Energy Usage by Humans:
Estimate of Impact on Atmosphere

Learning objectives:

1) To carry out calculations based on usage of energy by humans
2) To estimate the impact on the atmosphere of energy usage by humans

10^{18}

World energy usage per year : 500 exa joules

Image Credit NASA

Major constituents of dry air, by volume

Name	Formula	Volume in %
Nitrogen	N_2	78.084
Oxygen	O_2	20.946
Argon	Ar	0.9340
Carbon dioxide	CO_2	0.04
Neon	Ne	0.001818
Helium	He	0.000524
Methane	CH_4	0.000179

Not included in above dry atmosphere:

Water vapour	H_2O	0.001%–5%

Water vapour is about 0.25% by mass over full atmosphere

Water vapour strongly varies locally

Source: https://en.wikipedia.org/wiki/Atmosphere_of_Earth

Layers of the atmosphere:

Exosphere:	700 to 10,000 km
Thermosphere:	80 to 700 km
Mesosphere:	50 to 80 km
Stratosphere:	12 to 50 km
Troposphere:	0 to 12 km

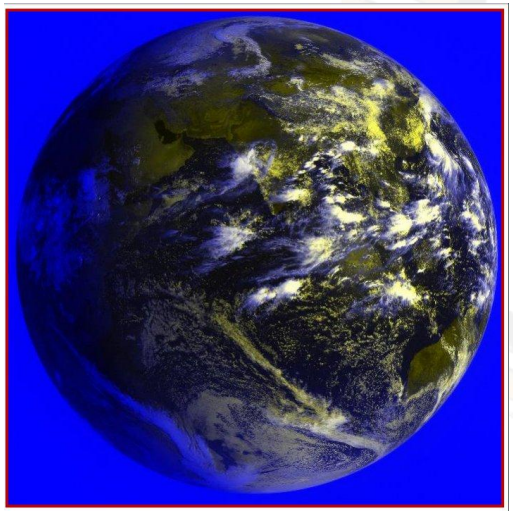
Approximately 80% of mass of Earth's atmosphere is in the Troposphere

Source: https://en.wikipedia.org/wiki/Atmosphere_of_Earth

Radius of Earth: 6371 km

Volume of Earth: 1.083×10^{21} m^3

Volume of Troposphere: 6.133×10^{18} m^3



INSAT 3DR, 18th Sept. 2016
Image Credit: ISRO

Volume of Troposphere: $6.133 \times 10^{18}\ m^3$

Volume of CO_2: $2.453 \times 10^{15}\ m^3$

Composition of Crude oil by weight:

Element	Percentage by weight
Carbon	83 to 85%
Hydrogen	10 to 14%
Nitrogen	0.1 to 2%
Oxygen	0.05 to 1.5%
Sulfur	0.05 to 6.0%
Metals	< 0.1%

Source: https://en.wikipedia.org/wiki/Petroleum

Combustion of carbon:

ΔH for formation of CO_2 = -394 kJ/mol

1 mole of CO_2 corresponds to 22.4 l at STP or 22.4×10^{-3} m^3 at STP

STP is 0^o C and 1 atmosphere pressure

Therefore 5×10^{20} J of energy corresponds to a release of:

$$\frac{5 \times 10^{20} \times 22.4 \times 10^{-3}}{3.94 \times 10^{5}}$$

$= 2.843 \times 10^{13}$ m^3 of CO_2

Therefore, time required to double the CO_2 in the atmosphere at the present rate of usage is:

$$\frac{2.453 \times 10^{15}}{2.843 \times 10^{13}} = 86 \text{ years}$$

Conclusions:

1) Energy usage by humans can significantly impact the composition of the atmosphere
2) This impact on the atmosphere can occur in a relatively short period of time!