Sustainability in Professional Engineering and Geoscience:

A Primer

Part 4. Climate Change

Developed by the Sustainability Committee of the
Association of Professional Engineers and Geoscientists of British Columbia
APEGBC

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Professional Engineers
and Geoscientists of BC

Sustainability Primer

Part 4. Climate Change

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1 Context and Introduction

APEGBC Sustainability Guidelines

Core to APEGBC's articulation of sustainability are the Sustainability Guidelines that state that, within the scope of a Member's task and work responsibility each Member, exercising professional judgment, should:

1) Develop and maintain a level of understanding of the goals of, and issues related to, sustainability.

2) Take into account the individual and cumulative social, environmental and economic implications

3) Take into account the short- and long-term consequences.

4) Take into account the direct and indirect consequences

5) Assess reasonable alternative concepts, designs and/or methodologies

6) Seek appropriate expertise in areas where the Member's knowledge is inadequate

7) Cooperate with colleagues, clients, employers, decision-makers and the public in the pursuit of sustainability.

Climate change is a naturally occurring phenomenon; however, most scientists agree that human activity has and continues to contribute significantly to climate change. Climate change is not inherently negative, but human societies are not well prepared to deal with its likely impacts – for example, 70 million people in Bangladesh alone live on low lands threatened by climate change-related sea level rises[i]. Here in British Columbia, temperature increases due to global warming have contributed to Mountain Pine Beetle outbreaks, drought conditions and increasingly severe forest fires.

The climate data clearly shows that climate change is occurring at a rate that is faster than what would be expected under natural conditions. As one example that is frequently mentioned: the earth's surface temperature has increased on average by 0.6 °C during the 20th Century and is likely to increase by 1.4-5.8 °C over the period 1990 to 2100[ii]. On a local scale, the temperature of the Fraser River has increased by 1.1°C since 1953[iii]. Observed air temperature changes in British Columbia are shown in Figure 2. Although these temperature increases do not appear to be significant, they are when considering the relatively short timeframe over which they have occurred.

The Government of Canada has recognized its international obligations to ratify the Kyoto Protocol and reduce greenhouse gas emissions to 6% below 1990 levels by the period between 2008 and 2012. According to the Provincial and Territorial Statement on Climate Change Policy, released in Halifax on October 28, 2002,

> "Provinces and Territories see climate change as a serious global issue that requires immediate and continuing action to reduce Canada's emissions."

The Statement also insists that the national climate change policy must support innovation and new technology.

The current situation provides opportunities for engineers and geoscientists to both show leadership on climate change issues and benefit from being first to market with new technologies and processes.

Air temperature is an important property of climate and the most easily measured, directly observable, and geographically consistent indicator of climate change. Historical data show that the average annual temperature increased in most parts of British Columbia between 1895 and 1995. Temperatures increased by 0.5°C to 0.6°C on the coast, 1.1°C in the interior, and 1.7°C in the north. Atmospheric warming of this magnitude affects other parts of the climate system, including precipitation, air, wind and ocean currents, and the hydrological cycle. Climate change affects ecosystems and species, and has both positive and negative impacts on human communities.

Indicators of Climate Change for BC 2002, BC Ministry of Water, Air, and Land Protection, Source: http://wlapwww.gov.bc.ca/pac/climate/cc print_page/ccindicator_print.html

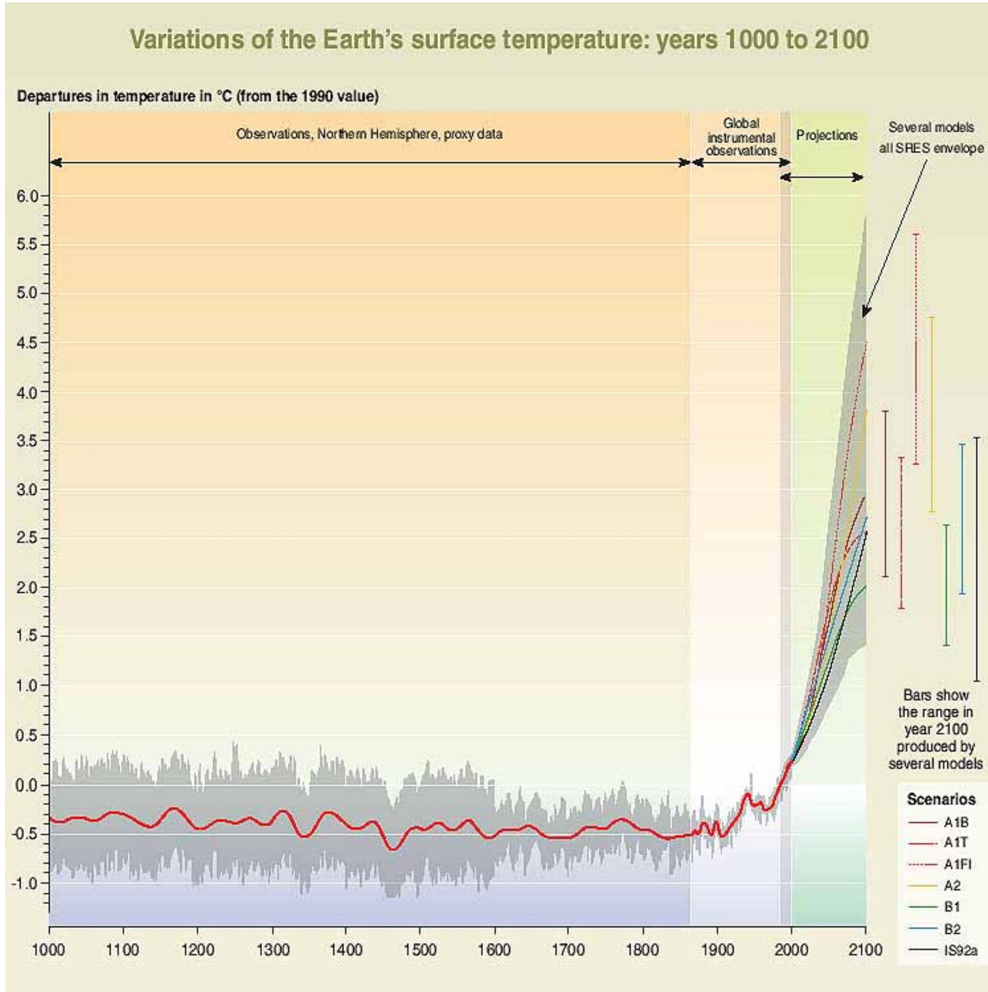

Figure 1: Past and Future Surface Temperature[iv]

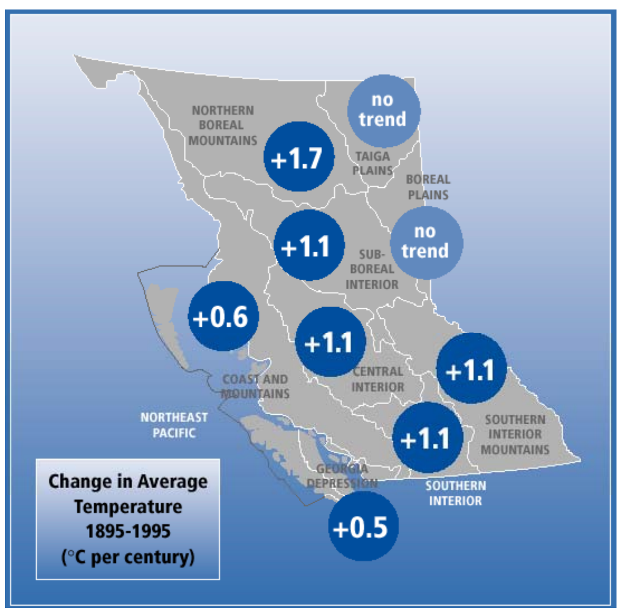

Figure 2: Observed Temperature Change in BC.

2 What the experts say

The World Meteorological Organization (WMO) and the United Nations Environmental Program (UNEP) established the Intergovernmental Panel on Climate Change (IPCC) (www.ipcc.ch) in 1988 in response to the increasing importance of global climate change. The role of the IPCC is to assess on a comprehensive, objective, open, and transparent basis the scientific, technical, and economic information relevant for the understanding of the risk of human-induced climate change. It does not carry out research nor does it monitor climate related data or other relevant parameters. It bases its assessment mainly on peer reviewed and published scientific/technical literature[v].

Proving the anthropogenic impacts on climate is a complicated issue, but the IPCC clearly states their position in the Third Assessment Report[vi]:

> “The Earth’s climate system has demonstrably changed on both global and regional scales since the pre-industrial era, with some of these changes attributed to human activities.”

> “There is new and stronger evidence that most of the warming observed over the last 50 years is attributed to human activities.”

The IPCC completed its First Assessment Report in 1990. The Third Assessment Report, completed in 2001, concentrates on new findings since 1995. The Third Assessment Report consists of reports from the three IPCC Working Groups, and a Synthesis Report. The three Working Groups' contributions represent nearly three years of work by approximately 450 Lead Authors and more than 800 Contributing Authors. In accordance with the IPCC procedures, the Working Groups' reports went through a triple review process. Comments received during scientific technical review from approximately 1000 government and expert reviewers were carefully analyzed and assimilated to revise the drafts with guidance provided by Review Editors[vii].

The most robust findings are summarized in Table SPM-3 of the Summary for Policymakers report. Some of the findings include[viii]:

1. Observations show the Earth's surface is warming. Globally, the 1990's were very likely the warmest decade in instrumental record.

2. Most of the observed warming over the last 50 years is likely due to increases in greenhouse gas concentrations due to human activities.

3. Global average surface temperature during the 21st Century is rising at rates very likely without precedent during the last 10,000 years.

4. Projected climate change will have beneficial and adverse effects on both the environmental and socio-economic systems, but the larger the changes and the rate of change in climate; the more the adverse effects predominate.

One of the pieces of evidence linking humans to climate change is carbon dioxide (CO_2). Greenhouse gases (GHG's), like CO_2, help to regulate the earth's temperature by radiating heat back to the surface that would otherwise be lost to outer space. Higher GHG's tend to radiate more heat back to earth causing an increase in temperature, or global warming. CO_2 concentrations, for example, have increased by 30% since the 1850's and are now at a record high of 386 ppm in 2000[ix] – a level that has not been exceeded during the past 420,000 years and likely the past 20 million years[x] (See **Figure 2** and **Figure 3**).

The IPCC emissions scenarios (possible future outcomes based on our current knowledge and understanding of global climate change and where we will be in 50-100 years) project CO_2 concentrations in the year 2100 to range from 540 to 970 ppm – significantly higher than the pre-industrial level of 280 ppm and our current level of approximately 386 ppm[xi] (See **Figure 2**). The burning of fossil fuels and changes in land-use are the primary human causes of CO_2 emissions and the resulting rise in CO_2 concentrations.

Clearly, climate change is one of the most important environmental issues of our time.

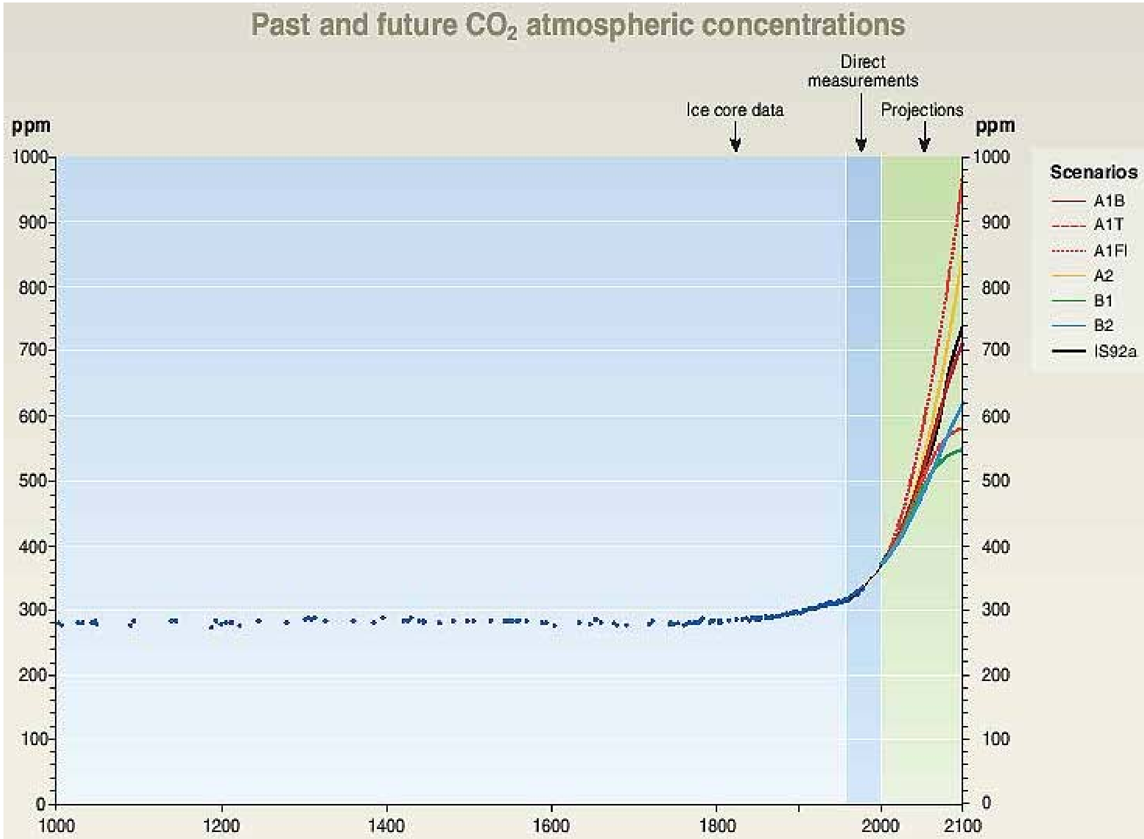

Figure 2: Past and Future CO_2 Atmospheric Concentrations[xii]

Global CO_2 emissions from fossil fuel burning, cement manufacturing, and gas flaring.

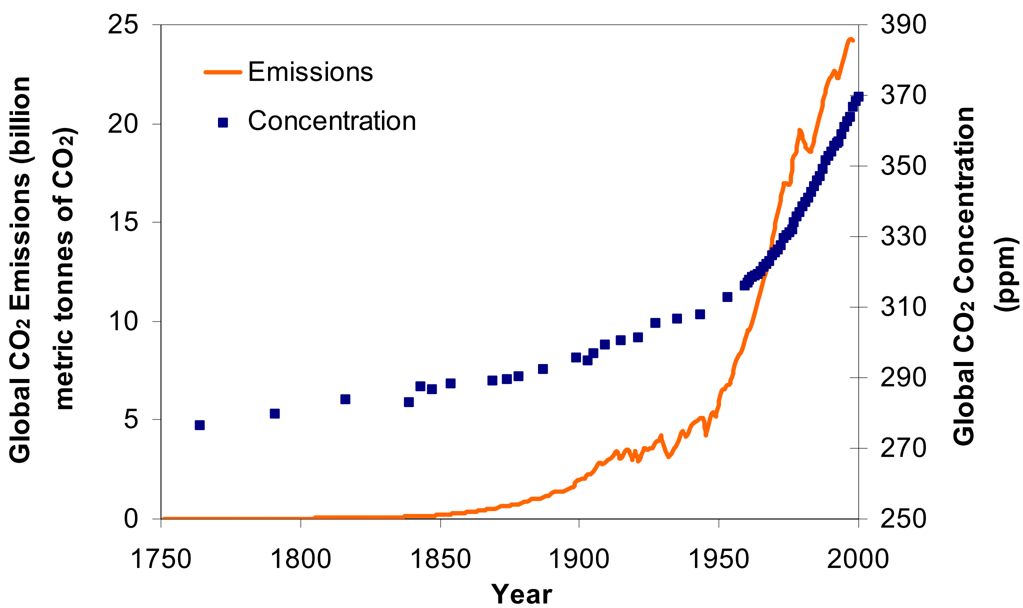

Figure 3: Global CO_2 Emissions and Concentrations

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3 How Does Climate Change Affect Engineers & Geoscientists?

The movement towards addressing climate change is rapidly gathering momentum. The Government of Canada has recognized its international obligations to ratify the Kyoto Protocol and reduce greenhouse gas emissions to 6% below 1990 levels by the period between 2008 and 2012. The Provincial Government of British Columbia has made a commitment to reducing its greenhouse gases by 16% between 2000 and 2005. In April 2003, the Association of Professional Engineers of Nova Scotia issued a statement in support of climate change mitigation and adaptation.

Recognizing that climate change will play an increasingly important role in engineering and geoscience practice, The Canadian Council of Professional Engineers recently organized a workshop on Climate Change – Impact and Adaptation with the support of the Government of Canada's Climate Change Action Change. The Action plan that resulted from the workshop was published in June 2003. It recommends developing an education strategy aimed at engineering students and professional engineers, and raising awareness of climate change within the profession[xiv].

Henry Hengeveld is Environment Canada's Senior Science Advisor on Climate Change. In his presentation to the Canadian Council of Professional Engineers in spring 2003, he outlined some of the predicted affects of climate change[xv]. They include:

- Wetter winters for most of Canada
- Drier summers in interior North America
- Retreat of Sea ice, particularly in summer
- Rising Sea levels
- Increased incidents of inland flood disasters
- Increased frequency and severity of drought in southern Canada
- Major changes in water resources

Engineers and geoscientists have an opportunity to benefit from showing leadership in the application of technology that addresses climate change. The demand for innovative processes and technology that reduce greenhouse gas emissions is increasing at the local, national and international level.

4 Keeping Informed

The Sustainability Committee recommends reading the *Climate Change 2001: Synthesis Report, Summary for Policymakers* (http://www.grida.no/climate/ipcc_tar/vol4/english/005.htm) – a 35-page document that summarizes the three working group reports. It is the most concise summary of the IPCC reports.

Two local climate change research groups (Canadian Climate Impacts & Adaptation Research Network CCIARN, http://www.britishcolumbia.c-ciarn.ca/) and the BC Climate Exchange at the Fraser Basin Council, (http://www.bcclimateexchange.ca/) are involved with APEGBC on climate change issues. Comments and questions can also be forwarded to the Sustainability Committee or Anthea Jubb, APEGBC Sustainability Researcher, Email: ajubb@apeg.bc.ca Ph.: 604 412 4860.

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5 Excerpts from Climate Change 2001: The Scientific Basis- Summary for Policymakers

Source: http://www.grida.no/climate/ipcc_tar/wg1/005.htm

The Third Assessment Report of Working Group I of the Intergovernmental Panel on Climate Change (IPCC) builds upon past assessments and incorporates new results from the past five years of research on climate change. Many hundreds of scientists from many countries participated in its preparation and review.

This Summary for Policymakers (SPM), which was approved by IPCC member governments in Shanghai in January 2001, describes the current state of understanding of the climate system and provides estimates of its projected future evolution and their uncertainties. Further details can be found in the underlying report, and the appended Source Information provides cross references to the report's chapters.

An increasing body of observations gives a collective picture of a warming world and other changes in the climate system.

- Since the release of the Second Assessment Report (SAR), additional data from new studies of current and palaeoclimates, improved analysis of data sets, more rigorous evaluation of their quality, and comparisons among data from different sources have led to greater understanding of climate change.

The global average surface temperature has increased over the 20th century by about 0.6°C.

- The global average surface temperature (the average of near surface air temperature over land, and sea surface temperature) has increased since 1861. Over the 20th century the increase has been 0.6 ± 0.2°C. This value is about 0.15°C larger than that estimated by the SAR for the period up to 1994, owing to the relatively high temperatures of the additional years (1995 to 2000) and improved methods of processing the data. These numbers take into account various adjustments, including urban heat island effects. The record shows a great deal of variability; for example, most of the warming occurred during the 20th century, during two periods, 1910 to 1945 and 1976 to 2000.

- Globally, it is very likely that the 1990s was the warmest decade and 1998 the warmest year in the instrumental record, since 1861.

- New analyses of proxy data for the Northern Hemisphere indicate that the increase in temperature in the 20th century is likely to have been the largest of any century during the past 1,000 years. It is also likely that, in the Northern Hemisphere, the 1990s was the warmest decade and 1998 the warmest year. Because less data are available, less is known about annual averages prior to 1,000 years before present and for conditions prevailing in most of the Southern Hemisphere prior to 1861.

- On average, between 1950 and 1993, night-time daily minimum air temperatures over land increased by about 0.2°C per decade. This is about twice the rate of increase in daytime daily maximum air temperatures (0.1°C per decade). This has lengthened the freeze-free season in many mid- and high latitude regions. The increase in sea surface temperature over this period is about half that of the mean land surface air temperature.

Temperatures have risen during the past four decades in the lowest 8 kilometres of the atmosphere.

- Since the late 1950s (the period of adequate observations from weather balloons), the overall global temperature increases in the lowest 8 kilometres of the atmosphere and in surface temperature have been similar at 0.1°C per decade.

- Since the start of the satellite record in 1979, both satellite and weather balloon measurements show that the global average temperature of the lowest 8 kilometres of the atmosphere has changed by +0.05 ± 0.10°C per decade, but the global average surface temperature has increased significantly by +0.15 ± 0.05°C per decade. The difference in the warming rates is statistically significant. This difference occurs primarily over the tropical and sub-tropical regions.

- The lowest 8 kilometres of the atmosphere and the surface are influenced differently by factors such as stratospheric ozone depletion, atmospheric aerosols, and the El Niño phenomenon. Hence, it is physically plausible to expect that over a short time period (e.g., 20 years) there may be differences in temperature trends. In addition, spatial sampling techniques can also explain some of the differences in trends, but these differences are not fully resolved.

Snow cover and ice extent have decreased.

- Satellite data show that there are very likely to have been decreases of about 10% in the extent of snow cover since the late 1960s, and ground-based observations show that there is very likely to have been a reduction of about two weeks in the annual duration of lake and river ice cover in the mid- and high latitudes of the Northern Hemisphere, over the 20th century.

- There has been a widespread retreat of mountain glaciers in non-polar regions during the 20th century.

- Northern Hemisphere spring and summer sea-ice extent has decreased by about 10 to 15% since the 1950s. It is likely that there has been about a 40% decline in Arctic sea-ice thickness during late summer to early autumn in recent decades and a considerably slower decline in winter sea-ice thickness.

Global average sea level has risen and ocean heat content has increased.

- Tide gauge data show that global average sea level rose between 0.1 and 0.2 metres during the 20th century.

Global ocean heat content has increased since the late 1950s, the period for which adequate observations of sub-surface ocean temperatures have been available.

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