GREENHOUSE EFFECT AND ITS IMPLICATIONS

Some information for those who may not know much about the causes and implications of the "Greenhouse Effect"

For those of you who have been living under a rock or asleep for the last 20 years or those who want to know more about it, here is a brief article.

- The Greenhouse Effect maybe the most important natural phenomena and may lead to major changes in our lifestyles within our lifetime.

Today, whenever there is a natural disaster, the Greenhouse Effect seems to be on the agenda. It wasn't so long ago that scientists were dismissive of the Greenhouse Effect and there are some still that do not believe it exists, just like there are still people out there that think the world is still flat and the Holocaust never existed. So what is the Greenhouse Effect?

What is the Greenhouse Effect?

The Greenhouse Effect is the culmination of various Greenhouse gases that have been trapped in the Earth's stratosphere that is leading to the changing of the word's climate.

- Under the influence of the sun's rays, the earth's temperature varies from 0 to about 50^{o}C with an average through night and day, winter and summer, of about 15^{o} C
- The warming is done by rays from the sun, including the very shortest, ultraviolet (UV) rays and the longest infra-red (IR) rays which give you that warm feeling when you walk out into the sunshine, much like an electric radiator warms you when you turn it on and get close to it.
- Some of the incoming rays are reflected back by the clouds in the sky and others by the sea and land, particularly deserts and snowfields.
- Not all those reflected rays go back into space, instead, the atmosphere re-radiates many of the IR rays towards the earth making it warmer still. It is this ability of the atmosphere to re-radiate warm rays which creates the Greenhouse Effect.
- Water vapour, carbon dioxide and certain other trace gases, absorb some of this radiation and prevent it being sent back into space. This "blanket effect" keeps the earth warm.

History of the Greenhouse Effect

It is not a new phenomena or concept. The term ***"Greenhouse gas"*** was first used in the Nineteen Century, by Irish born scientist John Tyndall in a paper he wrote in London's *Philosophical Magazine* in 1863.

It wasn't until the 1960's that Professor Bert Bolin of Stockholm University worked on the phenomenon. When he discussed it with fellow scientists they said "*This is science fiction. We don't believe it*". However by the mid 1970's things were starting to change rapidly as scientists were starting to accept he was right.

How do we know the Greenhouse Effect exists? What is the evidence?

1. **Scientists have analysed climates on planets like Venus and our moon.**

   Venus which is covered by a very dense atmosphere of carbon dioxide. Its surface temperature is around 500^{o} C. Whilst the moon which has no atmosphere has an average temperature of approximately -18^{o}C. Our atmosphere keeps the surface of our earth, with an average of 15^{o} C, some 33^{o} C warmer and thus habitable.

2. Evidence of ice cores

Over the past 160,000 years carbon dioxide and methane levels trapped in ice cores have varied with global temperature. Scientists have been able to drill out ice cores from the Arctic and Antarctic and measure the levels of carbon dioxide and methane.

3. Increase in surface temperature of approximately 0.5^{o}C over 100 years as carbon dioxide levels increase

Studies conducted by scientists have concluded that the earth's temperature remained fairly constant until the start of the Industrial Revolution. Indeed it did not change much until the start of the twentieth century.

- From 1880 to 1940 there was a warming of just a quarter of a degree. Most of it was lost between 1940 and 1970.
- From 1950 to 1980 the average surface temperature was 15^{o}C.
- Between 1970 and 1980 the temperature average went up by three-tenths of a degree C.
- 1987 and 1988 were the warmest years on record

4. Sea levels are rising and small glaciers are melting

Scientists using satellite and imaging technology have been able to monitor the melting of polar ice caps and glaciers.

What are the results of the Greenhouse Effect

By using very sophisticated computer modeling, scientists have been able to predict what the world's climate will be like when carbon dioxide levels have doubled.

1. Increase in world's temperature

It is thought that there will be an increase in the average global temperature by between 1.5 and 4.5^{o}C .

- By year 2030 an increase of 2^{o}C, by 2100 an increase of 6^{o}C.

The warming will be greater at higher latitudes and in winter. This will lead to the melting of polar ice caps and glaciers which is already evident, in places like Greenland, the Arctic and Antarctic.

2. Changes in World's climate

The Greenhouse Effect will lead to world-wide changes in weather and climate. Some places may get more rain and storms while other places may get less. Not all changes will be bad. However, almost everywhere in the world will have changes in weather, which will have a big impact on our lives

3. Rising Sea Level

It is estimated that by the year 2030, the average sea level will increase by approximately 20cms. This will be due mainly to the melting of the polar ice cap, but also warming of the atmosphere will heat the upper layers of the oceans, which will expand when heated.

For low lying countries in the Pacific like Tuvalu and Kiribati, and in the Indian Ocean like Maldives and other countries like Holland may altogether disappear.

4. Other impacts

Other impacts could be the dieing out of some species of animals and plants, such as coastal marine environments and coral reefs. Some plants would not be able to survive temperature increases. It takes thousands of years for forests to move north or south to cooler climates. According to Joel B. Smith,

co-author of an EPA report states that "**such a warming over a century would require forests to move five times faster than the fastest rate recorded by paleontologists since the end of the last ice age**".

What are the primary Greenhouse gases?

They are a number of organic compounds which have more than two bonds (i.e 3 atoms). The seven major Greenhouse gases are:

1. Carbon Dioxide (CO_2)
2. Ozone (O_3)
3. Methane (CH_4)
4. CFC's (Freons F11 & F12)
5. Water vapour (H_2O)
6. Nitrous Oxides (NO_x)
7. Ethane (CH_3CH_3)

Where do they come from?

- Most of the Greenhouse gases have resulted from the burning of fossil fuels. Everything from power stations, motor vehicles, refrigerators, and factory emissions
- However, CO_2 also results from deforestation which releases carbon locked in the soil when trees are felled.
- CH_4 is released from agriculture such as sheep, cattle and manures and places such as tips, sewage treatment plants and mines.

Fossil Fuel contributions

Due to the nature of carbon to hydrogen ratio, different fossil fuels emit different levels of CO_2.

Fossil Fuel	Carbon to Hydrogen Ratio
Coal	Approx. 1:1
Oil	Approx. 1:2
Natural Gas	Approx. 1:4

Table 1: approximate carbon to Hydrogen ratio for various fossil fuels

- **Hence combustion of coal produces twice the CO_2 of natural gas**

CO_2 Levels in the atmosphere

Pre Industrial Revolution	270 ppm
1988	345 ppm
Today	>355 ppm

Table 2: Levels of CO_2 in ppm (parts per million)

- By measuring bubbles of gases trapped in polar ice, scientists have shown that the amount of CO_2 in the atmosphere prior to the Industrial Revolution was about 270 parts per million (ppm).
- A special monitoring station established atop from the mountain Mauna Loa in the Hawaiian Islands showed that by 1957 CO_2 levels in the atmosphere to 315 ppm, an increase of 17%.
- By 1988, it had passed 345 ppm. A rise in 31 years of another 11%. An increased total of about 30% since the start of the Industrial Revolution.
- Expert's further forecast that CO_2 will reach a level of 500-700 ppm by the year 2050, a doubling inside 200 years.

Percentage Contribution of Greenhouse gases to the Greenhouse Effect

CO_2	55%
CFC (F-11/F-12)*	17%
CH_4	15%
NO_2	6%
Other	7%

Table 3: Percentage contribution of various Greenhouse Gases

* Please note that CFCs have been phased out since the mid-nineties

To stablise atmospheric concentration of various gases at present day levels, the following reductions would be required instantly

CO_2	60%
CH_4	15-20%
NO_2	70-80%
CFC (F-11)*	70-75%
CFC (F-12)*	75-85%

Table 4: Reductions of Greenhouse Gases required to stablise atmospheric concentrations

Remaining Scientific Uncertainty

No argument that increasing concentrations of heat trapping gases will lead to an increase in average temperatures world-wide. However there is an argument about the extent in some cases of various positive and negative effects.

1. Uncertainty in effects of clouds
   Cumulus- negative cooling effect reflect incoming sunlight
   High Altitude clouds- positive effect by trapping infra-red radiation from earth
   - This uncertainty explains variation in temperatures from 1.5^{o}C to 4.5^{o}C.
2. Combustion of fossil fuels e.g. coal to sulphur dioxide ($SO_{2)}$ has cooling effect.
3. Variations in sun's output are responsible for temperature increases.
4. Ocean levels will naturally increase due to thermal expansion of surface ocean water and melting of glaciers.
   - An increase in temperature will lead to increased precipitation, which will increase ice thickness at poles, thus reducing sea level.
5. Natural regional climatic changes, such as deforestation and bushfires, as opposed to global changes.

Policies for Greenhouse Emission Reduction

Problems

1. Different countries emit vastly different CO_2 levels per capita
2. Countries have very different per capita incomes
3. Very difficult to work out the warming potential for each Greenhouse Gas in terms of CO_2 equivalent.
4. Emissions of gases from various countries are not known with certainty

Policies

1. Each country can reduce by the same percentage
   - Existing emission levels are uneven per capita are taken as standard
   - Poor countries want to increase fossil fuel usage

2. Each country gets the same emission quotas on a per capita basis. These countries sell quotas to rich countries.

3. Rich countries could reduce emissions by 20% with no reductions required by poor countries.

   - Not all rich countries have high emissions of CO_2, and not all poor countries are low emitters because of deforestation.

4. Assume Australia which is high income and high Greenhouse Gas emitter per capita is required to reduce emissions by 20%.
   - How should it be reduced? By:
     a) each state?
     b) each industry section?

Some methods of reducing CO_2 emissions that have negative impact on our lives

- Better managing of natural resource;
- Reducing waste in manufacturing;
- Find alternative end uses for waste (recycle and reuse);
- Buying less junks and goods that we don't need (In Australia, estimated to be worth AUD$10 billion per annum);
- Buying quality goods that don't need replacing as often;
- Recycling more (e.g. it takes about 8 times more energy to convert bauxite to aluminium than it does to recycle it)
- Reduced use of motor vehicles;
- Increased use of public transport;
- More efficient lighting, heating and cooling;
- Better insulation;
- Less reliance on electricity and electrical goods and machines;
- More efficient electrical appliances;
- More efficient cars;
- Alternative technologies from natural sources such as wind, thermal and tidal;
- Converting landfills and sewage plants into methane plants;
- Bio-fuels such as bio-diesel, methanol and ethanol production from organic sources
- Reduce large scale deforestation and land clearing;
- Increase tree planting;
- More efficient agriculture including No till and Conservation agriculture methods;
- Organic farming.

Bibliography

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