

## **Climate Change: To What Extent Should We Mitigate and/or Adapt?**

**By Philip Curtis, P.Eng.**

To answer this question, we first must address current controversy surrounding stolen correspondence and documents from climate scientists. It is known that this criminal act was initialized by the powerful oil companies and statements were taken out of context, or where true, the statements aren't disputed by climatologists. It is well known that even the best climate models need to be adjusted to match current measurements of temperature, ice melt, or sea level rise. This procedure is common and is responsible for the strength of science, not a weakness. Further, climatologists may admit that more temperature data of the oceans is required at this time. Again, this is recognized as a way to make the evidence for climate change stronger, as it is the evidence to date that tells us that climate change is a fact, and hence, no debate exists.

It is the purpose of this column to present the factual evidence in support of current climate change and the predictions for much greater change. As a Chemical and Biochemical Engineer, I feel qualified to understand the evidence, although I admit, I am not a climatologist, yet my vocation has been to study the southern Ontario climate for twenty years, including the history of this climate. I have tried successfully to study the best sources of climate change data; that being from the North American Oceanographic and Atmospheric Administration, NASA, the United Nation's Intergovernmental Panel on Climate Change, James Lovelock, Tim Flannery, and the United Nation's Framework Convention on Climate Change, and other sources such as the Scientific American journal.

Although the earth's atmosphere extends to at least 100 kilometres, due to gravity the majority of its mass is in the Troposphere, within 11 kilometres of the earth. Most of our pollution stays in the Troposphere, a mere two and a half hair widths thick when measured on a 12 inch globe. This is the thin layer to which we put some ten billion tonnes of CO<sub>2</sub> each year. Prior to the Industrial Revolution, the concentration of CO<sub>2</sub> was 284 ppm. But due to the burning of coal, oil, and natural gas since, the concentration has risen to nearly 390ppm. With thanks to the experiments of Fourier, Tyndall, and Arrhenius in the 1800's, we know the relationship between greenhouse gases and temperature. Methane is approximately 24 times more energy absorbing than carbon dioxide but its concentration is much lower, such that carbon dioxide is the predominate gas responsible for global warming, and other gases are measured by their equivalent to CO<sub>2</sub>. Other greenhouse gases include nitrous oxide, ozone, halocarbons (CFC's, etc.), and water vapour. Water vapour makes up 95% of the greenhouse gases but without it we would all be frozen.

Climate models that successfully trace the last 600,000 years of climate, only predict our current climate if the CO<sub>2</sub> we have emitted is included. This is the strongest evidence we have that mankind is responsible for the earth's warming trend. The earth's average

temperature (average of day and night temperatures on land, ocean, and atmosphere) has increased nearly one degree since the Industrial Revolution began. It cannot be overstated that due to nonlinear feedback mechanisms, it is known that even if we stop all greenhouse gas emissions, once the temperature increase reaches 2 degrees, nothing can stop it from accelerating to 5 or 6 degrees Celsius. This is due to at least six positive feedback mechanisms (positive here means “temperature increasing”). These radiative forcings are:

- 1) The demise of the Amazon Rain Forest
- 2) The release of methane hydrates from the sea floor
- 3) Ice melting at the poles (80% reduction of solar albedo (reflectivity))
- 4) The warming of oceans, releasing water vapour and ocean stratification, reducing nutrients for algae (a carbon sink).
- 5) Release of CO<sub>2</sub> and CH<sub>4</sub> (methane) from melting permafrost
- 6) Runaway use of air conditioners fueled by fossil fuels. \*

\* Note that even this late in the game, 90% of all energy use on earth comes from fossil fuels!

At this point I would like to list facts about climate change thus far that show that it is well underway yet by far the worst is to come (2080's and beyond).

- It is estimated that world population will exceed 9 billion by 2050
- By 2050, 22% of people will be over 60 years of age (making it more difficult to sustain heat and drought)
- Coal production has accelerated upward since 1840 and continues to accelerate
- The United States and China used well over a billion tonnes of oil each in 2004
- From 1977 to 2005, air traffic doubled and tripled from airports around the world
- In 2005, the United States had 6.5 million miles of paved roads
- In 2006, hydro, nuclear and renewable energy sources only totaled 10% of world's supply (90% is fossil fuels)
- Even if we reduce CO<sub>2</sub> emissions, it is expected that CO<sub>2</sub> concentrations will be out of control by 2055.
- Actual measurements of temperature and sea level rise are worse than expected.
- By 2080, the poles will have risen at least 6 degrees Celsius and the Amazon Forest will be gone!
- From 1950 to 2000, tornadoes have risen from 200 per year to 1400 per year!
- Coral bleaching (death) is occurring around the world due to ocean temperature increase
- From 1980 to 2007, Arctic Sea ice extents in September reduced from 8 million square miles to 4 million square miles.
- Measurements show that the Arctic could be ice free within 15 years!
- In 2002, the Larsen Ice Shelf of West Antarctic collapsed four times

- All glaciers in the world have been shortening drastically, leading to spring floods and summer droughts!
- Sea levels have risen 200mm and will rise 23 feet if Greenland melts.
- Permafrost represents 20% of the earth's surface and is within 2 degrees Celsius of melting, releasing 800 billion tonnes of methane and carbon dioxide.
- World floods have increased from 250 in 1981-1985 to over 800 in 2001-2005.
- Precipitation is expected to go down 400mm by 2080 in many parts of the world, but will increase by 400mm in Canada.
- Due to runoff of bicarbonate from limestone, the acidity of the oceans (H+ concentration) will go up 300% by 2150.
- The continents of Africa, Asia, and Australia are 46%, 46%, and 86% at risk of desertification respectively.
- The east coast of Australia has a ten inch deficit in rainfall in the last 50 years and its west coast has had a ten inch increase.
- Dust and sand storms have increased from five to one hundred in China since 1950.
- By 2050, most of the world will be in a moderate to severe shortage of fresh water.
- The world's annual net loss of forest is nearly 30,000 square miles (one third of which is in the Amazon).

There is one negative feedback mechanism: the collapse of the Gulf Stream. As the Arctic melts, the southward flow of fresh water has slowed the Gulf Stream flowing north from the equator by 30%. It is expected that this trend will continue, lowering temperatures in Europe. Although an ice age is not expected, the Gulf Stream could see-saw back and forth yielding highly unstable conditions and ecosystem collapses.

To quote Tim Flannery in The Weather Makers, **“Earth’s average temperature is around 59 degrees F, and whether we allow it to rise by a single degree or 5 degrees F will decide the fate of hundreds of thousands of species, and most probably billions of people. Never in the history of humanity has there been a cost-benefit analysis that demands greater scrutiny.”**

To avoid this fate, it is thought that we must become carbon neutral (zero net emissions) by 2100.

### **Solution**

It is already known that there exist enough available renewable energy sources to completely replace fossil fuels. Such sources include solar, wind, nuclear, geothermal, wave, and catalyzed electrolysis of water (hydrogen from artificial photosynthesis).

There is work in progress that may make electrolysis 100% efficient based on knowledge of quantum tunneling.

### **Geoengineering**

Due to hundreds of coal mines planned for in China, it is not realistic to expect carbon neutrality by 2100. Hence, world scale projects may become desperate last measures. These include

- 1) Carbon capture and storage under ground as liquid (surface leaks would have to be detected at great cost and thwarted or else mass suffocation could result).
- 2) Mirrors in orbit to reflect sun's rays away from earth.
- 3) Artificial "sodium trees". These structures will adsorb CO<sub>2</sub> but will cost 15 trillion dollars.
- 4) Aerosols will block sun's rays but will be dangerous to coordinate around the world.
- 5) Carbon sinks (burnt carbon in ground to adsorb and absorb CO<sub>2</sub>).

### **Mitigation vs. Adaptation**

Mitigation is attempts to prevent climate change. Although it is this writer's opinion that change will progress, mitigation may reduce, at least partially, adaptation requirements. Adaptation will consist of millions and millions of people emigrating to safe havens such as Canada and New Zealand. Other habitable locations will exist; however, all will have to deal with social and political unrest due to immigration attempts. Once stable temperatures arrive, new economies will have to be formed. It is expected that human populations will rebound. **We can only hope that they have learned their lesson.**