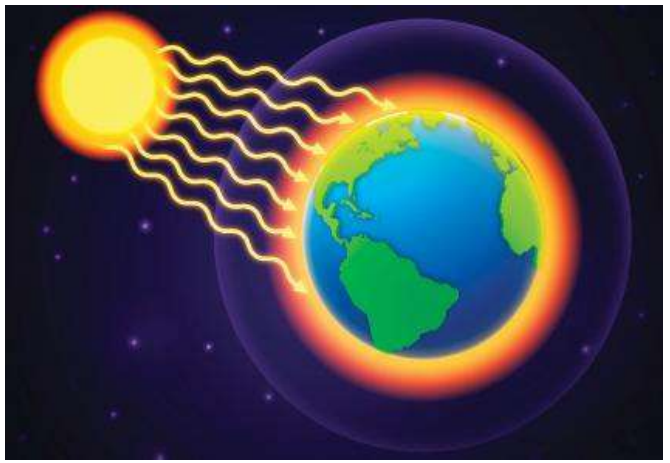
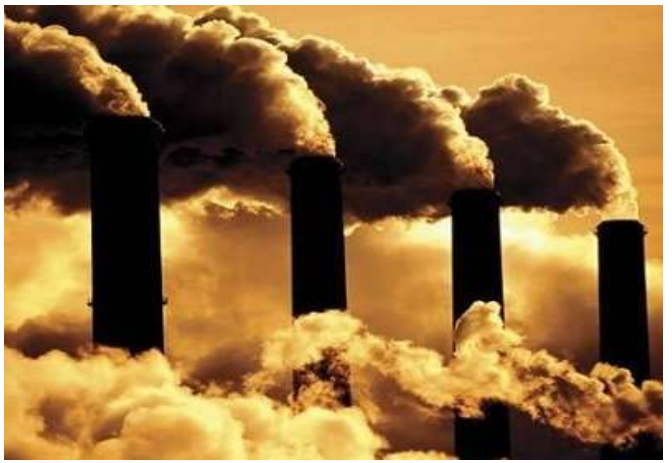



ENVC 24 : Energy and Environment

Part-5 : Environmental Implication of Energy Use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Green-house Gas Emission & Global Warming

There is a dramatic change of weather, e.g. in places with more than average rainfall has become less scarce in rainfall & other way around, meaning floods occurring at lands where rainfall was seldom. Summers are more hot & winters are more cold than past. For many centuries, human race has experienced that the season of a particular place will be of special kind, *that experience has now started to prove wrong*. After a long test, scientists have concluded that reason for this uncertainty in the climate is "Global Warming".

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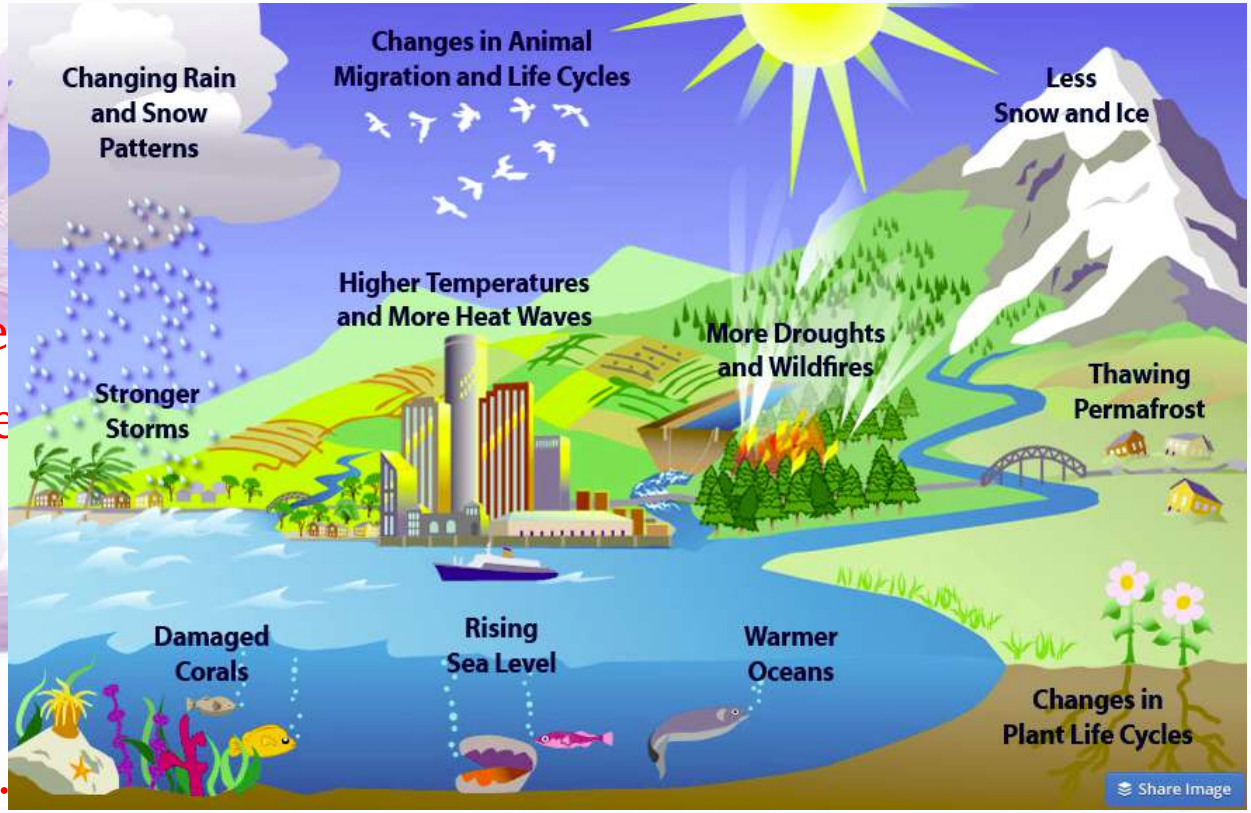
- 99% of Earth's atmosphere is with "fixed componets" (Nitrogen & Oxygen), which are not Greenhouse gas, having negligible effect on atmospheric temperature weather & climate. Absorption of infrared heat of solar beam by carbondioxide is the main source of heating the Earth's atmosphere.



Greenhouse Gas (GHG) Emissions

- Variable components, constituting less than 1% of atmospheric gases, have a greater influence on both short-term & long-term climate. The minor gases, such as water vapor, CO_2, methane(CH_4), nitrous oxide(N_2O) & sulfur dioxide(SO_2), absorb infrared heat emitted by solar beams – thus warming atmosphere. Variation in water vapor in the atmosphere changes the relative humidity.
  - Water vapor causes ~ 36 - 70% of the greenhouse effect (not including clouds).
  - Carbon dioxide causes ~ 9 - 26% of greenhouse effect.
  - Methane causes ~ 4 - 9% of greenhouse effect.
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- If CO_2 in the atmosphere continues to rise, the world will warm by 1.4 – 5.8°C by 21st century. With global temperature rise of 1.4°C, there won't be a major problem due to climate changes. However, if the temperature rises to the highest level of 5.8°C, there would be a dramatic change in climate, with disastrous consequences across the world.

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Global Warming Potential (GWP)

Global Warming Potential (GWP) is used within the Kyoto Protocol as a measure for the climatic impact of emissions of different GHG. GWP is calculated in terms of the 100-year warming potential of a kilogram of a gas, relative to that of a kilogram of CO_2 when computing overall sources and sinks. GWP typically have an uncertainty of $\pm$**35%**. CO_2 equivalents are commonly expressed as million metric tons of CO_2 equivalents ($MMTCO_2Eq$). Conversion formula is,

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Keeling Curve

Data on the increase in quantities of CO_2 annually in the atmosphere over several decades were recorded by a U.S. scientist Charles David Keeling (1928 to 2005) in Hawaii. This displays a continuous increase in the annual concentration of CO_2, thus establishing the role of human contribution to global climate change. These measurements were further extended in 2006 to reveal a steady increase in average CO_2 concentration in the atmosphere, from ~ **315** parts per million by volume (ppmv) in 1958 to over **380** ppmv by the year 2006.

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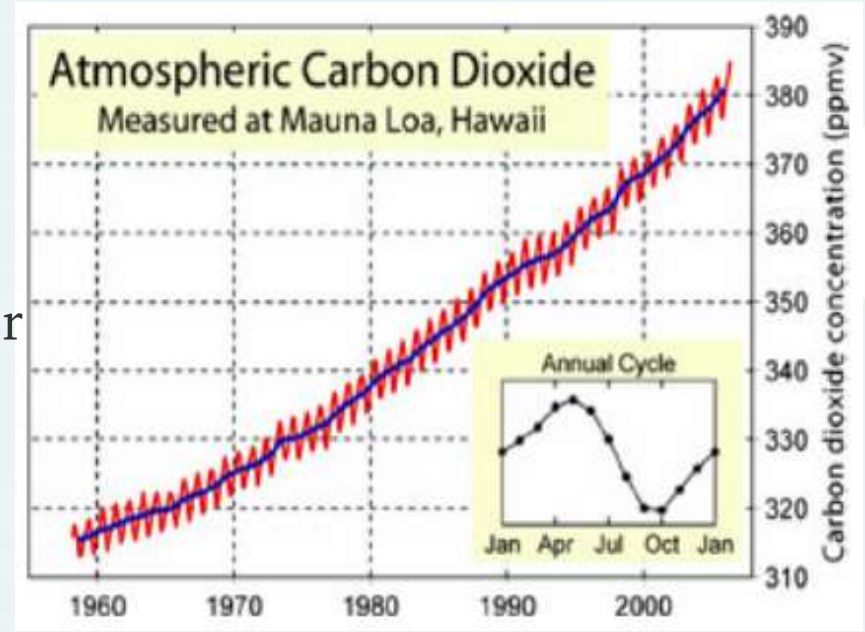
Keeling Curve



This equals **65** ppmv in the last 40 years, **15.96** ppmv over the decade 1990-2000 & **10** ppmv over the 6-year period from 2000-2006. As indicated earlier, the more recent data also indicate the same trend of increasing quantities of CO_2 in the atmosphere per year at a higher rate every year than the preceding one.

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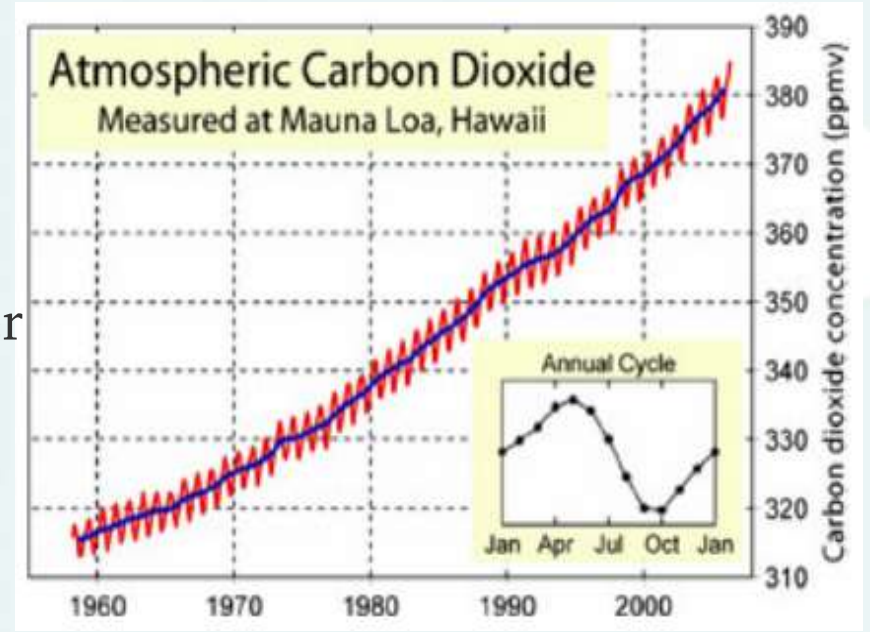

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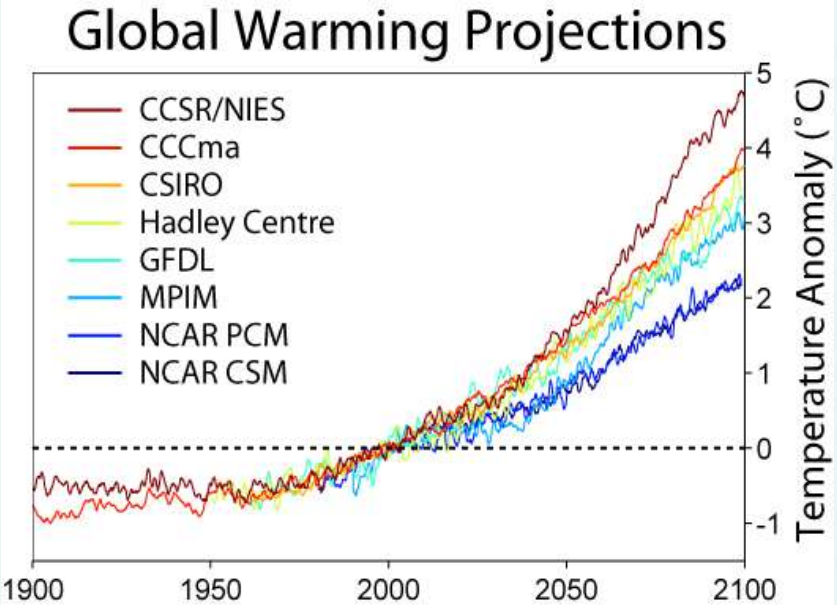
Global Warming Projection



Global warming increased the Earth's average near-surface air temperature by **0.74°C** during the last century. However, the enhanced concentration of GHG from man-made sources in the atmosphere can provoke a global average temperature rise of **2°C** as early as 2035. Various agencies have shown an increase in temperature from 2-5°C in 2100.

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Global Warming Projection

Increase in global temperature at these levels will have a great impact on the climate across the world. In the longer term, there will be more than a 50% chance that the temperature rise will exceed **5°C**. This rise would be equivalent to the change in average temperatures from the last ice age to today. To avoid the worst effects of global warming, the mean global temperature rise must be kept below **2°C**.

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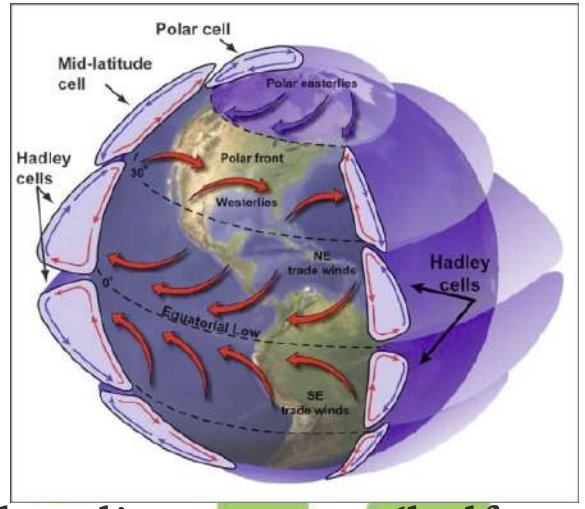
Effects of Climate Change due to Global Warming



Extension of Hadley's Cycle : Tropical belt covering Hadley's circulation has extended by **2 - 4.5°** in latitude (North-South NS), i.e. **225-530km** beyond the 1979 figures of **23.5°** NS in latitude. Global warming & depletion of the ozone layer are found to be responsible for extensions of Hadley's circulation cell. The expansion of the hot tropical & higher-temperature dry climate zone (half-covered by Hadley's cycle) has an effect on the mesothermal climate zone. Changes in climate zones lead to a fundamental shift in ecosystem & human settlements.

Disasters : Apart from normal seasonal variations in weather, change in wind circulation resulting from major fluctuations in temperature & pressure can cause abrupt changes, leading to disasters such as storms, cyclones, tornadoes, hurricanes, El Niño, La Niña etc. These disasters are observed more frequently with greater intensity.

Destruction of Biomes - Irreversible Change in Ecosystem : Biome is usually considered to have the attributes of a climax community i.e. a community that represents the most developed combination of plants & animals possible under the environmental conditions at a given time in a given area. Biomes are dynamic entities & can retain equilibrium to a considerable degree of variations in environmental conditions, such as those occurring during seasonal changes. However, prolonged environmental disruptions, such as that caused by climate change or fire, may alter a specific ecosystem irreversibly & bring a system with different characteristics. As a result, maps of biomes only represent the period in which they are in existence.

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Green Technologies to Reduce Global Warming

According to ***PBL Netherlands Environmental Assessment Agency*** & ***European Commission's Joint Research Centre***, increased energy efficiency, nuclear energy & the growing contribution of renewable energy are not compensating for the globally increasing demand for power & transport, which is strongest in developing countries. Also, the contribution of the ***Kyoto Protocol*** targets to global GHG emission mitigation is rather limited. It is clear that the climate & energy policies introduced after the protocol have served to stimulate & enhance many of the new economic & technological developments in the area of so-called ***green technologies*** which would otherwise not have been penetrated so fast in the market. Emissions from energy, transportation & manufacturing industries constitute **89%** of Global emission.

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Green Technologies to Reduce Global Warming

While transportation sector has been able to reduce emission figures through adoption of Green technologies, power plants have made a significant breakthrough by development of ultramega supercritical coal-based technologies. Top emitting sector (**40%** emission) includes thermal power plants using fossil fuels. Life of a thermal power plant is 50-100 years, so it's impossible to close down these plants just because they are the worst emitters of CO_2 . On the other hand, more of these plants are required to cater to the growing need for electricity. Green technologies are being used increasingly to improve the efficiencies of existing power plants & to develop materials that withstand degradation processes in the severe environmental conditions of the newly developed, highly energy-efficient supercritical & ultra-supercritical power plants. High energy-efficient processes with substantially low emission figures are called ***clean*** processes. The fiscal incentives in terms of carbon credits & liberal funding under the Kyoto Protocol's Clean Development Mechanism (CDM) have led to the development of clean processes by developed countries & the establishment of the same in developing countries.

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Corporate social responsibility (CSR)

CSR is a positive endeavor for the prosperity & well-being of both the corporations & societies in which they belong. The CSR activities allow the company to:

- Reduce GHG emissions & thus earn carbon credits, a tradable commodity that adds to the income. With carbon emissions beyond a specified limit, carbon credits for the excess carbon must be purchased at the existing market price.
- Encourage responsible use of resources, work for conservation of resources & develop renewable and sustainable resources. Efforts in these directions will reduce cost & improve sustainability. Recycling of metallic & other materials from generated scrap leads not only to the conservation of nonrenewable resources, but also improves the sustainability of the resource & results in cost reduction.
- Utilize waste or ensure proper disposal by introducing environmental-friendly waste-management techniques. A good environment & healthy atmosphere in the workplace improves productivity.

Corporate social responsibility (CSR)

- Reducing energy requirements by using energy-efficient processes, process automation & so on will reduce costs + earn carbon credits.
- Improving overall efficiency leads to higher productivity & lower cost of production.
- Improve sales figures by marketing real ***green*** products with a ***"green"*** tag.

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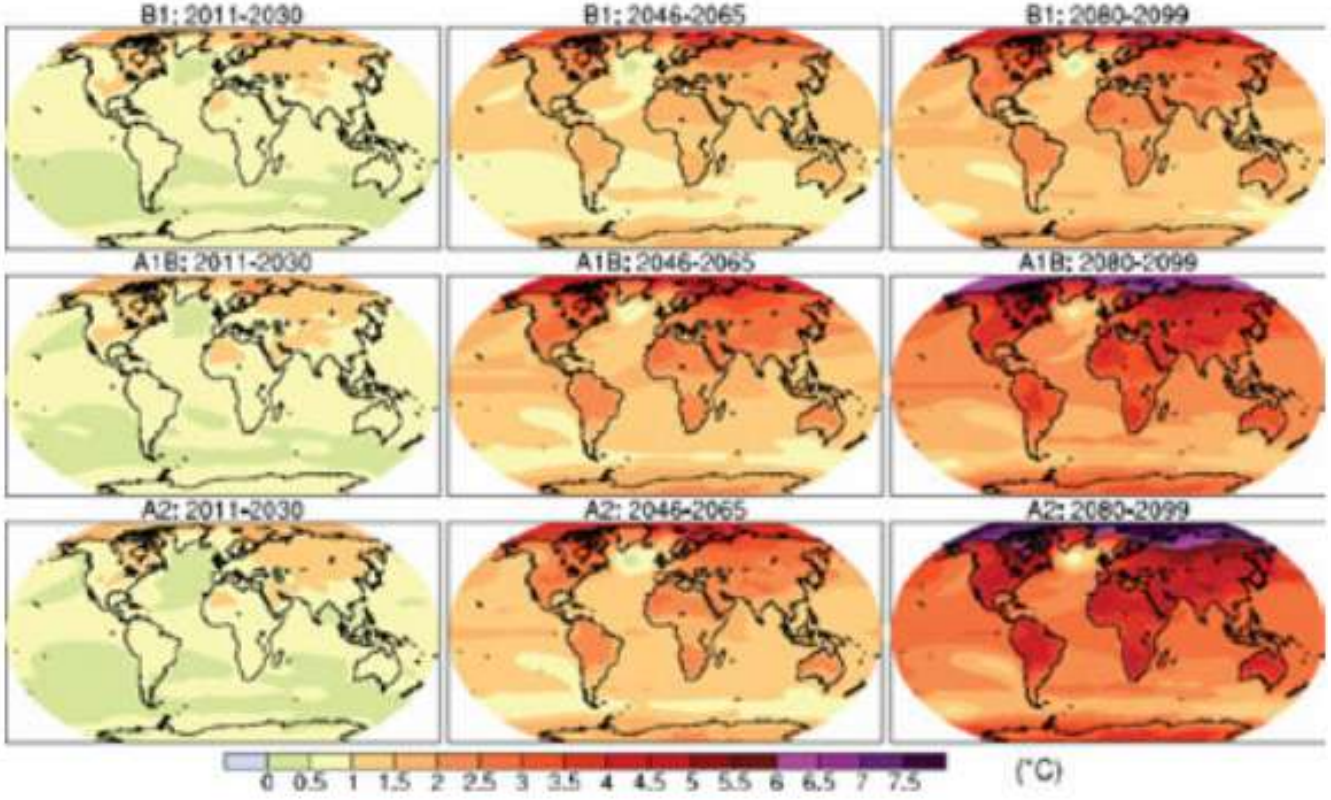
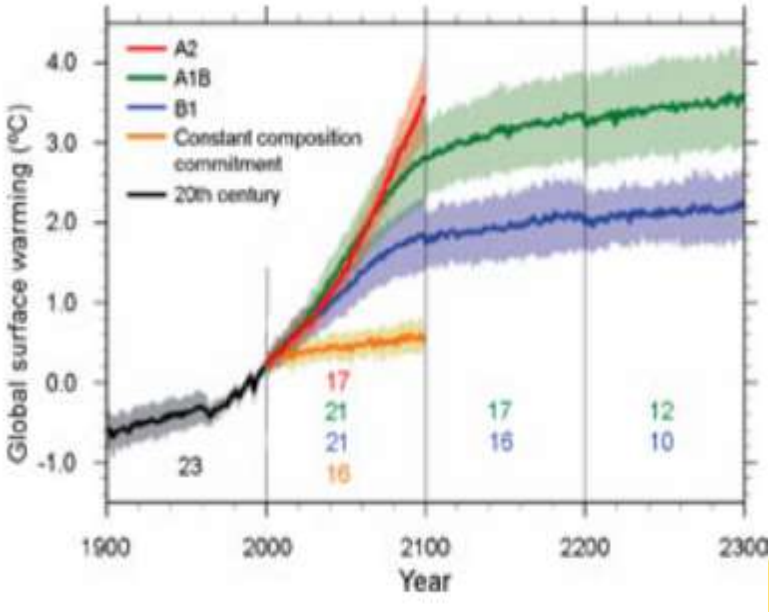
Global surface warming





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Energy security is the association between national security & the availability of natural resources for energy consumption. Access to relatively cheap energy has become essential to the functioning of modern economies. However, the uneven distribution of energy supplies among countries has led to significant vulnerabilities. Renewable resources & significant opportunities for energy efficiency exist over wide geographical areas, in contrast to other energy sources, which are concentrated in a limited number of countries. Rapid deployment of renewable energy, energy efficiency & technological diversification of energy sources would result in significant energy security & economic benefits.

Threats ➔ Threats to energy security include the political instability of several energy producing countries, manipulation of energy supplies, competition over energy sources, attacks on supply infrastructure/accidents, natural disasters, terrorism & reliance on foreign countries for oil.

Long-term security ➡ Long-term measures to increase energy security center on reducing dependence on any one source of imported energy, increasing the number of suppliers, exploiting native fossil-fuel or renewable energy resources & reducing overall demand through energy conservation measures. It can also involve entering into international agreements to underpin international energy trading relationships. All concern coming from security threats on oil sources long term security measures will help reduce the future cost of importing and exporting fuel into and out of countries without having to worry about harm coming to the goods being transported.

Impact of 1973 oil crisis & emergence of Organization of the Petroleum Exporting Countries (OPEC) cartel was a particular milestone that prompted some countries to increase their energy security. Japan (totally dependent on imported oil) introduced use of natural gas, nuclear power, high-speed mass transit systems & implemented energy conservation measures. UK began exploiting North Sea oil & gas reserves & became a net exporter of energy in 2000.

Long-term security

USA has continued to increase its dependency on imported oil although, following oil price increase since 2003, development of biofuels has been suggested.

Increasing energy security is also one of the reasons behind a block on the development of natural gas imports in Sweden. Greater investment in native renewable energy technologies & energy conservation is conceived. India is carrying out a major hunt for domestic oil to decrease its dependency on OPEC, while Iceland is planning to become energy independent by 2050 through deploying 100% renewable energy.

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Short-term security ➡ Petroleum, Natural Gas, Nuclear Power, Renewable Energy.

Crude oil is essential resource of Russia, China (70.5% coal dependent) & USA. Natural gas consists mostly of methane which is produced in 2 ways: ***biogenic*** & ***thermogenic***. Biogenic gas comes from methanogenic organisms located in marshes & landfills, whereas thermogenic gas comes from the anaerobic decay of organic matter deep under Earth's surface. ***Russia is the leading country in production of natural gas.***

Short-term security

Uranium for nuclear power is mined & enriched in Canada (23% of World's total), Australia (21%), Kazakhstan (16%) etc. Uranium is more common in the Earth's crust than Tin, Mercury or Silver & nuclear power reduces carbon emission. Currently, nuclear power provides **13%** of the world's total electricity. Geothermal, Hydro-electric, Biofuels (ethanol & algae) are cleaner than the consumption of petroleum. Most Life Cycle Analysis (LCA) results for perennial and ligno-cellulosic crops conclude that biofuels can supplement anthropogenic energy demands & mitigate GHG emissions to the atmosphere. Using oil to fuel transportation is a major source of GHG, so any one of these developments could replace the energy we derive from oil. Traditional fossil fuel exporters (e.g. Russia) struggle to diversify away from oil & develop renewable energy.

Energy Budget

Earth's energy budget accounts for the balance between energy Earth receives from the Sun & energy Earth radiates back into outer space after having been distributed throughout the **5** components of Earth's climate system & having thus powered the so-called ***Earth's heat engine.*** This system is made up of water, ice, atmosphere, rocky crust & all living things.

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- *Received radiation* is unevenly distributed over the planet, because Sun heats equatorial regions more than polar regions. Atmosphere/ocean work to even out solar heating imbalances through evaporation of surface water, convection, rainfall, winds & ocean circulation. Earth is in *radiative equilibrium* where incoming solar energy is balanced by an equal flow of heat to space & global temperatures are relatively stable. In a year, land surfaces, oceans & atmosphere absorbs & radiates back to space ~ **240** Watts of solar power/square meter.

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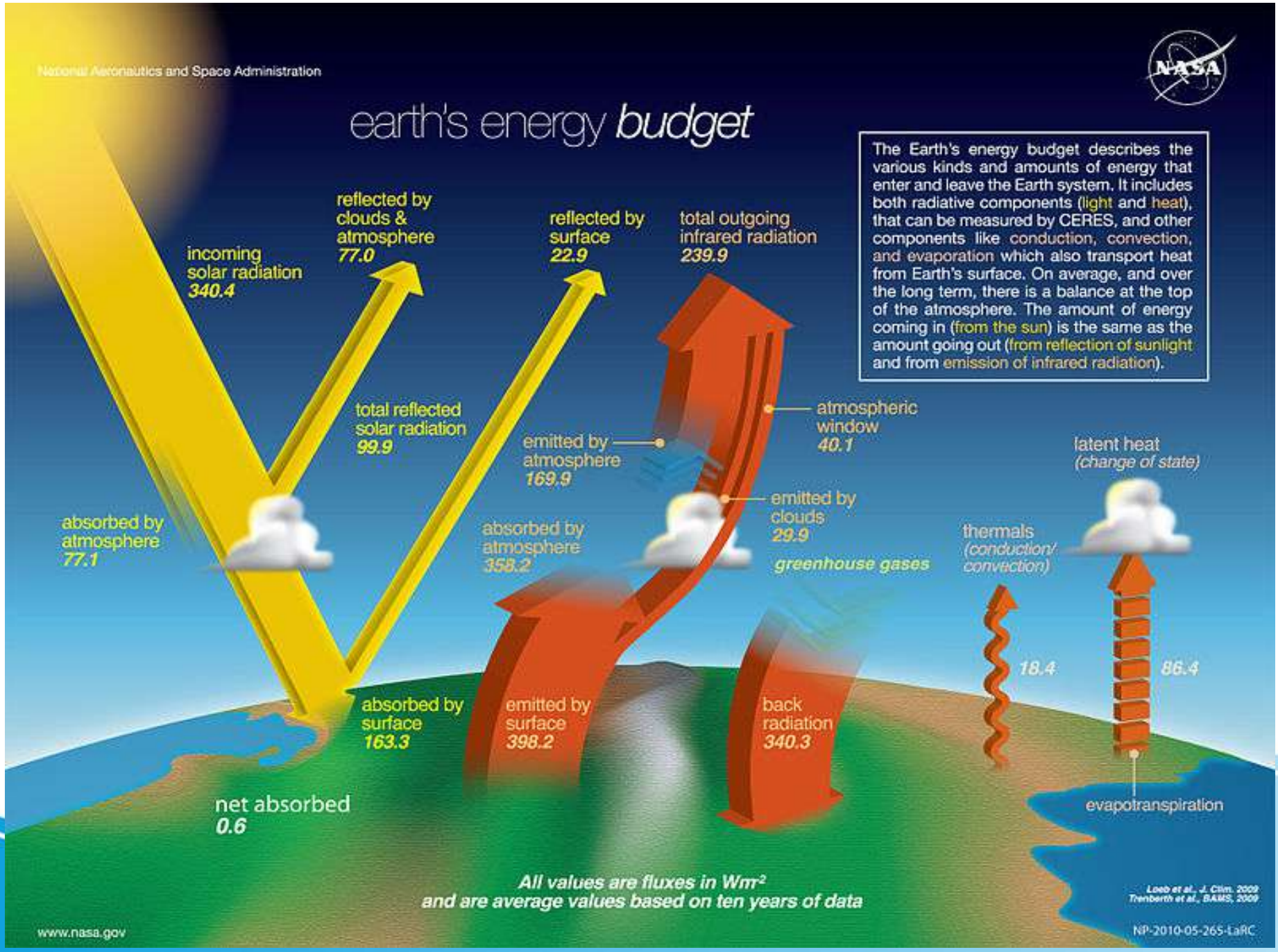
Energy Budget



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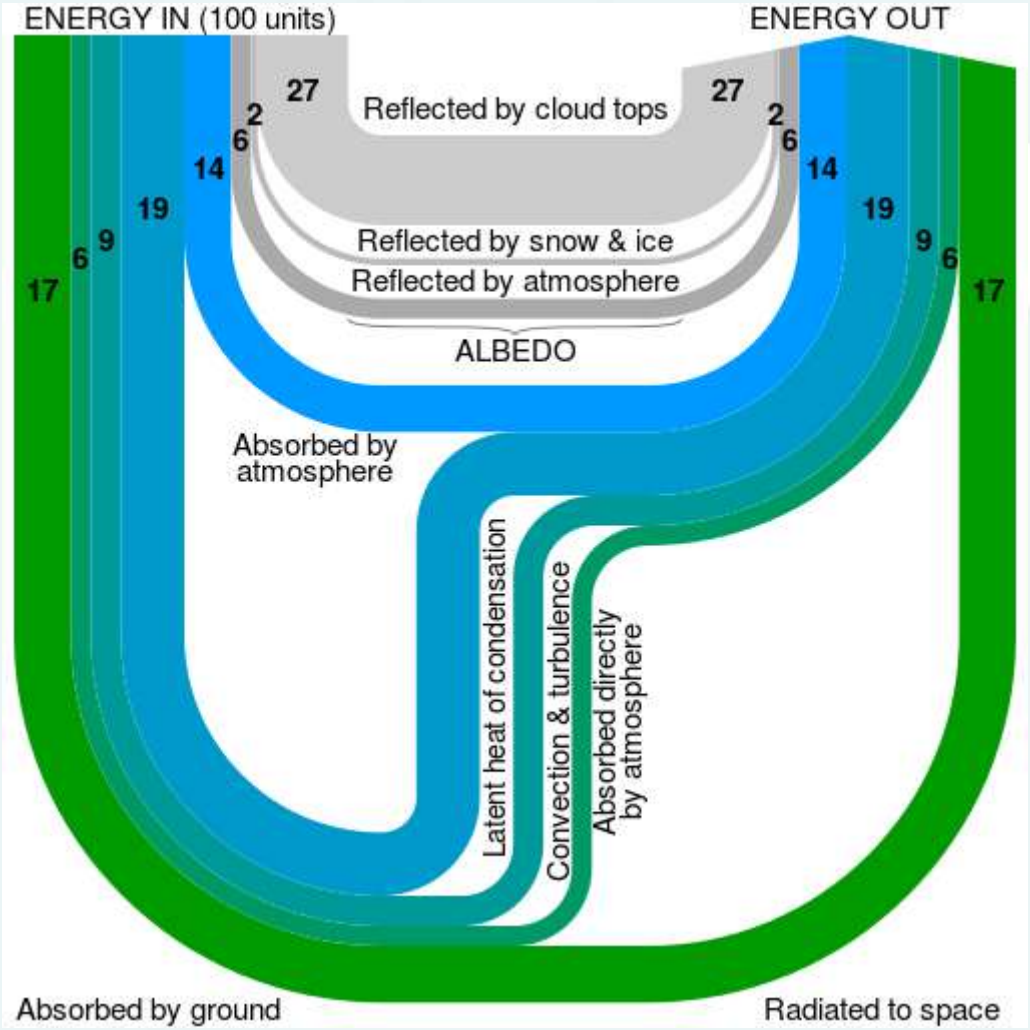
Sankey Diagram

To quantify Earth's heat budget/heat balance, let the insolation received at the top of atmosphere be **100** units (**100 units ~ 1360 Watts/square-meter**). Called the "***albedo***" of Earth ~ **35** units are reflected back to space (*27 from top of clouds, **2** units from snow/ice-covered areas & **6** units by other parts of the atmosphere*). **65** remaining units are absorbed (***14*** *within the atmosphere &* ***51*** *by Earth's surface*).



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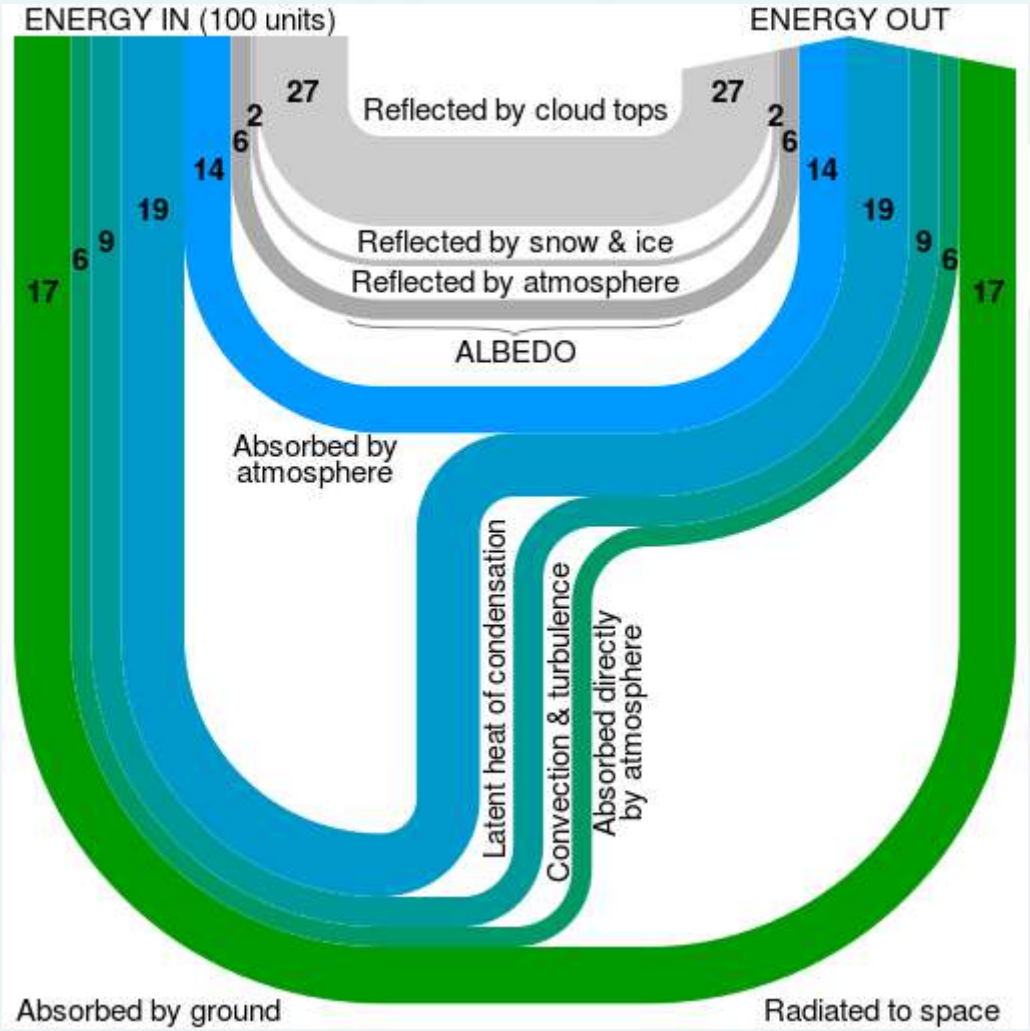

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Incoming shortwave radiant energy

Average flux at top of atmosphere (TOA) = $\frac{Solar\ Constant}{4}$ = **340 *Watt / m*^{2}**.

Of this received radiation by Earth, ~**77 *Watt / m*^{2}** is reflected back to space by clouds & the atmosphere & ~**23 *Watt / m*^{2}** is reflected by the surface albedo, leaving ~ **240 Watt/m^2** of solar energy input to the Earth's energy budget.

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Earth's heat & other effects

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Longwave Radiation

Longwave Raditation is the outgoing infrared energy leaving the planet.

GHG, Energy Security & Budget

We have finally posed Greenhouse Gas Emission, Energy security & Energy Budget as the final step to understand & save the environment while using different energy resources. Through a proper EM on these aspects can bring balance & save the planet from (blind) human greed.

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