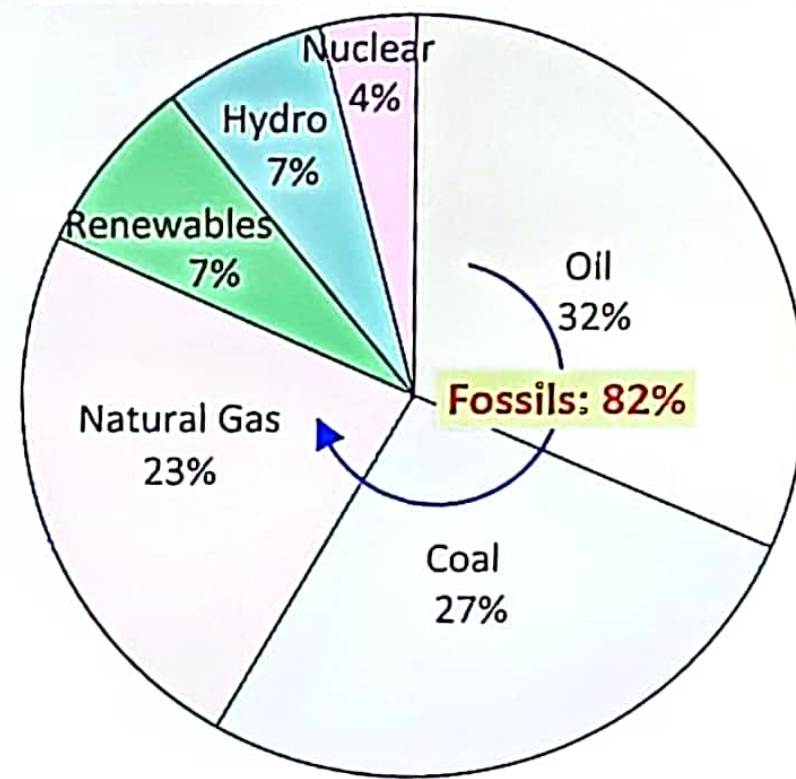
# SIGNIFICANCE OF FOSSIL HYDRO CARBONS

## Growth in World Total Energy Consumption

Year: 1990



Year: 2022



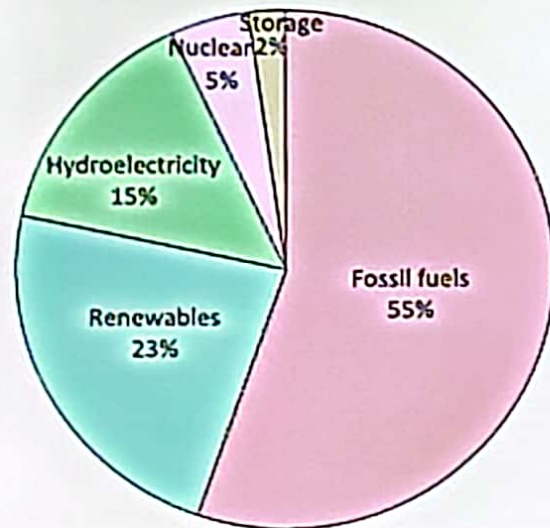
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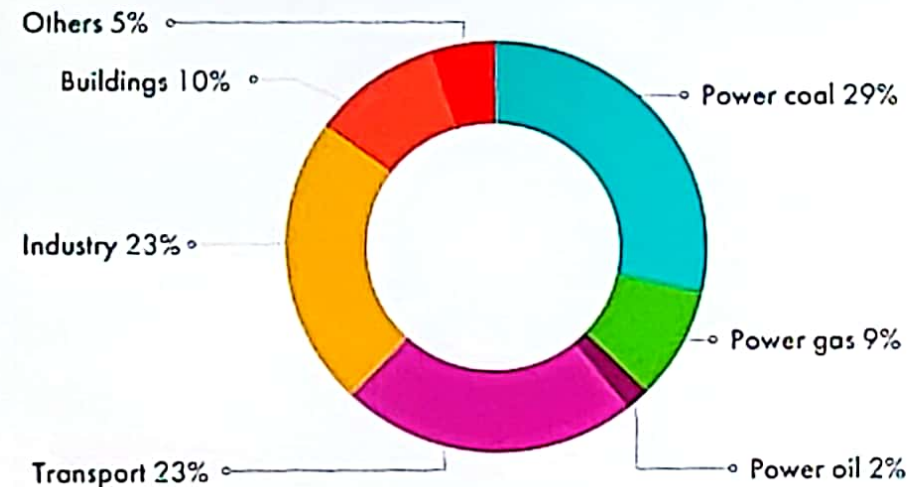
# ENERGY-POLLUTION NEXUS

- ❖ By the end of 2022,
  - ✦ Nearly 53% of world electricity generation was from fossil fuels.
  - ✦ Globally, there were ~ 1.49 billion vehicles (in India, it was 340+ million).
- ❖ Thermal power plants and automobiles contribute 60-65% of world CO<sub>2</sub> emissions.

Year: 2021



Fossil power generation share: 57%

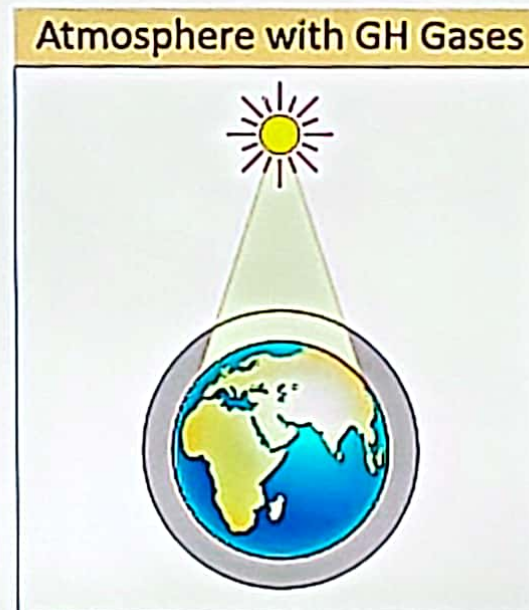
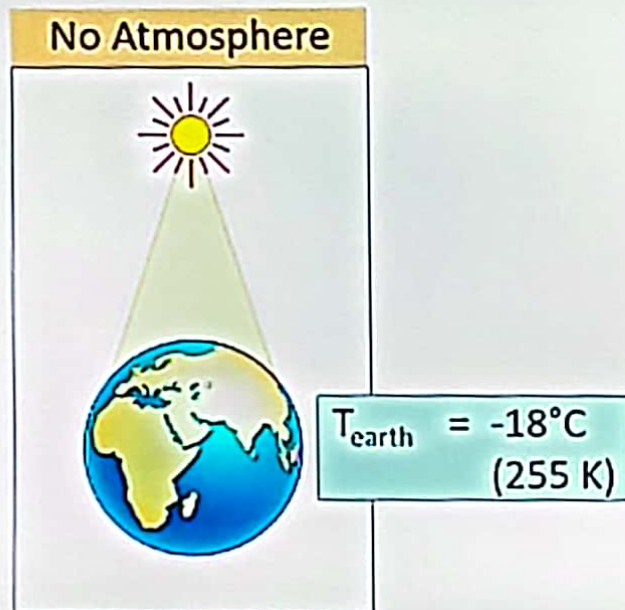


Fossil power generation share: 40%



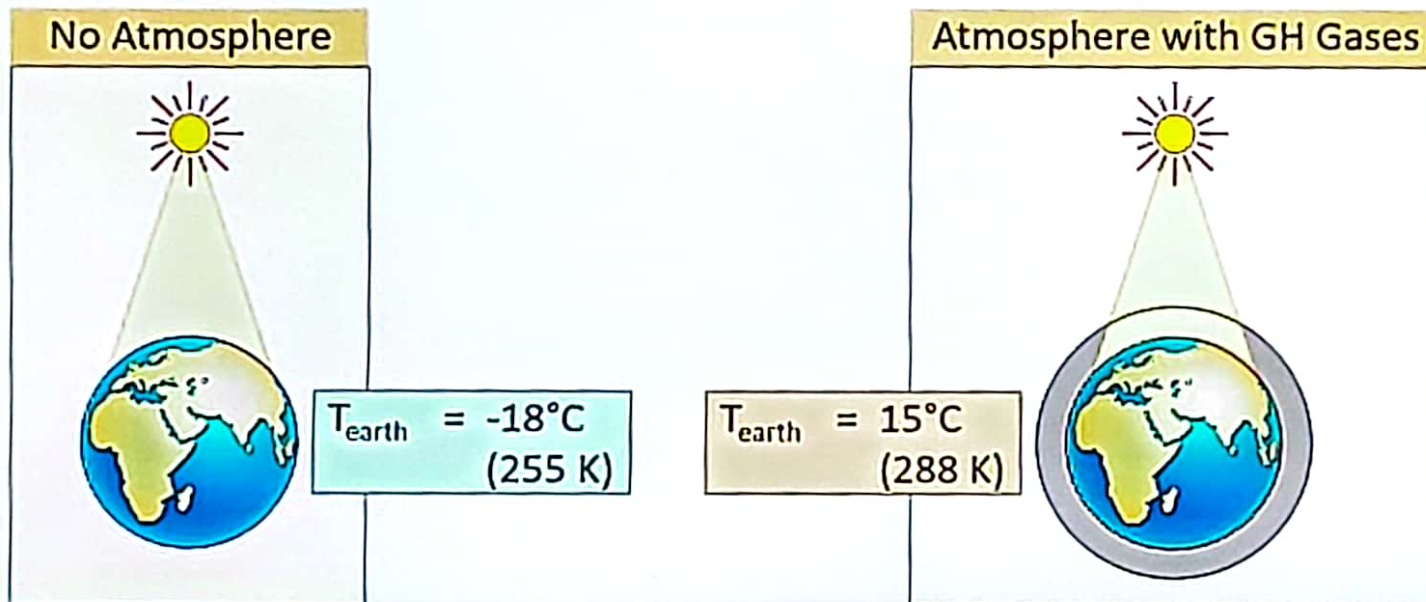
# GREENHOUSE GASES & THEIR SIGNIFICANCE

- ❖ However, the earth is having an atmosphere of layers of gases with varying densities.
- ❖ Earth's gravity keeps these gases from drifting off into the space.
- ❖ Some of these gases allow solar radiation to pass through, but absorb infra-red radiation.
- ❖ These gases, called as the Greenhouse (GH) Gases, act as a blanket covering the earth.



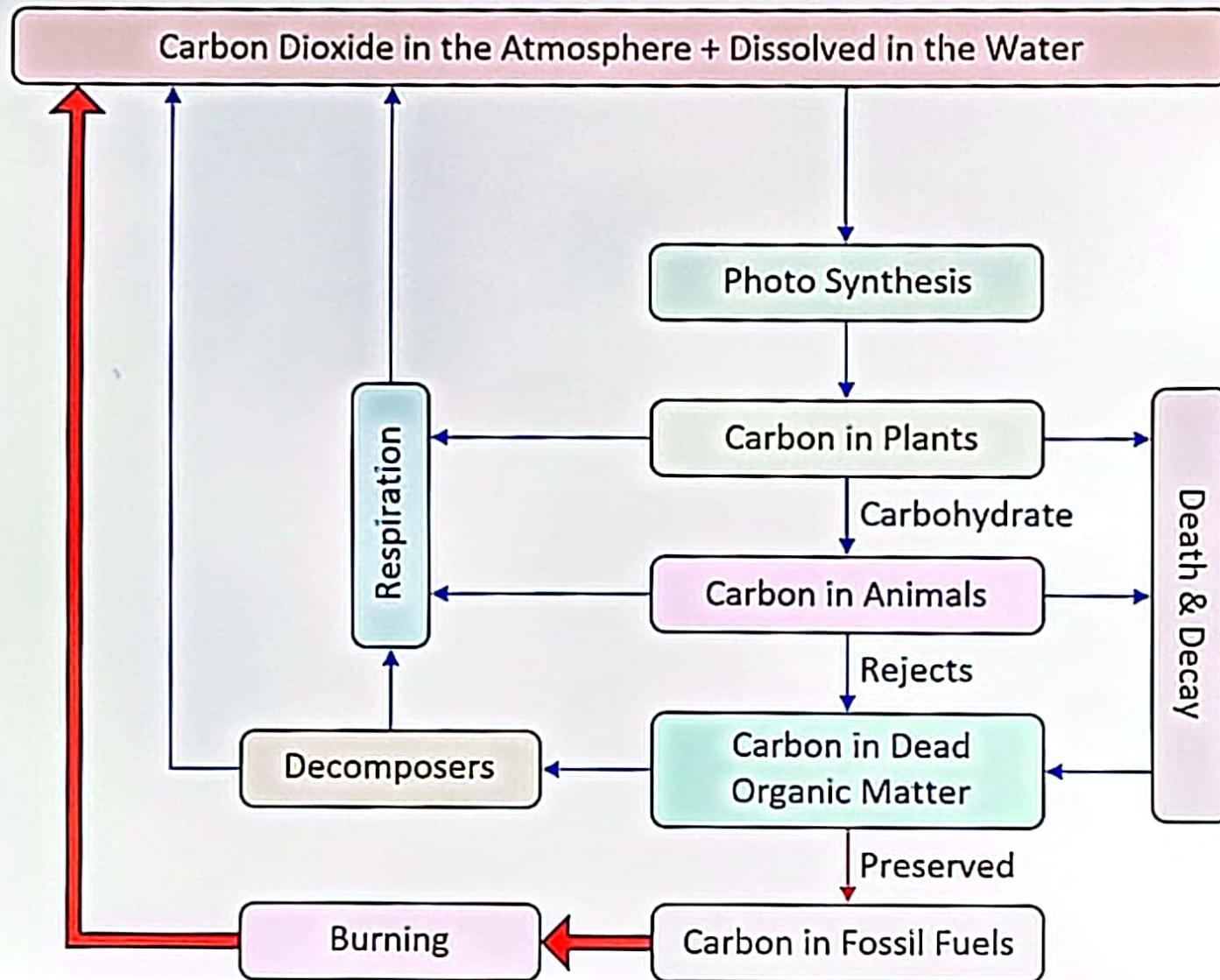
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- ❖ It is because of these GH gases that the earth's mean temperature is maintained at  $15^{\circ}\text{C}$ .



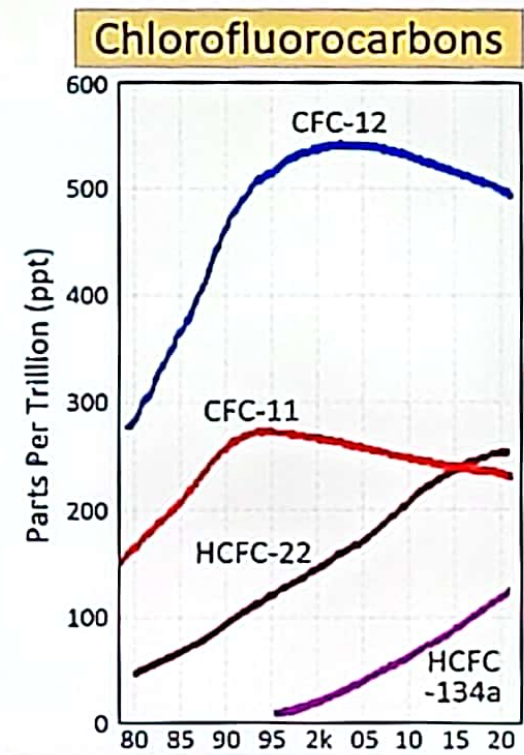
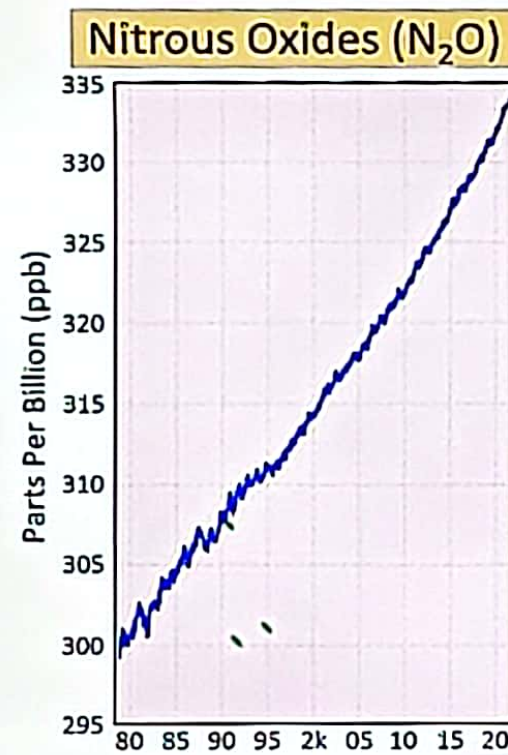
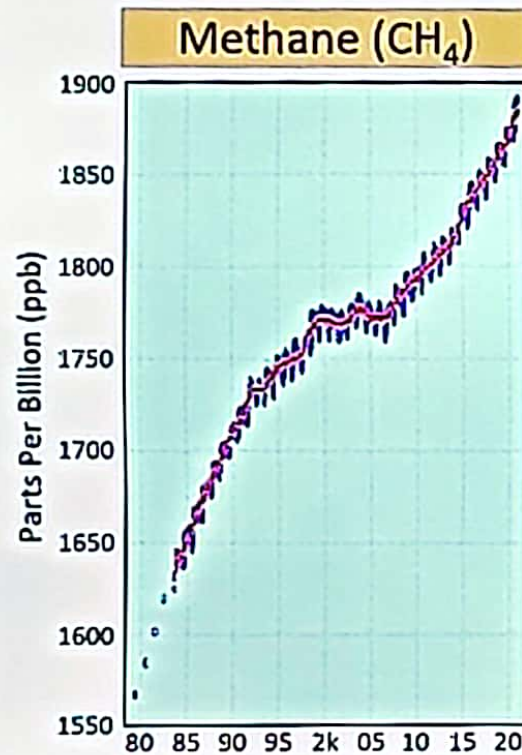
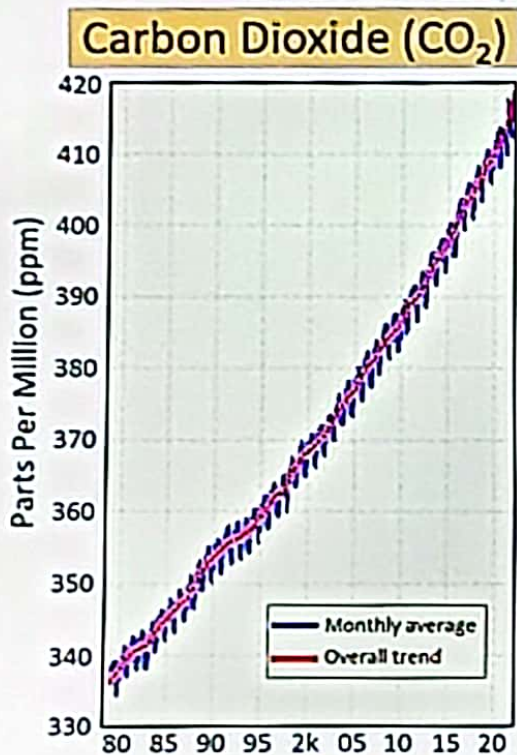


# CARBON CYCLE AFTER INDUSTRY REVOLUTION



# CONCENTRATIONS OF MAJOR GREENHOUSE GASES

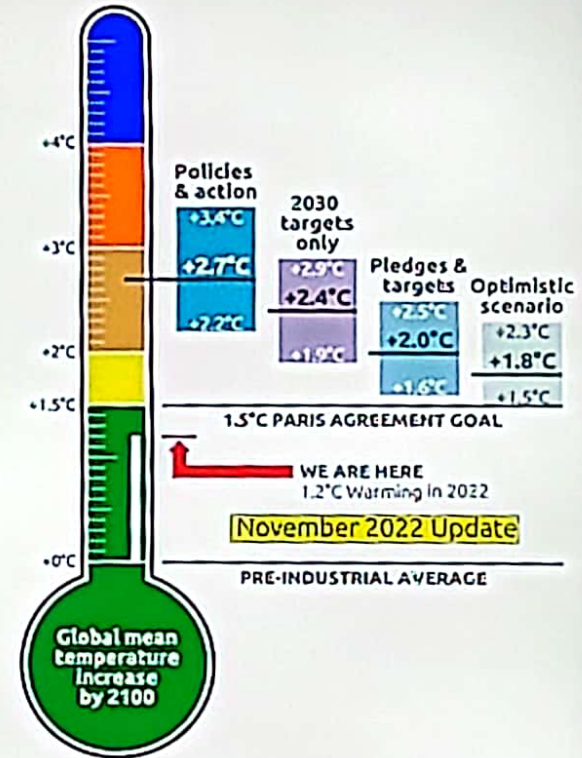
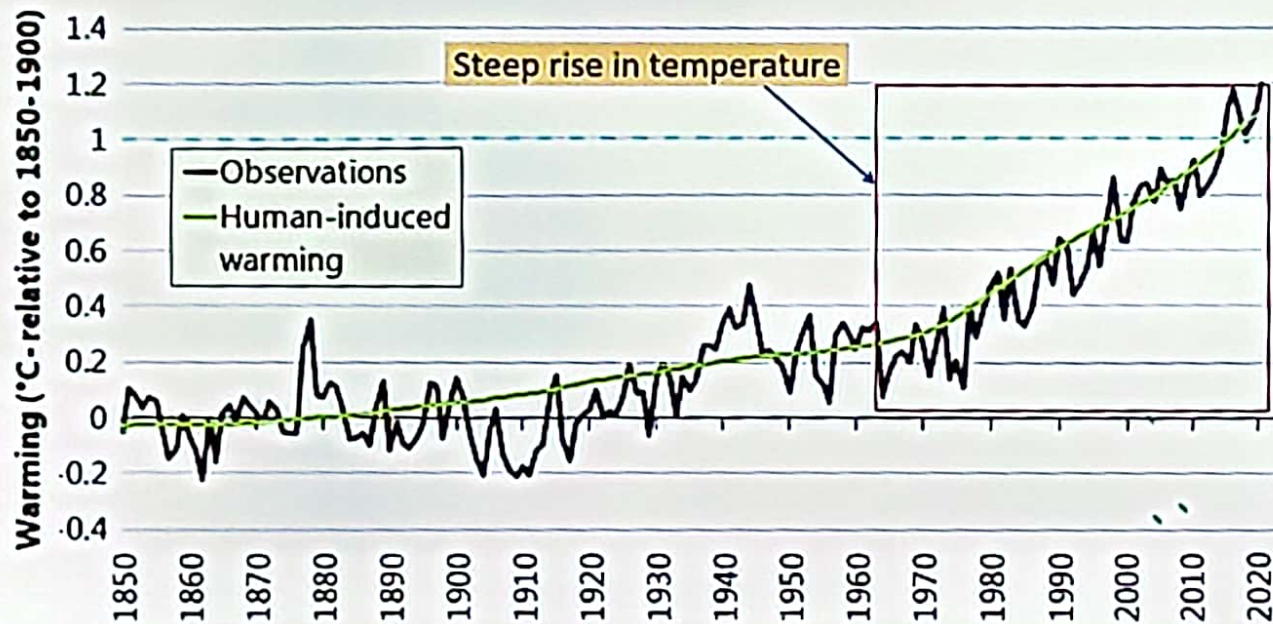
- ❖ Major greenhouse gases: Carbon Dioxide, Methane, Nitrous Oxide, CFC-12 and CFC-11.
- ❖ These five gases account for 96% of the long-lived greenhouse gases.
- ❖ Remaining 4% is contributed by 15 halogenated gases including HCFC-22 & HFC-134a.





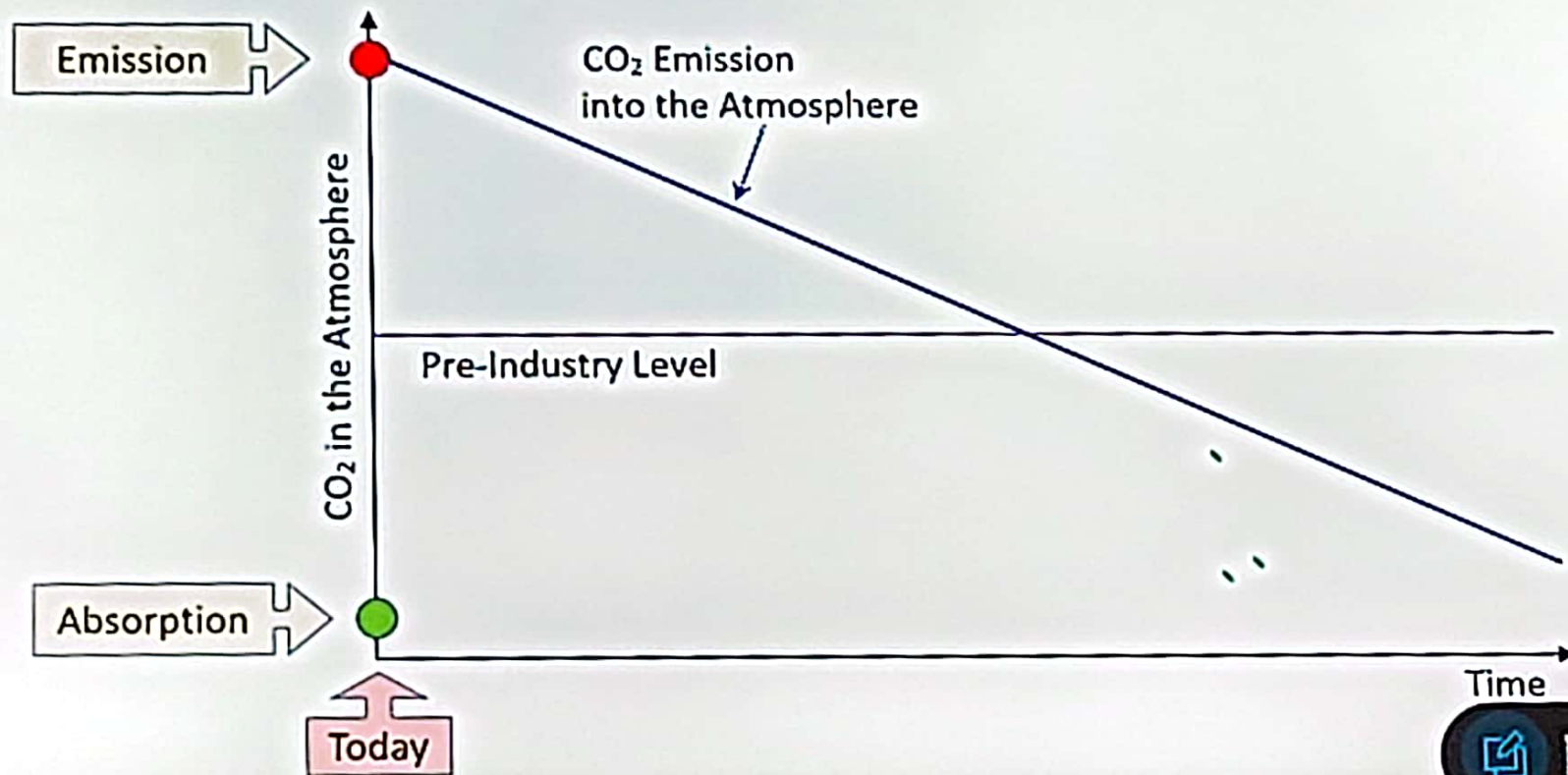
# CLIMATE ACTION TRACKER (CAT) THERMOMETER

- ❖ By the end of 2022, the rise in temperature was 1.2°C.
- ❖ At the current emission rates of GHGs, global temperature could increase by 2°C by 2050.



# NET ZERO EMISSION TARGET

- ❖ The Paris Treaty aims to reach global Net-Zero Emissions by the mid of this century.
- ❖ Net zero emission means achieving a balance between
  - ✦ the Green-House Gas emitted into the atmosphere
  - .AND. ✦ the Green-House Gas absorbed from the atmosphere



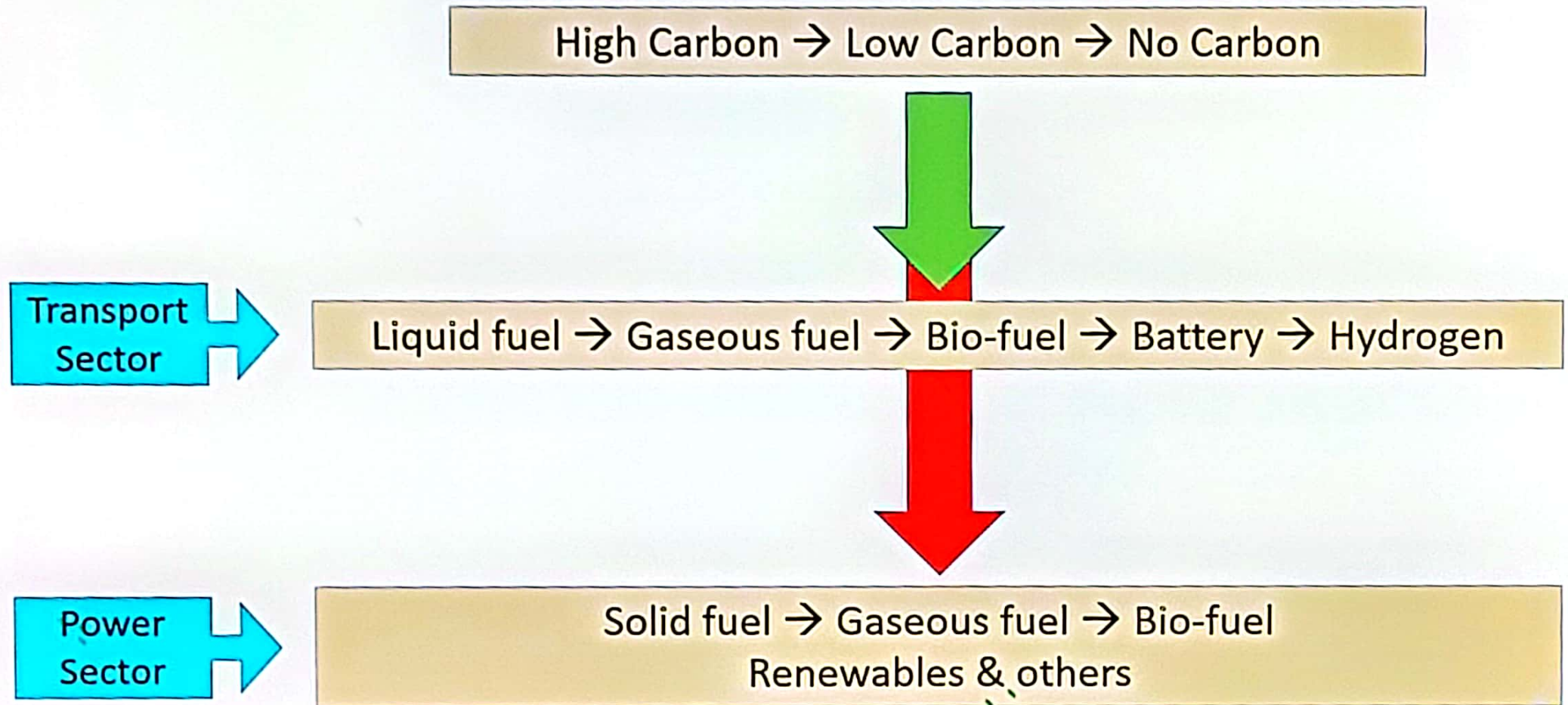


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  - ✦ the Green-House Gas emitted into the atmosphere
  - ✦ the Green-House Gas absorbed from the atmosphere
- ❖ Objective is to reduce net GHG emissions by 100%, by 2050 relative to 1990 levels.
- ❖ This needs the transformation of every sector of the world economy, which include:
  - ✦ Power
  - ✦ Transportation (land, water and air)
  - ✦ Industry
  - ✦ Agriculture



# OPTIONS TO DECARBONISE ENERGY SECTOR





# OPTIONS TO REDUCE VEHICULAR EMISSIONS

$$\text{Vehicle Emission} \propto \left\{ \begin{array}{l} \text{Type of fuel} \\ \text{Share of carbon in the fuel} \\ \text{Vehicle efficiency} \\ \text{Distance travelled} \end{array} \right.$$



# OPTIONS TO REDUCE VEHICULAR EMISSIONS

$$\text{Vehicular Carbon Emissions} = \frac{\text{Carbon}}{\text{Fuel}} \times \frac{\text{Fuel}}{\text{Distance}} \times \frac{\text{Distance}}{\text{Vehicle}} \times \text{Vehicle}$$

Possible Options →

Low  
Carbon  
Fuels

Efficient  
Vehicle

Efficient  
Roads

Reduce  
Vehicle  
Use

Responsibility ? →

Designer & Manufacturer

Govt. & Individuals

How to realise ? →

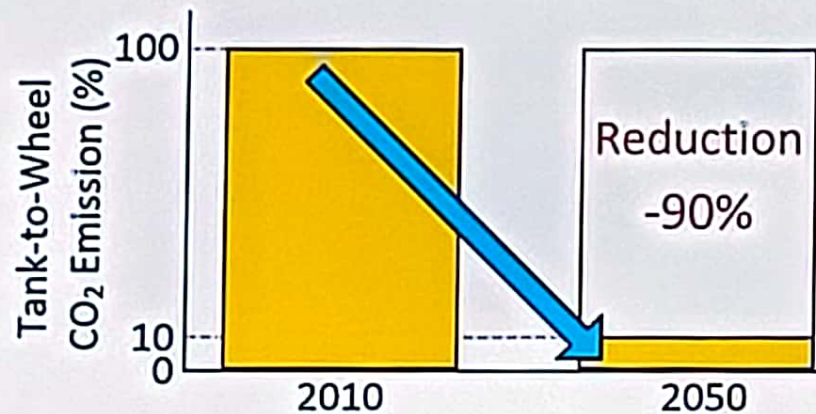
- ❖ Light-weight materials
- ❖ Low-rolling resistance tyres
- ❖ Regenerative braking
- ❖ Electric and hybrid vehicles
- ❖ Hydrogen powered vehicles



# CO<sub>2</sub> EMISSION TARGETS BY AUTO MAKERS

Auto makers target set in 2015:

- ★ 90% reduction in vehicular emissions by 2050 (as that of 2010 level)



Auto makers target set in 2020:

- ★ 2030 : Zero-emission standard for all new cars
- ★ 2040 : Net-zero for all transportation sectors
- ★ 2047 : In India, all vehicles will be zero emission

# TOWARDS ZERO CARBON FUEL EMISSIONS

Towards Zero Carbon Emissions

Solid fuels



Wood



Coal

Liquid fuel



Petroleum



Bio-oil

Gaseous fuels



Natural Gas



Hydrogen

10 atoms of C  
for 1 atom of  $H_2$

2 atoms of C  
for 1 atom of  $H_2$

1 atom of C  
for 2 atoms of  $H_2$

1 atom of C  
for 3 atoms of  $H_2$

1 atom of C  
for 4 atoms of  $H_2$

Zero Carbon

Hydrocarbons

Increasing Share of Hydrogen in Fuels



# OPTIONS TO DECARBONISE ROAD TRANSPORT

